SUSTAINABLE, SAFE & SECURE THROUGH DEMAND REDUCTION

Abstracts

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Advancing energy resilience and decarbonization by unleashing the potential of energy storage and demand-side flexibility
Misalignments of theory and practice: Exploring Swedish energy utilities’ understandings of energy justice, flexibility capital, and just energy transitions

Frans Libertson, Lund University, Sweden
Michael Hörner, Private consultant

Panel
1. Dynamics of consumption

Keywords
utilities, energy justice, flexibility capital

Ensuring that the existing social inequalities of the current energy system are not transferred to the new system is crucial for the transition towards a low-carbon economy. This is the domain of energy justice—a normative and evaluative framework that has been applied extensively throughout the past decade for understanding the perspective of disadvantaged energy users. However, less attention has been paid to the perspectives of supply-side actors, such as energy utilities, and their understanding of energy justice.

The purpose of this study is to explore how Swedish energy utilities perceive themselves and their roles in a just energy transition as well as scrutinize their understanding of energy justice and user flexibility. To answer these questions, 24 semi-structured interviews with representatives of prominent Swedish energy sector actors were analyzed by use of narrative analysis.

The results constitute four archetypes—the System Operator, the Housekeeper, the Green Tech Proponent, and the Entrepreneur—each of them placing unique emphasis on technology, humans and nature, and a reformist-transformative view of the energy sector. These diverging views on a just energy transition should not be regarded as mutually exclusive but rather as complementary since a just transition should encompass all perspectives. However, this study concludes that to remedy the misalignment between the theory and practice of energy justice, the energy sector would benefit from adopting roles that to a greater extent emphasize social equity. Future research should also investigate the extent to which energy utilities may be held accountable for energy injustices.
The socio-economic factors of sufficiency lifestyles: Empirical evidence for the elaboration of socially just decarbonisation policies

Aurore Flipo, Association négawatt, France
Abigail Alexander-Haw, Fraunhofer Institute for Systems and Innovation Research ISI, Germany
Fiona Breucker, Jacques Delors Institute, France
Elisabeth Dütschke, Fraunhofer Institute for Systems and Innovation Research ISI, Germany

Panel
1. Dynamics of consumption

Keywords
sufficiency, lifestyle, decarbonisation

Sufficiency consists of less materially intensive consumption patterns, focusing on well-being rather than material wealth. Such sustainable consumption patterns are commonly referred to as lifestyles and are increasingly seen as a key driver for achieving decarbonisation.

However, lifestyles have long been described as a crucial element of social stratification and social distinction processes within society (Bourdieu, 2015). Sustainable consumption in general is typically associated in the literature with high social status (Carfagna et al., 2014; Kennedy and Givens, 2019). Nevertheless, higher income households tend to emit more carbon (Jorgenson et al., 2018), while low income households tend to have lower carbon footprints (Duarte et al., 2021; Sampedro et al., 2022). Sufficiency should be distinguished from sustainable consumption, since sufficiency designates absolute reduction of consumption levels (Kropfeld, 2023) and thus, lower demand for goods and services (Samadi et al., 2017). While sustainable consumption and its determinants are well-documented, further research is warranted on the concept of sufficiency, the social stratification aspects of sufficiency orientations, and sufficiency lifestyles.

This contribution is based on the interdisciplinary H2020 project FULFILL (Fundamental Decarbonisation through Sufficiency by Lifestyle Changes). It aims to investigate the socio-demographic characteristics associated with sufficiency lifestyles. Furthermore, it investigates the drivers and barriers of sufficiency, and discusses policy avenues that can relieve these barriers and encourage sufficiency.
We use a mixed methods design. We use data from demographically representative surveys in Italy, Germany, Latvia, and Denmark (N=5080) based on both carbon footprints and well-being indicators. We categorise respondents into five sufficiency lifestyle groups based on their carbon footprint and the well-being measure. We operationalise a sufficiency as a lifestyle with low-carbon footprint and a high score on the well-being index. A low carbon footprint was defined in relative terms, i.e., as a footprint in the lowest quarter within the respective country. Similarly, we distinguished respondents in the lowest carbon footprint quantile into above and below median well-being. Based on these steps, we create five lifestyle groups. To establish connections between lifestyle group membership and various socio-economic and additional variables, we employ neural networks to estimate multinomial log-linear models using the R package nnet (Venables and Ripley, 2002).

We then analyse the motivations and practices of participants in sufficiency-oriented intentional communities in the five countries, based on in-depth socio-anthropological interviews (N=90). We analyse in particular the motivations, biographical trajectories and involvement processes of these individuals into sufficiency initiatives and practices. In a third section, we derive policy recommendations from these empirical findings.

We find that in our sample sufficiency lifestyles are positively associated with corresponding attitudes such as sufficiency orientation or a heightened environmental identity, and negatively associated with aspects of material deprivation.

Based on qualitative research, we also find that individuals engaged in sufficiency-oriented practices tend to benefit from economic, social, and cultural resources that allow them to overcome energy dependency and dedicate time to this endeavour. Gender is another important factor, appearing both in quantitative and qualitative data and suggesting that women are more engaged in sufficiency-oriented practices and lifestyles, than men.

Finally, based on this empirical evidence we explore potential avenues for democratisation of sufficiency-oriented lifestyles, including establishing binding rules through a democratic process that curb overconsumption while offering appealing low-carbon lifestyles for all.
Households revealed willingness to pay during winter electricity shortages

Nina Boogen, Zurich University of Applied Sciences (ZHAW), Switzerland
Christian Winzer, Zurich University of Applied Sciences (ZHAW)

Panel
1. Dynamics of consumption

Keywords
willingness to pay, heat pump, field experiment, consumer behaviour, energy crisis

Increasing energy efficiency is part of the strategy of many industrialized nations to combat climate change, to reduce local air pollution, to improve energy security and to prevent the need for constructing expensive new power plants. Further, reducing and/or shifting electricity demand also reduces the need to upgrade the transmission and distribution network. Moreover, in 2022 Russia's war on Ukraine led to a significant energy crisis with global shocks in energy prices, but particularly severe effects in Europe’s energy markets. Following, energy shortages were expected during the heating period and brought the topic of energy savings into people’s minds. Because of good preparation and a mild winter, there were no major shortages. But this might not be the case for coming winters.

There are previous studies that estimated the willingness to pay (WTP) of households for flexibility using stated preferences (e.g. Kubli et al., 2018; Motz, 2021; Winzer et al., 2023). As far as we are aware, there are no previous studies that tested households’ revealed preferences. Thus, we contribute to the literature by eliciting consumers’ willingness to curtail their heat pumps during winter electricity shortages using a sample of Swiss households.

We design and implement a randomized control trial (RCT) to test the revealed WTP of households for their heat pump’s energy consumption during winter electricity shortages. The experiment is implemented in cooperation with a Swiss utility, that invited 2800 heat pump households to take part. Participants that registered to take part in the study are invited to fill in a baseline survey. This survey collects detailed information about the respondents’ and their households’ socio-economic characteristics, dwelling characteristics, attitudes, energy-related knowledge of the participants and some stated preferences elicitations of their willingness to pay or accept during winter electricity shortages. Afterwards, the participants were randomly allocated between the treatment group (N=185) and the control group (N=166) using a stratified approach.

Between Jan–Apr. 2024 we provide treated households with weekly study price signals (relatively extreme electricity prices) via SMS. The households then decide whether to pay these (high) prices (accept the price which follows an according deduction form a virtual study budget) or to curtail their heat pump’s consumption (e.g., by lowering the target indoor temperature by 1°C) and thus avoid some part of the high energy costs. The intervention is
incentive-compatible, since the participants are endowed with a virtual study budget on which the behaviour of the participants has an influence on their real pay-outs at the end of the study time. Depending on this, the virtual study budget will be reduced accordingly week by week. During this period, we do not contact the households in control group.

After the 15-week study period, we invite the households in the treatment and control group to fill in a short follow-up survey. The follow-up survey collects information on the participants’ experience during the intervention and the behaviour regarding their heat pump. To evaluate the effects of the treatment, we combined data from the baseline household survey, the smart meter data provided by the utility, and the follow-up survey. The field experiment was registered in the AEA RCT Registry (ID: AEARCTR-0012277).

References

Exploring the scope of action for sufficiency oriented energy policies in Norway

Gisle Solbu, Norwegian University of Science and Technology, Norway
Tomas Moe Skjølsvold, Norwegian University of Science and Technology
Marius Korsnes, Norwegian University of Science and Technology

Panel
1. Dynamics of consumption

Keywords
energy sufficiency, energy policy, feasibility, energy politics, energy publics

From being a niche concept, sufficiency-oriented thinking is now gaining traction in mainstream policy-making, emphasizing the importance of meeting people's basic needs equitably and respecting ecological limits while avoiding excessive energy demands. As an example, the IPCC has recently highlighted the significant role sufficiency policies can play in mitigating emissions by complementing efficiency and renewable energy policies. Moreover, the recent European energy crises has underscored the benefits of sufficiency as a strategy to alleviate pressure on the energy system. However, while sufficiency is becoming a more widespread concept to address urgent issues, we see fewer attempts to engage in a deeper discussion about its implications on the core direction of our energy systems and the types of activities that we either want to encourage or constrain. We thus lack a contextual understanding of the scope of action for sufficiency-oriented energy policies, which gives room for questioning the feasibility of such pathways.

Our paper will gain insights into this challenge by studying political parties and the public's perception of energy-sufficiency strategies in Norway, using qualitative interviews and quantitative survey data triangulation. First, we investigate how political parties across the left-wing/right-wing axis perceive their agency, political willingness and political feasibility to push for more transformative interventions into the efficiency and growth-oriented practices that underpin most of today's policies. We find that all political parties, from left to right, acknowledge the need for sufficiency-oriented policy measures that address energy demand reductions, both through reduction in direct energy use and indirectly through reduced consumption of goods. However, we also identify a series of "ideological lock-ins" that limit how politicians experience their own scope of action to push for more radical policy interventions. E.g., from the perspective of a leftist socialist ideology, overconsumption is perceived as a systemic issue derived from capitalist structures, causing reluctance to push for policies that unfairly target individuals. From the liberal right, sufficiency practices should emerge naturally through market mechanisms, and there is reluctance towards state interventions that enforce changes. From both wings there exist imaginations of voters being unwilling to accept
disruptive changes to everyday life and societal trajectories. As a result, the viable political options for engaging with sufficiency are limited to tweaking existing instruments and moderate interventions, like removing VAT on repair work or banning planned obsolescence. In sum, the politicians frame sufficiency as an add-on to existing efficiency and growth-oriented instruments.

Next, in our analysis, we aim to compare the political parties’ perceptions with an analysis of the general public’s willingness to reduce energy consumption levels and their perception of sufficiency-oriented policies. This comparison will draw on a representative survey of the Norwegian population on the willingness to take part in transformative and potentially disruptive changes that can contribute to reducing energy-demanding practices. The comparative analysis will serve as a basis for developing a bottom-up understanding of short-term and long-term opportunities and challenges for sufficiency measures that are sensitive to the political context in which they will be implemented.
Determinants of behavioral change: Combining insights from digital tools, surveys, and smart meters to understand prosumers’ energy choices

Anne Kesselring, Fraunhofer, Germany
Sabine Pelka, Fraunhofer ISI, Germany

Panel
1. Dynamics of consumption

Keywords
prosumers, behavioural change, nudging, energy consumption

Behavioral interventions like nudging are proposed as powerful alternatives to price-based instruments in reducing energy consumption. Despite several promising examples, the evidence on nudging is mixed and in some cases simply unsuccessful. Part of the knowledge gap is that research shows evidence on outcomes, but we still do not fully understand the mechanisms. This paper explores the determinants of energy-related behavior for 111 prosumer households in Germany that were tracked over 1.5 years and treated with digital nudges in a field experiment from 2021 to 2023. Smart meter data on energy- and self-consumption are connected with five types of determinants: (i) intention as the psychological antecedent, (ii) tool usage, i.e., whether, when, and how participants used the digital tools, (iii) techno-economic predictors, (iv) weather conditions, (v) treatment-specific information. While the first two are directly linked to the consumption behavior and therefore the intervention, the other three are pre-determined, exogenous determinants. We exploit the unique condition of having different data types that cover both kinds of determinants.

First, we analyse the determinants that are directly linked to the intervention in a descriptive analysis: the (i) intention (i) and engagement with the digital tool. We show that the tool was used infrequently despite high stated intention, and that there is no systematic relationship between tool use and self-reported intention.

Second, we combine and compare all five kinds of determinants using regularization techniques (LASSO regression) to understand what drives the outcome variables. The exploratory analysis reveals that pre-determined variables are important predictors to both energy and self-consumption: heat pumps (in winter), photovoltaic size, and weather are consistently among the effective predictors for changes relative to baseline consumption. By contrast, the most relevant behavioral determinants differ across interventions and outcomes.

Additionally, these behavioral determinants can have unexpected signs. In particular, we
identify cases of a negative effect of app usage and intention, which we interpret in the context of the intention-action gap.

Overall, changes in consumption behavior are firstly driven by investments in energy technologies and their weather-dependent operation. Determinants directly linked to the behavioral intervention have a secondary, partly counterintuitive impact on the consumption behavior. The paper helps to understand determinants of behavioral mechanisms. This knowledge is critical for better intervention design and the effective use of behavioral approaches in policy portfolios.
Impact of energy price rise on electricity use and indoor temperatures in UK dwellings retrofitted with heat pumps

Rajat Gupta, Oxford Brookes University, United Kingdom
Sahar Zahiri, Oxford Brookes University, United Kingdom

Panel
1. Dynamics of consumption

Keywords
heat pump, dwellings, energy price, monitoring, indoor environment

The announcement of the UK Government's 'Ten Point Plan' for a green industrial revolution highlighted a key role of decarbonisation of domestic heating through heat pump deployment to support its net-zero emission target. Given that for every unit of electricity that heat pumps use to power the system, they can generate four units of heat, their deployment in homes is vital to achieve carbon emissions reduction target with higher efficiency. Additionally, the publication of a cost-of-living survey in the UK in 2023–24 revealed 44% of adults used less fuel in their homes to save on energy costs. This indicates key role of heat pump installation in such homes to reduce cost burden on households. To examine whether heat pumps represent a solution for better protecting vulnerable households from energy price rise, it is vital to study their reactions to such developments and the consequences on indoor temperatures.

This paper systemically examines observed changes in electricity use and indoor temperature over two winter seasons across 21 social housing (four bungalows and 17 flats) before (Dec 2021 to Feb 2022) and after (Dec 2022 to Feb 2023) the surge in energy prices in the UK. The dwellings were co-located in a socially deprived area in Oxford (UK), which were continuously occupied, and were retrofitted with ground source heat pumps without insulation improvement. Longitudinal monitoring of outdoor and indoor temperatures was undertaken at 15-minute intervals using data loggers. Heat pump electricity use data was gathered through heating controls of each dwelling.

Occupant surveys were also conducted to ascertain the thermal comfort responses of residents and usability of the heat pump system. Although mean monthly outdoor temperatures in the winter season of 2022–23 (Dec–Feb) were found to be colder, mean indoor temperatures across the case study dwellings were found to drop to 20 °C from 20.8 °C observed pre-energy price rise.

The weather corrected mean monthly heat pump electricity use was found to be 24% lower
after the energy price rise, which correlated with the 12% reduction in mean daily heat pump electricity use, likely to be driven by higher energy costs. Heating demand during the peak evening period was also observed to be lower post energy price rise due to reduction in total heating demand.

The change in residents’ heating preferences was confirmed through occupant surveys, indicating 25% of residents struggled to pay energy bills in line with the lowest mean monthly heat pump electricity use. These findings raise concerns for policymakers about the potentially negative impact of energy prices on the wellbeing of vulnerable residents inhabiting fuel poor dwellings. This also reinforces the need to rapidly insulate dwellings with heat pumps to reduce annual energy cost.
Cost-of-living-crisis, underheating and wellbeing – insights from a large survey study in Great Britain

Gesche Margarethe Huebner, UCL BSEER, United Kingdom
Jessica Few, UCL Energy Institute
Clare Hanmer, UCL Energy Institute
Martin Pullinger, UCL Energy Institute
Simon Elam, UCL Energy Institute

Panel
1. Dynamics of consumption

Keywords
homes, cost-of-living, heating, wellbeing

The winter of 2022/23 brought large increases in energy prices and the cost of living in numerous countries around the world, including Great Britain. Previous research has shown that cold homes have significant mental and physical health consequences.

We conducted a survey in January – March 2023 to understand the impact of the cost-of-living (CoL) crisis on British households, reaching a sample size of about N = 5000 households. For these respondents, we also have survey data from when they initially signed up to a long-term research study, the Smart Energy Research Lab (SERL), as well as their household energy consumption, collected via smart meters.

Here, we particularly focus on the concept of underheating and its relation to wellbeing. Wellbeing was measured with two items, “life satisfaction” and “finding things in life worthwhile” that are routinely used in UK Government surveys. We defined underheating as having self-reported thermostat settings of below 18°C, as being in the lowest decile of gas use normalized by dwelling size, and by a self-reported measure of being able to keep comfortably warm. About 12% of householders were unable to keep comfortably warm in their living rooms in the CoL winter and their wellbeing was significantly lower than for those who were able to. Those with thermostats set below 18°C also reported lower wellbeing levels than those with settings between 18 and 21°C. There was a strong link between wellbeing and financial status. Analysis of those with low normalized gas use is ongoing, as is linking with building factors.

The results emphasize the need to ensure everyone has a comfortable, affordable-to-heat home. This implies that pathways to net-zero, such as changing the relative price of gas and electricity or banning gas boilers, need to have their distributional impacts thoroughly assessed, as they could otherwise worsen the wellbeing of substantial parts of the population.
Designerly contributions to energy sufficiency – a narrative review and exploration of possibilities

Helena Strömberg, Chalmers University of Technology, Sweden
Sara Renström, RISE Research Institutes of Sweden, Sweden
Katharina Merl, Bolid, Sweden
Maria Håkansson, RISE Research Institutes of Sweden, Sweden

Panel
1. Dynamics of consumption

Keywords
energy sufficiency, design, designerly thinking, literature review

Adopting a sufficiency approach to energy use seems necessary to justly distribute resources within planetary boundaries. However, sufficiency can be seen as adversarial and a transition to sufficiency is not clearly staked out. Designers and designerly thinking are uniquely posed to address the dialectical space between the world that is and the world that could be (Margolin, 2007), and to make visions of the future more tangible, supporting discussions on preferable futures. Thus, this paper aims to explore how designers can contribute to establishing the required shift towards energy sufficiency.

Based on a narrative literature and design exploration, we outline and illustrate possibilities for designers to contribute. The question of basic human needs is central to Darby & Fawcett’s (2018) definition of energy sufficiency. Design, in particular user-centred design, has long worked with needs, uncovering latent needs and tacit knowledge. This design competence can open new avenues, for example by untangling needs from the material and energy-consuming ways we currently satisfy them with, through innovation of new “need satisfiers”, or through critical design that prompts reflection and debate. Critical design and similar approaches are further useful to address a key shift in societal and personal narratives surrounding energy sufficiency (cf. Tröger & Reese, 2021), e.g. progress vs. contentment, ideas of success, and how fast needs should be satisfied. Designerly competences can also be used to show existing diversity of practices and encourage exploration of them. Finally, design can address systemic aspects by creating innovative wellbeing-enhancing solutions. Such solutions could potentially shift the framing of sufficiency away from voluntary actions that lead to reductions of utility and moral licence for rebound effects (cf. Sorell et al, 2020). In conclusion, we argue that design competences should play important roles in a transition to energy sufficiency.
Tackling rising energy costs: the role of German climate policy in supporting vulnerable groups

Katja Schumacher, Öko-Institut, Institute for Applied Ecology Öko-Institut, Germany
Viktoria Noka, Öko-Institut
Cludius Johanna, Öko-Institut

Panel
1. Dynamics of consumption

Keywords
energy poverty, vulnerability, climate policy, energy crisis, social, low income, domestic energy efficiency

Recent spikes in fossil fuel prices have shown that rising energy costs can put a substantial burden on many households. While the recent war-related price spikes were unanticipated and very pronounced, higher fossil energy prices, e.g. through carbon pricing, will be needed within a policy mix to reach climate targets. Price increases affect vulnerable groups the most. Independent of the cause of rising energy prices, energy efficiency and a switch to non-fossil resources help to reduce this burden. Most often, however, vulnerable groups lack the financial means to invest or change their use patterns. Or they already use very little and cannot meet their needs. Knowing who these vulnerable groups are and in what respect they are most vulnerable is key to designing targeted policies and measures that both support households in terms of affordability of energy services and help them become resilient to rising energy prices.

In this paper, we put indicators into practice by comparing different vulnerability indicators with respect to heat energy. Our focus is on Germany which does not have an official definition of energy poverty and almost no policy measures to specifically support emissions reductions for vulnerable groups. The focus so far has been on social policies with direct income support. In a second step, we use our preferred indicator to model the distributional effects of selected measures for vulnerable groups. We draw on good examples from other Member States and look into i) socially differentiated support for low-investment heating efficiency measures, ii) expanded energy advice programs for vulnerable households, and iii) the provision of energy saving devices (such as heating thermostats, efficient lighting etc.). We assess the number of households that can be reached, the savings they can achieve, and the amount of public funding needed for such programs.
Staying cool in France: an extensive survey of summer comfort, natural home cooling practices and emerging air conditioning use in the French residential sector

Mathieu Durand-Daubin, EDF R&D, France
Marie-Hélène Laurent, EDF R&D, France
Guillaume Binet, EDF R&D, France

Panel
1. Dynamics of consumption

Keywords
air conditioning, residential buildings, consumer behaviour, future outlook, electricity savings, space cooling

According to the International Energy Agency, over the next three decades, the use of air conditioners is set to soar, becoming one of the top drivers of global electricity demand. In France, as summer heatwaves become more frequent, the residential air conditioners installation rate doubled in the last ten years, bringing the total share of equipped dwellings to 25% in 2021. To tackle the increase in energy consumption and changes in seasonality that could result from this trend in the future, we need a better understanding of current cooling practices. So far in this country, while heating consumption in winter caught all the light, little was known of energy consumption in summer. This paper offers an analysis of French households' summer cooling practices based on a unique representative survey of 8,000 households, asked about their building and equipment, comfort, everyday natural ventilation and shading actions, and cooling appliances usage.

We show how the diversity of summer comfort and temperature perception depends on building features, location, and heat waves. Natural cooling is still more frequent than the use of air conditioners. During summer 2021, most people regularly opened windows in the night and morning, and closed shutters in the middle of the day, while only half of the households with air conditioners used them in addition to natural cooling. Air conditioners use rates and set temperatures depend on comfort perception and the types of cooling equipment. Air conditioning is mostly occasional and space specific, as opposed to the norm of constant cooling that can be found in other parts of the world. Altogether, this detailed description of current cooling practices, their interactions and drivers, allow to anticipate a limited rise of this demand, shall people keep on their natural ventilation and shading actions.
Gender-blind energy efficiency policy-making in Europe: risks and challenges for the private rented sector

Manon Burbidge, University of Manchester, United Kingdom
Dimitris Papantonis, University of Piraeus, Greece
Saska Petrova, University of Manchester, United Kingdom
Stefan Bouzarovski, University of Manchester, United Kingdom
Akis Apostoliotis, University of Piraeus, Greece
Alexandros Flamos, University of Piraeus, Greece

Panel
1. Dynamics of consumption

Keywords
gender, domestic energy efficiency, energy poverty, energy efficiency policy, housing

Women across Europe are disproportionately vulnerable to energy poverty, a result of pervasive societal gender inequalities, such as lower incomes and unequal care responsibilities, whilst being underrepresented in decision-making spheres. Furthermore, pressures on social housing have seen more low-income families pushed into low quality, costly and precarious housing in the private rented sector (PRS), increasing exposure to energy poverty. Although recently gaining some recognition at the EU-level, gender-just measures to improve energy efficiency and alleviate energy poverty, particularly within the PRS, remain inadequate at all levels of policymaking, with energy policy continuing to be designed in a “gender-blind” manner. However, neglecting the impact of gender inequalities and housing tenure upon vulnerability to energy poverty will likely hinder the achievement of a just energy transition.

This paper uses a multi-method approach, encompassing an in-depth critical review of academic and grey literature, an analysis of existing European energy efficiency policies aimed at the PRS, and a scoping survey of 54 stakeholders, to unpack how gender is currently addressed in policy and the implications for alleviating energy poverty in Europe. Our results show that gender is extremely poorly understood and tackled by existing policies across Europe: a mere 2.5 % of analysed policies mentioned gender, one third of which are energy advice measures, which do not tackle the systemic underlying causes of energy poverty.

Only 6 % of survey respondents believed that gender was currently adequately addressed in existing policies, with female respondents more likely to rate policies as poor or very poor. Identified policy barriers that contribute to this situation include a dearth of disaggregated data, a widespread lack of awareness of the gendered impacts of energy poverty, poor gender-mainstreaming practices, and the inaccessibility and untargeted nature of current
efficiency measures. Based on these barriers, we conclude by synthesising key policy recommendations which could foster the deployment of more gender-just energy efficiency policies in the European PRS.
Towards the improvement of the energy poverty and energy efficiency policy implementation framework in rural and suburban areas across Europe

Dimitris Papantonis, Technoeconomics of Energy Systems laboratory (TEESlab)- University of Piraeus Research Center (UPRC), Greece
Akis Apostoliotis, Technoeconomics of Energy Systems laboratory (TEESlab) - University of Piraeus Research Center (UPRC), Greece
Marco Peretto, Institute for European Energy and Climate Policy Stichtung (IEECP), The Netherlands
Stefan Bouzarovski, Institute for European Energy and Climate Policy Stichtung (IEECP), The Netherlands
Alexandros Flamos, Technoeconomics of Energy Systems laboratory (TEESlab), University of Piraeus Research Center (UPRC), Greece

Panel
1. Dynamics of consumption

Keywords
energy efficiency policy, energy policy, energy poverty, sustainable development, renovation, EU policy, sustainable communities

While energy poverty is widely recognised and discussed, rural energy poverty has received limited attention - even though it is more prevalent than in urban contexts. Most policy actions and interventions to address issues of energy poverty, energy efficiency and building renovations in the housing stock are concentrated in urban areas. Our article aims to address this gap and improve the energy poverty-energy efficiency framework on rural and peri-urban contexts, by providing a comprehensive overview of their characteristics, the status of rural energy poverty and its unique driving forces, the current energy efficiency policy landscape at the European level, and the structural factors, which work as barriers to and solutions for the implementation of energy efficiency policies to address rural energy poverty.

Our approach is twofold; first conducting an in-depth review of more than 100 academic and grey literature sources, followed by a European-wide survey (conducted for the first time) to generate primary data on stakeholder needs and viewpoints for the design and implementation of energy efficiency policies in vulnerable rural and peri-urban areas.
Our findings indicate that rural areas’ unique characteristics are not adequately captured from the current policy landscape, and that although financial barriers and national policies, are always of the essence, a holistic assessment of barriers, a strong emphasis on the local context and the collaboration across different levels of governance is necessary. Our results also provide recommendations that governmental bodies at all levels could implement to improve energy efficiency and tackle rural energy poverty.

Overall, our work suggests key implications, which, if acted upon, could accelerate the deployment of energy efficiency policies in rural areas across Europe, while it serves as a basis for the development of an indicator that will capture effectively rural energy poverty.
The Potential for flexibility from a consumer perspective: insights from a Dutch Field Study

Nicole de Koning, TNO, The Netherlands
Joke Kort, TNO, The Netherlands

Panel
1. Dynamics of consumption

Keywords
consumer behaviour, demand response, energy price, energy services, smart grid, grid congestion, flexibility

Electrification is an essential part of the energy transition in the built environment. This is visible in the growth in number of heat pumps, electric vehicles, solar panels and home batteries. This presents major challenges for regional (and national) grid operators in preventing grid congestion. It also presents opportunities. Grid reinforcement is the common solution, but is not always feasible and desirable due to limited resources (money, lead time and technical staff). Large-scale deployment of smart flexibility services is an alternative to make best use of available grid capacity. In addition, flexibility (often abbreviated to flex) can ensure better local utilization of decentralized, sustainably generated electricity on the one hand and on the other hand can decrease energy consumption at times when there is less energy available. The application of flex services and products can only succeed if solutions deliver value not only for aggregators, business energy users and grid operators but also for consumers.

This study provides insights into the potential of flexibility from an end user perspective. What core values play a role for consumers in providing flexibility and what does this mean for the amount of flexibility that can be unlocked? Using an innovative mix of qualitative (interviews) and quantitative research (experience sampling study) methods, this question was investigated and tested in practice in a Dutch field study. In the experience sampling study participants were provided with short questionnaires with four questions; four specific times a day, for seven days. This study was executed in beginning of April 2023 when there were still cold temperatures outside.

The majority of respondents [64%] said they were familiar with terms such as overload or congestion of the power grid. The brief descriptions given by respondents show that even if respondents do not know the exact definition of grid congestion, they know approximately what the term means, but have little understanding of the underlying factors that cause congestion. The majority [65%] of respondents said they are not familiar with the terms “flexibility” or “flex grid services.”
The willingness of respondents to deliver flex is high. In 80% to 92% of the situations in which flex could be unlocked, respondents are willing to provide flex. Selfish value (financial rewards) is the most frequently chosen main reason for supplying flex. Here, the amount of reward or savings has moderate to no influence on the degree of willingness to supply flex. Biospheric value, after selfish value, is the second most important motivation. Altruistic value has the least influence on willingness to provide flex.

With the heat pump, between 80% and 81% of situations flex can be unlocked in the morning (8 a.m.) by temporarily reducing electricity consumption by the heat pump. In the evening (8 p.m.) this can be done in 87% to 92% of situations. In the afternoon (4 p.m.) flex can be unlocked in 86% to 87% of situations by extra electricity consumption by the heat pump (pre-heating buffer tank).

With electric car, flex can be accessed by charging the electric car around noon in 84% to 86% of situations. This percentage concerns only those who have the car parked at home at that time. With the electric car, flex can be unlocked around 8 p.m. in 80% to 81% of situations by charging less quickly.

Overproduction of electricity generated through solar panels consumers prefer to store for self-consumption; temporary storage in electric car, heat pump (pre-heating buffer tank) or in home or neighborhood battery).

The results from the consumer perspective aid in creating a representative picture of the actual residential flexibility that can be unlocked in the electricity system and under what preconditions. Also, the results can be used to take into account the consumer perspective in the design of flex services to maximize flex call-out.
Preparing for a disruptive future: Understanding the impact of new societal trends on future energy demand

Heike Brugger, Fraunhofer Institute for Systems and Innovation Research, Germany
Mahsa Bagheri, Fraunhofer ISI, Germany
Songmin Yu
Meta Thurid Lotz
Andrea Herbst

Panel
1. Dynamics of consumption

Keywords
trends, digital, prosumers, circular economy, demand analysis, energy efficiency policy, energy policy, sharing economy, energy model

The EU’s long-term 2050 strategy develops possible scenarios for a climate-neutral EU in 2050, with scenarios aiming at full deployment of all technology options. Other scenarios assume an increase in climate awareness among EU citizens reflected in changes in lifestyle and consumer choices, as well as a more circular economy. However, to fully capture potential societal trends in energy demand modelling, a comprehensive assessment of these trends as well as the improvement of energy demand models to be able to model these trends is crucial.

In this paper, we present a comprehensive approach to identify new societal trends based on 241 initial factors within 15 trend clusters that are expected to influence future energy demand. These trends can have potentially large (increasing or decreasing) impacts on energy demand and cross-sectoral demand shifts because they are not simply an extrapolation of historical trends (‘continuous or linear trends’), or because they may gain momentum as they are adopted by larger parts of society (‘disruptive or non-linear trends’).

We will present project results demonstrating how selected new societal trends can be incorporated in energy demand and macro-economic modelling. Our selected trends are:

1. the transition from consumers to prosumagers;
2. the move towards a circular economy and a low-carbon industry
3. the digitalisation of the economy and of private life; and
4. the trends towards a shared economy.
Within four scenarios, we quantify the impact of the new societal trends on future energy demand and macroeconomic indicators. The results of the sectoral and macro-economic scenarios show that the extension of energy demand models to include the new societal trends makes them more flexible to analyse the evolution of non-linear trends in future energy demand and thus provides important insights that go beyond modelling the extension of linear historical trends.
A distributional analysis of European countries' contribution to sufficiency in achieving a low energy future

Elliott Johnson, EDRC, University of Leeds, United Kingdom
Sam Betts-Davies, University of Leeds

Panel
1. Dynamics of consumption

Keywords
energy sufficiency, sufficiency, energy services, energy scenario, broader social context

A recent proliferation in low energy demand (LED) scenarios has seen a consensus begin to emerge around the potential for energy demand reduction (EDR) across developed economies, with absolute reductions of 50-55% by 2050, compared with 2020, being estimated as achievable. Realising these LED futures is not possible with efficiency improvements alone, and draw on more radical methods for reducing our demand, such as sufficiency, which ensures that people's basic energy needs are met equitably, whilst unnecessary overconsumption is avoided. Previous work that assessed the compatibility of a UK LED scenario found that a low energy pathway (i.e. overall reductions of 52%) was not compatible with minimum energy requirements at current or increased levels of inequality. However, this could be avoided by either by reducing income inequality, or by ensuring that the most efficient technologies were available at all income levels. However, the previous work looked only at absolute energy, whereas this analysis looks at energy services, which are more directly associated with wellbeing.

The recently published CLEVER scenario, which is premised upon a sufficiency framework, is a Europe-wide assessment of the potential for sufficiency with individual but related country pathways that are aggregated up to the European level. These individual pathways allow us to explore each country's relative contribution to sufficiency-led EDR out to 2050. This analysis, framed by the concept of 'Decent Living Energy', explores how inequality of energy service demands (ESDs) changes over time across countries, and how much energy-income inequality reduction is required for Europe to cut its energy demand in half. 'Decent Living Energy' estimates conceptualise the minimum energy required to meet the basic human needs, prerequisite to achieving wellbeing. They are a useful benchmark for assessing projected energy service demands' compatibility with social needs.

Gini coefficients are calculated across a multitude of energy service indicators (e.g. residential floor space, passenger-kilometres), as well as overall final energy demand, for current and 2050 levels. The purpose of which is to demonstrate the degree to which countries that currently have high levels of energy services need to reduce their demand to ensure that
everyone can achieve the required level of well-being whilst remaining within planetary limits. Similarly, income distributions are combined with ESD-income elasticities to produce a distributional analysis of the spread of ESDs across income deciles to determine if those at the lower end of the income ranges are meeting their minimum energy service needs. Income Gini coefficients are varied to assess where acceptable ranges of income inequality lie, whereby those who use the least amount of energy services are able to sufficiently meet their needs.

Whilst modelling exercises have demonstrated that energy demand reduction is imperative to achieve the net zero transition, a greater understanding is needed to ensure that LED futures are just and inclusive. Understanding differentiated national responsibilities to EDR within Europe, as well as where access to pre-requisite levels of energy service demands to achieve decent living standards must be increased, will aid policymakers in developing targeted mechanisms, ensuring that low-income countries are not left behind.
Integrating ‘bottom-up’ and ‘top-down’ approaches in climate policy

Tina Nyfors, University of Helsinki, Finland

Panel
1. Dynamics of consumption

Keywords
sufficiency, climate policy, bottom-up, top-down

Several governments have presented climate targets like net zero by 2050, but the means on how to reach them are largely missing. This abstract concerns integrating ‘bottom-up’ and ‘top-down’ approaches of sufficiency and efficiency. The bottom-up approach concentrates on a Finnish grassroots degrowth network, whereas the ‘top-down’ approach focuses on sufficiency-oriented climate policy. The aim is to examine how these could be combined to support a strong sustainability transformation.

The policy approach applies a sufficiency perspective based on Spengler (2018). Focus is on the steps following the strategy of ramping up eco-efficiency - recomposing consumption - including reducing consumption (Gough 2017). Policies entail systematically steering consumption away from identified carbon hotspots towards low-carbon options.

The grassroots approach builds on an ongoing empirical study on understandings of sufficiency in a Finnish grassroots network. Preliminary results indicate that multiple dimensions, including sufficiency as a criticism and sufficiency as a solution, concerning, for example, the growth based economic system, overconsumption, equality, human-nature relations, way of organizing human relations, and the nature of work.

The root causes of the sustainability challenges are deeply intertwined with how the state works. Economic growth as a fundamental interest contradicts the goal of ecological sustainability, given the impossibility of indefinite growth. While ecological sustainability becoming the primary imperative of the state seems unlikely, it holds unique capacities for regulation, controlling material flows and providing social welfare. This points to the need of integrating “bottom-up” and “top-down” approaches.

While building on understandings of sufficiency in Finland, the implications for policy as a leverage for sustainability transformations may be of relevance for affluent, overconsuming economies more broadly.
A behavioral economics approach to energy efficiency policies

Denisa Diaconu, Buildings Performance Institute (BPIE), Belgium

Panel
1. Dynamics of consumption

Keywords
energy efficiency investments, behavioural change, ESCOs, energy performance contracting (EPC), energy efficiency policy

Energy efficiency measures are usually praised for their economic benefits. This is why so often incentives to invest in energy efficiency are perceived as solely economic and policies focus particularly on its economic viability. However, energy efficiency solutions provide multiple benefits that can yield additional motivation for individuals to invest in energy efficiency. A neoclassical economics approach might not be able to exhaustively determine individuals’ behavior in regards with energy efficiency investments.

In this paper, a behavioral economics perspective will be used to collect more insights about the main determinants of individual attitudes towards energy efficiency investments, addressing how individuals’ preferences over time, risk perception and loss aversion influence energy efficiency investment decisions. These cognitive biases may help explain the energy efficiency gap, according to which households fail to invest in energy efficiency measures even though they appear to pay off under prevailing market conditions. Specifically, this paper seeks to investigate whether investments in energy efficiency provided through a third party, for instance an energy service company (ESCO), offer a viable mechanism to reduce the cognitive biases of individuals and therefore increase incentives to invest in energy efficient products and technologies.

Identifying the effects of these cognitive biases on energy efficiency investments is especially relevant to determining policy measures that can increase energy efficiency. Looking at the insights provided by the behavioral economics literature on energy efficiency, the current impaired condition of the ESCO market might be improved through a revised policy framework. Exploring the distinct effect of standard time discounting, present bias, risk and loss preferences on energy efficiency investments in conjunction with the current European Union (EU) legislative status of ESCOs, the main intention of this paper is to provide a set of policy recommendations to improve energy efficiency measures adoption in the buildings sector.
Can sufficiency be achieved through ‘re-programming’ existing resource-intensive infrastructures and institutions?

Toke Haunstrup Christensen, BUILD Aalborg University, Denmark
Kirsten Gram-Hanssen, Aalborg University, Denmark

Panel
1. Dynamics of consumption

Keywords
sufficiency, practices, household consumption

There is an urgent need in affluent countries to adopt everyday practices that entail significant reductions in resource consumption. Today’s resource-intensive practices are contingent on and unfold within existing material infrastructures and social institutions that have been established in times of abundance of cheap fossil fuels. While acknowledging that thorough changes in consumption require thorough changes in infrastructures and organizations, it is also evident that such radical changes will not happen as fast as the climate and biodiversity crises demand. In addition, deep changes in infrastructures would in itself entail massive resource investments, e.g. in the demand for rare earths or fossil fuels, and thereby exacerbate today’s overshoot of the planetary boundaries. Therefore, the adoption of less resource-intensive everyday practices must largely take place within existing infrastructures and institutions.

This abstract explores theoretically and empirically the possible pathways for adopting new, sufficiency-based everyday practices within existing resource-intensive infrastructures and institutions (e.g. existing material arrangements). It does so by developing the concept of “re-programming”, which defines two different, but closely interconnected, approaches to the shift towards sufficiency: Promoting sufficiency through either performing everyday practices in different ways within existing materialities and social institutions or by “modifying” or “adjusting” existing material arrangements and institutions in ways that promote resource-light practices. Main focus will be on the latter.

First, the abstract presents a review of how the sufficiency literature conceptualizes the relationship between resource-light everyday practices and material arrangements and institutions. This leads to the proposal of “reprogramming” as a concept of and strategy for transitions towards sufficiency. Second, the abstract builds on empirical findings from a recent interview study of young people moving from city centers to suburban areas. The empirical analysis focuses selectively on examples of the young people attempting to keep up previous
resource-efficient practices (e.g. cycling or saving heated floor space) within a suburban context built for a resource-intensive living (e.g. automobility and detached homes). Our main focus will be on mobility practices, as these turned out to be the domain of practices that attracted most attention in the participants’ own narratives about how moving out of the city centre had changed their everyday lives.

Finally, the paper concludes with a discussion of possible strategies, based on the concept of reprogramming, to promote sufficiency-based practices within existing resource-intensive materialities and institutions. Here, we will draw on and relate to practice-theoretical concepts, such as material arrangements (T. Schatzki), practice architectures (S. Kemmis) and institutional rhythms (S. Blue), as well as provide specific examples of how existing institutional and material arrangements might be reprogrammed (e.g., changing car-based infrastructures through turning highways into Bus Rapid Transits or developing combined mobility and activity hubs in suburban centres).

Reprogramming represents both a way of thinking, e.g. in policymaking, and a way of designing, e.g. in urban planning, and the paper suggests that strategies of reprogramming can be a relatively simple and quick way of promoting thorough changes in everyday practices towards sufficiency.
Who are the energy poor? An exploration of approaches to measuring energy poverty

Lucy Kinnear, Sustainable Energy Authority of Ireland (SEAI) Sustainable Energy Authority of Ireland, Ireland

Panel
1. Dynamics of consumption

Keywords
energy poverty, indicators, socio-economic

Developing policy that targets energy poverty first requires understanding which parts of the population are experiencing or at risk of experiencing energy deprivation. Many metrics have been developed to help academics and policy makers measure energy poverty and satisfy demand for statistical estimates of its prevalence. These metrics can be grouped thematically into expenditure approaches, consensus approaches, and objective approaches. There are, however, conceptual and methodological challenges, as each measure has strengths and limitations, and potentially capture different facets of the population experiencing energy deprivation, but there is little research into how characteristics of the energy poor population change depending on the selected indicator (Fizaine and Kahouli, 2018).

The Behavioural Energy and Travel Tracker – an Irish online study designed to capture a granular snapshot of everyday energy-related behaviours over time – has been collecting data on a nationally representative sample of 1,000 people monthly over the course of a year. The primary energy consuming activities captured relate to home energy and transport use, and data are collected on the socioeconomic characteristics of participants, their dwelling and household characteristics, and indicators of energy poverty (monthly energy costs, ability to pay, and energy-related deprivation). Using this dataset, we will select different indicators of energy poverty to model more extensively on the socioeconomic characteristics of the energy poor and which inefficient energy behaviours they are engaging in. From this we will describe if and how each deprivation indicator alters who is included in the energy poor population, which behaviours they engage in, whether the size of these socioeconomic predictors change, as well as the seasonality of both energy deprivation and the behaviours of the energy poor.
Quantifying the energy implications of sustainable consumption corridors for the UK: Understanding the potential for income redistribution to support to energy sufficiency in the United Kingdom.

**Sam Betts-Davies**, Sustainability Research Institute, University of Leeds, United Kingdom
John Barrett, University of Leeds, United Kingdom
Paul Brockway, University of Leeds, United Kingdom
John Barrett, University of Leeds, United Kingdom
Jonathan Norman, University of Leeds, United Kingdom
Anne Owen, University of Leeds, United Kingdom

**Panel**
1. Dynamics of consumption

**Keywords**
Inequality redistribution, Consumption corridors, consumption, sufficiency

Eliminating levels of inequality prohibitive of ensuring decent living standards, alongside climate mitigation, are frequently discussed as dual goals of a just transition to sustainable societies. Currently, neither are adequately addressed in the UK, given that many are not consuming at levels that provide decent living standards, and emissions reductions are insufficient to achieve climate targets. In recent years, energy sufficiency has received attention in the literature as a solution to these issues. Whilst much of this literature has explored sufficiency measures across energy service demand sectors, little has explored the impact sufficiency principles could have on the energy and emissions associated with household consumption of goods and services.

Thus, this analysis empirically models the impact of UK income and consumption redistribution on the energy and emissions of household-type income deciles, aggregate final energy demand, and aggregate consumption based GHG emissions, to understand the potential implications of income redistribution on UK climate mitigation. Conceptually speaking, the research employs a consumption-corridor approach to defining a socio-ecologically sustainable level of consumption. Consumption corridors describe a minimum consumption standard that
fulfils basic social needs whilst remaining within a maximum consumption level defined by an ecological ceiling.

In order to explore the energy and climate impacts of consumption redistribution, a series of redistributed consumption scenarios for the UK are developed, underpinned by this consumption corridor approach, whereby minimum and maximum levels of consumption are established. Whilst in the energy literature, various social floors in energy consumption have been proposed, such as the ‘Decent Living Energy’ framework, this analysis utilises a novel application of ‘reference budgets’, a concept born out of studies attempting to define relative levels of poverty. Reference budgets depict a basket of goods that is representative of a given standard of living.

For the UK, the Joseph Rowntree Foundation has produced annual baskets of goods for 13 different household sizes representing the income needed to achieve a minimum socially acceptable standard of living in the UK today. Based on participatory focus groups, this minimum income represents what the public believes is necessary for different household types to live with dignity, and fully participate in society. It represents a higher social floor than requirements to meet ‘universal’ basic needs, such as the notion of ‘Decent Living Energy’, that seek to define a universal set of material and energy conditions needed to achieve basic human wellbeing. Rather, this social floor defines an acceptable standard of living situated within the context of the UK beyond ‘just food, clothes and shelter’, to include ‘what you need in order to have the opportunities and choices necessary to participate in society’. Through these reference budgets, the research explores the extent that sufficiency in the consumption of goods and services is achieved in different household types in the UK.

Beyond establishing this social floor to ensure consumption levels are high enough to preclude the existence of relative poverty, a range of income caps are assessed to understand the extent to which high income consumption must be reduced for to support this increase in access to resources, whilst contributing positively towards decarbonisation.

The scenarios are modelled using an environmentally extended multi-regional input output modelling framework, to understand the energy and emissions impacts of this redistribution. Key insights explore the energy implications of meeting minimally acceptable consumption level in the UK and the identification of income groups and household types whose consumption would need to be reduced for redistribution to positively support climate mitigation.
The acceptance of more sufficient, 1.5-degree lifestyles by citizens: individual and structural barriers and enablers

Kristóf Vadovics, GreenDependent Institute, Hungary
Edina Vadovics, GreenDependent Institute, Hungary

Panel
1. Dynamics of consumption

Keywords
energy sufficiency, low-carbon lifestyle, enablers and barriers, sufficiency, 1.5-degree lifestyles, lifestyle

The Paris Agreement defines the goal of not exceeding 1.5°C global warming compared to pre-industrial levels. To make this objective more relevant to everyday lifestyles, it was expressed as per capita carbon footprints to be reached by 2030 (2.5 t CO2e/cap/yr) and 2050 (0.7 t CO2e/cap/yr) respectively, and the term “1.5-degree lifestyles” was conceptualised. Our project, EU 1.5° Lifestyles, identifies and explores behaviour-, and technology and financial investment based lifestyle options that citizens ought to implement in the most impactful consumption domains of housing, mobility, nutrition and leisure to reduce their carbon footprint and reach 1.5-degree lifestyles. In this presentation we focus on housing and mobility, primarily in Hungary, but comparing the results to the four other ‘case countries’ we studied at a general level (Germany, Latvia, Spain and Sweden).

In the project, we developed a mixed methods study comprised of several steps: first we identified impactful lifestyle options, and the enabling/obstructing structures relating to them. For both, we conducted literature review and expert interviews, and relied on the expertise of the consortium. We followed by organising Thinking Labs for both citizens and stakeholders. Importantly, this methodology is part of a larger research process that includes further citizen and stakeholder Thinking Labs to learn about rebound and spill-over effects as well as contribute to visioning and creating solutions.

As for our results, we first present the housing and mobility options in order of their preference by citizens, both for Hungary and the average of the case countries. There are both differences and similarities between the domains and groups. Eg., in the order of preference for the options, there are differences between Hungary and the five-country average in the housing domain, but not in mobility. Then, for both groups, in the housing domain citizens prefer options that are below-average-impact and require financial investment rather than behaviour change. In the mobility domain, their preference indicates readiness to adopt above-average-impact
and behaviour-change-based options, eg., giving up driving for cycling or public transport. In both domains and groups, options related to sharing (household devices, living space or cars) and downsizing are among the least preferred.

Looking at enablers for sufficient, 1.5-degree lifestyles, at the individual level participants reported saving costs and being true to ones’ values as important motivations. At the structural level, ease of implementation, and taxes and bans were mentioned. As for barriers, the boundary between the individual and the structural levels was less clear. Lack of financial resources, bad experience with an option (either personal or societal, e.g., enforced sharing in ‘communist’ countries) were reported along with existing social norms and traditions, lack of infrastructure or services, and inappropriate product design. However, importantly, when asked, both citizens and stakeholders were able to create contexts and conditions that could facilitate adopting even the least preferred options.

To conclude, we present implications for policies supporting sufficient, 1.5-degree lifestyles, eg., relating to the meaningful involvement of citizens to co-develop solutions, the need for multi-stakeholder dialogue to enhance understanding between different fields of policy (and research), and the need to make policies country-specific with attention to the socio-political and cultural context.

Acknowledgements
We would like to thank the EU 1.5° Lifestyles Consortium for contributing to the development of the research methodology, collecting data and participating in the analysis.

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The impact of nudges on prosumers with photovoltaics: survey results from Germany and Croatia

Sabine Preuß, Fraunhofer Institute for Systems and Innovation Research, Germany
Sabine Pelka, Fraunhofer Institute for Systems and Innovation Research (ISI), Germany
Anne Kesselring, Fraunhofer Institute for Systems and Innovation Research (ISI), Germany
Stephanie van Hove, Interdisciplinary imec research group for Media, Innovation and Communication Technologies, Belgium
Emma Martens, imec-mict-UGent, Belgium
Peter Conradie, Interdisciplinary imec research group for Media, Innovation and Communication Technologies, Belgium

Panel
1. Dynamics of consumption

Keywords
behavioural change, energy demand, photovoltaics, household consumption, Nudging, intervention, prosumers

Energy-efficient energy consumption can be realized on the household level by prosumers using digital devices and apps that support households to optimize their energy usage. Whether a household saves energy (or not) depends – among other factors – on the household's motivation and intention to save energy. Nudging interventions can be one solution to reduce the effort and (cognitive) resources for households and to reduce their energy costs in everyday life. For instance, nudges can be implemented via apps. Especially for prosuming households with technologies such as photovoltaic plants, testing nudging interventions in real-life contexts appears promising to increase the use of the photovoltaic electricity.

As part of the Horizon2020 project NUDGE, the present research examines the impact of different nudges on prosumers in Germany and Croatia. Specifically, three nudges each were introduced to 105 German and 82 Croatian households with roof-top photovoltaic plants, aiming to improve their energy consumption. We collected survey data before and after each nudging intervention (a total of four survey waves) over a period of more than one year. This paper presents the effects of the nudging interventions on four self-reported variables on the household level: the motivation and intention to save energy, the intention for self-consumption and the households' energy consciousness.
Results indicate that the nudges successfully increased prosumers' energy consciousness in both countries. Moreover, in Germany, the intention for self-consumption and, in Croatia, the motivation to save energy were significantly increased across the three nudges. However, the nudges also led to an unintended decrease in prosumers’ intention to save energy in both countries. Analyzing the effect of the nudging interventions separately for different groups and over time showed a mixed pattern – with only few significant effects. We discuss the reasons for the unintended nudging effects including the impact of the policy context (especially in Croatia) and additional factors such as the energy crisis. Further investigation of short- and long-term effects of single nudging interventions and within a broader sample are encouraged.
Demand flexibility among domestic electricity users in Ireland – an experimental investigation of preferences and fairness

Ciaran Lavin, Sustainable Energy Authority of Ireland (SEAI)
Sustainable Energy Authority of Ireland, Ireland
Hannah Julienne

Panel
1. Dynamics of consumption

Keywords
behavioural change, demand flexibility, fairness, consumer preferences

Demand flexibility, broadly construed, is an openness on the part of a consumer to changing the time at which they use electricity. Greater demand flexibility increases the security of supply, reduces costs, and increases the proportion of supply produced with renewable sources. It is increasingly important with increasing electrification, for instance in the heating and transport sectors. There are multiple prospective ways a user can be flexible with their demand. Users can shift their demand loads through straightforward behaviour changes, responses to real-time events, or by using timing settings on smart devices. Absolute reduction in use at peak periods is another option, as is enrolment in direct load control programmes.

A comprehensive account of factors that influence preferences regarding these demand flexibility mechanisms is lacking. This study contributes to closing that knowledge gap. The degree to which a person is willing or able to be flexible with their demand might influence their mechanism preferences. We hypothesise that a sense of fairness – or a perception that other actors are contributing properly to the collective demand flexibility – will be influential for both the degree to which a person is willing to be flexible, as well as the types of demand flexibility mechanisms that they are open to.

Further, we hypothesise that the initial framing of the topic will influence subsequent preferences, as might the specificity of information e.g., whether it is activity-specific or more general in nature. We test these and other potential influences on demand flexibility preferences in an online experiment with a nationally representative sample of Irish participants. Findings are relevant to future design and implementation of demand flexibility policies and programmes.
Causal stories on the energy poverty-health nexus: narratives from local stakeholders in France

Ute Dubois, ISG International Business School, France

Panel
1. Dynamics of consumption

Keywords
energy poverty, health, local authorities

While there is a growing awareness of the links between energy poverty and poor health among both academics and policy makers, practical approaches to formally address these links within a unified policy framework have not yet been developed in France. However, several stakeholders mainly at the local level are already working on issues related to both energy poverty and health, often with a focus on one specific aspect, such as social vulnerability, housing, or health. This research explores the views of different local stakeholders on the energy poverty-health nexus. Local authorities and other local stakeholders such as charities, housing associations, care services, health professionals, or energy suppliers, who are in direct contact with households, are well placed to identify the difficulties of vulnerable people related to both their energy use – especially the heating of their homes – and to their health. But what is their understanding of the complex relations between energy poverty and health, and to what extent are they able to integrate considerations related to the energy poverty-health nexus in their professional practice?

This research is based on a case study of a medium-sized city in central France. Based on semi-structured interviews with stakeholders working in different policy fields (social, energy, housing, and health), I explore how they view the energy poverty-health nexus. This research has both theoretical and practical implications. From a theoretical perspective, this research confirms the importance of considering the different understandings of the topic that drive stakeholders’ approaches and decision making, especially on issues that cut across policy fields, as it is the case with energy poverty. From a practical point of view, this work helps to reflect on the potential and limitations of integrating the energy poverty-health nexus into local public policymaking.
Better integrating findings from social sciences to consolidate sufficiency hypotheses in energy and climate modelling

Yves Marignac, NégaWatt Association, France
Mathilde DJELALI, Association négaWatt
Alexandre GABERT, Association négaWatt
Adrien JACOB, Association négaWatt

Panel
1. Dynamics of consumption

Keywords
sufficiency, lifestyle, modelling, consumption dynamics

While increasing pressure of climate urgency and geopolitical turmoil shed a new light on the role of sufficiency to meet climate neutrality and ensure energy sovereignty on a European level, the implementation of related policies still suffers from a vicious circle, where a lack of documented return of experience leads to a lack of emphasis on sufficiency options in models, which in turn leads to a weak undertaking of sufficiency in portfolios of concrete measures. It is therefore key to develop confidence in sufficiency-related assumptions about the reduction of demand, and the capacity to achieve them through relevant and effective policies and measures.

This paper will present an innovative work on refined sufficiency assumptions that was conducted in a large European-wide research project, which explores sufficiency-based lifestyles to meet 1.5°C objectives and contribute to sustainability. It investigates ways of consolidating quantitative sufficiency hypotheses integrated in energy and climate scenarios by using, in addition to existing studies and surveys, new and specific information gathered throughout the project. This consists in results from a comprehensive quantitative survey on possible motives and barriers to such changes on the micro level, a qualitative sociological analysis of dynamics of sufficiency related initiatives on a meso level, and the study of concrete sufficiency measures, all applied to a selection of five countries (Denmark, France, Germany, Italy and Latvia).

The work focuses on a selection of specific sufficiency leverages, such as sharing some products, reducing floor areas in housing by increasing shared spaces, shifting to bike, or flying less, so as to allow for a detailed analysis of possible dynamics of change through various categories of population. By framing a generic step-by-step approach and tailoring its application to very different cases, it eventually gives way to drawing global methodological recommendations.
Monitoring sufficiency: results of the French case from the first barometer launched in Europe

Didier Bosseboeuf, ADEME, France
Anaïs Rocci, ADEME

Panel
1. Dynamics of consumption

Keywords
sufficiency, monitoring, life-style, indicators

Sufficiency in our lifestyles will increasingly be a lever to be mobilized in response to the challenges of ecological transition. French institutions, including ADEME, are developing "a sufficiency road map" including monitoring activities such as sufficiency indicators (ODYSSEE-MURE) or opinion polls.

These barometers show that the French are aware of the need to change their lifestyles to deal with the climate emergency and the scarcity of resources. However, there is a strong paradox between, on the one hand, growing aspirations for a different model of society calling into question the economic system and current lifestyles, and on the other, practices and representations that remain largely anchored in a consumerist model.

In 2023, ADEME launched a new exploratory yearly barometer on "lifestyles and sufficiency" with a representative sample of the French population (4000, in order to assess and observe changes in sufficiency aspirations and practices of the French and their opinion on sufficiency policies.

Beyond the methodology (155 questions through internet) that will be summarized, we will select two innovative results beyond the classic presentation of a pool:

– Construction of sufficiency indicators to measure changes overtime, in particular to qualify what is the share of a “chosen” sufficiency and what is part of a “forced” or “punitive” sufficiency situation. Their analysis will be related to socio-economic factors.

– Development of household’s profiles related to their willingness to embark on sufficiency.
The long tail of the grid's edge: new opportunities for energy efficiency and demand side

Yael Parag, School of Sustainability, Reichman University, Israel
Naama Teschner, Ben-Gurion University of the Negev, Israel
Shiri Zemah Shamir, Reichman University, Israel

Panel
2. Future and innovative policies

Keywords
electricity grid, smart grid, energy security, local and regional energy planning, prosumer markets

The term "long tail" describes a distribution pattern in which numerous niche products or services collectively contribute significantly to total revenues, despite each having relatively low sales volume. Energy markets, especially electricity, are becoming long-tailed. Traditionally, these markets were centrally managed and dominated by a few large and regulated players, offering a limited number of services. However, national net-zero goals and ongoing processes like decarbonization, electrification, decentralization, digitalization, and liberalization are fostering energy innovation, reshaping the market, and emphasizing the economic value of resources at the grid's edge, particularly "behind the meter."

In evolving markets, distributed energy resources (DERs), such as solar PV panels, batteries, electric vehicles (EVs), and heat pumps, are becoming more affordable and prevalent, and with smart energy management capabilities, their economic attractiveness increases. Additionally, tailored and valuable energy services, such as "thermal comfort as a service", could be offered to consumers by commercial companies, while services, such as demand flexibility could be provided by consumers to commercial actors like aggregators. The market is also witnessing the entry of new players, including individual prosumers, local communities, small and medium businesses, installers of "behind the meter" resources, and tech-oriented start-ups. Each player is driven and motivated differently, and this variety of motivations is reflected in the diversity of business models, profit margins, and growth strategies.

Long-tail markets and their characteristics bring new opportunities for microgeneration installations and investments in energy efficiency and demand-side management. Consumers are motivated to enhance the efficiency of their energy infrastructure, appliances, and behaviors because energy savings and flexibility are no longer merely a personal benefit but could translate into tradable market resources. This, in turn, incentivizes the installation of energy-efficient technologies, solutions, and services at the individual, building, or community levels, unlocking opportunities that were previously overlooked. The economic rationale for
such investments is more pronounced, fostering a market environment where sustainable practices align with economic gains.

Long-tail energy markets have the potential to enhance system resiliency, improve market efficiency, reduce costs, contribute to decarbonization, alleviate energy poverty, and enhance services to consumers. These markets create opportunities for individuals, communities, and small businesses to participate in previously restricted activities. Consequently, these players play more significant roles in the ongoing energy transition. However, alongside the potential benefits, challenges emerge as regulations struggle to keep pace with technological and business innovation.

Examining the long-tailed system critically is essential to uncover potential negative impacts on grid resilience, costs, energy equity, and fairness. Concerns include diminishing control over resource quality and availability, challenges in long-term system planning and investment in new capacity, as well as protection against cybersecurity threats. Furthermore, the quality of services might be compromised in highly distributed markets, and differences and discrimination might emerge between low-income and high-income consumers. Ensuring equity and affordability is also a concern because investments in energy efficiency measures and low-carbon technologies could impose a financial burden on low-income and vulnerable energy communities and consumers.

Finally, as data becomes a tradable commodity in long-tailed markets, safeguards for consumers' privacy must be set. Policymakers should envision the potential negative impacts on society, issuing regulations that protect vulnerable consumers against undesirable effects.
From policy deficit to implementation gap? Workforce developments in Germany

Wolfgang Irrek, Hochschule Ruhr West, Germany

Panel
2. Future and innovative policies

Keywords
implementation, education, training, workforce shortage, recruiting young talents

This study investigates the current landscape of technical workforce development in the context of energy efficiency implementation and the energy transition towards greenhouse gas emissions neutrality, with a specific focus on both vocational and higher education pathways in Germany. The research employs a multifaceted approach, encompassing statistical analyses, a review of literature and online information, and 18 semi-structured interviews with 20 stakeholders from universities, vocational schools, chambers, company associations and initiatives, trade unions and companies.

The findings suggest a severely growing potential shortage of professionals with technical skills crucial for advancing energy efficiency, energy transition and climate protection objectives. The shortage of young talents could pose a significant obstacle in the transition pathway.

Consequently, companies and other pertinent stakeholders are increasingly exploring innovative strategies and good practices to attract and recruit young talents. The augmentation of technical workforce development can only be increased if all actors intensify their efforts and if policy establishes adequate framework conditions.
Saving electricity quickly to avoid grid meltdowns

Alan Meier, University of California, Davis, USA
Caetano Abramsonward, University of California, Davis, USA
Hayley Amo, University of California, Davis, USA
Henrique Lopes Rosenbach, University of California, Davis, USA
Isaac Loyer, University of California, Davis, USA
Edison Ma, University of California, Davis, USA
Sydney Ma, University of California, Davis, USA
Arlo Novicoff, University of California, Davis, USA
Brandon Roberson, University of California, Davis, USA
Alex Sharp, University of California, Davis, USA
Aria Zajec, University of California, Davis, USA
Hideki Shimada, National Institute of Advanced Industrial Science and Technology, Japan

Panel
2. Future and innovative policies

Keywords
electricity grid, customer behaviour, conservation, blackout

On a hot 6 September 2022, the California Governor’s Office messaged 27 million Californians, requesting that they immediately switch off every possible appliance or face a meltdown of the grid. Within minutes, demand fell by at least 2 GW and blackouts were averted. Similar near-outages and actual outages have occurred in Tokyo, Texas, Oklahoma, Alberta, and several times across Europe. Utilities and grid authorities around the world insist that they cannot rely on behavioural actions to rescue the grid; yet, when faced with no alternatives, they do just that.

The frequency of short-term electricity crises will likely increase as a result of intense heat waves, cold waves, wildfires, rapid electrification, and unexpected interruptions in supplies and transmission. Hence, policymakers need to understand the value of last-minute appeals to customers. Surprisingly little research has been undertaken to understand the content and effectiveness of those behavioural messages. We reviewed recent policy actions to quickly mobilise demand-side electricity reductions in over twenty critical events and identified several key elements of successful measures. We suggest further actions to make emergency behavioural responses a credible policy tool.
Nordic support policy for high energy costs: distributional and environmental impacts

Alexander Eriksson, Anthesis AB, Sweden
Erik Gråd, Anthesis AB, Sweden

Panel
2. Future and innovative policies

Keywords
energy policy, domestic policies and measures, consumer behaviour, climate policy, domestic energy efficiency

During the winters of 2021-2022 and 2022-2023, European households and firms faced unprecedentedly high prices of energy. European governments responded swiftly, implementing support policies to address the burdens of high energy costs. In this study, we evaluate support policies in the Nordic countries, examining their distributional effects and environmental impact.

We initially surveyed policies targeted at reducing costs for electricity and transport fuels, for households as well as for companies. We included financial support (direct monetary transfers), price support (such as electricity tax reductions), and other policy types (such as payment deferral schemes or informational campaigns). Ten policies were selected: three each in Sweden and Norway, and two each in Finland and Denmark, covering the most important policies in terms of budget and likely impact. The reported empirical evidence for impacts of these policies is limited, so our analysis is mainly based on reasoning from other policy impact assessments and economic and psychology theory.

Most policies analysed did not effectively target the most vulnerable households and businesses. Policies were in general broad, compensating everyone. Monetary transfers were mostly based on either current or past energy use. This results in compensation that is higher for households and businesses with higher energy use. The same conclusion holds for policies directed at reducing prices, such as energy tax reductions.

Households in higher income groups tend to have higher energy expenditures, and thus received more support. In some countries, such as Sweden and Finland, households in the higher income groups also spend a higher share of their income on energy. Not only did high-income households then receive more support in absolute terms, but they also received more support relative to their income. In this sense, most support policies were regressive. A one-off payment to disadvantaged households in Denmark stands out as successfully targeting the most vulnerable households.
Environmental impacts depend on whether demand for energy is expected to increase following the policy implementation. When compensated for high costs, incentives to reduce energy use and increase energy efficiency are weakened. This goes in contrast to the EU principle of Energy Efficiency First and national goals of increased energy efficiency. Price support, such as reduced energy taxes have direct effects on demand. For monetary transfers based on energy use, how incentives are influenced depends on how the support is calculated, and how well households and businesses understand this process. Some support was based on current energy use. Other, such as the Swedish electricity support, was based on energy use during a past reference period. This allows compensation without hampering incentives for current energy savings and improvements in energy efficiency. However, communication around this faltered, and misunderstandings were common.

Ultimately, how incentives were influenced is an empirical question, for which our analysis provide no answer. Certain policy design features, however, risk creating expectations for future support, which undermines incentives for energy savings and increased energy efficiency.

Implementing support swiftly is believed to be a main reason for the chosen policy designs. In preparation for possible future periods of high costs, Nordic governments could consider policy design that make use of well-developed social security systems to create policies with more desirable distributional profiles. Even though such policy design should be possible, preparations may signal to consumers that support will be provided in times of energy shortage and high prices, weakening incentives for energy savings and increased energy efficiency. How to best balance these issues remains an open question.
The crisis that made time-shifting normal: energy care and flexibility of Danish households during the energy crisis

Kirsten Gram-Hanssen, Aalborg University BUILD, Denmark
Anders Rhiger Hansen, Aalborg University BUILD, Denmark
Line Valforff Madsen, Aalborg University BUILD, Denmark
Rikke Skovgaard Nielsen, Aalborg University BUILD, Denmark

Panel
2. Future and innovative policies

Keywords
household electricity, practices, everyday life, electricity crisis, energy flexibility, energy vulnerability

Time-shifting households’ energy-consuming practices from peaks towards periods with higher renewable energy production is an important factor in a sustainable energy system. Previous studies have shown that it is possible to get households to time-shift energy practices, but also that dynamic electricity tariffs until recently was not well-known. Furthermore, earlier studies on temporal energy consumption patterns did not reveal time-shifting of energy practices for a larger group of Danish households.

This paper shows how the energy crisis in Denmark during the winter 2022-2023 made time-shifting normal, and it asks the question of how to understand this process of normalisation. Following substantial energy price increases during 2022-2023, with strong fluctuations during a day and from day to day, energy was placed high on the agenda in politics and media. The paper seeks to understand to what degree care for the energy system was a driver for households to start time-shifting and follow energy prices. The paper is based on a quantitative survey (N=1000) and in-depth qualitative interviews (n=30). For both methods, there was a general focus on everyday practices and experiences related to the energy crisis.

The quantitative results showed that 63% indicated having flexible electricity prices, and among those, almost 70% indicated that they followed the prices daily. Furthermore, more than half of those indicating they had flexible prices used timers on washing machines and dishwashers to plan appliance use. While there are some socio-economic variations, a factor which we call care for the energy system explains more of the variation in responses. The factor was created by combining responses on the following statements: I want to a) help Europe not having energy shortage; b) help my local energy systems to work more efficiently; c) help prevent a blackout; d) help to prevent climate change. Respondents scoring higher on this
factor, tended more often to have flexible prices and time-shift their energy consumption. However, there are some variations regarding age. While the oldest part of the population (60+ years) time-shifted the most, they were not the ones having and using timers on appliances the most. Surprisingly, income and gender seemed to have less impact.

In contrast, the qualitative interviews indicated clear differences in time-shifting behaviour between affluent families and families with a tight economy. At the same time, differences were also apparent between people who were interested in and cared for the energy system and those who were not. For some households, time-shifting was thus a necessity to save money whereas for others it was like a game to see how much could be shifted based on an interest in caring for the energy and environment. Time-shifting included all types of consumption, also cooking and media-use, among the most vulnerable. Economy was mentioned by most respondents. However, when scrutinising this motivation, it was not based on rational economic calculations, and several respondents time-shifted without knowing exactly what type of tariff they had. Rather, they reported that they time-shifted because it was normal to do so and because they had heard much about the energy crisis and felt they had to do something.

The paper concludes that the energy crisis contributed to normalising time-shifting due to a combination of media discourse and governmental communication about caring for energy and being aware of actual energy prices. In relation to policy, this suggests that people can change practices, and that price can be an instrument in a sustainable transition but that media attention to and governmental directions on the need for change are needed as well. Also, price instruments are likely to have severe consequences for some households, which must be mitigated to avoid social imbalance.
How to embed health and well-being in policies to ensure healthy, sustainable, and resilient buildings

Caroline Düvier, Buildings Performance Institute (BPIE), Belgium
Elisabeth Katharina Hoffmann, VELUX, Belgium
Essam Elnagar, BPIE, Belgium

Panel
2. Future and innovative policies

Keywords
health, sustainable, building design, EU policy, framework, indicators, data

In Europe, considerable attention is placed on enhancing the energy performance of buildings since the launch of the European Green Deal and the recent revision of the Energy Performance of Buildings Directive (EPBD) as part of the Fit for 55 Package. Despite recognising health as a vital co-benefit of energy efficiency in the recent European Commission guidelines on Energy Efficiency, there is still a noticeable lack of focus on the associated health aspects of buildings and the well-being of their occupants in building policies. This oversight results in unhealthy buildings with many detrimental effects on people and buildings.

To combat these issues and provide decision-makers with people-centred solutions, this study creates a holistic, unifying framework for healthy, sustainable, and resilient buildings. In this framework, five dimensions characterise healthy buildings: (1) improving mental and physical health, (2) designed for human needs, (3) sustainably built and managed, (4) resilient and adaptable, and (5) empowering people.

Each dimension is associated with a set of indicators that are both quantitative and qualitative in nature. Dimension 1 for example has indicators on indoor air quality, daylight, social connections, and connectedness to nature. Dimension 2 includes indicators related to human-centric design such as adaptability to different user needs and aesthetics. Dimension 3 encompasses indicators around the materials used to build (e.g. non-toxic and low-carbon), energy (embodied and operational), water (e.g. rainwater retention, greywater usage) and management (e.g. high-quality construction, processes and strategies). Dimension 4 contains indicators related to how well buildings can adapt to and be resilient to environmental and climatic influences, such as heat waves or extreme weather events, or the integration of blue and green infrastructure. The last dimension, empowering people, includes indicators on skills and knowledge, how data are shared and processed, the extent to which users are in control of systems and technologies, and smart technologies.

The framework was tested on 12 case buildings (renovations and new builds of public,
commercial, and residential buildings) across Europe’s climate zones. The case studies show that incorporating healthy building aspects can lead to higher returns on investment, reduce sick days for office workers, foster stronger social connections, and reduce the climate impact of the building. Using the framework helps project teams track to what extent their projects fulfil the indicators of the five healthy building dimensions.

As a next step, links between the indicators and data at EU-level and Member State level were established. Underpinning the framework with data allows project teams, policymakers, and other stakeholders to measure how well the overall building stock is performing in relation to each health dimension of the framework. This will help find gaps and develop concrete measures to increase the number of healthy buildings within the EU.

Specific areas of action to achieve healthy and sustainable buildings were identified: (i) Broaden regulatory focus, (ii) Ensure access to data, (iii) Increase cross-functional collaboration and information sharing, (iv) Use decision-making tools effectively, and (v) Place people at the centre. These areas of action were translated into ten policy recommendations targeted at different implementation levels, stakeholders, geographies and across all building stages. The goal of the areas of action and policy recommendations is to target all five dimensions of the framework in an integrated way, ensuring that all aspects of healthy buildings are enacted at different policy levels. All recommendations are important to consider right now – particularly in the implementation of the revised EPBD, but implementation varies from immediate action until 2050 – when the EU needs to have a climate-neutral building stock.
Compensating domestic customers for electricity grid services: the challenge of allocating the costs and benefits of controlled domestic water heating

Chris Granda, Energy Solutions Inc, USA
Helen Davis, Energy Solutions, USA
Daniela Urigwe, Energy Solutions, USA
George Chapman, Energy Solutions, USA

Panel
2. Future and innovative policies

Keywords
demand response, domestic hot water, electricity grid

Domestic electric storage water heaters (ESWH) are designed to consume electricity, store energy as hot water, and then supply hot water to users upon demand. This ability creates a significant demand response resource potential. The US and the EU each currently have close to 57 million ESWH, almost all of which operate autonomously and do not communicate with the electricity distribution grid. Today, when ESWH consume electricity is determined by when ESWH users consume hot water. Because domestic utility customers tend to share hot water usage patterns, ESWH are often drivers of domestic sector peak electricity demand.

Trends in technology and regulation in both the US and EU may create opportunities to better integrate ESWH into grids and develop the demand response potential for this important household appliance. Three US states already require that most ESWHs be sold with some degree of demand response enabling technology and more US states are considering similar regulations. A pending update to US federal minimum energy performance standards (MEPS) is expected to shift the US ESWH market from electric resistance to heat pump technology with implications for ESWH demand response. The size of the ESWH fleets in the US and the EU may also increase in coming years as the result of electrification policies and market forces.

Jurisdictions in both the US and EU are experimenting with innovative electricity tariffs to incentivize customers to adopt demand response capable ESWH. Today the infrastructure needed to turn fleets of ESWH into demand response resources is still in its infancy. The incremental costs associated with demand-response-capable or “smart” ESWH are significant and are now largely borne by consumers. However, the consumer benefits from participating in nascent ESWH demand response schemes is not well defined. To reach a future with fully realized ESWH demand response capability is now less a challenge of technology development and more a challenge of distributing costs and benefits appropriately.
This paper provides a practical perspective on domestic sector demand resource programme design for ESWH from the perspective of energy efficiency programme designers and explores the ESWH potential demand response resource with a focus on the ways that domestic electricity customers may be compensated for providing demand response services with their ESWH. The authors review and contrast approaches to recruiting and compensating domestic smart ESWH owners as participants in demand response schemes. The authors draw primarily from experience in the US but also reference research from Europe and other regions.
From policy to action: Assessing the effectiveness of heating and cooling Plans — A case study of Baden-Württemberg

Markus Fritz, Fraunhofer Institute for Systems and Innovation Research, Germany
Fabian Cloos, Fraunhofer ISI, Germany
Anna Billerbeck, Fraunhofer ISI, Germany
Ali Aydemir, Fraunhofer ISI, Germany

Panel
2. Future and innovative policies

Keywords
district heating, local and regional energy planning, heating systems, action plan, Heating and cooling planning

Strategic heating and cooling (H&C) planning has been recognized as an effective tool for driving the decarbonization of heating and cooling systems in urban areas. Consequently, the revised Energy Efficiency Directive (EED) now mandates municipal heating and cooling planning for municipalities with a population exceeding 45,000. Similarly, in Baden-Württemberg, a federal state in Germany, a comparable law has been in effect since 2020, requiring the development of heating plans by the end of 2023. Approximately 100 municipalities in Baden-Württemberg are subject to this legislation.

The main target of these heating and cooling plans is to devise action strategies and measures to enhance energy efficiency, as well as provide climate neutral heating supply. Notably, this law stipulates that at least five measures must be specified in the heating plans, with implementation starting within five years after development of the heat plan at the latest.

This paper examines the heat plans published in Baden-Württemberg until December 2023, with a focus on the proposed implementation measures. The aim is to evaluate the effectiveness of these measures in reducing greenhouse gas emissions. To achieve this, we categorize the measures into six different areas of action and three levels of intensity.

The results indicate that the majority of measures are planned within the area of action District heating and cooling and waste heat, while the fewest measures are found in the area Planning and conception. In the areas of action Increasing efficiency and renovating buildings and Feasibility studies, predominantly minor measures are employed, suggesting that the emphasis is not on improving energy efficiency and thus reducing heat demand.
The findings of this study can assist policymakers and stakeholders in developing effective heating and cooling plans, thereby facilitating the decarbonization of heating and cooling systems in urban areas.
Bottom-up initiatives for co-designing energy efficiency policies to address energy poverty

Mara Florina Oprea, IEECP, The Netherlands
Edoardo Pandolfi, ENEA
Samuele Livraghi, IEECP
Dimitrios Papantonis, UPRC
Vlasios Oikonomou, IEECP – Institute for European Energy and Climate Policy

Panel
2. Future and innovative policies

Keywords
stakeholder, energy poverty, energy efficiency policy, private rented sector, split incentive

In addition to the well-understood price of energy, income and housing conditions, factors affecting and increasing the degree of energy poverty felt by citizens also include the less-studied ownership status of households and the tenancy market. Despite the existence of several policies to tackle energy poverty, very few address the private rented sector (PRS), and moreover, stakeholder views are rarely taken into account in the design of such policies. This paper presents the role of stakeholder engagement in the redesign of ten energy efficiency policies within the framework of the ENPOR project for energy poor households in the PRS. It is based on the structured engagement of REACT (Regional Energy ACTion) group meetings (with the inclusion of all relevant stakeholders according to the type of policy) for discussing each element of the policy, followed by target group meetings with landlords and tenants to ensure balanced participation and contribution across all stakeholder groups.

The activities undertaken are described for each pilot policy (which are divided into renovation grants, Energy Efficiency Obligation Schemes, as well as information and advisory measure categories): specifically, information is provided about organized meetings, objectives and their unique key issues, the main conclusions and unresolved matters, and how finally policies were influenced. Targeted countries implemented the proposed co-design process successfully at different levels, considering the outcomes of REACT groups, although different settings applied to different policies and national circumstances. Nevertheless, the common lesson is that through these bottom-up initiatives, the policies managed to better address the issues inherent to the PRS and generate higher social acceptance.

The paper concludes with an overview of the organized REACT group engagements and the most important policy improvements are outlined for each pilot policy separately. Thanks to these collaborative efforts, many recommendations were elicited both for the targeted pilot policies and for the broader goal of energy poverty alleviation in the PRS.
Making EU policies fit for sustainable cooling: first reducing the needs by adopting a systemic view

Simon Pezzutto, EURAC Research, Italy
Dimitris Athanasiou, IEECP, Greece
Indriany Liongo, IEECP, The Netherlands
Giulia Conforto, e-think, Austria
Flavia Trovalusci, EURAC, Italy
Jérémy Clero, IEECP, Belgium
Bruno Duplessis, ARMINES / Mines Paristech, France
Jean-Sébastien Broc, IEECP - Institute for a European Energy & Climate Policy, The Netherlands

Panel
2. Future and innovative policies

Keywords
cooling, EU policy, climate change mitigation, climate change adaptation, summer comfort, passive cooling

Final energy consumption for space cooling in residential buildings tripled between 2010 and 2019 in the 19 euro-area countries, while households’ equipment rate in air conditioning in Europe rose from 14% in 2010 to about 20% in 2019. Cooling alone accounts for around 4% of final energy demand in the EU, with 106 TWh for space cooling and about 110 TWh for process cooling complemented by 0.6 TWh for district cooling. More frequent and intense heat waves accelerate this trend, and contribute to peak loads, and even power cuts. Above all, this represents a major risk for health, with over 70,000 excess deaths in Europe in 2003, and more than 60,000 in 2022. Heatwaves cause about 90% of fatalities related to climate-related extreme events.

Summer comfort is thus a major challenge for both, mitigation and adaptation policies. Policies for space cooling may be too much focused on cooling technologies, overlooking solutions to avoid, or at least minimise, cooling needs while ensuring summer comfort. Cooling demand is indeed influenced by various factors beyond cooling devices’ efficiency, including passive architecture building design based on bioclimatic principles, urban environment (e.g. urban heat island) and behaviours.

This paper reviews how space cooling is addressed in the EU policy framework, including changes brought by the fit-for-5 package. The paper then analyses policies and strategies of the five countries with the largest cooling demand (Spain, France, Italy, Germany, Greece),
focusing on national building regulations, comprehensive assessments on heating and cooling, draft updates of National Energy and Climate Plans, and National Adaptation Strategies and Plans. These analyses are crossed with a scouting of solutions for sustainable space cooling, to discuss their coverage in the current EU policy framework. We conclude that a shift may be needed in the policy framework to prioritise first measures that can minimise cooling needs, acknowledging that their implementation implies a coordination between EU, national and local policies, as the local level can best take into account local climate conditions and adapt urban planning.
Sufficiency for accelerating building energy transition: the need for technology and policy innovations

Max Wei, Lawrence Berkeley National Lab, USA
Tianzhen Hong, Lawrence Berkeley National Laboratory, USA
Jeetika Malik, Lawrence Berkeley National Laboratory, USA

Panel
2. Future and innovative policies

Keywords
sufficiency, energy demand, technical innovation, behaviour

Technological transformations such as energy-efficient technologies and clean energy infrastructure remain at the forefront of building decarbonization. However, deployment challenges such as high capital cost associated with renewables and electrification, coupled with equity concerns persist, impeding the energy transition. Worse, fossil fuels remain indispensable in creating renewable infrastructure. A complementary approach that is truly sustainable in accelerating low-carbon buildings is sufficiency that involves an absolute reduction in energy demand by avoiding superfluous consumption through behavioural or lifestyle changes, which are often supported by enabling technology and policy.

This paper intends to explore the role of technology and policy levers in developing a sufficiency-oriented research agenda for an equitable energy transition. First, we discuss with a few examples, how sufficiency in buildings needs to be viewed beyond behavior change and leverage innovation in technology and policy. Next, we discuss the linkages of building sufficiency policies with other sectors such as land use, urban planning and transportation and the need for an integrated approach for sufficiency policy and planning. Lastly, we identify key research priorities to facilitating greater sufficiency in buildings. The overall goal of this paper is to stimulate the broader community towards developing innovative and fresh perspectives for implementing a sufficiency-first approach for building decarbonization.
Taking new steps in the beyond growth debate: potentials and pitfalls of alternative economic concepts for the Netherlands

Stephan Slingerland, TNO, France
Stephan Slingerland, TNO, The Netherlands
Geerte Paradies, TNO, The Netherlands
Mauricio Rodriguez Acosta, TNO, The Netherlands
Eline Westbeek, TNO, The Netherlands

Panel
2. Future and innovative policies

Keywords
behavioural change, broader social context, qualitative sociology, beyond growth, societal transformation

In recent years a vivid public and academic debate has arisen about whether or not there is a need for more fundamental changes to our current economic system. In this ‘Beyond Growth’ debate many different alternative economic concepts are proposed. However, the exact implications of these concepts for future societies are still very unclear and the debate about them is blurred. In this project therefore eleven alternative economic concepts were selected, analysed and compared in detail. These are: ‘Green Growth’, ‘Mission Economy’, ‘Broader Welfare’, ‘Doughnut Economics’, ‘Degrowth’, ‘The Great Mindshift’, and ‘Buen Vivir’, and their Dutch counterparts ‘Green Growth NL’, ‘Broad Welfare NL’, ‘Post Growth NL’, and ‘Purpose Economy NL’.

For each of the concepts, viewpoints of the concept towards GDP, technological innovation, norms and value change and redistribution were examined. Furthermore, a theory of change assessment was performed for all concepts, analysing what final impacts each concept actually promises and which policy routes are indicated to get there. In this assessment, it was also investigated what implicit assumptions are underlying to the concept, what analysis of possible risks, drawbacks and side-effects is made, and how the concept describes its scaling mechanism. Finally, it was analysed to what extent current advanced modelling suites are capable of quantifying intended final impacts and policy routes of the concepts.

It was found that important distinguishing dimensions of the different concepts, next to their position towards GDP growth, are the degree to which they propagate change of current norms and values, as well as the degree to which they foresee direct governmental steering. Based on the different positions of concepts regarding these indicators, the concepts were divided into...
three main families and positioned towards each other in a taxonomy. It was also found that each of the economic concepts holds distinguishing possibilities for innovative policymaking and for new societal solutions, including e.g. 'Moonshot Missions' for Mission Economy, drastic working time reductions and inclusion of the caring economy for Degrowth, and a progressive consumption tax for Post Growth NL. However, it was also concluded that all concepts presently still show significant gaps in their proposed policy impact chains towards intended societal impacts and partly depend on underlying assumptions that are not yet fully underpinned by empirical evidence. This holds for instance for the supposed possibility of absolute decoupling of natural resource use from GDP growth in the Green Growth concept, or the presumed norms and values change towards more eco-centric attitudes in Degrowth. As for the possibility to model the impacts of alternative economic concepts, it was concluded that none of the models included in the analysis could quantify all distinctive features of the concepts. With a carefully selected suite of currently available models this should nevertheless be possible.

Overall, it was concluded that alternative economic concepts need further examination before they could be implemented in practice in the Netherlands. Four main routes were identified that could guide these efforts: to complete policy impact chains for all concepts; to analyse different scenarios of concept based on their distinct views on individual wellbeing and collective welfare; to quantify the potential impacts of the concepts and of individual innovative policy measures proposed by them; and to examine public support for policies that aim at influencing current norms and values. It is also suggested that broadening the current, mainly economy-centred public debate to the underlying normative questions regarding different societal definitions of our future welfare and the role of government in influencing our individual norms and values could lead to taking fundamentally new steps in a future Beyond Growth debate.
Health framings of meat consumption: experimental insights into policy acceptability in three European countries

Abigail Alexander-Haw, Fraunhofer Institute for Systems and Innovation Research, Germany
Joachim Schleich, Fraunhofer Institute for Systems and Innovation Research, Germany
Josephine Tröger, Fraunhofer Institute for Systems and Innovation Research, Germany

Panel

2. Future and innovative policies

Keywords

health, climate change, consumption, food and drink, sufficiency policies, acceptability

Reducing meat consumption offers dual benefits for both climate and health, aligning with sufficiency lifestyles discussed for mitigating climate change. While individuals often decrease meat consumption upon learning about its health effects, little is known about how health-related information influences the acceptability of meat reduction policies. Our research aims to help fill this gap.

To this end, we conducted a demographically representative survey among more than 2,000 adult individuals in France, Italy, and Latvia in October 2023. The survey elicited individuals' acceptability of various meat reduction policies, with a randomised nudge regarding the health risks associated with meat consumption. The policies included carbon labelling on food products, a 10% meat tax, and a meat-free day per week in public and private canteens.

Our preliminary findings from multivariate analyses indicate that the health-risk nudge causally increases the acceptability of the meat taxes in Italy, and a meat-free day in Latvia, i.e., the more coercive policies compared to the labelling. Furthermore, heterogeneity models reveal that the health-risk nudge exerts varying effects on different subgroups of the population. In France, the health-risk nudge results in a higher increase in policy acceptability for a meat tax for respondents who experienced food deprivation compared to those who did not. Moreover, in Latvia, female respondents who received the health-risk nudge have a higher probability of considering the meat-free day acceptable than males who received the health-risk nudge. In Italy, respondents without an academic degree who received the health-risk nudge are more likely to find both the meat tax and meat-free day acceptable compared to those with an
academic degree who received the same nudge. Further, we find correlational evidence that acceptability of policies is generally higher for policies which are deemed more effective, fairer, and less expensive, ceteris paribus. In addition, meat taxes are the least accepted policy in all countries while in France and Latvia (but not in Italy), meat-free days enjoy a higher acceptability than carbon labels. Finally, we find little evidence that age, gender, income and education levels are generally related with policy acceptability in our study.

Our findings also have implications for policy-making. Health-risk nudges can be effective in increasing policy support for more coercive policies, although the effects differ by country, highlighting the importance of considering socio-cultural factors in policy design. Moreover, recognising the heterogeneous effects of the health-risk nudge suggests the potential for targeted interventions aimed at specific subgroups to enhance policy acceptability.
Green Heat For All 2: the gap-o-meter of the heating & cooling decarbonisation

Davide Sabbadin, EEB European Environmental Bureau, Belgium
Gunnar Boye Olesen, INFORSE
Jose Campos Filho, INFORSE
Ann Vikkelsø, INFORSE
Béla Munkácsy, INFORSE
Tibor Marik, INFORSE
Bich DAO, European Environmental Bureau

Panel
2. Future and innovative policies

Keywords
heat pump, solar heating, electrical heating, condensing boilers, photovoltaics, financial incentives, cooling

Shifting as little as half of the annual €3.2 billion fossil heating subsidies paid by Member States to go to extra support for heat pumps and solar instead can transition Europe to 100% renewable heat before 2040 in a fair way, making significant headway for EU climate neutrality.

The study takes a mid-to low-income household as a reference in all analysed EU countries to investigate the extra investment needed for a transition that will leave no one behind.

The model is a simplified one that looks at the current replacement cost of a fossil fuel boiler with another boiler or renewable heating technologies. To stay realistic, the tech we chose for each Member State matches their heating demand, with air-to-water heat pumps for colder climates, but air-to-air combined with solar thermal energy for hot water in warmer ones. The model also integrates the existing subsidies and standard consumption patterns per country, and calculates the existing gap in subsidies to achieve the feasibility of the full decarbonisation of heating at household, country and EU-level.

The findings reveal that manageable extra investment totaling €21 billion over the upcoming decade and a half will ensure a fairer and cleaner energy landscape across the whole bloc. What this entails is a 7-year payback for all citizens installing heat pumps and full upfront cost coverage for families in need. If coupled with carbon taxation, the investment is even more affordable, at €14 billion. The study also encompasses an analysis of the existing subsidies schemes for heating and cooling technologies in the different EU countries.
Other significant findings include:
1) When it comes to day-to-day use, running a heat pump is already cheaper than running a gas or oil boiler in all Member States, except for Belgium where solar power is needed to breakeven.
2) With current subsidies, 16 Member States already have access to affordable heat pumps that payback within 7 years from the first investment, including Germany, Italy, Spain, Poland and the Nordics. With carbon taxes, this number becomes 20 out of 27.
3) Belgium, Ireland and the Netherlands are the least ambitious in setting targets for renewable energy share in heating and cooling, all aiming for below 10%.
4) Italy and Poland still generously subsidise fossil heating and installation of new boilers. Belgium continues to marginally support coal heating technology in some forms.

At the time of the research (October 2023), 10 European countries still finance fossil boilers (it is now 9 countries) while many mid-to-low-income families struggle to afford the switch to cleaner and cheaper heating due to the high upfront investments associated with heat pumps. However, the finding of this study puts into perspective the scale of this public investment compared to the amount that has already been poured and continues to pour down the fossil heating drain.

While a rough model, the findings are a narrative tool showcasing the feasibility of this transition, specifically with climate justice in mind. This is combatting the growing populistic attacks on EU and national buildings energy efficiency policies, often painted as an idealistic Brussels agenda. The findings of this study imply otherwise, that it is possible to make this transition fair and centred on mid-to-low income households: the funds are there to be shifted, it is simply a matter of political will to prioritise cheap and clean heat for the people over the fossil fuel industry.

In fact, the study shows that by redirecting current fossil heating spending into extra support for renewable heating immediately, we could theoretically decarbonise the whole heating stock by 2030, covering 100% of the upfront cost for the 30% of boiler users who are low-income or impoverished.

Sufficiency – from obligation to opportunity

Birte Schnurr, Wuppertal Institut for Climate Environment and Energy, Germany
Meike Spitzner, Wuppertal Institut
Lotte Nawothnig, Wuppertal Institut for Climate Environment and Energy

Panel
2. Future and innovative policies

Keywords
sufficiency rights, overcoming barriers, overcoming barriers

Sufficiency as a third and essential pillar complementary to efficiency and consistency can contribute substantially to the mitigation of climate change, provided the inherent potential for the transformation of production as well as consumption patterns can be unlocked. In Germany, however, the term is often associated with restriction policies and triggers fears of loss in the citizens. Yet, if sufficiency practices are understood as a right to be guaranteed by the state instead of individual choices and the personal benefits of a sufficient livelihood become clear, a positive narrative of sufficiency can be introduced in order to overcome (perceived) transition barriers. At the example of three conceivable sufficiency rights from the mobility and housing sectors, the structures needed to facilitate sufficient livelihoods as well as the barriers by jurisdiction and the respective regulatory framework are investigated.

The selected examples are used to illustrate the effects that e.g., a car-centric mobility policy, a great variation in tenancy agreements or a local supply system aimed exclusively at maximising economic efficiency have on the care economy and how costs are externalised to the private sector as a result. In addition, the gender dimension of this structural generation of demand is addressed, as the people affected by this are predominantly female. However, solutions can also be identified that create freedom instead of restricting it. For instance, routes to school that children can cover independently and safely not only create freedom of time for carers, but also freedom of movement for other vulnerable groups.

Facilitating changes of residence relieves the burden on people after the family phase in particular, reduces the pressure to build new housing and enables more people to live in an adequate housing situation. Mobility services, especially in rural areas, that protect people from mobility poverty, enable them to live independently and participate in society. Retailers also benefit from the additional customers. This paper points out how adequate political measures and planning ground rules backed by an appropriate legal framework can facilitate sufficiency at all levels of society.
The gas grid hurdle in the race to system efficiency

Marc Stobbe, Öko-Institut, Germany
Sibylle Braungardt, Öko-Institut, Germany
Tilman Hesse, Öko-Institut, Germany
Malte Bei der Wieden, Öko-Institut, Germany
Carmen Loschke, Öko-Institut, Germany
Megan Anderson, The Regulatory Assistance Project, Belgium
Veit Bürger, Öko-Institut, Institute for Applied EcologyÖko-Institut, Germany

Panel
2. Future and innovative policies

Keywords
gas grid, infrastructure, system efficiency, regulation, energy policy

Meeting energy and climate targets requires phasing out the use of fossil fuels in the heating sector, demanding an extensive overhaul of infrastructure. The expansion of district heating and electricity distribution grids will be essential for this transition, while parts of the gas distribution network will become redundant. Regional and municipal heating plans, mandated by the EED and the decarbonised gas and hydrogen market package, require planning that should involve identifying areas where gas distribution networks will be decommissioned or dismantled in the future. The process will be accelerated by phasing out or introducing efficiency regulations for heating installations.

How should the efficient and orderly transformation of the gas network be accomplished? To this end, we compare the status-quo as well as recent the developments of gas grid infrastructures across four European countries, namely Austria, Germany, the Netherlands, and the UK. Additionally, we analyse the current regulations for gas distribution networks, heat planning and heating systems. Our findings indicate that the current grid planning to meet end use needs for heating and cooking is misaligned with climate targets. Furthermore, the efficiency of the overall energy system is hardly considered. For instance, national regulations compel distribution system operators to connect consumers to the gas grid despite clear evidence demonstrating that gas is neither the most efficient solution from an end-use perspective nor from a system perspective. Nevertheless, regulation provides little incentive for the decommissioning and/or dismantling of gas networks. We recommend aligning the regulatory framework as well as heat and infrastructure planning with the climate targets in such a way that the transformation can take place in a system-efficient manner.
Estimating appliance presence and use through smart metres for effective demand-side management of residential cooling

Veena Shirsath, Ahmedabad University, India
Saket Sarraf

Panel
2. Future and innovative policies

Keywords
demand side management (DSM), smart metering, residential customers, cooling

The residential sector forms a quarter of total electricity demand in India, with space cooling accounting for 33-65% of total electricity consumption in residential apartments. With the rise of global temperatures and average incomes, residential cooling is expected to rise in Indian households, posing a challenge to low-carbon energy system transition. In fact, the projected residential AC demand for India is expected to cross the total current electricity consumption of Africa by 2030.

Air-conditioners contribute to peak demand, and hence DisComs have an incentive to affect cooling demand through targeted demand side measures. In order to introduce, monitor, and evaluate Demand Side Measures (DSMs), DisComs need to identify households contributing to the cooling load and know their AC usage.

This study aims to estimate appliance ownership, and consumption behaviour based on aggregated sub-hourly household level electricity consumption data. We use various machine learning models to predict AC ownership and usage patterns, commonly termed as Non intrusive Load Monitoring (NLM) or energy signature analysis.

Most work in this field is based on very granular current and voltage data. However, this data is difficult to access for a DisCom looking to implement demand side measures using smart metre data. Here we attempt to achieve a similar output with more readily available data for DisComs i.e., through smart metres measured at a 15 minute interval. This also allows for achieving scalable results. The resultant information is useful for DISCOMs to design better policies, such as shifting demand from peak to non-peak hours within the day, managing smart thermostats, and identifying households with inefficient appliances. Our results provide an important use-case to support the deployment of the Smart Meter National Programme and recent discussions on grid interactivity.

The general structure of our model uses a binary variable for AC use (whether AC was used at...
a given time or not) as the independent variable. The features involve the sub hourly total household energy use along with temperature measures for the given day, time of day, and month. The paper uses data from detailed submetering of household energy use of 144 households and their appliances at 15-minute intervals from 2018 to mid-2020 for three Indian states. Climate data is collected from the Indian Meteorological Department.

We use successively complex classification models, like logistic regression, ANN, RNN, and LSTM, to estimate appliance usage patterns. For each model, two different data structures are used. The first structure takes the whole day load curve as an input (wide form dataset). We use the first difference between the adjacent time periods as there is a significant correlation between them. The second structure takes each 15-minute interval as the input in time series format (long form dataset). This allows for a better account of the temporal dynamics of appliance use.

We find that LSTM model with the wide form dataset performs the best with a 77% accuracy and F1 score of 0.62. When testing the same model on test datasets to which the model was not exposed to, we get an accuracy of 68% and an F1 score of 0.17.

The results may be used by DisComs to identify appropriate households for demand-side measures and also formulate user-specific measures. The information can also be relayed to households for them to improve their energy consumption. Our model closely matches the accuracy of other NILM models which use appliance specific energy signatures but with a much more granular energy data. Household level socio-demographic characteristics could further enrich the model, but it is difficult to access that data by the DisComs. Our next steps include (a) expanding the model to predict the duration of AC use (in minutes), (b) AC energy consumption, and (c) creating a model ensemble for more robust prediction.
Net zero building renovations: How can both climate justice and social equity objectives be achieved?

Stefan Thomas, Wuppertal Institute for Climate, Environment and Energy, Germany
Oliver Wagner, Wuppertal Institute for Climate, Environment and Energy, Germany
Birte Schnurr, Wuppertal Institute for Climate, Environment and Energy, Germany

Panel
2. Future and innovative policies

Keywords
deep renovations, social impacts, just transition

For its fair contribution to limiting the overshooting time for the 1.5K target of the Paris agreement, the EU would have to decarbonize its building stock by around 2035. In theory, this would even be feasible. A study for Germany showed how an ambitious package of policies could achieve such a target. It needs to increase deep renovations to at least 3% per year, install 1 million heat pumps annually, and double the share of district heating while greening it. The core policies would be stringent MEPS coupled with lots of financial incentives. In the long run, it would even be cost-effective. Results from this study are forming the first part of this paper.

Reality, however, appears different. In the first days of Russia’s war of aggression against Ukraine, the German government adopted the aim to effectively ban all fossil heating by 1 January 2024. But when it drafted the law in early 2023, it missed to prepare plans at the same time to make energy efficiency easy and attractive via enhanced financial incentives and advice. Using targeted misinformation, incumbents and some political parties found it easy to confuse citizens about the social impacts of heat pumps, which led to a significantly watered down ambition in the final legislation. In the second part of the paper, we explain how this process unfolded, and what can be learned for countries that wish to fare better in energy efficiency policy-making.

Finally, we analyse how policies complementing binding energy efficiency legislation could be modified to enable all citizens, including those with lower incomes, to implement and benefit from the transformation of the building stock towards net zero. This particularly concerns targeted financial incentives and advice, including one-stop-shops. It will be decisive for (re-)gaining acceptance for energy efficiency renovation and low-carbon heating systems, and hence for a successful implementation of the new EPBD with regard to ambitious...
decarbonization of the buildings stock to support climate justice, combined with improving social equity and fighting energy poverty, including through renovation of the worst-performing buildings.
Ecodesign requirements for software: another possible horizontal approach?

Mathieu Rama, ECOS (Environmental Coalition on Standards), Belgium

Panel
2. Future and innovative policies

Keywords
Ecodesign Directive (EuP/ErP), software, Repairability, domestic energy efficiency

Software, as opposed to hardware, can be defined as the instructions, programs and data that power computers and execute tasks. Initially mainly installed on computers, software is now used on a wide variety of products. Smartphones, of course, but also a significant and growing quantity of IoT (Internet of Things) devices. Even though seemingly immaterial, software can have an important impact on the energy and material efficiency of a product.

Firstly, concerning energy efficiency, software practices have been identified as increasing the energy use of a product, leading batteries to empty earlier than anticipated. Secondly, concerning material efficiency, part-pairing has been identified as a major barrier to repair activities and software updates can also make certain products obsolete, resulting in being discarded even though technically functioning. The absence of software updates, also, can make certain products unsafe to use.

The issue of software sustainability is not flying under the radar of EU institutions. A few legislative texts, most of them having recently been through the co-legislative process, contain provisions about the design of software. Historically, this has started with ecodesign regulation. The first product category that has been subject to ecodesign requirements on software is ‘servers and data storage products’ where both data deletion and firmware updates are tackled. Smartphones and tablets have followed with rules on software updates availability and part-pairing. These rules will be in force starting June 2025. Computers will be tackled too once the current rules are finally revised.

However, the most promising legislative efforts to tackle the sustainability of software do not come from product specific ecodesign regulations. As software are now used by many different types of products, some of them not being in scope of ecodesign and energy labelling regulations, a horizontal approach makes a lot of sense. As opposed to a product-by-product approach, a horizontal approach applies to many types of products at once and potentially allows for more energy and material savings.

At EU level, this strategy has, for example, been implemented on off mode, standby mode, and networked standby through ecodesign requirements, as well as on batteries through a new regulation. This approach is also supposed to be favoured in the framework of the forthcoming Ecodesign for Sustainable Products Regulation.
Horizontal regulation on software actually already exist in the context of the new battery regulation: batteries have to have a reset function and part-pairing of batteries is unlawful under this regulation. Part-pairing has also recently been discussed by the European parliament who, in its amendments to the directive on common rules promoting the repair of goods, has suggested that Member States “[prohibit] any contractual, hardware or software technique that could prevent or limit repair”. The Cyber Resilience Act as well, focusing on making products with digital elements more secure, will eventually make products more durable and reliable through better resistance to cyber attacks.

This paper aims at investigating the opportunity for horizontal ecodesign requirements on software. After going through a series of examples of material efficiency and energy efficiency issues related to the design of software, existing European Union's regulations and standards aiming at solving these issues will be analysed. Whether these standards and regulations are going far enough to regulate this sector will also be discussed. Finally, recommendations will be made on what ecodesign requirements on software should contain if tackled horizontally.
From theory to practice: examining the success of emerging housing sufficiency policies

Clemens Rohde, Fraunhofer Institute for Systems and Innovation Research, Germany
Hans-Joachim Linke, Department of Land Management, Technische Universität Darmstadt, Germany
Mahsa Bagheri, Fraunhofer Institute for Systems and Innovation Research, Germany

Panel
2. Future and innovative policies

Keywords
sufficiency, energy behaviour, residential sector, policy assessment, housing policy

Living space per capita is the most frequently mentioned term in the context of sufficiency in the residential sector and the reason for high energy consumption in households. On the one hand, new construction increases the demand for often energy-intensive building materials, and on the other hand, energy demand during the use phase of buildings is positively related to the amount of heated space. Reducing demand by reducing the surface area of buildings is, therefore, expected to make the largest contribution to energy savings in this sector.

Sufficient lifestyles, which consume fewer resources without compromising health or social participation, therefore appear to be an effective solution for achieving this goal. A number of recommended policies to promote such sufficient lifestyles has been collected in the Energy Sufficiency Policy Database. However, the feasibility and effectiveness of such policies is not yet fully understood. As the sufficiency approach largely relies on the participation and individual choices of residents, the consideration of residents and their perception and acceptance of such policies is key to the success of sufficiency policies and ultimately to the achievement of climate goals.

This paper examines the lessons learned from selected sufficiency policies, focusing on the floor space used by households. By interviewing housing associations in Germany, the paper aims to investigate the implementation experiences of these policies. The results of the study indicate the impact of circumstances on the success or failure of the policies studied. Based on the analysis of success factors and limiting barriers of the policies studied, the paper makes recommendations improve future policy design by providing targeted alternatives for optimising floor area, resulting in reduced energy consumption while still meeting the needs of the occupants.
Catch me if you can: Energy savings beyond the low hanging fruit

Jörg Balsiger, Université de Genève, Switzerland
Cédric Jeanneret, Service Industriels de Genève, Switzerland

Panel
2. Future and innovative policies

Keywords
politics of attention, participation, energy sufficiency, innovation

“In the competition for hearts and minds, improving the efficiency with which we use energy faces an uphill challenge; images of heat exchangers, solid state lighting, infrared scanning technologies, more and better roof insulation, double and triple glazing, air sealing systems, or even smart meters do not get the pulse racing.” (Convery, 2011, 189)

Why do energy savings measures “not get the pulse racing”? In Convery’s view, they cannot compete with “the glow” of energy supply projects or the local economic benefits of new power plants. Yet, we also know that energy supply projects regularly take years or decades to conclude at significant financial, political, and environmental cost. Conversely, energy savings measures often pass under the radar and are frequently, though not always implemented relatively quickly and easily as the proverbial low hanging fruit. In this paper, we suggest that the binary view of high attention = high impact versus low attention = low impact is neither accurate nor helpful. To speed things up and nuance the discussion, we highlight the relevance of capitalizing on low attention but high impact approaches.

First, we develop a conceptual framework that brings into relation energy savings impact and attention (aspects such as participation by different actors, a measure’s material footprint; and political consequences) and how the two evolve over time. Second, we offer examples from Geneva and Switzerland, aiming to populate the framework-derived matrix, analyze movements across cells in the matrix during a project’s life, and identify complementarities between different quadrants of the matrix, for example between programs of the Service Industriels de Genève and the Swiss Confederation.

Finally, we address "scope conditions" under which higher hanging fruit can be reached (because they attract less attention) and conclude with recommendations for planning and implementing energy efficiency and sufficiency measures.
Searching for energy savings quantifications for the Sufficiency Potential Database – like looking for a needle in a haystack

Celia Burghardt, INATECH, Freiburg University, Germany
Kaya Dünzen, Oeko-Institut, Germany
Jenny Kurwan, Wuppertal Institut, Germany
Benjamin Best, Wuppertal Institut, Germany
David Schöpf, Wuppertal Institut, Germany
Mirko Schäfer, University of Freiburg, Germany
Frauke Wiese, University of Flensburg, Germany
Carinna Zell-Ziegler, Öko-Institut, Institute for Applied EcologyÖko-Institut, Germany

Panel
2. Future and innovative policies

Keywords
mitigation potential, energy sufficiency, decarbonisation, literature review, modelling, policies and measures

Reducing energy demand through sufficiency is necessary to achieve just and sustainable decarbonisation. Energy and climate scenarios therefore need to consider sufficiency in their decarbonisation pathways. However, to date, scenarios that consider sufficiency are very rare. Research has shown that modelers often lack quantified potentials of sufficiency measures, which they would need as input to energy system or sector models.

The aim of this paper is to fill this gap by providing an open access database with quantified energy savings potentials of sufficiency policies and measures for Germany. The database also includes existing quantifications of GHG savings from sufficiency policies and measures to demonstrate their potential.

To fill this database, we conducted a systematic literature review using Web of Science for peer-reviewed literature and Google Scholar for grey literature in English and German. We used the term "sufficiency" as well as a combination of the terms "absolute reduction"/"avoid" with terms such as "demand" or "consumption". After screening the 430 search results, only 14 of the papers and reports were found to contain relevant quantified sufficiency potentials. We added 35 papers known to the authors and provided by several sufficiency expert communities, so that the database is based on 49 literature sources quantifying sufficiency
This literature review shows that (1) there is literature on quantified sufficiency potentials for Germany. Most quantifications are found for the building sector. (2) The data is very diverse in terms of base year, time horizon and quantification method (simulation, evaluation, territorial vs. LCA view) and therefore not always easy to compare. Differences in reduction potentials also arise from the system in which the measures are quantified; for example, the energy saving from a reduction in living space is lower in a system with energy efficient buildings than in a system with a less efficient building stock. (3) The literature is not easy to find as the term sufficiency is often not used and searching for a combination of terms describing sufficiency leads to a lot of inappropriate results - it feels like looking for a needle in a haystack. Using literature known to the authors and expert networks to find appropriate literature was more helpful.

We conclude that our database, to be published later this year, is a first step to help modelers better account for sufficiency potentials in scenarios and to help policy makers understand the savings potential of sufficiency. We also call on researchers to further quantify the energy and GHG savings potential of sufficiency options to fill gaps identified.
Grid impacts of Seattle’s Building Emissions Performance Standard: a generalized modeling study & load impact analysis

Madeline Kostic, City of Seattle City Light, USA
Mazen Daher, Electric Power Research Institute
Siva Sankaranarayanan, Electric Power Research Institute
Maggie Sheng, Electric Power Research Institute

Panel
2. Future and innovative policies

Keywords
electrification, building regulations, commercial buildings, multi-family dwellings, electricity grid, building performance standards

The City of Seattle’s ambitious Buildings Emissions Performance Standard (BEPS) requires all buildings over 20,000 square feet (1,860 square meters) to reduce greenhouse gas emissions over time, eventually to zero by 2050. BEPS is expected to lower Seattle’s total greenhouse gas emissions from buildings by 27% by 2050. The most technologically feasible and cost-effective route to achieve these emissions reductions is for building owners to electrify fossil fuel end-uses, given Seattle City Light’s status as a carbon-neutral utility. The electrification of space conditioning, water heating, and cooking will cause increases in electricity consumption and, in many cases, result in increases in electric service sizes. For the customer, electric service upgrades translate into higher electrification project costs and typically longer construction timelines. For the utility, individual and cumulative customer service upgrades will increase workloads for customer service and engineering staff and require distribution system upgrades.

BEPS combined with Seattle’s energy benchmarking data of over 3,000 buildings enable the utility to precisely project where and when building electrification will occur. This study applies the modeled outcomes of several efficiency and decarbonization measures to building benchmarking data. A multi-step approach is undertaken, wherein (1) the sample stock is characterized based on typology, vintage, and heating fuel; (2) end-use makeup is estimated based on EnergyPlus prototypes developed as part of a prior study conducted by EPRI; (3) the obtained end-use makeups are scaled based on benchmarking data, to obtain a unique composite for every building in the set; (4) efficient electrification measures are applied to the composite benchmarks based on outcomes identified in EnergyPlus, from which (5) impacts to electric infrastructure, costs, and emissions are assessed.

This study is vital for understanding the role of electrification in meeting BEPS at different
stages along the compliance horizon, the geographic load impacts to inform short- and long-term planning at the electric utility, and the potential customer costs associated with compliance. This generalized modeling methodology is widely applicable to other jurisdictions that have building performance standards, climate action plans, and/or energy benchmarking data.

The results of the study demonstrate that BEPS will have diverse impacts for both customers and the grid. Building types with relatively large baseline electrical loads, such as office buildings and grocery stores, which have high ventilation (the former) and refrigeration (the latter), are much less susceptible to high peak load exacerbation than building types with minimal baseline electrical loads, such as multifamily housing. The average per building increase in peak load (measured by kilowatts) is 35% with a range of 2% to 72%. Likewise, load growth is not spread evenly across the utility’s service area and is concentrated in the Downtown and University District neighborhoods. Over the course of the Seattle BEPS’s compliance horizon, compliance will result in an increase of individual covered buildings’ peak loads amounting to a combined 154 megawatts. The utility can expect an increased volume of increasingly complex customer service upgrades due to (a) significant increases in individual buildings’ peak loads, and (b) increases in the number of buildings with a peak load exceeding 500 kilowatts (an important complexity threshold for service upgrades). Furthermore, widespread customer electrification will lead to grid-side distribution upgrades to meet increased electrical loads, particularly in the most impacted areas. This study allows the utility to plan more accurately for the increased volume of customer and grid-side upgrades and suggests a progressive need for increased material procurement and staffing during the 2030-2050 period.
To achieve net zero by 2050 will require the electricity system to be based on renewable generation by 2035. To integrate vast amounts of solar, wind and other variable generation, the system will need to become far more flexible. Demand-side flexibility is key to cost effective decarbonisation and has recently come to the fore as a tool to swiftly reduce our reliance on imported Russian gas.

Electricity customers have a central role: Those who can offer the value of their own household flexibility will stand to gain huge individual benefits. Homes are the greatest source of flexibility potential, with electrified home heating offering the largest private cost savings of all flexibility sources.

Moreover, Europe's electricity markets are evolving so that when we use energy will increasingly determine our bills not just how much we use. Those who can shift their energy demand will reap increasing rewards, while the relative cost of being unable to respond flexibly when markets encourage it is likely to grow.

The ability to shift energy use is not, however, evenly distributed. Lower-income and vulnerable households are routinely shut out of opportunities that could lower bills and reduce energy poverty. Most emerging flexibility-focussed policies, tariffs and innovations do not have these goals in mind.

This paper addresses the barriers to lower-income households offering the flexibility of their energy use without energy rationing or adding to daily stress and inconvenience. Building flexibility capacity through adequate fabric insulation and flexible assets is key — an adequately insulated building stock is Europe’s greatest heat storage device. Tariffs, products and services that offer the benefits without exposing households to excess risk, or removing social protections, are needed. Policy tools need to target the kind of flexibility that will deliver the most social value, alongside system value, rather than only focusing on the easiest-to-access flexibility.
Switzerland's new Energy Efficiency Obligation Scheme for electricity suppliers – challenges and solutions

Frédéric Renkens, Office fédéral de l’énergie OFEN (Suisse), Switzerland
Paul Stadler, SFOE, Switzerland

Panel
2. Future and innovative policies

Keywords
energy efficiency obligation

The Swiss parliament adopted on the 27th of September 2023 a revision of the Energy Act and the Electricity Supply Act, which should enter into force the 1st of January 2025. It introduces, among others, for electricity suppliers the obligation to achieve a yearly efficiency increase in the use of their sold electricity, thanks to the implementation of various efficiency measures by existing consumers. However, they are free to enter the business area of efficiency services or to externalize it and buy savings “certificates” from third parties. In both cases, they may transfer the costs for these measures on their electricity prices. In order to keep them competitive, their electricity efficiency measures may have to be as cost-effective as possible.

Although there is still the possibility for a referendum to prevent the law from coming into force, the implementing ordinance and the precise conditions, in particular for the electricity suppliers to get their electricity savings accredited, is currently under development.

The presentation aims to discuss various challenges in this process: among others establishing a sound and effective accreditation procedure for the electricity savings that keeps the administrative burden low for both, electricity suppliers and the federal authorities; ensuring additionality as well as a fair consideration of efficiency measures already implemented by proactive suppliers in the near past; providing the appropriate incentives, by promoting for instance an often more beneficial systemic approach instead of a component-based approach; transposing to the Swiss case learnings of other countries that have implemented similar energy efficiency obligation schemes for energy suppliers. Tackling these challenges appropriately seems paramount for this policy instrument to quickly generate significant electricity savings and strengthen both security of supply and climate protection.
“Now you’re cooking with electricity” – healthier and more efficient kitchens in the EU

Michael Scholand, M2S2 Energy Limited, United Kingdom

Panel 2. Future and innovative policies

Keywords
Ecodesign Directive (EuP/ErP), energy efficient products, future outlook, cooking, indoor air quality

Although the scientific community has published research papers for over five decades linking gas cooking to poor indoor air quality and negative health impacts, the public has remained largely unaware of the risks of cooking with gas. This fact is borne out by three class-action lawsuits in the United States of America (USA) against gas appliance manufacturers and European non-governmental organisations (NGOs) calling on policymakers to require reporting of information on combustion emissions from gas appliances. In addition to these developments, new collaborations between experts in the health and energy communities – with growing support from professional chefs and even retailers – are gradually raising awareness and informing consumers about the risks of gas and the benefits of cooking with electricity.

This paper addresses the health, safety and technological trends that are driving the cooking market transition away from fossil fuels, towards safer, cleaner electric cooking. In shifting away from gas, households across the European Union (EU) will remove the largest source of indoor nitrogen dioxide (NO2) emissions, significantly improving indoor air quality and consequently their health. This paper incorporates a broad spectrum of literature and published materials relating to gas cooking, setting out the context. It then draws upon available consumer surveys, interviews with industry experts, professional chefs and other key stakeholders in the cooking sector, reflecting their experiences. The paper compares gas and electric cooking, examining the differences with respect to indoor air quality, efficiency, cooking performance, temperature control, leakage/safety, climate impacts, technology trends and running costs. All the evidence indicates that the future of cooking is electric, but the question remains ‘how long before we get there?’

The EU has an opportunity to lead the world with policy measures that will expose the health and environmental impacts of cooking with gas. Using three policy mechanisms – the Ecodesign Directive 2009/125/EC, Energy Labelling Regulation (EU) 2017/1369 and the Gas Appliances Regulation (EU) 2016/426 – Member States have complementary policy pathways to support and accelerate the EU’s cooking market towards cleaner, more convenient and environmentally sustainable practices. Complementing these three policy instruments are the

Phasing out gas cooking across the EU would remove a significant source of methane emissions, from unburned gas released by the burners as well as leaks from the appliances. The authors calculate that if the average leakage rate of methane found in California (Lebel, 2022b) were applied to all EU households cooking on gas (Eurostat, 2024), it would equate to 42.3 to 68.8 million cubic metres of methane. That quantity of methane is equivalent to 2.6 to 4.2 million metric tonnes of CO2 annually, or 1.5 to 2.4 million average sized EU passenger cars (Statista, 2021).
Looking ahead – opportunities and benefits of moving from lighting products to smart systems

Peter Bennich, The Swedish Energy Agency, Sweden
Michael Scholand, M2S2 Energy /SSL Annex, United Kingdom
Georges Zissis, University of Toulouse / SSLC Platform chair, France
Nils Borg, Borg & Co AB, Sweden

Panel
2. Future and innovative policies

Keywords

Smart Lighting Systems and Controls
Smart Lighting Systems are being adopted around the world, but their rate of penetration is low and their value proposition is seldom fully recognised. This talk will provide an overview of the new work being undertaken by the IEA 4E Smart Sustainability in Lighting and Controls (SSLC) Platform. This new work will be conducted over the next five years under the umbrella of the IEA 4E TCP – the Energy Efficient End-Use Equipment Technology Collaboration Programme. The SSLC Platform work complements on-going research, standardisation and product development being conducted by industry and academia. All the activities of the Platform are policy-driven with a focus on how to best implement policies to accelerate energy-efficiency.

Starting in 2010, the SSL Annex actively worked to develop information and analysis that is highly relevant for product regulations, international standards and market surveillance activities. Through its website, email announcements, press releases and other public engagements, the SSL Annex shared its research, analyses and recommendations with the global lighting community. Publishing more than 50 documents and delivering over 70 public-facing presentations and seminars, the SSL Annex supported and accelerated the global transition to energy-efficient, quality lighting.

Over the coming five years (2024-2029) the SSLC Platform seeks to continue this track-record of success, with efforts concentrated on three key priority “focus areas” developed by the Platform’s member governments:
1) Market Assessment and Benchmarking – research into smart lighting, sensors, controls and lighting systems, including test methods, new system solutions and interoperability. This focus area will also include collecting and analysing market data and tracking product performance.
2) Understanding Impacts of Lighting – evaluation of lighting’s impact on health and the well-being of people, energy consumption, use of materials and other resources and
ecosystems. This focus area will also assess the application of the circular economy principles and conduct a life-cycle assessment on lighting systems.

3) Support for Standards and Regulations – develop harmonised quality and performance recommendations for products and systems; support standardisation by participating in standardisation activities at the IEC and CIE, and by contributing to the development and assessment of new test standards. This focus area will also support lighting metrology through an interlaboratory comparison on lighting sensors, controls and/or systems.

All of the SSLC Platform work will be communicated to wide-ranging audiences including: governments, policymakers, regulators, standardisation bodies, test labs, lighting associations, businesses and more.

International Cooperation

With the transition to digital lighting, new multi-disciplinary challenges have emerged for governments cutting across the health, environment, technology and energy sectors. The SSLC Platform offers an ideal forum for policymakers and their technical experts to jointly conduct research, analyse data and share lessons learned. Topics covered in the SSLC Platform would be expensive and resource-intensive for any one individual country to conduct. This work proposed in the Fourth Term Workplan will be carried out primarily through members’ in-kind contributions, with part of the work contracted to experts when necessary. The quality of the policy outcomes is improved through collaboration and cooperation, with Member governments’ sponsored Experts readily and easily communicating with each other and contributing to the output. And, through cooperation with other Member Countries and Experts, these topics can be addressed jointly, achieving better outcomes at a significantly lower cost.
Just energy transitions in coal-intensive regions: a multi-impacts approach to quantitatively evaluate the Territorial Just Transition Plans (TJTP)

Marco Peretto, IECCP, The Netherlands
Diana Susser, IECCP

Panel
3. Policy, finance and governance

Keywords
energy efficiency action plans, energy poverty, coal

Coal-intensive regions are particularly vulnerable to and affected by the planned changes needed to reduce pollution and move towards a climate neutral society. The Just Transition principle aims to ensure that decarbonisation policies do not harm some parts of society and communities more than others. As such, countries that are part of the European Union have developed so called Territorial Just Transition Plans (TJTPs), in line with the European Green Deal.

The following report illustrates a quantitative tool which was developed as to assess the degree to which impacts resulting from the implementation of a just transition have been addressed and how these can be reflected quantitatively. We conducted a literature review to select key impacts and then conducted a quantitative analysis in six just transition regions.

We find that there are gaps in the measurement of multiple transition impacts. These gaps should be addressed in each region to define tailored policies and investments that can help minimise negative impacts and capitalise on positive benefits for communities. The multiple-impacts approach outlined in this report can contribute to better define and assess regional impacts of transition towards climate neutrality and support the development of measures that minimise negative impacts and enable truly just transitions.
What makes the Dutch neighbourhood approach to become natural gas-free acceptable? An assessment of citizen’s perceived legitimacy on climate neutral building policies

Caren Herbstritt, PBL Dutch Environment Assessment Agency, The Netherlands
Astrid Martens, PBL Netherlands Environmental Assessment Agency, The Netherlands
Jarry Porsius, PBL Netherlands Environmental Assessment Agency, The Netherlands
Kees Vringer, PBL Netherlands Environmental Assessment Agency, The Netherlands

Panel
3. Policy, finance and governance

Keywords
climate policy, citizens, Legitimacy, Heat Transition, district heating, electrical heating, local authorities, renovation

Combating climate change requires major changes in the built environment. According to the national Dutch climate agreement all homes have to be heated without natural gas by 2050. The national government chose a neighbourhood approach, mandating municipalities to issue gas-free policy strategies for the local heat transition. Implementing this local approach firmly intervenes in citizens’ immediate living environment. In a democratic system, the implementation of such strategies relies on the acceptance of the population. Therefore, it is important to better understand which policy characteristics affect citizens’ perceived legitimacy. We present the results of a study on the perceived legitimacy of policy choices to opt out of natural-gas heating of Dutch buildings.

We used a mixed methods approach on a representative sample of Dutch citizens (n= 2034), to collect data through a survey and a vignette study to analyse the factors that may affect the perceived input-, process- and output legitimacy. We used 5 focus group interviews to get a better view on the reasons why policy characteristics are perceived as being more or less important.

We observed a broadly shared feeling of poor representation and distrust in government, which affected respondents’ judgment. Dutch citizens are positive about the idea of gas-free heating,
but skeptical about the policy plans. When carrying out current policy plans, we find that the chance of public resistance is high. Citizens are more likely to see policies as legitimate if costs are redistributed through the government and district heating infrastructures are publicly owned. Citizens want to be heard and their concerns taken into account, although to different degrees of participation and involvement. The existence of large uncertainties about local technological choices, investment costs and long-term end-user tariffs is a challenge in the process. Citizens value upfront certainty and equity across neighbourhoods when it comes to cost and changing to a new heating system.
Credible and comprehensive? Comparing policy mixes for Local Energy Systems in England, Scotland and Wales

Janette Webb, University of Edinburgh, United Kingdom
Faye Wade, University of Edinburgh, United Kingdom
Jess Britton, University of Edinburgh, United Kingdom

Panel
3. Policy, finance and governance

Keywords
devolved government, energy localization, energy policy

Definitions of Local Energy Systems (LES) in Britain encompass interconnected technical and social domains, with the expectation that local integration of heat, power and storage will make most efficient use of decentralised energy, reducing GHG emissions and whole system costs. British centralised energy systems however pre-date privatisation, and the value of, and routes to, integrated local energy remain contested. Governance and regulatory principles, business structures and finance are in flux. Devolved government however provides a natural experiment for research into varied political support for LES over time and between central (UK) and devolved Scottish and Welsh governments. This paper [1] asks: In what ways do emerging policy mixes for Local Energy Systems differ across Britain? What are the implications of any variation for likely effectiveness of LES policy?

Method
The paper develops and tests a policy mixes approach to examine differential LES policies in England, Scotland and Wales. A policy mix is conceptualised in terms of building blocks, including elements (policy strategy and instruments) and characteristics (qualities and performance) [2]. Policy mixes are evaluated using two characteristics: credibility (whether a policy mix is believable and reliable) and comprehensiveness (the extent to which a policy mix addresses all market, system and institutional failures). Credibility was evaluated using policy duration, long term target-setting, managing organisation and budget. Comprehensiveness was evaluated first by calculating balance, defined as the dispersion of policy across instrument types, and second according to specificity (whether instruments focus on a technology, a sector or whole economy).

Analysis encompassed 105 policy instruments introduced by UK, Scottish and Welsh Governments between 2010 – 2021. Relevant instruments were identified through publicly available overarching energy strategies, alongside strategies specifically concerned with ‘local’, ‘community’ or ‘area-based’ energy.
Results
The number of policy instruments relevant to LES across England, Scotland and Wales has significantly increased since 2010, and all three jurisdictions have a highly diverse instrument mix (balance).

In England the policy mix is characterised by fluctuation and short-termism, including withdrawal of several instruments supporting community-scale renewables, making this the least credible. The mix of instrument types is however more comprehensive than in Scotland and Wales.

Strategies in Scotland and Wales demonstrate a more credible and ambitious policy mix, including long-term policies and new instruments added over time. However, constrained political powers result in less comprehensive policy mixes than in England. Prospects for realisation of LES in the devolved jurisdictions of Scotland and Wales are hence uncertain.

Conclusion
The paper highlights strengths and weaknesses of the policy mixes concept as an analytical tool for exploring policy divergence in devolved governments. Analysis demonstrates that distinct approaches to LES are possible in devolved policy systems. However, none of the policies are designed to challenge systemic interdependencies of GB’s liberalised and largely centralised energy system. Ultimately this limits capacity for developing integrated LES and highlights the need for regulatory and institutional innovation in policy, in GB and elsewhere, to realise envisaged energy, cost and GHG savings and socio-economic benefits.

Reference
Is the “heating hammer” hitting energy efficiency policy? – learnings from the debate around the German buildings energy act

Sibylle Braungardt, Öko-Institut, Institute for Applied EcologyÖko-Institut, Germany
Friedhelm Keimeyer, Oeko-Institut e.V.

Keywords
heating, populism, policy

As a key element of its strategy to increase energy efficiency and renewable energies in buildings, Germany has recently revised its building energy act. The revision of the law has received unprecedented media attention and has dominated the energy policy discourse in 2023 in Germany and beyond. Driven by the German tabloid “BILD”, a campaign making use of populist discourses and misinformation has filled the front pages of German newspapers. The high media reception of the so-called “heating hammer” has strongly impacted not only the provisions of the law itself but has also caused considerable damage to future energy efficiency policy developments, leading to a withdrawal of a previously announced tightening of energy efficiency standards as well as the watering down of Germany’s position in the trilogue negotiations on the Energy Performance of Buildings Directive.

Given the relevance of the process and the discourse for current and future policy developments, our paper provides an analysis of the different steps in the policy process and their respective media reception. We first summarize the main elements of the revision of the German Buildings Energy Act and discuss how these have evolved from the first draft to the final adopted provisions.

We then discuss the evolution of media coverage between the first uptake in February 2023 until the adoption of the law in September 2023. We conclude by reflecting upon the increasing role of populist discourses on energy policy development.
International policy responses to the energy crisis triggered by the Russian invasion of Ukraine: A global comparison of best practices

Regina Betz, Center for Energy and the Environment / Zurich University of Applied Sciences (ZHAW), Switzerland
Tetiana Kurbatova, Sumy State University, Ukraine

Panel
3. Policy, finance and governance

Keywords
energy crises, policy response measures

The invasion of Ukraine by Russia in 2022 triggered a major energy crisis as it became highly uncertain how much gas and oil would be delivered to European countries in the short term and the exact impact of the invasion and sanctions in the medium and long term. These developments had and have repercussions not only on the European energy market but globally.

High and volatile energy prices impose a burden on households and businesses dependent on these fossil fuels. Supply shortfalls pose a systemic risk for many economies threatening economic and social welfare. In addition, substituting away from fossil fuels takes time and investment therefore, a large part of households and businesses will still be dependent on these energy sources for electricity, heating and transport in the medium term.

In order to address these challenges and lighten the burden on businesses (not least to prevent potential political unrest) governments in Europe and around the world responded with a range of emergency measures. While there are similar measures undertaken to combat the crisis like government campaigns to the general public to save energy, there have also been unique measures by individual countries, which can be explained by the scale of their dependency on Russian gas and oil and the status of electricity market liberalization in the country.

The aim of this paper is to compare data on the exposure of countries and their policy measures taken to combat the energy crisis triggered by the Russian invasion of Ukraine. By clustering the countries according to their dependency on Russian fossil fuels and electricity price impacts, we want to find out if countries within the same cluster take similar response measures, thus teasing out which characteristics may determine certain response measures and what do they mean for the decarbonization strategies of countries. We differentiate between measures on the supply and demand side as well as between long-term and
short-term as well as regret and no-regret measures from a decarbonization perspective. The latter are for example those measures aimed at reducing fossil energy consumption and increasing energy efficiency as well as diversifying away from imports, as these types of measures have the potential to sustainably address both the energy and climate crises in the long term.

Data to cluster countries according to their exposure to the energy crisis is collected from different statistical data sources such as EUROSTAT as well as from country experts. This data forms the basis for clustering the countries according to factors like gas imports and share of Russian gas imports, gas in the electricity mix, share of gas or electricity in heating. The information on the emergency measures introduced by EU countries is based on the Agency for the Cooperation of Energy Regulators (ACER) dashboard, as well as information from country experts. Additionally, submitted country information by expert interviews provide data for countries outside the European Union.

We find that measures are mostly adapted to the specific situation of a country (e.g., market structure, gas import dependency, gas share in the electricity mix, gas share in heating). Almost all countries took short-term measures by introducing electricity price caps, lowered the VAT on energy prices or provided subsidies, which were often financed by a windfall profit tax on the excess profits from the sale of electricity and gas by utilities. The reduction of electricity and gas prices in comparison to the real scarcity may have been counterproductive as incentives for energy savings and efficiency investments are reduced. Finally, many countries did also invest in new fossil fuel infrastructure such as LNG-terminals. As a result, a lot of money was distributed, but little was achieved for the long-term net-zero transformation.
Implementing the energy efficiency first principle in European regions: Insights from the REGIO1st Planning Framework

Tim Mandel, Fraunhofer Institute for Systems and Innovation Research, Germany
George Konstantopoulos, National Technical University of Athens, Greece
Andriana Stavrakaki, National Technical University of Athens, Greece
Songmin Yu, Fraunhofer Institute for Systems and Innovation Research, Germany
Vlasios Oikonomou, Institute for European Energy and Climate Policy (IEECP), The Netherlands

Panel
3. Policy, finance and governance

Keywords
energy efficiency first principle, local and regional energy planning, energy supply and demand, multiple benefits

The energy efficiency first (EE1st) principle is a key element of the recast Energy Efficiency Directive that emphasises the prioritisation of energy efficiency measures in all energy planning and investment decisions. However, regional authorities often face challenges in putting the EE1st principle into practice, integrating it into regional energy strategies and balancing it with other energy-related needs. To address these challenges, the REGIO1st project, co-funded by the LIFE programme, focuses on raising awareness of the EE1st principle among regional governments and their agencies, and providing them with the necessary tools and guidance to integrate this principle into their energy planning and decision-making processes.

A key feature of the project is the development of the REGIO1st Planning Framework. This framework is a comprehensive toolkit for integrating the EE1st principle into regional energy planning. It outlines a structured approach with different stages, each equipped with specific Excel and text-based tools. These tools facilitate data collection, stakeholder engagement, cost-benefit and multi-criteria analysis, ensuring a comprehensive planning process. The framework and its tools will be made available online in the first quarter of 2024, ensuring easy accessibility and usability. Currently, the REGIO1st Planning Framework is being applied in six European pilot regions. The pilots not only test the usefulness of the framework, but also adapt it to different regional contexts, demonstrating its versatility and effectiveness in practice.
This paper introduces the REGIO1st Planning Framework, exploring its purpose, methodological foundations, structure and the variety of practical tools it offers. It also discusses its current application in pilot regions, highlighting how it supports regional authorities in integrating the EE1st principle into their regional energy strategies.
Effect of energy prices on the energy requirement and wellbeing of households

Kees Vringer, PBL Netherlands Environmental Assessment Agency, The Netherlands
Astrid L. Martens, PBL, Environmental Assessment Agency, The Netherlands
Daan P. van Soest, Tilburg University, The Netherlands
Malik Çürük, Tilburg University, The Netherlands

Panel
3. Policy, finance and governance

Keywords
energy price, energy poverty, energy tax, consumer behaviour, behavioural change

Reducing residential energy consumption is a key component of any country’s strategy to meet the greenhouse gas emission reduction obligations as agreed upon in the Paris Agreement. Surprisingly little is known about the impact of energy taxes on the amount of gas and electricity consumed, and on the distributional effects thereof. The fallout of the Russian invasion in Ukraine in March 2022 caused in the early summer of 2022 a strong, unexpected increase in the residential prices of both gas and electricity in the Netherlands, with a peak in November 2022. The price rise was expected to be long lasting, which makes the households’ behavioral response likely to be predictive of their response to the introduction of a large energy tax.

Our research questions are (a) how affects a large, unexpected and presumably long-lasting increase in the energy price the residential energy consumption?, (b) How did households experience the price increase and in what way did they change their energy behavior? Answering these questions will help policy to find an optimal tax rate to obtain reduction in households’ CO2 emissions and also shed light on the distributional consequences of these taxes.

To answer these research questions we gathered two types of data. First, we obtained individual energy and contract data of about 40,000 households. We focus on the subset of households with energy contracts with fixed prices; changes in the market price of energy do not affect the prices paid by households until after their fixed-price contract expired. The remaining duration of the contract is quasi-random at the time of the price increase and the households with fixed prices throughout the sample period can serve as a control group for those with a renewed contract. We analyzed these data with a dif-in-dif analysis. Second, we gathered questionnaire data from about 1600 households on three different occasions between November 2022 and November 2023. Respondents were asked questions on their energy
behavior and changes therein, and about energy literacy and energy price perceptions.

We find that the price elasticity of natural gas demand is about -0.15 for changes about 70 percent while the short and medium-run demand elasticity strongly correlate with the size of price shock tending to a very low -6.2 percent for the largest price increases (320%) in our sample. Price elasticity was thus lower for very high price increases, suggesting a ceiling effect in behavior change. The reduction in natural gas demand appears to be persistent. Effects were similar for different income groups. Households anticipated higher gas prices by reducing their gas use even before their contracts ended and prices increased. In addition, longitudinal questionnaire data shows only small changes in self-reported behavior between November 2022 and November 2023, such as self-reported thermostat temperature settings. We did not find a change in energy literacy over time. The share of households that reported having great difficulty paying their energy bills gradually decreased during this period. In summary, the large price increases led to a persistent decrease in household energy demand.
Towards better energy-efficiency policy implementation and alleviation of energy poverty: Introducing the “ENPOR” tool to quantify implications of the split incentive barrier in the European Union’s private rented sector

Dimitris Papantonis, Technoeconomics of Energy Systems laboratory (TEESlab)- University of Piraeus Research Center (UPRC), Greece
Christos Tourkolias, Center for Renewable Energy Sources & Saving, Greece
Vlasios Oikonomou, Institute for European Energy and Climate Policy Stichtung (IEECP), The Netherlands
Vassilis Stavarakas, Technoeconomics of Energy Systems laboratory (TEESlab) - University of Piraeus Research Center (UPRC), Greece
Alexandros Flamos, Technoeconomics of Energy Systems laboratory (TEESlab) - University of Piraeus Research Center (UPRC), Greece

Panel
3. Policy, finance and governance

Keywords
energy policy, EU policy, energy poverty, domestic energy efficiency, energy efficiency policy, renters, landlords, split incentive

“Split incentives” refer to any situation in which the benefits of a transaction do not accrue to the actor that pays for the transaction. In the building sector, split incentives are typically linked with cost recovery issues related to energy-efficiency upgrade investments due to the failure of effectively distributing financial obligations and rewards between involved actors. Especially in the Private Rented Sector (PRS), which accommodates the 30% of the European Union (EU)’s housing, split incentives among landlords and tenants, or the “Landlord-Tenant” dilemma, is one of the main barriers when it comes to energy-efficiency policy implementation, and alleviation of energy poverty. This article aims to address this barrier by introducing the “Split Incentives Quantification Tool” (Q-SpliT), developed under the European Commission (EC)-funded Horizon 2020 “ENPOR” project.

The tool’s main objective is to identify the share of the triggered benefits among landlords and tenants due to the implementation of energy-efficiency policy programmes. To do so, the tool
focuses on quantifying energy savings and positive externalities triggered by energy-efficiency interventions to identify an “optimal” allocation of costs, or subsidy rates for each side, towards the better design, financing, and implementation of energy efficiency policies that could also support the alleviation of energy poverty towards a just and fair transition for all. To test and demonstrate its applicability, the tool is currently further developed and used in real cases across the EU, in the context of the EC-funded LIFE “RENOVERTY” project. Overall, our work suggests key implications, which, if acted upon, could support overcoming of existing barriers, provide useful insights to all key actors, and enhance the deployment of well-designed and well-targeted policies across the EU’s PRS.
Investments in energy efficiency measures in the residential sector in Central and Eastern Europe: the EE1st principle in practice!

Vlasios Oikonomou, IEECP – Institute for European Energy and Climate Policy, The Netherlands
Marco Peretto, IEECP, The Netherlands
Shima Ebrahimi, IEECP, The Netherlands
Christos Tourkolas, CRES, Greece

Panel
3. Policy, finance and governance

Keywords
Energy Efficiency first, heating, Energy Efficiency Directive (EED)

The Energy Efficiency First principle (EE1st) is a cornerstone in the EU policy and is aimed to steer the Member States’ energy investment decisions towards prioritization of energy efficiency. This study examines the implementation of the EE1st when comparing the financing of demand side energy investments (renovations of buildings, switching fossil fuel boilers to heat pumps, and promoting Nearly Zero Energy Buildings (NZEB)) to supply side in expanding fossil fuel infrastructure in Bulgaria, Croatia, Hungary, Poland, Romania, Slovakia, and Slovenia.

These alternatives are compared in an economic and a social cost-benefit basis encompassing multiple benefits of energy efficiency. From an economic perspective, the support in fossil fuel infrastructure has the lowest cost-benefit ratio in these countries, which signifies that gas investments for heating in buildings bring the lowest benefit to the national economy. In contrast, the zero-energy buildings seem as the most cost-efficient option. When incorporating the multiple benefits of energy efficiency in the debate and carrying out a social cost-benefit analysis, the energy efficiency upgrades together with all heating decarbonisation measures are positive in terms of cost-benefit ratio, and the most efficient one is the zero-energy buildings.

The substitution of fossil-fuel boilers with more efficient ones and the general support in fossil fuel infrastructures performs also negatively from a social cost benefit analysis in all countries. In brief, the most socially and economically profitable solutions are the renovation of the building stock while concurrently promoting the installation of both heat pumps and photovoltaics. Subsidizing buildings renovation is in all cases is considered more economically viable than public spending on fossil fuel networks. Based on the EE1st decision criterion of
the economic and socio-economic performance, public spending should not be targeted at fossil fuel boilers further but rather shift towards energy efficiency upgrades and zero-energy buildings in most countries.
Multi-level governance: Involving subnational authorities and other stakeholders in national energy and climate policy making

Giulia Pizzini, IEECP, The Netherlands
Marine Perrio, IEECP, France
Thibaut Maraquin, Energy Cities, France
Jérémy Clero, IEECP, Belgium

Panel
3. Policy, finance and governance

Keywords
Multi-level governance, governance, European Commission, local and regional energy planning, local authorities, local administrations, National Energy and Climate Action Plans

The EU climate law and the Governance of the Energy Union and Climate Action Regulation (1999/2018) operationalises for the first time in European legislation the concept of Multi-level Governance. The notion made its debut in scientific literature in the 90s as a useful concept to understand some of the decision-making dynamics within the European Union. In one of its White Papers in 2009, the Committee of the Regions first used the concept to describe coordinated action between different governance levels and other stakeholders. However, it is only in 2018, with Article 11 of the Governance Regulation, that the European Commission required for the first time Member States to implement that concept into national policy making.

Yet, succeeding in setting up and implementing such process requires a complete change of mindset for most European Member States, more used to top-down approaches and to integrating stakeholders’ feedback via one off consultations, carried out when an advanced draft of the measure or policy at stake is ready for adoption. As outlined in the recent State of the Energy Union report, issued in October 2023, the European Commission is not yet satisfied with how Member States are embedding the concept of Multi-Level Governance. Member States in particular are evidently struggling to transition from consultations to a more comprehensive, inclusive and permanent exchange with relevant stakeholders, including sub-national authorities.

This paper describes the work done in six Member States in the framework of the NECPlatform project, which aims at supporting them in setting up Climate and Energy Dialogues to comply with Article 11 of the Governance Regulation. The abstract will describe the results of the research work done to assess the enabling and blocking factors for setting up such dialogues, outline the work done so far and the progress still necessary to achieve such results.
Climbing a new hill: a review of Member States’ strategies to meet their energy savings obligation for 2021–2030

Jean-Sébastien Broc, IEECP - Institute for a European Energy & Climate Policy, The Netherlands
Oikonomou Vlasios, IEECP, Greece
Samuel Thomas, RAP, France
Barbara Schlomann, Fraunhofer ISI, Germany
Danai Sofia Exintaveloni, University of Piraeus, Greece
Clemens Rohde, Fraunhofer ISI, Germany
Dario Di Santo, FIRE, Italy

Panel
3. Policy, finance and governance

Keywords
Energy Efficiency Directive (EED), energy savings obligation, fit-for-55 package, energy efficiency policy

The EU and 21 out of 27 Member States achieved their headline 2020 target for energy efficiency in terms of maximum final energy consumption (not to exceed). This was partly due to COVID19. The picture is even more mixed when looking at Member States’ energy savings obligation: 14 Member States met their target of cumulative energy savings over 2014-2020, whereas ten Member States failed, and final data were missing for the three remaining ones (based on Commission’s report).

The Fit-for-55 package brought more ambition for the 2030 targets, including for the energy savings obligation, now Article 8 of the Energy Efficiency Directive (EU) 2023/1791 (EED). New provisions also require Member States to achieve a share of their energy savings among priority groups (energy poverty ringfence), while energy savings from installing or purchasing fossil fuel technologies will progressively be excluded, in line with the EU Green Deal’s objectives of a Just Transition and climate neutrality.

This paper reviews the latest data about the previous obligation period (2014-2020) and the current one (2021–2030). Member States are in very diverse situations as regards both their achievements of the 2014–2020 target and their results in 2021, the first year of the new period. When comparing performance averaged over 2018–2020 and 2021, all types of trends can be found, with some countries previously missing their target now achieving more savings,
while some countries previously overachieving their target for 2014–2020 are now far from being on track in 2021. It shows that there is little predictability when looking at overall trends only.

This paper summarizes the main changes brought by the EED recast, highlighting the impacts they may have on Member States’ strategies and capacities to meet their revised obligations. All Member States except Cyprus need to increase their rate of new annual savings, some very significantly. Most of them will need to clarify which measures will deliver energy savings among priority groups. Implementing the EED recast should push Member States to act fast and big, in line with the Global Pledge on Renewables and Energy Efficiency signed at COP28. Based on the large differences in strategies and achievements of Member States so far, the paper ends with a discussion of the importance of experience sharing to support Member States to fill their savings gap.
White certificates, superbonus, and the new auction scheme

Dario Di Santo, FIRE, Italy
Cesare Negro, FIRE, Italy
Jacopo Romiti, FIRE, Italy
Livio De Chicchis, ENEA, Italy
Daniele Forni, FIRE, Italy

Panel
3. Policy, finance and governance

Keywords
energy efficiency policy, tradable white certificates, white certificates, tax relief

The Italian mix to achieve the targets on energy savings set by the energy efficiency directive includes many policies. Among them, the two that have played the main role over the last decades have been the white certificate scheme (WhC) and tax reliefs (including superbonus and ecobonus). This paper aims at illustrating how such policies have worked, what results they have achieved, what issues have been met over the years, and how everything reflects in the Italian National Energy and Climate Plan (NECP).

The Italian WhC has been in place since 2005 and has achieved 29 Mtoe of energy savings since its launch. The scheme is a tradable one, with an important role for ESCOs, that has involved in recent years mainly industry, even if it is open to all the sectors. Among its main characteristics there is the fact that all energy savings, since 2017, are effectively measured according to an approach in line with International Performance Measurement and Verification Protocol (IPMVP) option B.

Ecobonus has been in place since 2007 and has achieved 26 Mtoe of energy savings by 2020. It is a tax relief scheme, covering from 50 % to 85 % of the capital expenditures recoverable on tax payments over 10 years and limited to energy efficiency measures for buildings. The relief quota depends on the type of intervention (it is higher for condominiums if associated to anti-seismic measures). The energy savings are estimated on the basis of the information provided in the applications. In 2021 a new fiscal measure was launched, the superbonus, that is a tax relief recoverable in 5 years with a relief quota equal to 110 % in the first phase (currently is 70 %). The measures created a massive demand of building renovation and the cumulated cost is about 100 billion euros.

The paper will finally offer a view on the possibility to link tax reliefs with tax credit transfer as an option to involve also citizens in energy poverty conditions.
Putting the ETS 2 and Social Climate Fund to Work: analyses and approaches for the EU-27, Poland and Romania

Veit Bürger, Öko-Institut, Institute for Applied EcologyÖko-Institut, Germany
Nelly Unger, Öko-Institut, Institute for Applied Ecology, Germany
Johanna Cludius, Öko-Institut, Institute for Applied EcologyÖko-Institut, Germany
Alexander Eden, Adelphi, Germany
Iryna Holovko, Adelphi, Germany

Panel
3. Policy, finance and governance

Keywords
EU Emission Trading Scheme (EU ETS), Social Climate Fund, indicators, energy poverty, Central and Eastern Europe (CEE)

Starting from 2027, The ETS 2 is set to cover emissions from fossil fuels used in buildings and road transport. These two sectors together are responsible for 32% of the EU’s total GHG emissions, which have so far proven difficult and slow to abate. In this study, we explore the likely impact of the ETS 2 and vulnerability patterns using Eurostat household microdata for the EU 27 and national data for Poland and Romania to provide a deep dive analysis for these two Member States, likely being particularly impacted. We find that, on its own, the ETS 2 carbon price will likely be regressive – it will disproportionately burden lower-income households who spend a larger share of their income on fossil fuels. This also holds for lower-income Member States.

We go on to examine patterns of vulnerability across the EU 27, as well as in Poland and Romania to show that energy poverty and – to some extent – transport poverty levels are generally higher in lower-income Member States, but with important variations, depending on the specific country and the indicator chosen to measure energy and transport poverty. We explore these country-specific factors in the context of Poland and Romania, noting the importance of using wood as a heating fuel in Romania and coal-fired boilers in Poland.

We note that impacts are highly country-specific, which is why response strategies should be tailored. This can happen through the funding of the Social Climate Fund. For the Social Climate Fund to be a success, it must be well implemented. In a final step, we therefore present results from focus groups and workshops in Poland and Romania that highlight the
opportunities and challenges that policy makers and stakeholders perceive in relation to
drawing up their Social Climate Plans, in particular related to (i) identifying the vulnerable, (ii)
designing a set of policy measures and (iii) engaging stakeholders.
From scenarios to action – developing Science Based Investment Guidelines

Ali Aydemir, Fraunhofer Institute for Systems and Innovation Research, Germany
Clemens Rohde, Fraunhofer Institute for Systems and Innovation Research, Germany
Maike Wilhelm, Fraunhofer Institute for Systems and Innovation Research
Markus Fritz, Fraunhofer Institute for Systems and Innovation Research
Stefanie Engstfeld, Kreditanstalt für Wiederaufbau (KfW)
Sandra Lutz, Kreditanstalt für Wiederaufbau (KfW)

Panel
3. Policy, finance and governance

Keywords
energy efficiency financing, long-term scenarios

In recent years, financial institutions and their role in the transition towards global emission reduction targets have gained attention in the climate change debate. Initiatives like the energy efficiency finance institutions group (EEFIG) have highlighted the importance of financial institutions. The concrete operationalisation of this topic is however a major challenge. In our paper we will present the approach chosen by the German Development Bank (KfW), which was assisted by the authors in crafting a comprehensive and compatible strategy aligning with the Paris Agreement for KfW as part of its transition process.

Based primarily on IEA’s Net Zero Emissions by 2050 scenario, financing guidelines for various sectors have been developed, which regulate new financing by the bank. These guidelines mainly use technical criteria for the individual financing to ensure that they are in line with a 1.5°C compatible transition pathway. As the guidelines consider the lifetime of the assets and not only the financing lifetime, the requirements in the sectors are ambitious and require the bank not to finance certain technologies at all. In our contribution, we present the underlying system of the KfW guidelines and provide an overview of currently implemented guidelines. Finally, we discuss the approach chosen in context to possible other approaches.

KfW’s experience in implementing financing guidelines with a more focused technological approach demonstrates how guidelines can be developed to align with Paris Agreement objectives in the future. The approach differs from other efforts that typically take the form of either standardized frameworks or monitoring activities.
Translating national net zero policy into local implementation: a UK case study

Colin Nolden, University of Bristol Law School, United Kingdom
Jacob Barnes, Energy group, Environmental Change Institute, University of Oxford, United Kingdom
Morag McDermont, University of Bristol Law S, United Kingdom

Panel
3. Policy, finance and governance

Keywords
net zero, local authorities, climate action plan, climate policy, policy translation

In the UK, the decarbonisation of subnational administrative levels such as cities and local authorities more generally can be mainly attributed to national efforts to improve energy efficiency and decarbonise the electricity system. This suggests that place-based transitions to net zero (NZ) are determined largely by the translation of national strategy into local delivery, resourcing, and capabilities combined with the effective balance of power and decision-making capabilities between administrative levels. In this paper we critically interrogate this translation process by comparing and evaluating Climate Action Plans (CAPs) across two English city regions – West of England and West Yorkshire Combined Authorities – which comprise a total of 12 local authorities within. Unlike jurisdictions where local authorities are required to develop energy and climate strategies aligned with national NZ targets, such as The Netherlands, England does not.

Overall, our results reveal a misalignment of ambitions, motivations, and resourcing with local and regional NZ delivery being undertaken within a fragmented policy landscape. While UK climate law and resulting strategy collectively determine how supportive environments are for local NZ delivery, a myriad of subnational, regional and local tiers of government with widely diverging responsibilities over people, assets and land have developed their own CAPs with widely diverging NZ targets and ambitions.

We find local NZ governance is further hindered by the competitive allocation of funding which favour short-termism over long-term planning horizons necessary to structurally lower energy demand. These findings challenge a top-down framing of NZ policy translation and highlight its detrimental impacts on local decarbonisation efforts and energy efficiency in particular. We conclude with policy recommendations to culture effective and just multi-level governance for NZ delivery.
EU-27 country mapping of financing schemes to decarbonize buildings, heating and cooling

Giulia Conforto, e-think energy research, Austria
Marcus Hummel, e-think energy research, Austria

Panel
3. Policy, finance and governance

Keywords
financing, funding, grants, subsidies, financial incentives, energy efficiency investments, heating, cooling, renovation, thermal insulation, decarbonisation

Despite a significant decrease in greenhouse gas emissions from buildings (31% in the EU between 2005 and 2021), the decarbonization of the sector is still too slow and the current trajectory is not on track to meet the 2030 and 2050 targets. Access to finance is still mentioned as one of the main barriers to building retrofit, despite a substantial offer of financing options proliferated in recent years, varying across countries in the number of programmes, scope and type of support offered. To shed some clarity, this study aims to answer the research questions: “What financing options are currently available for energy efficiency in buildings, in Europe?” and “Can we identify any factors driving financing in this sector?”.

We carried out an EU-27 comprehensive and detailed mapping of funding supporting energy efficiency and renewable energy in buildings. Almost 600 private and public schemes were collected at the European and national levels, including some local ones. Focus sectors included building efficiency, efficiency and renewable sources in heating and cooling, and district heating and cooling, with additional focus on cooling alone and geothermal for district networks. As many programmes do not disclose their budget, a bottom-up sum of the budgets revealed, resulted in incomplete and inconsistent data. Thus, we used data from an external source on public expenditure in energy and energy efficiency in buildings and industry at the country level. The dataset was then assessed for correlations against selected social, energy, economic, and financial indicators.

The first finding is that traditional instruments dominate the offer, with grants, green loans, green mortgages, and tax rebates prevailing. These are not necessarily the most effective, but the easiest to set up and administer. A correlation can be identified between the size of public expenditure for energy efficiency in buildings and industry, the number of financing schemes, the population, and the total final energy consumption in buildings. Climate, and thus heating and cooling needs, do not seem to affect either public expenditure or the number of schemes dedicated to reducing energy demand and emissions in buildings while increasing winter and...
summer comfort. In particular, while heating is considered a need, cooling seems to be still considered a “nice to have” treat. A closer look at a few outliers suggests that country-specific dynamics play a significant role in shaping the offer of public and private financing for building decarbonization.

This mapping fills an important gap in the literature: as no similar work could be found to date, it can be considered the first EU-27 comprehensive and detailed database on financing options for building decarbonization. The study showed also that information on these schemes is fragmented, dispersed, hard to find, and suffering from fast obsolescence, which creates another barrier to finance in terms of access to information. Thus, to raise awareness among beneficiaries about their financing options and facilitate their access to them, targeted extracts of this mapping will be made available in the Support Facility of the Project Act!onHeat, CoolLIFE and SAPHEA Tools and Knowledge Hubs.
From draft to final NECP updates: Setting criteria to assess Member States' plans to implement the 2023 Energy Efficiency Directive

Arianna Vitali Roscini, Coalition for Energy Savings, Belgium
Antonin Chapelot, Coalition For Energy Savings, Belgium

Panel
3. Policy, finance and governance

Keywords
Energy Efficiency Directive (EED), governance

With the entry into force of the revised Energy Efficiency Directive (EED), Member States must plan and implement additional energy savings policies and measures to reach the higher 2030 EU energy efficiency target.

The starting point for better planning is the update of the National Energy and Climate Plans (NECPs) that EU countries have to submit to the European Commission (Commission) by 30 June 2024, as required by the Governance Regulation. These updates must build on and improve the draft NECP updates that were due in June 2023, also by taking into account the Commission’s country-specific recommendations.

Following a detailed review and analysis of key energy efficiency elements within the draft NECP updates, the paper will identify common trends and lessons learned resulting from our assessment of the draft plans. It will also provide a set of criteria to read and evaluate the final plans that can be used by interested actors. The criteria include, among others, whether the plan shows a true commitment to the declared objective, planned policy and measures are enough to achieve the national energy efficiency contributions, the measures and the calculation of the expected energy savings are reliable and well explained, and there is enough evidence of the use of the Energy Efficiency First principle as an overarching principle to draft the plan.

The paper will focus on checking selected new provisions of the 2023 EED in the final NECP updates, particularly Article 3 (energy efficiency first principle), Article 4 (Energy efficiency targets), Article 5 (public sector leading on energy efficiency), Article 6 (exemplary role of public bodies’ buildings) and Article 8 (Energy Savings Obligation).

In conclusion, the paper aims to support policymakers and stakeholders in their assessment of the efficiency dimension of the final NECP updates, as their quality is the first step towards ensuring that the new EED can successfully be implemented on the ground.
Theorising and developing political feasibility for energy demand reduction

Marie Claire Brisbois, University of Sussex, United Kingdom
Marie Claire Brisbois, University of Sussex, United Kingdom
Janine Morley, Lancaster University, United Kingdom

Panel
3. Policy, finance and governance

Keywords
political feasibility, energy efficiency policy, incentives, public policy

Policy pathways that prioritise absolute energy demand reductions are the only pathways currently available that meet 1.5 °C targets without relying on negative emissions technologies. In the energy sector, readily available technologies and programs consistent with demand reduction pathways (e.g. retrofits, public and active transportation, consumer goods standards and repair) are proven, readily available, and often have high levels of social support because they produce significant social and environmental co-benefits. Yet these solutions often seem politically infeasible at scale in many countries, or they remain a much lower priority than supply-side policies. The political (in)feasibility of systematic energy demand reduction remains one of the main impediments for progress toward 1.5 °C targets.

Despite its key role, political feasibility remains poorly theorised, especially for energy demand reduction. This paper unpacks the question of the political feasibility of energy demand reduction by reviewing existing perspectives on political feasibility and highlighting strengths and gaps. We develop an understanding of political feasibility specifically for energy demand reduction, develop an approach of analysing the concept, and then unpack three interacting drivers that we feel offer strong explanatory value for understanding the political feasibility of demand reduction: economic incentive structures and temporal and material infrastructures.
Lighting and appliances for lives and livelihoods; a foundation for strategic energy efficiency policies in East and Southern Africa

Karin Reiss-Haimbala, UNIDO, Austria
Theresa Grader, UNIDO, Austria
Monica Gullberg, Swedish International Development Cooperation Agency, Sweden
Readlay Makaliki, SADC Centre for Renewable Energy and Energy Efficiency, Namibia

Panel
3. Policy, finance and governance

Keywords
energy efficient products, energy poverty, gender, business models, product quality, sustainable development, energy efficiency policy

Markets in East and Southern Africa are inundated with low-quality and inefficient on- and off-grid energy appliances. Furthermore, energy security is also an issue as most countries are faced with electricity generation deficits resulting in load shedding to match electricity supply and demand daily. Well-implemented energy efficiency measures are inexpensive ways to mitigate the deficit energy supply and improve energy security.

The Sida-funded program on Energy Efficient Lighting and Appliances in East and Southern Africa (EELA), implemented by UNIDO and partner organisations in East and Southern Africa, addresses challenges through a local-driven, regional harmonized approach aiming to achieve a market transformation towards EELA. Besides promoting the uptake of high-quality and efficient lighting, air-conditioners and household appliances, the focus also lies on devices designed for income-generating activities to improve livelihoods in the communities in the East African Community (EAC) and Southern African Development Community (SADC) regions.

Achieved project milestones include enhanced policy dialogue and messaging, enhanced market governance capacities, the adoption of harmonized Minimum Energy Performance Standards (MEPS) for lighting and cooling appliances with attendant energy efficiency (EE) labels, development of EE Tool-kits such as the regional compliance frameworks, energy efficiency public procurement guidelines, electronic waste management guidelines as well as strengthened regional reference laboratories for appliance testing and pilots for private sector EE market development.
Enhancing EU energy efficiency policy through Heat Pumps on Subscription (HPoS): a strategy for mobilizing private finance and optimizing public support

Filippos Anagnostopoulos, IEECP - Institute for European Energy and Climate Policy, The Netherlands
Sotiris Papadelis, HEBES Intelligence, Greece

Panel
3. Policy, finance and governance

Keywords
heat pumps, business models, policy implementation, subsidies, governmental support, energy efficiency financing, financing, ESCO market development

This work explores the Heat Pumps on Subscription (HPoS) business model, an innovative approach where energy service companies are subsidised for installing and operating heat pumps, with tenants paying a connection fee and a monthly subscription. Our study analyzes the potential of HPoS as a tool for enhancing the effectiveness of public subsidy schemes in promoting heat pump adoption within the European Union.

By examining the interplay between public funding programs for energy efficiency and commercial initiatives, we argue that a coordinated approach can significantly boost demand for heat pumps. The paper thus discusses Pay-for-Heat-Pumps (P4HP) schemes, proposing that they can complement existing legislative and financial incentives by fostering market transformation and functioning beyond subsidy support – a primary goal of public funding programs intended to also stimulate economic activity.

The P4HP concept, we argue, can improve the long-term impact of subsidies by fostering market evolution and enhancing service provider capabilities. The paper examines Denmark’s implementation of Heat as a Service models supported by public funding, emphasizing the importance of embedded quality incentives for service providers to ensure technical, administrative, and financial competence.

We also delve into the role of private financing in large-scale heat pump deployment, identifying three critical conditions for attracting investment: significant scale, measurable and billable output. These conditions are fulfilled by aggregating heat pump installation projects
under the HPoS model. This approach aims to provide actionable insights for policymakers and stakeholders, facilitating the transition towards market based solutions across the EU.
Accelerating NetZero: Introducing a novel financial approach and new narratives for retrofit

Marina Topouzi, ECI – Environmental Change Institute, University of Oxford, United Kingdom
Peter Mallaburn, Energy Institute, University College London, United Kingdom
Yekatherina Bobrova, Environmental Change Institute, University of Oxford, United Kingdom

Panel
3. Policy, finance and governance

Keywords
building refurbishment, energy efficiency policy, financial incentives, multiple benefits

Retrofitting owner-occupied housing in the UK and across Europe remains an enormous challenge in meeting net zero targets. Successful energy retrofit policies require the alignment of diverse stakeholder interests, supply chain skills and capacity and energy performance standards. However, current policies often lack explicit strategies for aligning and capturing the value of successful retrofit for stakeholders, resulting in limited effectiveness of recent financial retrofit schemes.

Previous work by the authors identified this aspect in the retrofit policy environment as an urgent call for a fundamental change in the way schemes are designed and rolled out. In this paper, we present the findings from the feasibility stage of a Retrofit Salary Finance (RSF) scheme, a novel fiscal policy approach that leverages the post-Covid trend of hybrid working to promote retrofit home improvements in owner-occupied houses. The insights were collected through engagement activities (i.e. surveys, workshops, and one-on-one conversations) with key representatives from central and local government, the construction sector, lenders, employers and homeowners.

The findings were analysed through the lens of cognitive framing and systems thinking with casual loop relationships. This looked at the scheme’s value and barriers for different stakeholder groups to construct narratives that effectively promote retrofit by resonating with their diverse cognitive frames. The findings emphasise the importance of focusing on shared value and implementing management practices using existing mechanisms. The novelty of the scheme is perceived as an opportunity not only to address immediate retrofitting needs but also to contribute and catalyse broader environmental and socio-economic objectives, aligning with both local and national strategies. The paper contributes to policy design and implementation, allowing the adaptation of the Retrofit Salary Finance scheme to different contexts or countries.
Has the energy crisis polarized citizens views on energy efficiency policy? – An analysis on the German discourse on X/Twitter

Carmen Loschke, Öko-Institut, Germany
Sibylle Braungardt, Oeko-Institute, Germany

Panel
3. Policy, finance and governance

Keywords
energy savings, energy efficiency policy, sentiment analysis, policy measures

The energy crisis following the Russian invasion of Ukraine has prompted an acceleration of policy efforts to encourage energy savings. Numerous policy interventions were proposed and implemented as a reaction to the energy crisis in the countries affected by the interrupted supply of Russian gas. With public acceptance being a key success factor for the implementation of policies addressing energy savings, our paper analyses the discourse on energy conservation policies during the crisis in Germany, using X data (formerly Twitter).

The analysis aims to quantify whether the energy crisis has polarized the discourse on energy efficiency policy. The results of the quantitative analysis are to be backed up by a qualitative manual analysis of a sample of tweets, which could also provide insights into the users' argumentation. By analysing a set of 136,837 Tweets related to energy and gas saving posted between January 2022 and May 2023, we show a heightened public focus on energy efficiency policy during the crisis and elicit the stance in the reactions to statements of policy makers and to proposed and implemented policy interventions.

Our findings show the dynamics of both the positive as well as the negative discourse and indicate that the crisis has contributed to a polarization of attitudes towards policies addressing energy savings. The enhanced understanding of citizens attitudes towards policy measures in times of crisis can inform future policies aiming to encourage energy savings.
Towards gender-responsive EU energy legislative acts for the buildings sector transformation by a structured Gender Impact Assessment

Stefan Kronshage, German Aerospace Center (DLR), Institute of Networked Energy Systems, Germany
Meike Spitzner, Wuppertal Institut fuer Klima, Umwelt, Energie gGmbH, Germany
Stefan Thomas, Wuppertal Institut fuer Klima, Umwelt, Energie gGmbH, Germany

Panel
3. Policy, finance and governance

Keywords

In the EU directives EPBD and EED, the gender dimension is neither directly addressed, nor seem these key legislative acts have yet been assessed regarding their gender implications and potential gender-transformative power (Clarke, Sahin-Dikmen 2021). This is astonishing as the EU Gender Mainstreaming obligations are legally binding on EU and member state level (Treaty of Amsterdam of 1997, Treaty of Lisbon in 2008 Art. 8). Gender Mainstreaming requires every sectoral policy to actively deliver gender equality contributions and to align sectoral policy measures in a gender-responsive manner.

With the Gender Impact Assessment (GIA) presented by the German Environmental Agency in 2020, Spitzner et al. have introduced a structured method to comprehensively assess the impacts and transformative opportunities of initiatives with far-reaching influence. This GIA framework has particularly been tailored for climate policy contexts.

In our research, we apply key elements of the GIA framework to the EPBD, by linking energy systems analysis, infrastructure systems gender research and European energy policy research, all especially informed of buildings and climate policies. From a rough GIA pre-examination of the EPBD we show that it is necessary and whether it is possible a) to anchor the gender equality requirement in the EPBD by identifying entry points for a gender-responsive alignment and implementation of the directive, for example, in the Energy Performance Certificates on instrumental level or for extending the cost optimality requirements towards the inclusion of multiple impacts, and b) to formulate gender equality effectiveness as
an explicit goal - analogous to what has been done for reduction of energy poverty.

This way, the EPBD as one of the key EU energy legislative acts will firstly be linked to the legal EU gender mainstreaming obligation in a structured way. Doing so, concrete approaches will be presented from the GIA for a more gender-responsive EPBD and thus more effective and transformative policy instrument.
From conflicting agendas to cooperative sustainable urban development: the triple integration of sustainability in vertical, horizontal and sectoral structures

Anja Bierwirth, Wuppertal Institute for Climate, Environment and Energy, Germany
Fiona Bunge, Wuppertal Institute for Climate, Environment and Energy, Germany
Steven März, Wuppertal Institute for Climate, Environment and Energy, Germany

Panel
3. Policy, finance and governance

Keywords
sustainability, urban planning, climate policy, local administrations

Time is pressing with regard to climate protection targets and adapting to the consequences of climate change. In addition, there is a lack of affordable housing and social infrastructure in many of Germany's larger cities, while at the same time there is a great need to renovate buildings and infrastructure in many places. In cities, these complex challenges overlap and put pressure on administrations and politics. At the same time, the regular processes in urban planning and development are lengthy and often conflicting. Achieving objectives — from energy efficiency and climate protection, land and environmental protection to social goals — hardly seems realistic.

In different projects, the Wuppertal Institute for Climate, Environment and Energy has dealt with integration challenges of multi-level policy, structures and processes in municipal administrations, and issues related to an accelerated implementation of climate action. We now analysed obstacles in building and planning law that stand in the way of achieving a climate-neutral building stock, supported the urban planning and the environmental department in the City of Wiesbaden to develop and test the application of “rules of sustainable urban development” including new, co-operative working structures in the administration and developed a conceptual model to support sustainable urban development through stringent policy design in a multi-level system, a co-operative approach at municipal level and a thematic integration of different sustainability dimensions through a "triple integration".
The paper describes the challenges municipalities are facing with regard to achieving sustainable development in general and climate-neutrality in particular. It explains the methodological approach and the concept of a "triple integration" model. From this, recommendations are derived for an integrated and stringent approach to foster implementation at the municipal level.
Building fabric improvement and heat pump deployment: a set of policy conundrums

Gavin Killip, Nottingham Trent University, United Kingdom
Tina Fawcett, University of Oxford, United Kingdom
Marina Topouzi, University of Oxford, United Kingdom

Panel
3. Policy, finance and governance

Keywords
domestic policies and measures, heat pump, retrofit, minimum energy performance standards (MEPS), energy policy

Minimum building energy efficiency standards and retrofit targets for fabric improvement have long been a cornerstone of effective policy for energy demand. However, there is increasing policy focus on residential heating (and cooling) being provided from renewable electricity via heat pumps. Do fabric standards matter anymore and, if so, why?

This paper looks at the trade-offs and policy complexity facing countries which are currently largely dependent on fossil fuel boilers for heating. What should the balance be between mandating building fabric improvement and heat pump deployment, what are the choice criteria, and who gets a say?

The paper examines building interventions through the concept of 'trigger points.' It evaluates a segmented market approach and proposes a policy framework that emphasises 'understanding first' as a strategy to facilitate informed decision-making, rather than imposing specific measures. For example, the mandate to replace all fossil-fired heating systems presents a new opportunity for policy intervention: transitioning to a new heating system can act as a trigger for at least minimal fabric improvements. The paper explores various tests associated with the 'understanding first' approach, discussing how to strike a balance between simplicity and complexity in policy. It also delves into practical considerations for implementing the 'understanding first' approach, including affordability, energy security, and fostering a just energy transition.

Understanding is identified as a necessary, but not sufficient, aspect of policy for the decarbonisation of heating. The paper concludes that while a deeper understanding is crucial, it must also translate into new narratives for different actors to enable tangible, measurable changes in the built environment. There is no one right answer – and policy needs the flexibility to recognise this. Setting minimum quality standards for deployment, and a policy framework which allows for local decision-making within nationally (and internationally) determined targets
is likely to be part of the answer. This paper sets out the challenge for policy in devolution and coordination, providing a set of unresolved conundrums that future policy needs to meet. The discussion presented aims to enrich and provoke further debate, rather than offering conclusive solutions to complex problems.
Local government perspectives on development of energy plans across scales

Sheridan Few, University of Leeds, United Kingdom
Richard A. Oduro, University of Leeds, United Kingdom
Peter G. Taylor, University of Leeds, United Kingdom

Panel
3. Policy, finance and governance

Keywords
energy localization, local and regional energy planning, decision-making process, strategic decision-making, networks, energy supply and demand

As action on climate change moves from a strategic to an implementation stage, the role of place, local government, and interactions across geographical scales becomes increasingly important. In the UK, a process referred to as local area energy planning (LAEP) is gaining traction as a primary vehicle for energy plans at a local level. However, relatively few local authorities have developed plans at this stage, and routes to delivering these plans are not yet clear.

It is timely to collect early evidence on the value and challenges associated with this process before wider rollout. This work presents outcomes of a series of interviews with local authorities from across the Yorkshire and Humber region of the UK who have produced, or are producing, LAEPs. It explores their perspectives and experiences around the role of diverse parties (community groups, consultancies, network operators) in developing and adapting these plans, and the role of models in supporting or constraining these processes. It explores the benefits and disbenefits associated with consistency of approach across regions, and challenges and opportunities associated with the different geographical scale of different energy solutions. It explores justice perspectives around the inclusion or exclusion of vulnerable energy users in development of plans, and how benefits to these groups can be maximised whilst avoiding disbenefits. Finally, it explores theories of change, and routes to delivery of local energy plans.

Based upon these emerging themes, this work makes comparisons with approaches to local energy planning in other regions of the UK, and makes recommendations for how these could be developed in the future. The work focuses particularly on the evolving role of networks in future energy plans, and how these relate to current and evolving energy demand and supply.
Embracing the famous African proverb “if you want to go fast, go alone; if you want to go far, go together”, a group of governments decided to work together on lighting policy, recognising that their combined, collective efforts would achieve better outcomes than if they addressed the same issues on their own. The IEA 4E Solid State Lighting Annex (SSL Annex) was founded on the principle of intergovernmental collaboration on lighting. Over the last 14 years, the SSL Annex has demonstrated its value through its effectiveness and impact in the lighting market. Now embarking on a new five-year term, the governments wish to continue developing this working relationship and sharing of information, data and research.

Founded in 2010 under the framework of the International Energy Agency’s Energy Efficient End-use Equipment (4E) Technology Collaboration Programme (at the time “Implementing Agreement”), the SSL Annex works to advise member countries seeking to promote energy efficient lighting and to implement quality assurance programmes for solid state lighting (SSL). This framework brought governments together to share research, collaborate and work together to accelerate global adoption of SSL through work in four critical areas: (1) SSL testing, metrics and standards: supporting the lighting metrology community and improving the comparability and accuracy of LED product testing; (2) Smart lighting, digitalisation and connectivity: working to minimise standby power losses and optimise energy savings through smart lighting systems including wireless communication and intelligent controls; (3) Public health, productivity and environmental impacts: help governments and the public understand and track the latest science and research on how LED lighting impacts human health and the environment; and (4) SSL product quality and performance: publishing and promoting thoroughly researched quality and performance requirements which help to facilitate harmonisation on key quality and performance metrics globally. In this paper, an overview of this work is provided, followed by three in-depth examples of how this intergovernmental cooperation was absolutely pivotal to the positive outcomes realised in the lighting market.
An important feature of the SSL Annex is the flexibility to conduct projects and publish deliverables that are responsive to emerging needs and are outside the scope of the original workplan. The fact that there is an institutionalised structure for cooperation between countries on lighting establishes foundation of trust, and lowers the barrier for quickly cooperating on unanticipated research and regulatory issues that could arise.

This paper also looks at how the SSL Annex in particular, and IEA Technology Collaboration Programmes in general, serve as a structure that complements and supports international standardisation and regulatory efforts.

The 14 years of cooperation between the member governments, in combination with the published work, market impacts and achievements of the SSL Annex, culminated it receiving the coveted Award for Outstanding Achievement in Solid State Lighting in November 2023 from the International Solid State Lighting Alliance.
Thirty years of European Energy Services Companies and Energy Performance Contracting: what we have achieved and what is the current Status?

Paolo Bertoldi, European Commission, Joint Research Centre (JRC) Ispra, Italy
Sergi Moles Grueso
Benigna Boza-Kiss

Panel
3. Policy, finance and governance

Keywords
energy services, ESCOs, energy efficiency financing, Energy Efficiency Directive (EED), ESCO market development

In order to reach climate neutrality by 2050, recent EU policy developments aim to mobilise public and private finance for the energy system transition. Energy service companies (ESCOs) are private-sector market players that have a potential to contribute to energy saving goals and channel private finance into energy efficiency projects. In particular ESCOs through the implementation of Energy Performance Contracting (EnPC) are a solution to address investment gaps hindering the energy efficiency, building performance, and decarbonization goals. EnPCs not only mobilize private sector resources but also offer energy-saving guarantees, mitigating financial risks for both clients and providers.

Although ESCOs have been present in Europe since the 1970s there were not recognised as a key player in the implementation of energy efficiency. Only with the 1992 SAVE Directive their role was recognised in EU energy efficiency policies. Since then, there has been an overall increasing support from the EU and Member States first, with the Energy Saving Directive in 2006 and then with the Energy Efficiency Directive in 2012.

The European Commission JRC has carried out market research assessing the ESCO market size, the type, size, projects and the barriers preventing ESCO to fully exploit the economic energy savings potential. Drawing on data from national expert and stakeholder surveys in 2005, 2012, 2017, 2000 and 2022, the article presents the most complete information and assessment about the last thirty years of ESCO market developments, with focus on the period 2005 to 2022. The authors have identified four types of ESCO national developments. In the “successful”
markets, a strong and typically large ESCO market was present throughout most of the last 17 years. These markets include DE, UK, AT, FR and to a lesser extent IT and ES. In the “adventurous” markets, the role and strength of the ESCO/EnPC market was fluctuating over time, depending on the changing policy environment, which affected the overall market development (CZ, BE, SI, DK, SE, SK, HU, PL). The “small” markets, which have some ESCOs for specific projects, but has not been seen a significant roll-out (BG, RO, PT, IE, FI, NL, LV, HR). Finally, the “no-go” markets, have intended to kick-start the ESCO markets, but not yet succeeded after repeated trials (EL, LU, EE, LT, CY, MT).

The author assessed the conditions (e.g. policies, financing, trust, facilitators, etc.) that facilitated or hindered the markets and therefore determined the characteristics of ESCO national markets. While ESCOs’ activities initially focused on short payback projects in buildings and public lighting, more recently the policy focus is on ESCOs contributing to societal benefits of energy and carbon savings, increasing deeper renovation of buildings and renewable energy.

One special focus of the JRC reports has been EnPC projects in the public sector, which initially focused on buildings light renovation and public lighting, but recently showing a growing trend towards deeper renovations, integrating renewables, storage and flexibility and district heating. Projects have also been implemented in larger residential buildings (e.g. social housing) and in the industry sector.

Member States shall implement EU directives, particularly with focus on financing and renovation of buildings. Addressing current challenges requires market intelligence, technical support, and sector-specific qualifications, alongside the retargeting of public funds towards projects with longer returns, while leveraging private financing for the other interventions. The EU strategic directions, coupled with technical assistance, play pivotal roles as market drivers. The rightness/value of supporting ESCO markets through public policy or financial benefits has been often on the table for debate. The role of ESCOs in the energy efficiency arena, as well as in the building sector renovation targets is still strongly advocated.
Better data and analytics enable informed decision making on building operations and decarbonization

Tianzhen Hong, Lawrence Berkeley National Laboratory, USA

Panel
4. Monitoring and evaluation

Keywords
Open data, data collection, analytics, building performance

Research-grade datasets, compliant with the FAIR (Findable, Accessible, Interoperable, and Reusable) principles, from real buildings can address essential gaps that limit our present data analytics capabilities. However, it is currently time-consuming and hard to find datasets that have adequate data coverage, good data quality, and clear documentation. This talk presents an open access dataset (https://bbd.labworks.org/project/bbd) of high-resolution performance data from 12 real buildings of diverse types. The dataset was developed from a U.S. Department of Energy funded project which is a collaborative effort led by Lawrence Berkeley National Laboratory with partnership of Pacific Northwest National Laboratory, Oak Ridge National Laboratory, and National Renewable Energy Laboratory.

The open source data pipeline used to curate, standardize and publish the dataset to comply with the FIAR principles will be introduced. The dataset has been downloaded by more than 600 users. Case studies applying data analytics to extract valuable information from the dataset for informing improvements of building operations and decarbonization will be presented. Challenges (e.g., data standards and metadata models) and opportunities (e.g., big data, AI/machine learning) in curating and using FAIR datasets will also be discussed.
“Every kilowatt hour counts!” Swedish households’ sensemaking and decision-making during and after the energy crisis of 2022–2023

Hanna Björner Brauer, RISE Research Institutes of Sweden, Sweden
Maria Håkansson, RISE Research Institutes of Sweden, Sweden
Sara Willermark, University West, Sweden
Hanna Hasselqvist, RISE Research Institutes of Sweden, Sweden

Panel
4. Monitoring and evaluation

Keywords
electricity crisis, households, household consumption, household electricity, energy efficiency investments, practices

In the winter of 2022/2023, Europe suffered what was labelled an “energy crisis”, with aggressively increasing electricity prices and risks of power cuts. Sweden was no exception, and households were encouraged by authorities to reduce electricity use, especially during peak hours. Swedish households responded to this call and contributed to mitigating the impacts of the energy crisis. To capture this unique turn of events, we conducted two rounds of semi-structured interviews with nine householders living in detached houses in Sweden, during and after the crisis, totaling 18 interviews. The first round of interviews was carried out in December 2022, and the follow-up interviews in June 2023. The aim was to explore how households made sense of the energy crisis. More specifically, we investigated how the energy crisis affected householders’ decision-making concerning their house and electricity use, with a specific focus on energy related investments. Our results show that households made sense of the energy crisis in different ways and that they attached different meanings to the crisis such as preparedness, self-sufficiency, solidarity, sufficiency, environmental concern, and financial concern. These meanings seem to affect how households already prepare, or imagine preparing, for future winters in their decision-making.

The results indicate that the energy crisis affected the households’ decision-making regarding energy related investments in mainly two different ways. Firstly, the energy crisis accelerated interest in making investments including solar panels, home batteries, heat pumps, insulation measures, air fryers, and fire stoves. Acceleration or reinforcement of unsustainable investments was also observed; one household felt they did the right thing by investing in a diesel generator, while another sold their chargeable hybrid and returned to a diesel car because the energy crisis made them feel the reliability of electricity supply was too uncertain. Secondly, the follow-up interviews revealed that while investments remained very relevant,
experience of dealing with the high prices also made some householders confident that they could deal with future power shortages, without making expensive investments. Importantly, although the householders were uncertain about what to expect from upcoming winters in terms of the electricity situation, some of them believed we may experience similar crisis winters in the future. The analysis demonstrate how possible household investments are influenced by the experience of the crisis, material preconditions in the home, and knowledge as well as how these individuals made sense of the energy crisis. There are a number of barriers for the aforementioned investments: that some entail significant expenses that often necessitate loans, that there are uncertainties around future electricity prices, and that the households do not have enough knowledge about what is the most suitable investment.

We argue that this decision-making is important because these investments will put households in different positions to adapt to future crisis or changes in the power system, based on if and how they can improve the energy performance and resilience of their homes.

Thus, there is an increasing need for authorities managing the power system to communicate with households to help them navigate an uncertain energy future. These findings are useful to understand how households need to be supported when facing future crises, for example regarding decision-making around energy related investments.
The impact of the ‘cost of living crisis’ in Britain: energy saving actions by fuel-poor households in winter 2022/23

Clare Hanmer, University College London, United Kingdom
Eoghan McKenna, UCL, United Kingdom
Ellen Zapata-Webborn, UCL, United Kingdom
Jessica Few, UCL, United Kingdom
Martin Pullinger, UCL, United Kingdom

Panel
4. Monitoring and evaluation

Keywords
smart metering, survey, fuel poverty, domestic energy efficiency, energy epidemiology

The Smart Energy Research Laboratory (SERL) Observatory, which collects smart meter data from nearly 13,000 British homes, has the scope to gather additional data in times of change. In early 2023 a survey was sent out to participants to gauge the impact of the ‘cost of living crisis’ and associated steep rise in UK energy prices. More than 5,000 households provided information about their income levels and whether they were struggling to pay fuel costs. Within this group we identified households spending more than 10% of their income on energy (designated Expenditure Fuel Poverty: EFP) and those who reported being unable to afford to heat their living room to a comfortable temperature (designated Feeling Fuel Poor: FFP).

In this paper we apply epidemiological techniques to SERL data to identify the demographic and dwelling characteristics of the EFP and FFP groups and compare these with the rest of the survey respondents. To examine the impact of energy-saving actions following the steep rise in prices, we assess the relative percentage reduction of gas demand for the two groups between winter 2021/22 and winter 2022/23 using a machine-learning counterfactual model. There was an overall reduction in gas demand of 9.5% for the whole sample in January to March 2023 compared to the previous winter, suggesting widespread energy saving actions at a time of very high energy prices. Those who reported feeling fuel poor reduced their gas demand on average by 17.5%, while the mean gas demand reduction of the larger EFP group was 10.0%.

We reflect on the benefits of epidemiological techniques applied to large scale, longitudinal smart meter and survey data, and discuss the implications for data collection and analysis and for policy to identify and support those in fuel poverty.
Behavioural measures for energy efficiency: key findings and policy advice from the NUDGE project

Filippos Anagnostopoulos, IEECP - Institute for European Energy and Climate Policy, The Netherlands
Marta Gabriel, INEGI, Institute of Science and Innovation in Mechanical and Industrial Engineering, Portugal
Merkouris Karaliopoulos, Athens University of Economics and Business, Greece
Peter Conradie, IMEC, Belgium
Anne Kesselring, Fraunhofer ISI, Germany

Panel
4. Monitoring and evaluation

Keywords
Energy Efficiency Directive (EED), behavioural change, consumer behaviour, Randomised Control Trials, data monitoring, control and monitoring devices, energy monitoring, Data analysis

This paper places focus on the innovative findings and forward-looking policy suggestions stemming from the Horizon 2020 NUDGE project. NUDGE has been instrumental in investigating the effectiveness of behavioural strategies to enhance energy efficiency through the implementation of randomized controlled trials (RCTs) in various residential buildings, in energy communities, and schools across five EU Member States.

The project provides valuable insights, particularly on the effectiveness of innovative behavioural policy measures and interventions, with a focus on their impact in the current context of an external energy crisis. Embracing core behavioural science concepts, NUDGE employed diverse methodologies and tools to dissect participant behaviours. This thorough approach led to the creation of user profiles, tailored nudging strategies, and a rigorous analysis of their impact. The research incorporated data from user feedback and modern sensor technologies such as smart meters, mobile applications, and indoor air quality sensors in real-world experimental settings.

The project's extensive research and experimental efforts have yielded policy recommendations applicable to both governmental and private entities. Notably, this work has been crucial in evaluating the potential integration of behavioural nudges into the policy frameworks of the EU and national decision-makers, providing key insights into their practicality and constraints, especially in times of energy crises.
The paper explores the key takeaways from applying nudges, emphasizing significant outcomes, pinpointing areas for ongoing research, and outlining policy advice to boost energy efficiency amidst dynamic consumption patterns and the need for effective monitoring and evaluation in the context of external policy impacts.
The rule of thumb reigning over the lands of data scarcity: streamlining multiple impacts around energy savings as primary input

**Frederic Berger**, Fraunhofer Institute for Systems and Innovation Research, Germany

**Panel**  
4. Monitoring and evaluation

**Keywords**  
multiple benefits, Energy Efficiency Directive (EED), indicators, methodology, EU project

Since IEA’s 2014 landmark publication “Capturing the Multiple Benefits of Energy Efficiency”, several EU projects and articles have advanced the concept of multiple impacts (also known as multiple benefits, co-benefits, or ancillary benefits).

A generous collection of indicators has been developed to quantify and monetise a myriad of impacts. However, this approach has shown shortcomings, when it comes to the necessary data to apply these indicator sets. As a consequence, these assessments could generally merely be realised by experts with access to significant data volumes and expert guesses. Yet, in light of the enshrinement of wider benefits into EU legislation (as key component of the Energy Efficiency First Principle under the EED’s Article 3), more practitioners and policymakers will need to assess multiple impacts thoroughly. Therefore, in the course of the MICAT project (Multiple Impacts CAIculation Tool), existing indicator sets have been streamlined to require only energy savings as input data. Thereby, the approach has been drastically simplified to enable a significantly wider group to assess multiple impacts of energy efficiency.

While additional data and parameters (i.e. investment costs, energy prices, energy mixes, measure lifetimes, and monetisation factors) still improve the results’ accuracy, they are not necessary, as the tool can fall back on default values and standard conversion equations. This allows users with different data availabilities to receive the best possible results.

This paper describes the underlying methodologies and assumptions taken to develop the streamlined indicator set at the core of the MICATool, the easy-to-use, free, and open-source online tool developed in the framework of the MICAT project. Considering the implications and resulting inaccuracies, assumptions and fallback values are discussed. Thereby, the paper describes the progress necessary to expand the group of users able to assess the multiple impacts of energy efficiency.
Efficiency unleashed: Evolution and impact of Germany's funding scheme for energy and resource efficiency in the economy

Lisa Neusel, Fraunhofer Institute for Systems and Innovation Research, Germany
Simon Hirzel, Fraunhofer Institute for Systems and Innovation Research, Germany
Stephan Heinrich, Prognos AG, Switzerland
Karsten Weinert, Prognos AG, Germany
Anna-Maria Grodeke, Prognos AG, Germany

Panel
4. Monitoring and evaluation

Keywords
funding, financial incentives, electrification, energy management, industry, resource efficiency, energy efficient technologies, industrial processes, programme design

The Federal Funding Scheme for Energy and Resource Efficiency in the Economy (EEE) is the central public funding programme for addressing energy efficiency and reducing greenhouse gas emissions in German companies. In 2023, it exceeded a funding volume of 1 billion euros for the first time. The multi-measure scheme consists of several modules. In its original setup, it covered support for investments 1) energy-efficient cross-cutting technologies, 2) process heat from renewable energies, 3) measurement and control equipment, sensors and energy management software and 4) energy and later also resource optimizations of plants and processes. Recently, two new modules have been added, focusing on 5) transformation concepts and 6) electrification in micro and small enterprises.

On the one hand, the paper aims to examine key performance indicators from the four evaluation rounds since 2019 in order to review the target achievement, effectiveness and economic efficiency of the EEE's measures. Overall, the programme as a whole has achieved gross GHG emissions savings of a good 4.8 million tonnes of CO2 since its introduction until the end of 2022. On the other hand, the paper illustrates the evolution of the EEE over the last five years in order to derive exemplary implications for the evaluation of (other) dynamic funding schemes.

The results suggest, among other things, that it is important to distinguish major structural breaks, such as changes in funding directives during the year or new funding objects, at an
early stage in order to prepare for them in an ongoing evaluation. Consequently, it is advisable for policy-makers to be aware that a redesign of a funding programme may also have substantial repercussions on its evaluation.
All energy characteristics of all Dutch homes in one model: How Hestia helps to map all costs and benefits of the heat transition

Casper Tigchelaar, TNO - Energy Transition Studies, The Netherlands
Arjan Zwamborn, TNO, The Netherlands
Evie Cox, TNO - Energy Transition Studies, The Netherlands
Folckert van der Molen, PBL, The Netherlands
Peter Mulder, TNO - Energy Transition Studies, The Netherlands
Kim Fernández Gómez, TNO - Energy Transition Studies, The Netherlands

Panel
4. Monitoring and evaluation

Keywords
big data, homes, multiple benefits, cost benefit, modelling, energy efficiency policy, Micro-data, dynamic simulations, income

The Dutch Environmental Assessment Agency (PBL) and the Dutch Organization for Applied Scientific Research (TNO) have developed the Hestia model that allows for micro-level calculations of the effects of the energy transition on homes and households. In Hestia, the technical and energy characteristics of all 8 million Dutch homes have been determined down to the building component level (roof, floor, facade, window, door, heating and hot water generation, ventilation, and cooling).

The energy transition, in the Netherlands and Europe, has entered a new phase, shifting from policy development to policy implementation. The question of how to make the built environment more sustainable has been broadly addressed. Now, policymakers are particularly interested in understanding the implications of the chosen policy for specific target groups. Simultaneously, operative stakeholders within local government and the construction sector want to know where to start and which renovation concepts are feasible and desirable. Additionally, the financial sector seeks information about the sustainability status of their mortgage portfolios.

To address these new types of questions, a much higher level of detail is required. Collecting and making detailed data available at the level of individual homes and households is one crucial aspect. Additionally, tools and models like Hestia are necessary to extract relevant information from this detailed data. Given that the energy transition is interconnected with various other societal developments, linking it with additional data is of paramount importance.
Due to the high level of detail, Hestia can yield more than just energy and CO2 effects. The model also provides insight into income and labour market effects. In addition, it provides a basis for estimating the environmental impact of materials for renovation scenarios. Hestia has been used by TNO and PBL for the national Climate and Energy Outlook. It has also been used in collaboration with the Netherlands Bureau for Economic Policy Analysis (CPB) to calculate income effects of insulation for each household in the Netherlands. This has made it possible to identify vulnerable target groups who are not financially able to finance and/or get a return on their investments in energy savings.

By simulating renovation decisions of households, the model is able to reconstruct the (energy related) changes in the housing stock from 2000-2020, as observed in the statistics. Because of the calibrated extensive simulation capabilities, Hestia is able to assess the effects of local and national policies for the years up to and including 2050. The model can also calculate so-called ‘what-if scenarios’ to assess the effects of CO2-neutral end states.

At present, cooperation with local parties is being initiated to use Hestia for better proposals for energy renovations in neighbourhoods. By providing this centrally generated data at the neighbourhood level, local parties save a lot of costs on data collection themselves.
Ex-post energy savings assessment methodologies using smart-meter data: the case study of a switch from direct electric heating to an air-to-air heat pump

Dominique Osso, EDF-R&D, France
Guillaume Binet, EDF-R&D, France
Benjamin Petiau, EDF-R&D, France
Marie-Hélène Laurent, EDF-R&D, France

Panel
4. Monitoring and evaluation

Keywords
evaluation methods, electrical heating, heat pump, smart metering

The need to electrify end uses to achieve carbon neutrality by 2050 and strengthen energy independence means that we need to seek out and evaluate the most efficient technologies. To limit these future increases in electricity consumption, existing consumptions must also be reduced. Thus, retrofitting direct electric space heaters with a heat pump is a dual opportunity to speed up the decarbonization of the French residential sector and to moderate both individual and overall electricity demand increase. We then use this case study to evaluate a range of evaluation methods.

To assess the energy savings achieved by the switch from direct electric heating to air-to-air heat pump, in the absence of information to set up a control group (difference in difference), we monitored the daily electricity consumption of a dwelling, via the existing smart meter during 2 periods: 3 years with direct electric heating (DE) before retrofit, and 2 years after the installation of the air-to-air heat pump (HP).

The daily meteorological data were used to assess the thermal gradient (consumption versus temperature). The aim is to capture the heat-sensitive part of the daily consumption (mainly linked to space heating).

Several methods have been used to estimate energy savings by comparing the before and after situations: Linear, quantile and partial least square regressions, Multivariate adaptive regression spline model, and Machine learning based on generalized additive model.
The impact of the energy savings estimated according to the methodology is assessed and the uncertainties that may exist within each method and between methods is presented. The conditions of use and advantages of each method are discussed as they apply to other smart meter consumption, such as gas and other renovation.
Integrating Multiple Benefits into the reporting on energy and climate policies – an illustrated conceptualisation

Niklas Reinfandt, Fraunhofer Institute for Systems and Innovation Research, Germany
Frederic Berger, Fraunhofer ISI, Germany
Barbara Schlomann, Fraunhofer ISI, Germany

Panel
4. Monitoring and evaluation

Keywords
Energy Efficiency Directive (EED), reporting, multiple benefits, Energy efficiency first

The EU Commission’s Fit-for-55 package has outlined the need for pathways to climate neutrality by mid-century to have a shot at complying with the 1.5°C target of the Paris Agreement. Energy Efficiency and Renewables appear as key strategies in such pathways, while the still in today’s energy systems predominant fossil fuels need to be phased out rapidly. Therefore, pathways reaching climate neutrality in the middle of the century, as compared to unsustainable pathways maintaining substantial amounts of fossil fuels, are now clearly in the spotlight. Nevertheless, two important questions require further analytical support:

• What speed of phasing out fossil fuels leads overall to the highest benefits? Can in particular higher shares of energy efficiency more quickly phase out fossil fuels for the benefit of societies and the environment?
• Are all pathways to climate neutrality equally rewarding to society as a whole or are there broader aspects to be taken into account, notably when it comes to the role of energy efficiency options, as compared to carbon-neutral supply options (such as renewable supply options)?

While the first question has been asked already for quite some time, the second question regarding a better differentiation between different carbon neutrality pathways is rather new. For the second question, the reduction of greenhouse gas emissions (GHG) itself is not a differentiating criterion anymore, compared to scenarios with fossil fuels, as all pathways aim to achieve climate neutrality by mid-century. At the same time, other impacts such as land use, material uses, employment, or import dependence and energy security gain importance. Therefore, to answer these questions, a broader view on Multiple Impacts (MI) (also known as Co-Benefits, non-energy Benefits) is necessary for an enlightened decision-making process regarding the choice between climate neutrality pathways, in intermediate target setting for
2030 and 2040 (or intermediate years), and for policy action and implementation.

At a political level, the increasing need to address these issues is reflected in the growing importance of the principle of "energy efficiency first" (EE1). EE1st not only plays an important role in the European Commission's strategies, particularly in the European Green Deal, but is also increasingly anchored in EU legislation, including in the Governance Regulation ((EU) 2018/1999) and the Renewable Energy Directive ((EU) 2023/2413). However, the most important development came with the revised Energy Efficiency Directive (EU/2023/1791), which establishes the EE1st principle as an overarching policy and decision-making principle. Its Article 3 requires for all relevant policy, planning, and major energy-related investment decisions a “proper assessment of the wider benefits of energy efficiency solutions where appropriate, taking into account the entire life cycle and long-term perspective, system and cost efficiency, security of supply and quantification from the societal, health, economic and climate neutrality perspectives, sustainability and circular economy principles in transition to climate neutrality”. These MI are especially important since energy system costs alone are not a clear argument for EE1.

As a consequence, it is paramount to understand how to translate the EE1 principle into practice through the consideration of the different MI, how it can enable the perception of energy efficiency as a driver for other major policy objectives, such as secure and affordable energy supply and how to report them for this purpose. In addition, an accessible and realisable concept is necessary to support Member States complying with their obligation to report under this article and in the monitoring and verification of plans requested by the European Commission (e.g., National Energy and Climate Progress Plans).
Projections in hindsight for the buildings sector: understanding drivers for future policymaking

Kelsey van Maris, VITO NV, Belgium
Annabel Vella, VITO/Energyville, Belgium
Nele Renders, VITO/Energyville, Belgium
Tom Dauwe, VITO/Energyville, Belgium
Sonia Quiroga Gomez, Universidad Complutense Madrid, Spain

Panel 4. Monitoring and evaluation

Keywords
evaluation, monitoring, retrospective analysis, modelling, scenario study, building sector

The number of energy and GHG scenarios in European countries has risen significantly in the past decades. Retrospective review of these projections is essential for ensuring their robustness for future policymaking. By comparing projections with actual data, this study aims to understand: (1) how past projections for 2005-2020 compare with energy balances and emission inventories reported for the same period, and (2) which drivers and parameters are essential in understanding uncertainty in projection scenarios.

This study is conducted within the scope of Horizon Europe project PATTERN, which provides guidance on retrospective comparative analysis within the climate and environment policy context. The guidance demonstrates how to increase knowledge transfer between ex-post and ex-ante evaluations. To illustrate the learnings of a comparative analysis, GHG emission scenarios and their underlying assumptions for Belgium and the Netherlands were analysed, focusing on scenarios developed for buildings in the residential and services sectors for the period 2000-2020.

The analysis is based on GHG and energy scenarios estimated for research and policymaking, including official reporting under the EU GHG emission Monitoring Mechanism, now known as the Governance Regulation. The policy background of the scenarios was compared against the actual evolution of energy efficiency and emission reduction policy in buildings in both countries. Similarly, the projection parameters were compared to actual data to assess the accuracy of the development of key parameters and their effect on GHG emissions. Through the application of the index decomposition method, the causes of deviations from ex-post data are explained in terms of activity (population or services value added), energy and emission intensity and weather effects.

Over the assessed period, the policy landscape in both countries strongly progressed towards lower energy and carbon intensive buildings. As shown by the European Environment Agency database for climate mitigation policies and measures, the number of measures increased from...
almost none in 2000, to a total of 48 and 33 measures by 2020 in Belgium and the Netherlands, respectively. This was highly steered by three key EU legislations: the Energy Performance of Buildings Directive, the Effort Sharing Directive and the Energy Efficiency Directive. National measures mainly cover regulatory instruments (for example, tightening minimum energy standards for new buildings), financial instruments (for example, Rational Energy Use subsidies for Belgian households and Sustainable Heat Subsidy for Dutch households), and information measures (for example, Energy Performance Certificates).

The growth in the type and number of policy instruments over the years is reflected in the 2005-2020 projections through continuous improvements in carbon and energy intensity of the buildings sector. These expected improvements materialised partially in actual energy consumption and related emissions, but improvements for energy intensity tend to be generally overestimated. The projections also show difficulty to reflect well external conditions, such as economic fluctuations (covid), rising temperatures (heating degree days) and even demographic growth (households), although being important drivers of historical trends. This becomes visible in the deviations of projections from actual levels of annual energy use and emissions.

On average, 2020 residential projections for these parameters deviated by around 6% and 12% for Belgium and the Netherlands, respectively. Furthermore, the analysis indicates that drivers in the services sector are generally less understood than in the residential sector, reflected by high variability between scenario outcomes. Findings of this ongoing analysis aim to better understand the impact and uncertainty of policy drivers and projection parameters to support future scenario development.
A review on Smart Readiness Indicator: potentialities and challenges on current initiatives

Dimitra Tzani, University of Piraeus Research Center, Greece
Alexandros Flamos, University of Piraeus Research Center, Greece

Keywords
Energy Performance of Buildings Directive (EPBD), energy performance certificates, EU policy, energy policy, Smart Readiness Indicator, smart buildings

The 2018 revision of the European Energy Performance of Buildings Directive (EPBD) aimed to further promote smart building technologies, through the establishment of the Smart Readiness Indicator (SRI) as an optional common European Union (EU) instrument to evaluate the technological readiness of buildings to interact with their occupants, the energy grid and to operate more efficiently. Although most studies in the literature highlight the need for a smart readiness assessment instrument and are overall in favor of the SRI, there is still confusion regarding the assessment methodology and the most suitable implementation and application framework for the SRI-scheme.

Overall, this study aims to answer the following questions: i) How ready and able are the targeted MSs to integrate SRI into their national regulation? ii) How are they progressing with the SRI implementation and what are their plans for the future regarding SRI? In this respect, a thorough investigation of the market and policy context related to the SRI takes place for 6 Member States (MSs), namely Austria, Croatia, Cyprus, France, Portugal and Spain, and their first experiences with the SRI implementation are being analysed.

To enhance and verify our analysis a two-round stakeholder consultation process is also conducted to collect feedback and insights from key national stakeholders. The results indicate that the complexity of the service catalog of the SRI and its functionality levels are among the main challenges MSs are facing along with the absence of climate-specific characteristics. While, on the other hand, MSs identify the integration of the SRI with other instruments such as the Energy Performance Certificates and synergies with other technologies such as smart meters and building automation and control systems as key opportunities to facilitate its implementation. Overall, the study aims to inform policymakers at national and EU level especially in light of the EPBD recast.
Urban Heat Island, the missing links: smart monitoring & evaluation and citizens engagement

Ezilda Costanzo, ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy
Michele Zinzi, ENEA - Italian national agency for new technologies energy and sustainab, Italy
Primo Di Ascenzi, ENEA - Italian national agency for new technologies energy and sustainable development, Italy
Danila Severa, Rome Municipality _ Climate Office, Italy

Panel
4. Monitoring and evaluation

Keywords
smart cities, big data, Urban Heat Island, citizens, M&E

July 2023 and October 2023 have been the hottest than ever at global level. Last summer Southern Europe experienced extreme heat, breaking many local high temperature records. Climate warming and heat peaks are exacerbating the Urban Heat Island (UHI) effect, the relative warmth of a city compared to surrounding rural areas. Solutions able to mitigate urban overheating can prevent energy demand for cooling increase (there might be up to 14 billion items of cooling equipment in 2050!) and generate multiple effects on comfort and health, air and water quality and biodiversity, but also on urban regeneration and socio-economic development. So far main UHI measures in Sustainable Energy and Climate Action and/or Adaptation and Resiliency Plans seem to lack a suitable integrated and participated approach as well as monitoring and evaluation (M&E) strategies. Yet some exemplary plans do exist and can show the way to new approaches.

Opportunities from digitalisation, smart city technologies and citizens availability to participate in planning and data collection remain underexploited. Mobile computing and mobile-based technologies allowing for participatory planning tools and co-creation, citizen science, volunteered geographic information (VGI) are integrating innovative concepts to increase UHI awareness, generate big-data and empower cities and communities to reduce the UHI effect. But only a few smart cities, – like Barcelona, currently combine bottom-up data, evidence-based planning and M&E. Reliability, privacy and interoperability constraint impede the spread of such applications.

After recalling the state of the art of M&E and participation in climate adaptation plans, the paper provides some examples of urban overheating mitigation policies and actions encompassing these two aspects. Then, it briefly mentions what advancements smart cities
applications can offer: for instance, greatly simplified UHI estimations through mobile transects for a widespread availability of ambient temperature data without the need for costly equipment and many hours of dedication by the researchers.

Finally, the paper showcases a possible participatory M&E approach embedded in the new Rome adaptation strategy and inspired by the selected best practices. This second part is based on findings from a field study in municipal nursery schools, where an outdoor evaporative cooling system may locally reduce the outdoor air up to 5 °C and ensure the thermal comfort conditions for the majority of the interviewees who had before experienced overheating outside of the misted zone. The success of the initiative kicked off the idea of implementing a program for the real time monitoring and alerting of cool shelters in the city of Rome, by integrating an existing Smart City Platform (SCP).
Crisis ready - how longitudinal data helps to make sense of crises and how to prepare for the next one

Tina Fawcett, ECI – Environmental Change Institute, University of Oxford, United Kingdom
Phil Grunewald, University of Oxford, United Kingdom
Eoghan McKenna, University College London, United Kingdom
Phil Grünewald, University of Oxford, Engineering Science

Panel 4. Monitoring and evaluation

Keywords
big data, energy price, price sensitivity, fuel poverty, energy policy, smart metering

During the winter 2022-23 residential energy prices were exceptionally high in Europe. In the UK, the electricity retail market was temporarily suspended and replaced with the government's 'energy price guarantee' and other financial support costing an estimated £69 bn (€80.7 bn). Despite this significant intervention, UK households experienced unprecedentedly high gas and electricity prices. How did they respond?

While in aggregate, prices rose and demand fell, the distribution of these effects was dramatically uneven among different societal groups. We present results from three sources of data: the Smart Energy Research Lab (SERL), the Energy Demand Observatory and Laboratory (EDOL) and Utilita. The data span the period 2019 to 2023 for over 17,000 UK households and include gas and electricity consumption, tariff data, demographics and contextual information.

The results highlight diversities and complexities in customer responses to price changes. We found that high prices put pressure on the most vulnerable households in different ways. Among the Utilita data for 11,500 prepayment meter customers, a group where fuel poverty is highly concentrated, annual gas use per household fell by 20 %, while electricity use fell by 3 %.

When specifically comparing high resolution price elasticities for electricity among the EDOL sample, many low-income households were not able to reduce their demand further. The SERL studies showed that more affluent households are more responsive to increases in electricity price while those struggling financially are more responsive to rising gas prices. They also explored what actions were taken to reduce energy demand and by whom.

These studies have proved to be valuable, yielding novel and valuable insights in times of
crises. They have also demonstrated that collection of energy and contextual data and its evaluation are important roles for academic research in the net zero transition. By investing in longitudinal studies, governments have the means swiftly to understand future crises and to take the necessary action to avert serious social consequences.
EDOL: The Energy Demand Observatory and Laboratory

Martin Pullinger, University College London, United Kingdom
Eoghan McKenna, University College London, United Kingdom
Gesche Huebner, University College London, United Kingdom
Jessica Few, University College London, United Kingdom
Clare Hanmer, University College London, United Kingdom
Simon Elam, University College London, United Kingdom

Panel
4. Monitoring and evaluation

Keywords
domestic energy efficiency, energy monitoring, evaluation, residential buildings

This presentation will introduce the Energy Demand Observatory and Laboratory (EDOL). EDOL is a 5-year collaboration between University College London and the University of Oxford, funded by UK Research and Innovation, that builds on the success of the Smart Energy Research Lab (SERL) in providing a unique energy data resource for the research community. We will discuss how EDOL monitoring of residential energy consumption will inform investigation of EDOL’s four key research challenges: 1) Reducing energy waste; 2) Managing energy disruptions; 3) Integrating demand into flexible systems; 4) Improving the resolution of energy demand modelling.

We will discuss how EDOL enables epidemiological and observational studies investigating the drivers of energy demand in residential buildings, as well as evaluation of the impact of large exogenous events such as the coronavirus pandemic in 2020/21 and the impact of rapidly rising energy costs in 2022/23.

The SERL “Observatory” panel of 13,000 representative GB homes, and the associated longitudinal dataset (which is comprised of: half-hourly gas and electricity smart meter data and linked contextual data - survey data; Energy Performance Certificate data and hourly weather data), provides the foundation for EDOL. However, whereas SERL provides whole-home data, EDOL will collect many additional in-home data streams (e.g. indoor temperature and air quality via sensors, data from smart thermostats and appliances, heat pumps etc.) which will enable disaggregation of energy use to activities and appliances and help us answer not just the What and How but also the Why of energy use.
But why? The need for a causal understanding of changes in energy use

Phil Grünewald, University of Oxford, Engineering Science, United Kingdom
Phil Grunewald, University of Oxford
Zeynep Tekler, University of Oxford

Panel
4. Monitoring and evaluation

Keywords
energy demand, behavioural change, data, energy policy

Change is at the heart of the energy transition. Technologies, buildings and people – all change. But why?

Some changes happen naturally, other changes are the result of deliberate or random interventions. Some result from centrally devised policies, others are personal choices.

For effective and deliberate change to be achieved, a sound understanding of what causes the change can be helpful in developing the right mechanisms, and to avoid wasting time and effort on ineffective ones.

The importance of ‘understanding the causes of change’ seems self-evident, but the practical implementation for studies that provide evidence of causes (rather than mere correlation) are challenging. Ambition is required. Even after the event, it can be difficult to attribute effects to causes. Was a demand reduction the result of price, policy or products?

We present findings from ten years of deliberate research design intended to get a handle on ‘causes’ in changing energy demand. Inspired by the work of Judea Pearl (Pearl and Mackenzie 2018), we present an iterative three step process to understand causation. 1) Causal model 2) Observation and 3) Intervention. The causal model creates a framework for the research design and helps to systematically hypothesise about causal pathways and confounding variables. It informs what experimental design is required and what variables need to be observed. In some cases deliberate and controlled intervention are needed to test and revise the hypothesis.

Examples of the successful implementation are presented for behavioural interventions (demand response), technology interventions (heat pumps) and market interventions (price elasticity).
This approach is currently being scaled up as part of the UK Energy Demand Observatory and Laboratory (EDOL), which establishes statistically robust control groups to act as counterfactuals for interventions, which are tested in matched laboratories. Only with such longitudinal data at sufficient scale can causes be understood.
Evaluating the energy performance of residential buildings in developing countries: a case study in South Africa

Simon Elam, University College London, United Kingdom
Jessica Few, University College London, United Kingdom
Martin Pullinger, University College London, United Kingdom

Panel
4. Monitoring and evaluation

Keywords
domestic energy efficiency, evaluation, residential buildings, building energy certification

This presentation will discuss the complexities of undertaking a large scale evaluation project of residential buildings in South Africa at a time when households are facing rapidly rising energy costs combined with unprecedented levels of load-shedding (scheduled power outages).

Background: The International Finance Corporation (part of the World Bank Group) fosters sustainable economic growth in developing countries. IFC has developed the EDGE voluntary green building system to help boost the uptake of green building design. Buildings constructed to EDGE standards are predicted by EDGE-modelled calculations to reduce in-use water and energy by 20% compared to the local base case, as well as reducing embodied energy in materials by 20%. The EDGE Impact Evaluation programme aims to evaluate the real-world performance of buildings constructed to the EDGE standard in emerging markets, comparing energy and water consumption in EDGE-certified buildings to the consumption predicted by the EDGE model, and to conventional buildings.

Methods: The impact evaluation approach for the study utilizes a quasi-experimental design involving a matching process to balance EDGE property and conventional property characteristics across the sample recruited in the main phase, followed by appropriate statistical and modelling methods.

Findings: We will highlight the key learnings from the pilot phase study, including the potential impact from the variation of mitigation strategies (behavioural and technological) in response to load shedding and rising energy costs, and the challenges faced in the monitoring of rapidly evolving and highly heterogenous implementations of low carbon technologies (e.g., heat pumps, PV, solar thermal etc) in residential buildings in South Africa.

Further work: We will introduce the next phase of the EDGE Evaluation Study as the programme is rolled out in Colombia and Indonesia.
Monitoring everyday energy behaviours using the Day Reconstruction Method: Ireland’s Behavioural Energy & Travel Tracker (BETT)

Hannah Julienne, Sustainable Energy Authority of Ireland (SEAI), Sustainable Energy Authority of Ireland, Ireland
Ciarán Lavin, Sustainable Energy Authority of Ireland, Ireland
Lucy Kinnear, Sustainable Energy Authority of Ireland, Ireland

Panel
4. Monitoring and evaluation

Keywords
behavioural change, quantitative survey, energy behaviour, travel, heating, smart grid, demand patterns, consumer behaviour, domestic hot water, domestic appliances

The last two years has seen the convergence of three interconnected crises in Europe – an energy crisis, a cost-of-living crisis, and the worsening climate crisis. The policy response to these is necessarily multifaceted, but it is clear that energy demand reduction has a crucial role to play.

In order to tailor demand reduction campaigns and interventions so that they provide advice that is relevant to the recipient and likely to make an impact, there is a need to first understand how people are actually using energy time and where people have margins for change. Some attempts to capture this information have been made through tracking surveys that measure self-reported behaviour and attitudes over time. However, data collected using such methods can suffer from recall bias or exhibit ceiling effects.

To address this gap in evidence, we developed Ireland’s Behavioural Energy and Travel Tracker (BETT) – an online tracking study designed to capture a granular snapshot of everyday energy-related behaviours over time, which ran monthly throughout 2023 and is ongoing on a quarterly basis. The study uses an adapted version of the “Day Reconstruction Method” (Kahneman et al., 2004), in which respondents accurately reconstruct their activity over the previous day using a structured online questionnaire. The approach is similar to that taken by Ireland’s Social Activity Measure (Lunn et al., 2023), which provided a comprehensive picture of social activity and viral transmission risk in Ireland to inform policy during the COVID-19 pandemic.

Initial analyses focused on tracking the prevalence of a range of inefficient energy behaviours and examining the factors (sociodemographic and psychological) affecting people’s propensity
to engage in these, in order to inform Ireland’s “Reduce Your Use” energy saving campaign. Subsequent work has included using the rich data generated by BETT to identify the activities most responsible for peak electricity load, to inform demand flexibility initiatives, and in-depth analysis into individual and dwelling characteristics driving home heating demand.
Crowd sourcing data collection for effective appliance policy – the case study of air conditioners in Indonesia

Fiona Brocklehurst, Ballarat Consulting, United Kingdom
Clara CAMARASA, IEA, France

Keywords
air conditioning, crowd sourcing, market surveillance, market data

One of the challenges of making effective policies for appliances (for example Minimum Energy Performance Standards, MEPS) is getting access to up-to-date market data. Mandatory energy labels provide information on the energy efficiency and other features (such as size or capacity) of a product which is useful for policy makers as well as consumers. But collecting data on a representative sample of the market from conventional sources – commercial providers or commissioned surveys – is slow and expensive. Web crawling is a newer method which is cheaper and quicker but has its own limitations. Crowd sourcing data digitally is another new approach which can supplement, or possibly replace these methods.

In this paper we compare data gathered on one product group, air conditioners, in one market, Indonesia, using different methods: web crawling, crowd sourcing and the government mandatory data registry. We find that crowd sourcing was able to collect energy and price data on many models and the results appeared to be generally consistent with those from the other sources. Further, data from web crawling and crowd sourcing both showed that there are many high efficiency models for sale at the same price as low efficiency models. This means that there is scope to tighten the MEPS without affecting low-income consumers (who might struggle to buy air conditioners which cost more initially even if they are cost effective over their lifetime).

We find that the big advantage of crowd sourcing, particularly in markets where online shops are less popular, is making data collection, including prices, at low cost. This extends their usefulness to policy evaluation and to assist with market surveillance, improving appliance policies in every stage of their life cycle.
Data Synergy in times of crisis

Sarah Higginson, United Kingdom
Catherine Jones, Science and Technology Facilities Council, UKRI
Marina Topouzi, Environmental Change Institute, University of Oxford
Gesche Huebner, Bartlett School of Environment, Energy and Resources, University College London Energy Institute
Michael Fell, Bartlett School of Environment, Energy and Resources, University College London Energy Institute

Keywords
data

We face multiple, interlinking crises, all of which require the collection and sharing of quality data to understand them. Sharing data is good practice for responsible research and often a funder requirement. However, many projects still fail to deliver on the FAIR data sharing principles (that data be Findable, Accessible, Interoperable, Reusable). Whether qualitative or quantitative, high quality data collection, management and analysis is a crucial foundation for excellent, socially relevant research, particularly when it is interdisciplinary and the assumptions underpinning single disciplinary ontologies and methodologies might be contested.

Energy research produces interesting, specific data challenges: 1) the prevalence of large-scale consortia means many institutions are involved; 2) the multi-disciplinary approach favoured in such consortia results in a wide variety of domain standards and expectations; 3) as an applied area of study, energy researchers often collaborate with commercial partners, who may restrict data sharing.

Building on the authors’ experiences of data management in RealValue, an H2020 project, and two UK-based consortia, the Centre for Research into Energy Demand Solutions (CREDS) and UK Energy Research Centre (UKERC), plus learning from a recent expert workshop of research system stakeholders, this paper will explore the concept of ‘data synergy’.

Data synergy, a term coined during RealValue, describes data from multiple stakeholders, sources or disciplines that, when combined, are more valuable than any of the sources on their own. It has four dimensions — resources/ time, people, methods/ metrics, and technology — and considers data collection, sharing and management a socio-technical process that balances these dimensions.

The aim of this paper is to elucidate a set of principles and processes that will guide the international energy community moving forward, ensuring we are able to meet future challenges quickly based on FAIR data, whatever the project focus or methodology.
The route to decarbonization: are EU countries on track to reach 2030 energy efficiency targets?

**Keywords**
Energy Efficiency Directive (EED), national energy efficiency plans

This paper assesses the progress of European Union (EU) Member States towards achieving their 2030 energy efficiency targets. Using data collected from various sources, such as national plans and strategies mandated by EU regulations, such as draft National Energy and Climate Plans and the 2023 National Energy and Climate Progress Reports, the analysis offers insights into evolving strategies and more ambitious targets.

A comprehensive review of Member States' proposed and enacted policies is provided. Additionally, a dedicated section explores the decarbonisation efforts within the building sector. The assessment shows progress towards targets outlined in national Long-Term Renovation Strategies, emphasizing energy savings and reduction of direct greenhouse gas emissions. Furthermore, it evaluates the energy efficiency standards of Nearly Zero-Energy Buildings (NZEB), delineating common features and disparities among Member States, and quantifies the adoption of NZEB.

The findings depict a positive yet fragmented landscape, with notable challenges persisting, particularly concerning escalating renovation rates. Despite recent advancements, the data reported could benefit from further enhancement, as it currently lacks consistency and harmonization across Member States.
Agneta Persson, Anthesis Sweden, Sweden

Panel
4. Monitoring and evaluation

Keywords
statistics, non-residential buildings

Adequate, detailed energy statistics is one of the prerequisites for improving energy performance. Improved energy statistics for buildings is necessary and urgent in order to provide agencies and policy makers with verified data on energy end use and the distribution of energy by purpose when designing and evaluating energy policies and programmes, i.a. national implementation of EU directives, and meeting the new requirements for energy statistics from Eurostat. Property owners need improved energy statistics to optimize their buildings’ energy performance, for benchmarking, and for comparisons between building categories. Researchers need improved energy statistics to be able to conduct effective research, and lots of other actors need improved energy statistics to develop and design new business models and for speeding up the energy efficiency implementation.

The most recently updated Swedish detailed energy statistics (end use for lighting, ventilation, computers, etc) for non-residential buildings is the STIL2 project, carried out in 2005-2010. Energy audits were performed in approximately 1,000 buildings, with a special focus on electricity end use. STIL2 was implemented step-wise for different building categories.

It is now 13 years since the last part of STIL2 was carried out. There is a large need to update and renew the statistics, and the Swedish Energy Agency has decided to do that it in the STIL3 project. The first phase of this project concerns office buildings, and is currently carried out. 2024 school buildings will be analyzed, followed by healthcare buildings in 2025 etc. Each phase will include the development of a statistically accurate sampling frame for the chosen building category, the selection of buildings, audits of the selected buildings and analysis of the audit results.

This paper presents the project aiming to improve the energy statistics for office buildings. The aim is to carry out audits in 150 office buildings, and analyse the audit results by type of end use (in kWh/m² building area), and the results will be compared with the STIL2 results. Based on this comparison an analysis will be made in order to evaluate what impact different policy measures have had sinc the STIL2 project was cariied out. A hypothesis is that ecodesign will have had the strongest impact of the energy end use in offices.

The auditors participating in the project have all been trained in order to finetune and streamline their assessment of energy end users. The statistical method for chosing the
sample buildings have been carefully developed, and owners of the chosen buildings are recruited to participate in the survey. However, the project has encountered some challenges in recruiting the owners of the chosen buildings, which has lead to a delay of six months of the final project results. So far approximately 75 office buildings have been audited. The final results are expected to be available in October 2024.
When data doesn’t motivate: potentials and limitations of app-based feedback for sustainable energy consumption

Devon Wemyss, ZHAW Zurich University of Applied Sciences, Switzerland
Francesca Cellina, University of Applied Sciences and Arts of Southern Switzerland
Evelyn Lobsiger, Zurich University of Applied Sciences
Pascal Kienast, Zurich University of Applied Sciences
Pasquale Granato, University of Applied Sciences and Arts of Southern Switzerland
Tiziano Gerosa, University of Applied Sciences and Arts of Southern Switzerland

Panel
4. Monitoring and evaluation

Keywords
data collection, in-home feedback, collaboration

Feedback on energy consumption has been widely shown to have a relevant, if insufficient and non-persistent, impact and thus remains a foundational element of many behavioural and social practice interventions in buildings. Using sensors and smart meters, data collection has become cheaper and the resulting personalized feedback, frequently offered via apps or webportals, is timelier and more granular. We argue, however, that a technology-focused and data-driven approach does not address the motivations of a broader population.

Our critique is a result of a behavioural intervention where we co-designed a smartphone app for energy savings with household members, technology providers, and utilities (1). The app went beyond consumption feedback to include personalized goal setting, social interaction and gamification elements. Results after one year of app use by 220 households found approx. 5% energy savings, compared to a control group. In the first months after the intervention, the savings actually reached 11%, though they dropped to nearly zero nine months later. Survey responses show that savings mainly came from reducing indoor temperatures. Whereas other routines around showering and laundry appear not to have changed. This hints at the difficulty of shifting cultural conventions on cleanliness-related topics.

Surveys and online workshops with participants showed that the voluntary participants were particularly affine to data-driven solutions and were already implementing energy efficiency practices at home. They told us they were not interested in social interaction with other participants, but rather wished for even more detailed information on energy consumption.
feedback, which could hardly be provided under the current technology and regulatory framework. This coincides strongly with the “resource man” conception by Strengers (2) showing that this style of energy savings interventions remains most interesting to those already engaged with the topic.

To achieve more impact (maintaining savings over a longer period of time) and scale-up (beyond the highly-motivated users), we propose new approaches combining users and business to better capture the value of data. To move beyond conventional individual interventions can highlight the collective challenge of climate change mitigation, and thus interventions can attempt to be even more closely embedded with everyday lifestyle routines. For example, living lab participatory approaches involving public and private actors (e.g. cities, energy providers, technology installers, trade unions, NGOs, universities, political decision-makers.), as well as the households themselves, offer a setting to explicitly question and re-negotiate current social norms and conventions around household energy consuming routines. While long-term change will necessarily involve data collection as part of a corrective feedback process, the behaviour change has the chance to persist if held within a supportive environment where regulation, infrastructure, norms, and ultimately behaviour can adapt and align (3).

Monitoring and evaluating building stock decarbonisation progress across the EU during the crisis 2020–2021

Judit Kockat, Buildings Performance Institute Europe, Belgium
Jerson A.P. Amorocho, Buildings Performance Institute Europe (BPIE), Germany

Panel
4. Monitoring and evaluation

Keywords
monitoring, building retrofitting, energy efficiency, crisis, CO2 emissions, CO2 reduction

Aiming for reduction of more than 55 % until 2030, and with buildings accounting for about 36 % of CO₂ emissions, the decarbonisation of the building stock is crucial for meeting Europe’s climate neutrality goals. Therefore, its monitoring is essential. This paper builds on our previous research that introduced the EU Buildings Climate Tracker. The tracker’s indicators are examined to understand the impacts of the pandemic and energy crises on the operational emissions of the EU building stock. We also discuss the resulting lessons for data needs, energy efficiency and sufficiency and what conclusions can be drawn for policy.

The EU Buildings Climate Tracker serves as a tool to observe building decarbonisation since the ratification of the Paris Agreement in 2015. The tracker is based on indicators selected by a defined set of criteria and aggregates their results in a high-level index, graded from 0 to 100, reflecting the progress of the building stock towards complete decarbonisation by 2050.

This paper focusses on the decarbonisation progress during 2020 and 2021, when the Covid-19 pandemic created new realities in the use, operation, and development of the building stock. Key components of the research firstly encompass indicator insights: the tracker monitors and evaluates the decarbonisation of the building stock comprehensively by observing the development of (1) CO₂ emissions, (2) final energy consumption, (3) the share of renewable energy, (4) cumulative renovation investments, and (5) annual domestic energy spending.

Secondly, this analysis reflects on the indicators’ ability to measure the effects of energy efficiency efforts in buildings and discusses whether they provide comprehensive and useful insights especially during that time of crises. While no single indicator provides sufficient insights, the collection of indicators allows a more detailed picture. A number of monitoring gaps were identified that partly touch upon learning from crisis dynamics. They originate from insufficient availability of data, specifically with regard to covered topics, frequency and detail level.
Increasing energy performance and material efficiency for heating products through self-monitoring and reporting of real-world data

Carlos Lopes, Swedish Energy Agency, Sweden
Emma Olsson, Swedish Energy Agency, Sweden
Ola Gustafsson, RISE – Research Institutes of Sweden

Panel
4. Monitoring and evaluation

Keywords
heating systems, Ecodesign Directive (EuP/ErP), monitoring

The Commission has proposed to introduce requirements on self-monitoring and reporting in the regulation on space heaters under the ecodesign directive. This paper analyses the advantages, addresses the challenges and discusses the way of setting such requirements, with a focus on heat pumps.

The paper assesses how requirements on self-monitoring and reporting of real-life data can contribute to increasing the products and systems functional performance, as well as to improving their energy efficiency. It further assesses the possible benefits in terms of increased durability and material efficiency due to better operation and maintenance.

Technical details for setting a requirement on self-monitoring are described. These include system boundaries, the sampling rate of the measurements and to display the data to the user, the key parameters to monitor, which data to be stored and the adequate level of metering accuracy.

Lastly, the paper discusses the benefits of using real-world data collected from a policy perspective (i) to provide better information to consumers and market actors, (ii) to allow for better design, implementation and evaluation of policies, such as minimum performance requirements and (iii) to improve market surveillance through a more “risk-based approach”.
High efficiency bioclimatic architecture for the XXI century. Mitigation and adaptation to climate disruption

Lorenzo Pagliano, end-use Efficiency Research Group - Politecnico di Milano (eERG-PoliMi), Italy
Silvia Erba, end-use Efficiency Research Group - Politecnico di Milano (eERG-PoliMi), Italy
Andrea Sangalli, end-use Efficiency Research Group - Politecnico di Milano (eERG-PoliMi), Italy

Panel
4. Monitoring and evaluation

Keywords
building envelope, passive cooling, design process

Europe is struggling with an ageing building stock, whose rapid and radical transformation is needed to meet the goals of reducing energy use and protecting the climate. African countries are facing an acute housing shortage, with the continent's population projected to double by 2050, and the fastest urbanization rate in the world.

The technical guidelines produced within H2020 project www.ABC21.eu represent an effort to respond to the development and refinement of our knowledge about thermal comfort, the use of simple technologies such as ceiling fans which have evolved to incorporate airfoiled blades with sophisticated aerodynamic design, the availability of new modelling tools, some traditional construction materials manufactured using local resources (such as raw earth, which benefit now of better compression methods), new materials able to achieve a net transfer of energy to the deep sky event during daytime, while being exposed to direct solar radiation. Future weather files representing the environment in which buildings will operate at 2050 and 2080 were generated and used. Policy measures and training needs are proposed for mitigation and adaptation to climate disruption.

Given the lack of data on actual behaviour of buildings, the ABC 21 project has realised of measurement campaigns (air temperature and velocity, mean radiant temperature, weather parameters at the site,...) and post occupancy evaluations in a set of bioclimatic buildings. We report on results and potential improvements to iconic buildings in Africa and EU.
Nexus of electrification and energy efficiency retrofit of commercial buildings at the district scale

Tianzhen Hong, Lawrence Berkeley National Laboratory, USA
Sang Hoon Lee, Lawrence Berkeley National Laboratory, USA
Wanni Zhang, Lawrence Berkeley National Laboratory, USA
Kaiyu Sun, Lawrence Berkeley National Laboratory, USA
Barry Hooper, San Francisco Department of the Environment, USA
Janghyun Kim, National Renewable Energy Laboratory

Panel
5. Sustainable communities

Keywords
decarbonisation, electrification, energy efficiency action plans, simulation

Rapid electrification of buildings at the district scale is needed for cities to achieve climate change mitigation goals. However, most electrification studies focus on either the single building level or the city/region building stock level, and depend on the slow and uncertain process of requesting personally identifiable customer energy usage data from utilities. To answer a key question facing local policymakers: “Where can electrification proceed at scale without first upgrading the grid?” this poster presents a study to quantify and inform building electrification impacts at the district scale using detailed building energy modeling and based on public records datasets. We explore how energy efficiency retrofits can help mitigate increased peak electric demand, and quantify impacts to energy use and carbon emissions. Building energy models of a baseline, and scenarios of simple electrification, energy retrofits, and electrification in combination with retrofits were created and simulated for 54 commercial buildings in two contiguous districts of San Francisco.

Results show: (1) A simple electrification scenario increased annual electricity consumption but reduced annual site energy usage by 15% to 17%, mainly due to replacing inefficient gas furnaces and boilers with more efficient heat pumps. Peak electricity demand increased 7.4% for Fisherman’s Wharf (still within the capacity of the existing power grid), while the Design District showed a marginal decrease. Annual carbon emissions were reduced by 46% and 37% mainly due to the low-carbon electricity serving San Francisco. (2) When the baseline buildings were retrofitted with energy efficiency measures, the annual site energy consumption was reduced by 41% for the Design District and by 28% for Fisherman’s Wharf. The Design District had 42% electricity savings and 34% of natural gas savings. Fisherman’s Wharf had electricity and natural gas savings of 34% and 11%, respectively.

The peak electricity demand significantly decreased by 40% (from 906 kW to 542 kW) in the
Design District and by 34% (from 1472 kW to 970 kW) in Fisherman’s Wharf. The annual CO2 emissions were reduced by 39% in the Design District and by 22% in Fisherman’s Wharf. (3) Combining electrification with efficiency upgrades reduced peak demand by 26% and 40%, and annual carbon emissions by 63% and 64% for the two districts. These results indicate that impacts of electrification depend on the mix of building uses within a district, and coupling electrification with energy efficiency upgrades is an effective strategy to decarbonize buildings while maintaining or reducing the peak electric demand.

The study demonstrates urban building energy modeling can be a powerful tool to assess city building stocks for informing decarbonization planning and policies.
Barriers and solutions for homeowners' associations undertaking deep energy renovations of condominiums

Ragy Elgendy, Delft University of technology, The Netherlands
Erwin Mlecnik, TU Delft, The Netherlands
Henk Visscher, TU Delft, The Netherlands
Queena Qian, TU Delft, The Netherlands

Panel
5. Sustainable communities

Keywords
barriers, deep renovations, Homeowners associations, solutions, Condominiums

Buildings in the EU consume around 40 % of energy and are responsible for 36 % of greenhouse gas emissions. This necessitates building energy renovations as a coping strategy for energy reduction. Residential buildings consume about 27 % of the energy use in Europe. Multifamily residential buildings, known as condominiums, feature individually owned apartments and are managed by Homeowners' Associations (HOAs). HOAs constitute a considerable percentage of the owners of the residential sector in Europe. However, the deep energy renovation rate is still low due to the complex process and the barriers faced by HOAs.

There is a lack of understanding of the main barriers to undertaking deep energy renovation projects by HOAs and their potential solutions. Therefore, this paper investigates barriers, incentives, and possible solutions that motivate HOAs to undertake deep energy renovation projects. This study employs a combination of qualitative methods, including archival research, the gathering of information through observations at meetings organized by the EU, four interviews, and a workshop with eleven experts. This exploration was conducted from the perspective of three actors: home renovation providers, public authorities, and policymakers in the Netherlands and Flanders. The barriers are grouped under four categories, namely: financial, legal, social, and technical.

The findings indicate that communication, cost, and legal structure are the most significant barriers. The incentives play a vital role only in the early phases of the renovation. The findings can inform policymakers, energy practitioners, and
Neighbourhoods as a seed for climate action

Christian Klöckner, Norwegian University of Science and Technology, Norway
Eugenio de Gregorio, Link Campus University, Italy
Giuseppe Carrus, Roma 3 university, Italy
Erica Löfström, Norwegian University of Science and Technology, Norway
Michael Brenner-Fliesser, Joanneum Research, Austria

Keywords
climate action plan, ecological citizenship, neighbours, collective action, social capital, individual action

This paper takes a complex multi-perspective approach to understand drivers and barriers of climate action on the neighbourhood level in a selection of European neighbourhoods. The starting point for the analysis is the assumption that actions to protect the climate on the level of citizens are most motivating and promising, when conducted jointly with others who are closely related, for example by living in the same neighbourhood, thus building on established social systems. The paper outlines the multiple perspectives chosen for the analysis, namely drivers and barriers on the individual, collective, cultural, and structural level.

On the individual level, four factors from the Theory of Planned Behaviour were included in the analyses: (individual) intentions to act, attitudes towards climate action, perceived (individual) efficacy, and social norms. Three of these are mirrored on the collective level (intention, efficacy, and social norms). Identification with the neighbourhood, perceived collective awareness about climate issues in the neighbourhood, the social capital in the neighbourhood, and trust in neighbours were also measured. On the cultural level, three variables which serve as proxies for (potentially) different local cultures are used: (a) the country the respondents live in, (b) rural vs. (semi)urban, and (c) the time of residence in the neighbourhood. On the structural level, a number of sociodemographic variables like gender, age, household size, number of household members below 14 years of age, social status, education and work situation were recorded. The measurement instruments for each of the factors are described in more detail in the method section below.

A survey was implemented in nine European neighbourhoods (3 in Austria, 2 in Norway, 2 in Italy, 2 in Finland). The neighbourhoods were partly in rural communities (4) and partly in urban or semi-urban areas (5). In total, 1,084 answers were retained between autumn 2022 and summer 2023 and the impact of factors from the different perspectives on the self-reported number of implemented climate actions were tested in a structured, regression-based approach.
Intentions on the individual and collective level impact the number of climate actions implemented by citizens, but individual intentions are more important. In addition, local cultural aspects have an impact on climate action, but also the higher engagement in rural communities in general. Individual intentions to act are slightly less important in rural, than in semi/urban neighbourhoods. On the structural level, males and households with younger children report fewer climate actions, whereas larger households in general and people with university degree report more. Intentions to act individually are mostly determined by perceived individual efficacy and attitudes, but also selected cultural and structural factors. Collective intentions to act depend on the social capital in the neighbourhood and social norms, as well as selected structural and cultural factors.

This quantitative multi-neighbourhood study on collective climate action demonstrated that factors from the individual, collective, cultural, and socio-structural level together determine if people engage with their neighbours in actions to mitigate climate change. This underlines the importance of focussing on all these levels, when trying to stimulate engagement. Currently, local climate action seems to be framed as an individual behaviour, rooted mostly in individual level drivers. However, the analyses also indicate that there is a large potential for increased engagement especially in neighbourhoods with strong social capital, if social norms support climate action. Cultural differences shape how the different factors influence intentions and actions, which underlines the need to tailor intervention approaches to local cultures.
Lessons learned from innovative energy solutions to enable zero emissions areas

Åse Lekang Sørensen, SINTEF, Norway
Synne Krekling Lien, SINTEF, Norway
Vitalis Pavlovas, Statsbygg, Norway
Marius Kolby, Statsbygg, Norway
Anne-Lise Akervik, NTNU, Norway

Panel
5. Sustainable communities

Keywords
best practice, case studies, community energy systems, renewable energy, demand response, electric vehicles, biomass, batteries, solar energy, zero-emission neighbourhoods, vehicle-to-grid

In line with the EU's vision of "local energy communities", Campus Evenstad, a Norwegian university campus, takes energy actions that contribute to the clean energy transition. The campus has been developed over several years, demonstrating a number of innovative and sustainable technologies and energy solutions, for example, vehicle-to-grid (V2G), biomass-based combined heat and power (CHP), solar energy, energy storage, energy efficiency measures, and a zero-emission building.

The aim of this paper is to share experiences from operations of the energy solutions. The lessons drawn from Campus Evenstad demonstrate that, despite the difficulties associated with being an early adopter, there are valuable learnings and positive outcomes gained from putting solutions into action. The project yields significant insights and practical knowledge that have benefited the property owner, the wider construction industry, and the scientific community at large. Dissemination of the project's experiential knowledge has far-reaching implications for future property concepts and decision-making processes across the industry.

Campus Evenstad is a pilot in The Research Centre on Zero Emission Neighbourhoods in Smart Cities (FME ZEN). This paper summarizes the lessons learned from implementing innovative energy solutions, in the process of transforming an existing university campus into a zero-emission neighbourhood. A lot of operational experience has been gained, both on individual technologies and the interaction between these, and the interaction with the national energy system. Dedicated professionals, from the property developer, operating staff, and campus management to researchers, have been central to the realization of the solutions.
Impacts of saturation levels of DER on flexible demand

Robert Passey, University of New South Wales, Australia
Jose Zapata, ITP Renewables

Keywords
saturation, distributed energy resources (DER), synergistic, residential, batteries

The uptake of Distributed Energy Resources (DER) can have a significant impact on the need for, and impacts of, demand flexibility. Current modelling of DER takes an incremental approach to uptake and so may not incorporate the level required for rapid decarbonisation. This paper reports the outcomes for demand flexibility in the context of saturation levels of uptake and operation of residential DER (70% of households install rooftop solar PV and 80% of these have behind-the-meter batteries). Controlled load (water heating) is then shifted to the middle of the day and electric vehicles are operated under two different charging profiles.

The modelling uses a hypothetical ‘DER Suburb’ of 935 real residential load and solar PV profiles from Victoria, Australia. Batteries are modelled so they dynamically respond to changes to the underlying load and so create entirely new load profiles, which highlights the synergistic, and sometimes unexpected, interactions resulting from implementing flexible demand. Two different household battery operational options were modelled: one where batteries only met the needs of their ‘host’ home (load-following), and one where they could also charge from other households’ excess solar and export to help meet other households’ loads (local trading).

The electricity flows for solar, batteries and total load were tracked separately, allowing the construction of detailed load profiles that identified the source of electricity. The changes to load profiles were also assessed in terms of their impacts on aggregate network demand peaks (which dictate the size of the networks) and solar export peaks (which can cause voltage rise and reverse power flows) – both of which can increase costs for all customers.

Only 20% of households had controlled load (CL), limiting the impact of shifting it. Although shifting CL slightly reduced total solar exports and export peaks, it also slightly increased demand during the evening network peaks. This was because less solar was available to charge the batteries, reducing their ability to discharge in the evening. Allowing batteries to trade meant that shifting CL reduced peaks very slightly more. This was because, with trading, batteries were more effective because they could charge from other household’s solar and discharge to meet other households’ loads.

Electric vehicle charging decreased PV exports and export peaks as expected. Although total
PV exports were reduced by 47%-84%, PV export peaks were reduced by only 7%-15%. This was because peaks occur at particular times of the day (PV exports can be reduced at any time) and occur in clusters of low load days (and so even with EV charging the batteries are not fully discharged overnight, and so are less able to soak up solar). As expected, day EV charging reduced solar exports and peaks the most, although night EV charging also reduced them because it helped to drain the batteries that could then soak up solar.

Although daytime EV charging increased network peaks, shifting them from 6:30pm to 11:30am, in summer they were still lower than without DER. The winter peaks were much higher because there was not enough solar to overcome the increased EV demand, even with batteries. Interestingly, where local trading was allowed, daytime EV charging resulted in greater increases to the summer peaks. This is because the batteries were used to charge other households’ EVs and so had less capacity left in the evening. This did not occur for winter peaks because the excess solar had already been used up.

Night EV charging also increased demand during all these periods, shifting the network peaks to 3:30am, with local trading resulting in greater increases, in this case also for the winter peaks. Night charging increased the summer network peaks more than daytime charging did, simply because of the lack of solar. The inability of DER to reduce winter network peaks highlights the need for other types of demand flexibility.
Towards net-zero for hospital estates: stakeholder-led refurbishment strategies

Kubra Doguc, University College London, United Kingdom
Teresa Domenech Aparisi, University College London, United Kingdom
Rokia Raslan, University College London, United Kingdom

Panel
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Keywords
energy efficiency action plans, sustainability, stakeholder, decision-making process, Hospital Buildings, building refurbishment

In the UK, healthcare buildings, most of which are part of the National Health Service (NHS) vast estate, will be key to achieving the national target for 80 % reduction in building GHG emissions. Despite the NHS's ambition to make its building stock low carbon, there are significant challenges in developing sustainable refurbishment strategies for NHS hospital buildings. Decision-making in selecting building refurbishment measures is a complex process for hospitals due to their unique requirements in terms of energy efficiency, occupant comfort and economic viability.

The involvement of stakeholders in the decision-making process is both essential and beneficial to gain valuable insight into the relevant issues and to develop realistic, implementable, and comprehensive solutions that reflect key strategic and operational priorities. In achieving this, Analytical Hierarchy Process (AHP) may provide a useful framework by which to determine the importance of the given criteria, such as building systems, building envelope, cost and disruption, hospital zones and sustainability goals, through stakeholder opinions, reflecting their priorities when considering refurbishment.

This paper details the implementation and outcomes of an AHP approach to engaging stakeholders in the decision-making process for the formulation of refurbishment strategies. A case study Deep-plan/Tower hospital (DPTH) building, a typology that has been found to have a higher energy demand due to the increased need for mechanical systems, is analysed to demonstrate the impact of stakeholder involvement in the selection of the optimal refurbishment strategy and the consistency of their decisions.

The outcomes and insights emerging from this study highlight that compliance with building regulations (25 %) and reducing energy demand (17 %) were the main drivers for refurbishment amongst the stakeholder group. In ranking the preferred refurbishment measures for this hospital building typology, stakeholders prioritised systems-based measures...
such as HVAC upgrade (37 %), over window replacement (22 %) and shading installation (21 %). Intensive care units (18 %) and operating theatres (17 %) were deemed to be the most important target zones for implementing these measures.
Cultural audience engagement for climate action

Ezilda Costanzo, ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy

Panel
5. Sustainable communities

Keywords
citizens, community, cultural engagement, climate empowerment

Reaching wider audiences to define and promote new sustainable lifestyles is a major challenge. The arts can emotionally transfer scientific messages complementing or even replacing conventional knowledge valorisation. Culture is increasingly committed to sustainable development. Cultural and creative initiatives may boost Climate action and a just and clean energy transition by establishing a multidisciplinary dialogue between citizens, artists, curators but also experts and researchers. Such an engagement can help energy experts and planners better develop mitigation and adaptation strategies. Cultural and creative organisations (museums, but also libraries and theatres) can contribute carrying out social practices and guaranteeing inclusiveness and accessibility, leveraging sense of belonging and pro-activism. Digitalization and IoT open key opportunities to this extent, such as crowd-sourced and open co-creative approaches, allowing for harvesting data that might be even integrated in sustainable energy and climate plans. After providing an overview of the programmatic framework, the paper will present some exemplary initiatives, replying to the following questions:

• How is Culture supporting action for Climate? Is the energy and climate research and academic world actually playing a role in cultural practices?

• Is empowerment, hence behavioural change, for climate through art, heritage and cultural & creative industry (CCI) currently assessed?

• Is an integration between cultural and climate policies being practiced?
Solar resource-efficiency gain for energy communities based on current solar energy system deployment

David Lingfors, Uppsala universitet, institutionen för samhällsbyggnad och industriell teknik, Sweden
Joakim Munkhammar, Uppsala University, Sweden
Johan Lindahl, Becquerel Sweden AB, Sweden

Panel
5. Sustainable communities

Keywords
community energy systems, photovoltaics, solar energy, energy sharing, power flow analysis

The concept of Energy Communities (EC) has been introduced in the European Union (EU) to promote energy efficiency and clean-energy transition. The EU Member States are therefore currently analysing how to promote ECs in their national context, e.g., incentive programs and juridical frameworks for internal energy sharing and providing external grid services. In Sweden, current and previous incentive programs for solar Photovoltaics (PV) have mainly been directed towards small residential, commercial or public decentralized installations, which is reflected in the high share of small systems in the Swedish PV portfolio.

This study investigates the gap between the property-optimised and EC-optimised deployment of PV systems. Hence, by studying the current (property-optimised) distribution of PV, it is possible to evaluate to what extent this distribution is resource-efficient, i.e., quantify the gap to an EC-optimised distribution, where the best roofs for solar energy are utilized, in line with the goals of ECs. In a previous project, a method was developed that identifies existing Solar Energy Systems (SES), both PV and Solar Thermal, in aerial images using AI, with high precision (>95 % identified). Also, their orientation (tilt and azimuth) and impact from shading were determined based on Light Detection and Ranging data. The methodology has so far been applied to several Swedish municipalities. In this study, 20 “neighborhoods” in the Falun municipality, Sweden, defined as all customers/buildings connected to the same substation, were analysed, under the assumption to constitute hypothetical ECs. Simulated power output from actual identified PV systems, within each of these ECs, were compared to the output of PV modules hypothetically assumed to have been deployed on the “best” roof locations instead, or if “Large” roofs of high solar irradiation and low shading would have been prioritised.

The voltage rises in one of the ECs were analysed through power flow analysis for these three scenarios, under the two conditions; (1) that the installed capacity of each system is fed into the grid and (2) that the actual peak power output is fed into the grid, resulting in lower voltage rises than in the first case and thereby allowing a higher PV penetration before the voltage
limits are violated. The results show that shading decreased the annual yield by 12, 4 and 3 %
the “Actual”, “Large” and “Best” scenarios, respectively, compared to modelling without
shading. The peak output is however not affected by shading.

Finally, the study gives rise to some policy recommendations as a virtual EC for customers
connected to the same substation is shown to be more resource-efficient in comparison to
creating a parallel grid within the EC, which is currently allowed in the Swedish legislation. In
addition, the substation boundary would probably simplify the dialogue between the distribution
system operator and the EC, when optimising the local energy system, preferably to better
match PV power generation and demand, i.e., increasing the electricity self-sufficiency, as this
will benefit both parties.
Progress & impacts of Ireland's Sustainable Energy Communities

Rory Geary, Sustainable Energy Authority of Ireland, Ireland
Andrew O'Callaghan, SEAI, Ireland
Joel Franklin, SEAI, Ireland

Panel
5. Sustainable communities

Keywords
sustainable communities, grants, local energy system, socio-economic

Ireland’s Sustainable Energy Community programme (SEC) provides state support, through coordination and grants, for the establishment of community energy groups. The purpose of the sustainable energy community is to build local capacity and knowledge, mobilise local networks, identify concrete steps and take action to improve the sustainability of local energy use.

The programme seeks to guide each community through a Learn, Plan and Do process to encourage deployment of renewable energy and energy efficiency projects at the local level. Since its commencement in 2015, the programme has established a network of over 750 Sustainable Energy Communities (SECs). Ireland’s 2023 Climate Action Plan sets out an objective to utilise Sustainable Energy Communities to drive grant uptake in the built environment.

In this study we examine the patterns behind the establishment of SECs, their progression along the Learn-Plan-Do pathway, and the degree of grant application activity that follows the SEC’s initial establishment.

For the analyses, we use administrative programme data for the SEC network linked to SEAI’s residential energy grants databases, as well as Census and socio-economic data available at Small Area level. Small Areas are Ireland’s smallest statistically defined geographic areas and are constructed to contain an average of 100 households. Given Ireland is divided into over 18,500 Small Areas, the data provide a high resolution to assess the SEC programme.

Logistic regressions are performed to establish important factors influencing SEC formation. Subsequently a difference-in-difference approach is applied to assess the impact of SEC presence on grant activity. Findings suggest that, to date, Sustainable Energy Communities have been more likely to form in rural areas, with slightly older populations, fewer resident children and where local residents are more likely to be employed in the agricultural sector than the general population. We also observe increases in solar PV and home retrofit grant uptake in areas with SECs present, relative to those areas without SECs. The programme also appears to be associated with a decrease in Electric Vehicle grant uptake in the period studied.
Building sufficiency – five measures for an unerring and just transition of the building sector

Patrick Zimmermann, ifeu – Institute for Energy and Environmental Research
Heidelberg gGmbH, Germany
Firdes Firat, BTU Cottbus-Senftenberg, Germany

Panel
5. Sustainable communities

Keywords
sufficiency, energy sufficiency, existing buildings, living space

The building sector phases transformational challenges not only due to its huge negative environmental impacts but also because of injustices and difficulties to provide affordable and liveable housing for the majority. Until now, the focus in planning processes and political discussions to overcome these challenges has clearly been on technical measures like efficiency (thermal insulation) and consistency (renewable energies and materials) as well as classic real estate and housing policy approaches (focus on new construction and social housing subsidies). In contrast, the sufficiency strategy has only played a minor role.

This article aims to define the sufficiency strategy more specifically for the building sector by suggesting five specific building sufficiency measures. First, the prioritization of the use of existing buildings over new construction will be described from an ecological and an economical point of view, with an analysis of the housing potential in existing buildings in Germany. Second, the paper elaborates why per capita living space is a relevant parameter in this context, which should be given more attention in policy instruments as well as urban and building planning. Using Germany as an example, its social and regional distribution is explained. Based on the considerations of the donut economy, a socio-ecological target corridor for the living space per capita in Germany is derived by literature research and statistical or data evaluation. The three other sufficiency measures – mindful user energy behaviour, low tech or robust buildings strategies and adaptability – are briefly explained at the end.

Finally, the article lists possible policy interventions to leverage the potential of sufficiency for a climate-neutral and affordable building stock.
Launching into the unknown: citizen views on citizen participation for municipal hydrogen projects

Sophie Lohmann, IREES GmbH, Germany
Karin Schakib-Ekbatan, IREES, Germany

Panel
5. Sustainable communities

Keywords
citizens, hydrogen, survey, quantitative study, participation, municipalities

Citizens are a crucial stakeholder group for the energy transition, especially in urban communities where residents are more likely to live close to new energy infrastructure. Hydrogen presents a special case here: In contrast to PV or wind turbines, the public has so far had nearly no exposure to or experience with hydrogen technologies. Knowledge is therefore low and it is unclear how this affects willingness to participate as citizen stakeholders.

To answer this question, a pre-registered random mailing survey was conducted in three German cities in which green hydrogen projects are currently being planned or built. It assessed citizen knowledge about green hydrogen, willingness to engage in citizen participation, and local acceptance of hydrogen infrastructure projects (electrolyzers, refueling stations, and/or pipelines, depending on city). The data are based on a mixed-mode (online/paper) sample with mailing addresses randomly drawn from municipal registers. N = 166 residents from the three cities make up the final sample. On average, they were M = 47.52, SD = 17.89 years old and 54% male. Unless indicated otherwise, all items were measured on 5-point scales.

As expected, nearly everyone (99.9%, or all but two people) had heard of hydrogen, but few had in-depth knowledge, M = 2.96, SD = 0.89. Surprisingly, level of education was unrelated to how much respondents knew about hydrogen – the only demographic predictor was gender such that men reported knowing more about hydrogen than women did.

Most people had not yet heard about the hydrogen project in their city, although this differed by how advanced the project in their city was (12%, 25%, and 60% had heard about it, depending on city). This low project awareness is perhaps why people thought citizen participation was only of medium importance for this hydrogen project, M = 3.72, SD = 1.10. If citizen participation events were offered in the future, 60% said they would be willing to participate. This intention was unrelated to how attached they felt to their community or how long they had lived in town and did not differ across the three cities.
Local acceptance was medium-high, M = 3.88, SD = 0.92, with 77% of respondents approving or strongly approving of the project. Respondents indicated not only how much they accepted the project, but also the extent toward which their answer would change under different circumstances (conditional acceptance). Using gray instead of green hydrogen was by far the most unpopular option: 77% of respondents indicated that their acceptance would decrease under those circumstances. Other conditions that would decrease acceptance were increased land use of the project or if hydrogen had to be transported on the roads using trucks. In contrast, acceptance would increase with various forms of participation: The strongest increases were associated with financial participation (48% indicated that their acceptance would increase if profits partially went into the municipal budget for social projects; 41% if profits were partially paid out to the citizens themselves). Non-financial, deliberative citizen participation in the form of consultations or co-decision-making would also increase acceptance, though to a lesser extent (31% said their acceptance would increase).

This project offers a snapshot of citizen views about hydrogen at the onset of the hydrogen economy: We collected the perspectives of citizens who overall know little about hydrogen and are often unaware of relevant projects in their hometown, but are already or will soon be affected by hydrogen developments in their region. There was a general willingness to accept local hydrogen projects, but this acceptance is conditional: Most importantly, hydrogen must be produced using renewable energy only and citizens, the municipality, or both have to be involved in the project through financial and/or deliberative participation to increase acceptability.
Barriers and drivers in local and regional sustainable energy actions: a review and empirical investigation

Danai Sofia Exintaveloni, University of Piraeus Research Center (UPRC), Greece
Alexandros Flamos, Department of Industrial Management and Technology, University of Piraeus

Panel
5. Sustainable communities

Keywords
barriers, drivers, local authorities, regional authorities, Sustainable Energy & Action Plan (SECAP), Sustainable Energy & Action Plan (SECAP)

Although the role of local and regional authorities is increasingly identified as crucial towards a successful energy transition, these bodies often face significant challenges that hinder the implementation of local sustainable energy actions. At the same time, several strengths and opportunities in the general context could be exploited to overcome the obstacles, support and enhance implementation. Existing studies perform mostly qualitative assessments of these barriers and drivers and/or only for specific sectors and regions each time. Thus, an overall quantitative analysis across multiple counties and sectors is lacking in the literature.

The present study aims to fill this gap by employing a novel framework that uses two indices, namely (i) the frequency of existence and (ii) the level of importance to empirically investigating the factors affecting the implementation of energy efficiency and sustainable actions in public and private buildings, public lighting, transport and cross-sectoral areas across the EU.

Through a literature review, 50 initial factors that can affect the implementation of local and regional actions were identified and grouped into 6 broad categories namely, (i) economic and financial factors, (ii) knowledge and informational factors, (iii) social, cultural and behavioural factors, (iv) policy and regulatory factors, (v) institutional/organisational factors and finally and (vi) technical and technological factors. Following, the empirical assessment builds on a dedicated questionnaire that was distributed to local and regional authorities’ representatives and aimed to collect feedback from a large number of actors who are engaged in the planning and implementation of local sustainable energy projects. The survey investigates additional aspects of each city’s context including questions on population, existence of a Sustainable Energy & Action Plan (SECAP) or equivalent plan, the history of the authority with implementation of relevant projects and decision-making processes in place.

The current analysis, taking input from 84 responses, indicates the high energy prices, the
anticipated energy and cost savings and the municipality prioritising sustainability and energy efficiency actions as crucial drivers for the implementation. The most significant barriers include the lack of funding and access to funding sources, the high initial investment and long payback period and the bureaucracy linked with such activities. The outcome of this research aims to facilitate policymakers to better understand the implementation barriers as well as the enabling conditions for the successful materialization of local and regional projects.
Imagining a sustainable future within planetary boundaries: a multi-layered research-by-design investigation

Griet Verbeeck, Hasselt University, Belgium  
Elke Knapen, Hasselt University, Belgium  
Rafael Novais Passarelli, Hasselt University, Belgium

Panel  
5. Sustainable communities

Keywords  
research, education, role of envisioning, planetary boundaries, design, design process, collaboration

To keep our future liveable, we need to evolve to a society that respects the planetary boundaries, while offering a good life for all. Yet, we see more often doom scenarios of a future where we fail than imaginations of a future where we succeed. Therefore, in an ongoing research project, we investigate how we can envision a radical and positive future and what the impact of this envisioning can be. The research setting is a collaboration of a Research Seminar and a Design Studio in a master of architecture, and we work with students who are enrolled in both courses simultaneously. In a yearly recurrent research-by-design experiment, the students investigate and imagine, each year for a different site, how a local community could look like that allows all members to flourish, while respecting the planetary boundaries. So, a set of future scenarios is built up that enables conversations with local communities on radical and positive futures.

The research creates data and knowledge in an iterative way year after year and has multiple layers: 1) the research by the students (each year a new group), diving into the challenges of living within planetary boundaries and investigating through design what a radical and positive future could possibly look like for a specific site; 2) the research by the tutor-researcher from the Research Seminar on a) how to guide and support the students in this process to maximize the outcome, and b) a critical analysis of the quality of the design outcome in view of the goal of a future within planetary boundaries; 3) the research on the impact of the collaboration between both courses to enhance the academic quality and academic outcome of both, and 4) the research on the impact of envisioning a radical and positive future on the knowledge and attitude of students and of local communities towards a sustainable future and their role in it.

This contribution will present the outcome of the first iteration and the lessons learned so far.
Factors affecting Norwegian households' adaptive energy performance upgrades in response to the energy crisis

Yechennan Peng, Norwegian University of Science and Technology, Norway
Christian Klöckner, Norwegian University of Science and Technology, Norway

Panel
5. Sustainable communities

Keywords
solar energy, households, retrofit, flexible energy use, energy-efficient upgrades

Energy performance upgrading behaviours in relation to buildings are crucial in mitigating carbon emissions. The related concept of "building energy performance improvement" is typically associated with building retrofits or investments in energy-efficient appliances. Determinants of flexible energy use adoption and installation of private photovoltaic (PV) panels are understudied in the Norwegian context.

The objective of this paper is to identify the key socio-demographic, dwelling, household contextual, and psychological factors that have a significant impact on household energy efficiency behaviours in different categories, including private PV installation, flexible electricity use, and dwelling energy efficiency upgrading. This study applied household-based survey data collected in 2023 from Norway and employed repeated measures ANOVAs and the Lasso regression model.

The findings indicate a substantial increase in household energy efficiency behaviours over the past three years, with the anticipated tripling of households for private PV adoption and doubling for flexible energy use for the next three years. After the energy crisis, the substantial increase in electricity prices significantly amplifies households' intentions to adopt PV systems, and the household's commitment to supporting the energy system serves as a motivational factor for respondents to participate in flexible energy use.
A new area-based mapping approach to examine the heat pump suitability and readiness of UK dwellings

Rajat Gupta, Oxford Brookes University, United Kingdom
Chenfei Liu, Oxford Brookes University, United Kingdom
Matt Gregg, Oxford Brookes University, United Kingdom

Panel
5. Sustainable communities

Keywords
local and regional energy planning, heat pump, dwellings, community

Heat pumps are critical for meeting the UK’s legally binding commitment to achieve net zero by 2050. An area-based approach that can target appropriate homes is necessary for the rapid deployment of heat pumps at scale. This paper describes the application of an online and interactive local area energy mapping tool (LEMAP) to assess air source heat pump (ASHP) suitability for 865 dwellings in a suburban area of Oxford, UK. The tool brings together GIS based spatial data on energy, buildings, socio-demographics, tenure, fuel poverty and electricity networks to (1) identify the baseline current energy demand, (2) target dwellings that are heat pump suitable but require adequate insulation and support (3) target dwellings that are heat pump ready.

The suitability and readiness elements of the ‘targeting’ approach required versatile data that included building footprints from the Ordnance Survey, Energy Performance Certificates (EPC) and socio-demographics (Experian Mosaic). Heat Pump Suitable dwellings were regarded as dwellings that required current levels of insulation to be improved adequately, while Heat Pump Ready dwellings had current good levels of insulation (>EPC rating D). About 483 of the total 865 dwellings were considered suitable (56 % of the target area), of which 432 were considered Heat Pump Ready. Ten dwellings were targeted as ‘priority’ among the Heat Pump Suitable dwellings since they used electricity for heating. The suitable dwellings comprised owner occupied and social housing. They were located in two secondary substation areas with grid loading of 40–60 %. Fuel poverty was prevalent and digital capability was low, raising concerns about the rollout of smart energy technologies without adequate education and training. The findings helped to customise the offering and financial incentives for heat pump deployment, combining fabric improvements for Heat Pump Suitable and rapid deployment for Heat Pump Ready dwellings along with resident engagement.
Positive Energy Neighbourhoods as drivers of local energy transitions

Emily Bankert, BPIE -Buildings Performance Institute Europe, Belgium
Victoria Taranu, BPIE

Panel
5. Sustainable communities

Keywords

Positive Energy Neighbourhoods (PENs) are an innovative policy concept to reimaging traditionally supply-side focused local energy initiatives. They integrate sufficiency design principles and deep renovation to reduce demand alongside collective production and storage of renewable energy adjusted to the local context. Municipalities can achieve renovation and climate targets by engaging key stakeholders to adjust technical, social and financial solutions to each neighbourhood. However, demo projects from the oPEN Lab Horizon 2020 project show that PEN projects’ potential is limited by regulatory and financial barriers.

This study employed a combination of policy analysis, desk research and focus groups with key enablers of oPEN Living Labs located in Belgium, Spain and Estonia, such as public authorities, business developers, architects and social housing associations. Key regulatory gaps and barriers, as well as best practices, were identified in national, regional and local policies. The lessons learnt from the implementation of the 2018 Energy Performance in Buildings Directive (EPBD), Renewable Energy Directive (RED) II and Electricity Directive (EMD) can inform the upcoming transposition of the ‘Fit for 55’ package in Member States. The goal is to establish a PEN-friendly policy framework to reap the full potential of neighbourhood and participatory approaches in building renovation policies.

Findings show policy efforts towards energy efficiency and renewable energy at the building scale but fall short in enabling and facilitating neighbours to collectively renovate and harness of benefits of collective energy production and storage of renewable energy. Limited transposition of REDII and EMD disincentivises the monetisation of renewable energy and flexibility services and jeopardises PEN business models. Also, regulations or incentives to adopt a whole life carbon perspective in renovations are currently absent from the established policy landscape. Going forward, these results will inform tailored policy recommendations across Member States, empowering citizens to collectively contribute to the complex but urgent energy transition ahead.
From vision to reality – integrating energy goals in the development of a new urban district in Sweden

Alexandra Calvén, Lund University, Department of Energy Sciences, Sweden
Janneke van der Leer, Chalmers University of Technology, Department of Architecture and Civil Engineering, Sweden
Kerstin Sernhed, Lund University, Department of Energy Sciences, Sweden
Wiktoria Glad, Linköping University, Department of Thematic Studies, Sweden

Panel
5. Sustainable communities

Keywords
urban planning, energy performance, developers, district heating, urban areas, renewable energy, instruments, energy goals, goal translation

Urban areas play an important role in attaining the sustainability and energy goals set by municipalities. Despite the often ambitious sustainability visions and goals for new urban areas, there is limited understanding of how these aspirations are integrated into the planning and development process. This paper aims to provide insights into how energy-related visions and goals, in a new district in Sweden, are formulated and further translated into instruments employed by the municipality. Brunnhög, a new sustainability-profiled district in Lund envisioned to become a leading example of sustainable urban development, is used as a case study. The district’s long-term energy goal is to generate more energy than what is used, emphasizing a strong focus on energy efficiency and local renewable energy generation. Key to Brunnhög’s energy strategy is the implementation of the world’s largest low-temperature district heating network supplied with excess heat from two high-tech research facilities. The planning process for Brunnhög began in 2006 and the district is expected to be completed in 2055, accommodating an estimated 40,000 residents and workers.

Adopting a municipal planning perspective, this paper combines analysis of planning documents with interviews conducted with developers and the municipality’s project manager for Brunnhög. The results provide an overview of how the energy-related visions and goals for Brunnhög have been included in the planning documents for the district and describe the utilization of three instruments used by the municipality to achieve these visions and goals: (1) collaboration contract with the local energy company, (2) land allocation competitions, and (3) sustainability agreements with the developers.

The formulation of visions and goals for Brunnhög, divided into long-term visionary goals and more immediate operational goals, allows for adjustments of specific aspects based on changing circumstances while still maintaining a commitment to broader visions and goals. The
Translation of energy goals into commitments is an evolving process, with the level of ambition influenced by factors such as the demand for housing and office space, competition among developers, and prevailing sustainability trends. This paper concludes that the integration of sustainability criteria into land allocation competitions is a powerful instrument for driving ambitious building projects. However, in contexts where the municipality lacks ownership of the land or faces subdued market conditions, there is a need for additional tools to be developed. Furthermore, sustainability agreements with developers serve as an important tool to track the sustainability commitments made in land allocation competitions. However, implementing a more systematic review and evaluation of these agreements, including long-term assessments, is necessary to learn from the experiences and hold the actors accountable. The findings of this study contribute to a better understanding of how energy goals can be sustained throughout lengthy urban development processes. Insights gained from development processes such as Brunnshög are essential for implementing the necessary changes to decrease the climate impact of new urban development projects and to mainstream the practices of sustainable urban development.
Exergy communities – analyzing energy quality losses in local energy system solutions

Magnus Åberg, Uppsala universitet, institutionen för samhällsbyggnad och industriell teknik, Sweden
David Lingfors

Panel
5. Sustainable communities

Keywords
community energy systems, exergy analysis, resources

City-district energy system solutions in the shape of energy communities are promoted for increased local self-sufficiency and self-consumption, for example by the EU through the Clean Energy for all Europeans Package. However, there is currently a lack of methods for evaluating the matching of district-level energy supply and demand that takes the energy quality (i.e., the exergy) into account. Such methods are needed to identify and avoid unnecessary energy quality losses in local system solutions in order to increase overall resource utilization efficiency. There is a risk that energy systems adapted to city-district level will lead to a one-sided focus on electricity in general, and PV-production in particular, due to this technology’s relative non-dependence on scale for efficiency. This, in turn, risks bringing about electrification that displaces both energy efficiency measures and efficient use of low-value energy resources, such as waste heat or waste-based district heating, and thus reduces the overall resource efficiency. It is in this context that this project fulfils its main purpose.

In the project, an analytical method is designed and applied that enables adequate evaluation of resource utilization, partly by defining a measure of exergy matching that enables adequate analyses of integrating thermal systems with electrical systems in residential areas, neighbourhoods or individual buildings. Results are presented for self-sufficiency and self-consumption of locally produced solar electricity, together with exergy efficiency for a residential area with different types of local energy system solutions.
Empowering communities: assessing the viability of community-based demand-side management (CBDSM) in the renewable energy transition of Burkina Faso and Sudan

József Kádár, Hungary
Marine Cornelis, Next Energy Consumer, Italy
Omad Abdelshakour, Arava Institute for Environmental Science, Israel

Panel
5. Sustainable communities

Keywords
energy transition, demand side management (DSM), sustainable communities, Africa, bottom-up initiative, consumption dynamics

The energy landscapes of Burkina Faso and Sudan face similar challenges, such as limited access to energy and growing electricity demand. This paper explores the potential and challenges of community-based demand-side management (CBDSM) as an innovative solution to empowering Burkina Faso and Sudan communities.

Burkina Faso and Sudan share common energy access challenges, as most of their populations live in rural and underdeveloped areas. Many of Burkina Faso's residents lack access to clean and reliable electricity. Likewise, Sudan faces energy challenges from rapid urbanization and the need for expanded electricity access. The success of implementing CBDSM in Burkina Faso and Sudan depends highly on addressing the socio-economic aspect of energy use.

Community engagement and participation are crucial elements that foster a sense of ownership and responsibility among residents. Previous research shows that the CBDSM can effectively reduce overall energy consumption, optimize peak demand, enhance energy supply reliability, and promote energy transition in marginal communities in developed and developing countries such as Burkina Faso and Sudan. Despite the potential benefits, challenges persist, including the need for policy frameworks that support community-driven initiatives, technical investments, and capacity building at the local level. The successful implementation of the integration of CBDSM in Burkina Faso and Sudan requires collaboration involving governments, local communities, and international stakeholders.
In conclusion, CBDSM is a promising solution to address energy challenges in Burkina Faso and Sudan. By actively empowering communities to manage their energy demand, these nations can enhance energy security, optimize resource use, and tackle climate change using renewable energy sources. Community microgrids are essential to the energy transition, offering a comprehensive and community-focused approach to renewable energy production.
Approaching grid-interactive and energy efficient affordable housing in India through a living lab setup

Saket Sarraf, ps Collective, India
Ruchi Kapoor, ps Collective, India
Shravya Reddy, Regulatory Assistance Project, South Africa
Cesar Alejandro Hernandez Alva, Regulatory Assistance Project, USA
Craig Burton, Global Building Performance Network, Australia

Panel
5. Sustainable communities

Keywords
affordability, Demand flexibility, demand side management (DSM), grid interactivity, carbon-neutral housing

Problem
Traditionally, carbon emission reduction efforts have focused on optimizing specific systems like transportation or buildings, overlooking the benefits of simultaneously optimizing multiple systems. This paper explores synergies in co-optimizing India's electric grid and affordable housing. It addresses challenges such as grid stability, clean energy adoption, and increasing energy demands due to economic mobility and climate events.

Co-optimization not only advances decarbonization but also promotes social equity and incentivizes investment in a cleaner future. While our paper focuses on grid-side interventions, our project aims for simultaneous decarbonization of both buildings and the power grid.

Approach and benefits
India's plan to construct millions of affordable housing presents a unique opportunity for scaling up grid-interactive, energy-efficient buildings. We analyze the effects of integrating Energy-Efficient appliances, Battery Energy Storage Systems (BESS), Demand Flexibility (DF), and Distributed Energy Resources (DERs) in affordable housing through modeling. By 2030, our assessment shows significant reductions in peak demand (up to 64%) in affordable housing, achieved through EE (24%), BESS (10%), and DF (30%) measures.

These reductions lead to cost savings for DisComs in upstream costs like transmission charges, future energy capacity charges, and total power procurement costs, compensating for revenue loss from reduced energy consumption. Additional benefits include enhanced resilience, increased renewable adoption while maintaining grid instability, and improved resilience against extreme events.
Living lab setup
The model findings are being leveraged to engage policymakers in establishing a "Living Laboratory" (or living lab) for affordable housing in three Indian cities, aimed at showcasing these advantages. The living labs will serve as a collaboratively developed, shared platform for problem-solving and risk mitigation, benefiting all stakeholders. This inclusive process will span multiple years of occupancy to ensure thorough understanding, acceptance, measurement, and documentation of innovation outcomes.

Possible policy instruments for implementation
We aim to utilize the living lab setup to facilitate the implementation of the following policy interventions for widespread decarbonization:

(a) Development of regulatory frameworks to enact policies and regulations incentivizing the adoption of grid-interactive building technologies and practices. This could entail establishing energy efficiency standards, mandating grid-interactive capabilities in new constructions or major renovations, and streamlining permitting processes.

(b) Implementation of financial incentives, such as tax credits, grants, or rebates, to offset upfront costs associated with grid-interactive technologies and promote their adoption.

(c) Revision of building codes to incorporate grid-interactive capabilities, mainstreaming these technologies and practices within the construction industry. This might involve integrating smart meters, energy storage systems, and demand response capabilities into building codes and standards.

Benefits
The residents gain from lower energy costs and reliable, clean energy. DisComs benefit from reduced investments, improved finances, and less cross-subsidization. This enables integrating more renewable energy with reduced reliance on large-scale storage. The living lab setup fosters public awareness, aids market transition, and utilizes government-supported housing projects to promote grid interactivity. This stimulates research, innovation, and accelerates decarbonization efforts in India.

Acknowledgements
This initiative is done in collaboration with RAP and GBPN and with active participation from local DisComs, policymakers, residents, NGOs, academic institutions, vendors, real estate developers, and regulators.
Approaching sufficiency measure integration in sustainability assessment of neighbourhoods

Annika Hock, BBSR - Federal Institute for Research on Building, Urban Affairs and Spatial Development, Germany

Panel
5. Sustainable communities

Keywords
sufficiency, neighbourhood, sustainability assessment, indicators

For the built environment, sustainability targets aim towards renewable energy supply and energy renovation strategies, combining efficiency and consistency measures. The sustainability strategy of sufficiency, with its perspective of enabling and promoting changes in societal practices towards an absolute reduction of consumption appears to be necessary, but is underrepresented in sustainability measures and policies. Further, the environmental impact of the built environment in form of energy, material and land consumption is not limited to CO2-emissions and equivalents; also, it includes not only buildings, but their surrounding infrastructure, as i.e. regenerative energy supply and sustainable mobility depend on synergies and interactions at the neighbourhood scale.

Sustainability Assessment (SA) offers a tool to holistically approach impacts in terms of ecological, economic as well as socio-cultural dimensions. Thereby, SA of buildings is already widely spread, the assessment of a buildings broader spatial impact in a neighbourhood perspective, as well as concerning planetary boundaries, however, is inconsistent. To develop measurable sufficiency criteria for the built environment, this investigation approaches sufficiency for buildings and their spatial relation by outlining relevant parameters based on a semi systematic literature review. Further, a synoptic analysis is approached to understand present sufficiency representation in existing neighbourhood SA (NSA) systems.

Eight sufficiency-parameter are outlined which offer a framework to depict sufficiency related indicators in neighbourhood assessment. A table overview presents categorized quantitative and qualitative indicators. Additionally, the overall valuation percentage of outlined parameter is summarized. The findings provide a fundamental understanding of sufficiency barriers and carriers in neighbourhood sufficiency assessment (NSA) and constitute the basis to determine sufficiency indicators in a next research step.
Quantifying multiple benefits of sustainable plus energy neighbourhoods for investment and policy decision-making

Victoria Taranu, Buildings Performance Institute (BPIE), Belgium
Victoria Taranu, BPIE, Belgium
Zuhaib Sheikh, BPIE, Germany
Sriraj Gokarakonda, BPIE, Germany

Panel
5. Sustainable communities

Keywords
multiple benefits, cost benefit, ESG finance, positive energy neighbourhoods

Sustainable plus-energy neighbourhood (SPEN) is an innovative concept of decarbonising the building stock which is being tested within the Horizon 2020 project syn.ikia. The neighbourhood approach considers the interaction of the building with the urban infrastructure.

The four syn.ikia demo projects deploy sufficiency design measures, such as shared spaces, assets and services (e.g. RES, HVACs, heat and electricity storage). SPENs aim for high energy efficiency to reduce energy demand and achieve a positive energy balance at the neighbourhood scale. SPENs require additional investments compared to business-as-usual (BAU) projects, however, they also provide multiple added social, economic and environmental benefits.

At a societal level, they contribute to lower GHG emissions, leading to lower mortality and morbidity rates. Improved accessibility to public and cycling infrastructure contributes to physical and mental health, as well as inclusion and affordability.

At an individual level, improved IEQ yields health and productivity benefits for the dwellers. Such projects rely heavily on public funding; to scale up SPEN to the private residential sector, therefore, there is an increased need to access private funding.

The EU Taxonomy and ESG Finance encourage sustainable investments in real estate. Investors, asset managers and policymakers need evidence-based and commonly accepted methodologies to assess ESG aspects of projects. MBx tool, developed within syn.ikia project, is a step forward in quantifying and monetising the social welfare, micro-economic and environmental benefits of projects, by considering the added values of the SPEN approach.
This decision-making tool for policymakers and investors uses Social Cost-Benefit Analysis method to compare the benefit-cost ratio and return-on-investment of SPEN against that of BAU. MBx tool can help investors identify ESG investment opportunities and future-proof real estate assets.
Conceptualisations of energy and stakeholder expectations of households in an energy community

Sofie Nyström, KTH Royal Institute of Technology, Sweden
Cecilia Katzeff, KTH Royal Institute of Technology, Sweden
Miriam Börjesson Rivera, Uppsala University, Sweden

Panel
5. Sustainable communities

Keywords
community, households, stakeholder expectations, energy community

Energy communities (EC) have been suggested by the EU as a way of making a clean energy transition by increasing the production of renewable energy while also empowering citizens to participate in their local energy system. This is seen as a critical step in decentralizing the energy system in a democratic way, treating households as energy citizens rather than consumers. The concept can be realized in many different forms such as local organisations, and cooperatives. In Europe, there are examples of energy communities where energy is locally produced, shared, stored, and consumed. In Sweden the number of such ECs is still small, mainly due to unclear legal requirements. Sweden has historically been privileged with an abundance of centrally produced inexpensive electricity from hydro and nuclear power. The power grid is owned by municipal or national companies, where the role of citizens is to be a passive end point, which purchases (and sometimes sells) electricity. This leads to a centralized perspective of electricity where citizens are stuck in the position of individual consumers, rather than part of a collective participating in the energy system.

Our contribution argues that this established framing of households may constitute a barrier for the development of energy communities in Sweden. Another potential barrier is treating energy as a commodity rather than an ecological resource or a social necessity. In this contribution, we describe preliminary results from interviews with stakeholders in the formation of energy communities in Sweden, focusing on expectations of households and the conceptualization of energy. Our contribution describes one case in the development of energy communities in Sweden. In this case housing cooperatives (HC) are recruited to form a local energy community through energy efficiency measures and, eventually, expanding to increased local energy production and virtually sharing electricity. Our interview study covers stakeholders that were part of initiating and forming the energy community, from early planning stages to practical implementation.

We see two examples that illustrate the ambiguity of how energy is conceptualized and the role of households in the EC. First, we observe a conflict between environmental and economic
values. The EC is on the one hand argued to be an important step towards breaking the dependence on fossil fuels by providing local renewable forms of energy, mainly from PV panels and geothermal heating pumps. Stakeholders also describe how their own engagement with the EC stems from climate anxiety. This indicates that energy is primarily viewed as an ecological resource requiring careful conservation.

However, when describing the practical implementations of the energy community and the reasons for joining it, economic reasons dominate the reasoning such as participating in local flexibility markets and saving money. Our second finding is that agency is shifted from a citizen level to housing cooperatives and their representatives. For instance, housing cooperatives have made decisions regarding the timing of EV charging without prior information to residents. Representatives of the EC emphasise that the structure is one of ‘representative democracy’ where people assigned as ‘energy responsible’ are mandated by HCs to make decisions on behalf of their buildings, for example to decide when electric loads such as heating pumps and ventilation can be shut off between certain hours.

The general principle seems to be that being part of an EC is not supposed to affect households in any way, their role is mainly a passive one not to be disturbed. To conclude, the observed case represents a form of semi-decentralised EC where middle-out actors such as housing cooperatives are the decision makers on behalf of individual consumers. Different framings of energy carry different weight, where energy as a commodity continues to be the dominant representation.
Demand flexibility potential in agriculture

Marta Lopes, INESC Coimbra, IPC-ESAC, Portugal
Ana Soares, INESCC, Univ. Coimbra, Portugal
Carlos Henggeoler Antunes, INESCC, Univ. Coimbra, Portugal
Raquel Miranda, INESCC, Portugal
Pena João, INESCC, Portugal

Panel
5. Sustainable communities

Keywords
demand response, agriculture, flexibility, energy transition

The energy transition involves the widespread deployment of low-carbon technologies, particularly decentralized renewable energy sources, which requires enhanced grid flexibility to accommodate variable production considering demand patterns, while ensuring cost-efficiency. Traditionally, flexibility in the energy system has primarily relied on supply-side resources. However, given the variability associated with renewable energy sources, it is crucial to explore new sources of flexibility from the demand-side by making the most of the adaptive nature of some types of consumption. The agricultural sector possesses valuable flexibility resources such as water and heat pumps, water tank towers, on-site generation from renewable sources, and electrical storage (including static batteries and electric vehicles).

For instance, the irrigation flexibility potential in California has been estimated to reach 850 GWh yearly. Demand-side management programs in agriculture have had limited success so far because they have not considered adequately the unique constraints of farming activities while aligning with the grid requirements. In Portugal, energy flexibility pilots have only been implemented in energy intensive industries and in the residential sector.

This work aims to present the flexibility potential for the agriculture sector, namely in energy intensive activities such as intensive horticulture and fruit farming, considering the technical potential, productive and organizational restrictions and behavioural preferences. The flexibility potential is assessed through load profiles captured using energy audit techniques in real-production contexts, which is validated through semi-structured interviews performed to farmers, while capturing drivers and barriers. Additionally, a review of the regulatory framework is provided and recommendations for the design of demand response policies derived.
Using transformative experiences to spur reflections on our role in the eco-system: a proof of concept

Erica Löfström, Norwegian University of Science and Technology, NTNU, Norway

Panel
5. Sustainable communities

Keywords
visualisation, sustainable communities, case studies, workshop, qualitative study

In the Anthropocene era, studies have underscored the health benefits of spending time in nature. This is particularly crucial for children, as frequent engagement with the natural world often cultivates a lifelong environmental conscience. However, opportunities for such interactions are diminishing, raising concerns for both individual well-being and the nurturing of environmental mindfulness in upcoming generations. The prevailing discussion emphasizes the urgency of strengthening our connection with nature, but this viewpoint still largely treats nature as a resource for human benefit. We believe that this human-centered perspective needs reevaluation, and that a major shift of our understanding of the earths ecosystem and our role in it may be necessary. We're pushing for a change in thinking – to see nature as something more than just a way for us to feel better. Our long-term goal is to contribute to helping people develop a deep care and understanding for all parts of the ecosystem and, thus, contribute to the much needed major transition to a society where humans successfully can coexist with nature as part of sustainable communities.

With the ambition to not only evoke emotional resonance with nature, but to also use this as a starting point for collective reflections and joint co-creation of a more sustainable future, we endeavor into a transformative approach. As a first step, we carried out two explorative reflection workshops with different stakeholders: one in a rural setting and one in an urban one. With the aim to convey ecological insights in a manner that resonates not merely with the mind but engages the "heart", we used different transformative experiences (disruptive eco-visualisations) as interventions with the intent to evoke an emotional response amongst the workshop participants. This emotional response was used as a starting point for reflections on our current and potential future role as humans in the eco-system. The results helped us to create a Proof of Concept (PoC).
Heat transition cooperatives: a promising implementation model to decarbonise urban districts

Klemens Leutgöb, e7 Energie Markt Analyse GmbH, Austria
Mirjana Wissinger, e7 GmbH, Austria
Rachel Leutgöb, e7 GmbH, Austria
Winfried Braumann, REENAG Holding GmbH, Austria
Gernot Tscherteu, realitylab GmbH, Austria
Ella Jollands, e7 GmbH, Austria

Panel
5. Sustainable communities

Keywords
building stock, urban areas, decarbonisation, cooperatives, implementation, demonstration buildings, financing, housing laws

The replacement of decentral gas floor heating systems in the urban building stock poses a serious challenge for a decarbonised heat supply in Europe. For example, in Vienna almost 30% of all flats are supplied by decentral gas floor heating systems and alternatives are rare and expensive.

The available alternatives generally consist of transferring to a central low-temperature heat supply, heat pumps with deep drilling, adaptation of the distribution system and (partial) improvement of the building envelope. Due to restrictions on space in urban areas, solutions for individual buildings are often impossible, so cross-property approaches must be developed, which are also more cost-effective due to economies of scale. However, cross-property projects require a collaborative organisation to jointly implement the capital-intensive investments and manage the operation of the systems.

Against this background, the paper demonstrates that cooperatives are a promising implementation model to coordinate and balance different legal frameworks, financing conditions and interests that challenge the implementation of cross-property projects.

The paper is based on the experience gathered from very different demonstration projects in Vienna, including: Multifamily building from the Gründerzeit period, whose central heat pump solution will also supply the two neighbouring single-family houses; a joint decarbonised heat supply for neighbouring multifamily buildings constructed in the sixties, consisting of both condominium and cooperative buildings; and a suburban residential buildings cluster, including historic buildings.
From the demo experience, generic principles are derived for how cooperatives shall be established and organised to manage the financing of the decarbonisation investment, create clear responsibilities for the ongoing operation of the facility, and to meet the various requirements of private and housing laws.
Energy citizenship and staying within the 1.5-degree limit. The contribution of energy citizenship to a just and within-limits Europe

Edina Vadovics, GreenDependent Institute, Hungary
Anita Szőllőssy, GreenDependent Institute, Hungary
Frances Fahy, University of Galway, Ireland
Rasa Ikstena, University of Latvia, Latvia

Panel
5. Sustainable communities

Keywords
energy citizens, sustainable communities, energy system transformation, carbon limit and energy justice, sustainability

In order to transform the energy system into one that is just and within ecological limits, all stakeholders, among them citizens, need to be activated. The objective of the European research project, EnergyPROSPECTS, has been to develop a comprehensive understanding of the conditions conducive to active energy citizenship (ENCI). To do this, we defined ENCI rather broadly allowing for diverse forms to be considered as “Energy citizenship refers to forms of civic involvement that pertain to the development of a more sustainable and democratic energy system. Beyond its manifest forms, ENCI also comprises various latent forms: It is an ideal that can be lived up to and realised to varying degrees, according to different framework conditions and states of empowerment.” (Pel et al. 2021).

Then, we mapped the diversity of ENCI in Europe, and created a database of 596 cases. In a further research step, 40 of the mapped cases were selected for more detailed, multi-foci studies of ENCI characteristics and supportive conditions. Among these, we explored whether, and to what extent ENCI cases connect the social and environmental dimensions of sustainability, and how these are manifested in their objectives and operations. Our exploratory study is based on both the desk-based research of the 596 cases as the initial identification of main issues, and the in-depth, mixed methods study of the 40 cases. We looked at the level of energy democracy, citizen power and equity/justice apparent in the cases for the social dimension; and the level of environmental sustainability and recognition of the carbon limit for the environmental. (Vadovics & Szőllőssy 2024).

In our presentation, following the introduction of ENCI and our methodology, we describe the four clusters we created based on how these five aspects are treated in the cases: one where high levels of consideration are given to both the environmental and social dimension, one
each with high level of consideration for either the environmental or the social dimension, and one where none are given a high level of consideration. We illustrate all with case examples from different European countries, including an analysis of how the five aspects are manifested in the objectives and operations of the cases.

Building both on the literature and our study, we present the notion of sustainability-driven energy citizenship developed as a result of our study, and compare it to socially and environmentally-driven ENCI as well as ENCI that has more moderate sustainability goals. We also show that based on our outcomes, there appears to be a discrepancy in how cases understand environmental sustainability and the carbon limit.

Finally, we draw conclusions as to the current and potential role of ENCI in the just and within-limits energy transition, and how the connection between these two aspects could be enhanced. To conclude, we reflect on how our findings could inform policy making for a sustainable energy system.


Acknowledgements
We would like to thank the EnergyPROSPECTS consortium partners for contributing to the development of the research methodology, and case researchers for collecting cases data and contributing to case analysis.

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An Eye-Catcher for more effective and inclusive resident participation in the heat transition

Renee Kooger, TNO Energy Transition Studies, The Netherlands
Nicole de Koning, TNO
Cyril Tjahja, Vrije Universiteit Amsterdam

Panel
5. Sustainable communities

Keywords
data collection, Inclusive, heat transition

Different kinds of participation methods are used to involve residents in municipal heat transition plans. An important conclusion of a recent European study on existing participation tools and methods, is that participation tools often ignore the question of how residents themselves would like to be involved. Existing participation tools often make assumptions to what extent and in which manner residents want to provide their input. This does not always correspond to the way in which residents actually want to be involved. This can create a mismatch between the needs of residents and the efforts of a municipality to get residents involved. Previous research by TNO concluded that many municipalities have (very) few resources (time, money and capacity) to devote to resident participation. Moreover, some groups of residents (e.g. residents who experience a language barrier, young families and youths) are often not reached by more traditional research methods like in-depth interviews or questionnaires.

In order to effectively use existing resources for resident participation by municipalities, it is important that they are tailored to the participation needs of a diverse group of residents. Desk research and focus groups with experts on resident participation confirmed that there is currently no instrument which municipalities can use to determine if, to what extent and in what way different types of residents want to be involved in the heat transition. TNO has therefore developed a practical and creative tool called the “Blikvanger” (Eye-catcher). This is a tailor-made wooden object which can be placed in proximity of the target group (at a school, mosque, grocery store etc.).

The tool uses several interactive objects such as selecting smileys and placing magnets to gather information in a fun and different matter. The Eye-catcher has twice been piloted. Once in the municipality of Wierden, were it was used as part of an "energy fun fair". The municipality wanted input of a diverse resident group on the local heat transition plans. The energy fun fair was set up at a busy spot near a shopping center and contained different objects. Besides the Eye-catcher these included e.g. a wheel of fortune were residents could win sustainable prices,
a smoothie bike were residents could cycle and produce a smoothie at the same time, activities for young children like drawing and face painting. Residents would be attracted to the different fun elements of the energy fun fair and could be approached to answer the questions on the Eye-Catcher. These included different questions which were drafted together with the municipality. 1) how do you feel about transitioning towards a more sustainable home? Residents would select a smiley ranging from a (very) unhappy smiley to a (very) happy smiley.

Residents were asked to elaborate on their choice. 2) What do you need for this transition? Residents could then flip different signs with suggestions like: financial support, communication and knowledge/advice. 3) what do you want to do together with other residents and the municipality? Here residents could place a green or red magnet at the different answering options e.g. "I want to join a fix team", "I want to buy insulation measures with my neighbors". 4) Do you talk to your neighbors/friends about sustainability? And if you do, what topics do you talk about? This was an open question were an answer could be filled in on a piece of whiteboard. Lastly, the residents could leave their 'signature' by placing their hand in a piece of pin art.

All the questions on on the Eye-catcher including the name/title that is featured on the tool can be adapted to the needs of the user of the tool. In a different pilot the Eye-catcher was set up at a conference where the tool was used to gather input from municipalities on a proposed method that TNO was developing. At the ECEEE summer study the tool will be presented and will be used in practice.
Developing a capability approach for place based interventions aiming to catalyse adoption of heat pumps

Nick Banks, ECI Energy Group – Environmental Change Institute, University of Oxford, United Kingdom

Panel
5. Sustainable communities

Keywords
heat pump, community energy systems

Heat pumps are now widely recognized as the critical technology for de-carbonisation of domestic heating in the UK and Europe. Yet the UK remains at the bottom of the European heat pump installation league despite generous grants and policy support. This has prompted government and practitioners to try to develop new approaches to catalyse uptake of the technology including the use of place based approaches which attempt to harness the skills and resources embedded within communities. But these approaches have often been developed without the support of a robust conceptual framework sensitive to the critical attributes of a place influencing whether a heat pump will quickly diffuse through a community or whether it will be rejected or only adopted by a few. These attributes include the combination of economic, technical, social and digital factors possessed by individual households and the attributes of community itself – its social capital and structure, social norms, local planning and governance arrangements. To meet this need, we offer a conceptual framework founded in economist philosopher Amartya Sen’s Capability Approach and then road tested on two major place based projects in the UK each aiming to build smart energy communities. This has lead to: a) further theoretical development of the framework, b) identification and quantitative measurement of indicators of capability using a survey administered in a specific community aiming to install 150 air source heat pumps over the next year, c) development and delivery of engagement strategy and value propositions for smart heat pumps.

The paper presents the conceptual framework, the results of the community survey and critically evaluates the success of an engagement strategy informed by the Capability Approach in catalysing adoption of heat pump technology.
Can x minute neighbourhoods save energy?

Dan van der Horst, University of Edinburgh, United Kingdom
Matthew Lane, University of Edinburgh, United Kingdom

Panel
5. Sustainable communities

Keywords
accessibility, non-motorised traffic (NMT), urban planning, safety, perception

A growing number of cities are embracing the policy concept of x-minute neighbourhood (XMN). At its heart, this is about policies to ensure that key facilities and services are available within easy walking (or cycling, and sometimes public transport too) distance from the homes of citizens. Usually referred to as 10-, 15- or 20-minute neighbourhoods or cities, the concept is less discrete than the use of these numbers might suggest. Indeed, the unit (minutes) is a proxy of physical distance.

The XMN concept predates Covid-19, but the policy interest has grown particularly rapidly during the pandemic when many temporary measures were brought in to improve walking and cycling conditions for local residents. XMN has the potential to reduce emissions by encouraging and enabling people to switch transport mode from driving to walking for the purpose of accessing key services. This could also be seen as a measure of energy efficiency, broadly understood as favouring activities or behaviours that are less energy intensive. I trace how this concept has been promoted by UK policy makers at the sub-national level and the remarkable political backlash it has received through conspiracy theories spread on social media, alongside a pro-car, right-wing narrative.

I then examine the key components of XMN and discuss how this concept is likely to play out in different parts of town and what this might mean for its potential to help improve energy efficiency and reduce greenhouse gas emissions.
Coherence of novel policies for lithium-ion batteries for electric vehicles: A multidimensional analysis of material flows and environmental impacts

Robin Barkhausen, Fraunhofer Institute for Systems and Innovation Research, Germany

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
electric vehicles, life cycle analysis, energy policy, scenario study

The steep increase in electric vehicle sales observed today will lead to large quantities of lithium-ion batteries being retired in the coming decades. Against the background of the new Battery Regulation (EU) 2023/1542 with a stronger focus on resource efficiency aspects, a multi-dimensional analysis was developed to analyse the material flows and environmental impacts of passenger car electric vehicle batteries in the EU-27 for the years 2011 to 2050.

We use a flexible model combining material flow analysis and life cycle assessment, which is suitable for the ex-ante assessment of material flows and environmental impacts of circular economy product policies. The model uses a layered approach where material and environmental impacts are derived from product flows via a product database that defines physical properties for product variants. Our analysis aims to provide valuable insights into the impacts, trade-offs and coherence of novel policies, focusing on the impacts of a recycled content requirement and material-specific minimum recycling efficiencies.

By assessing the market impacts, we aim to contribute to the development of effective policies that promote energy efficiency and resource conservation in the context of battery management. The results of this study can inform decision-making processes and support the transition to a more sustainable and environmentally friendly electric vehicle industry.
The Green Fleet Index: measuring the real rate of the EV transition

Tim Chatterton, RAC Foundation, United Kingdom
Ivo Wengraf, RAC Foundation, United Kingdom

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
decarbonisation, electric vehicles, personal mobility, fleet dynamics, car buying patterns, car transportation

We are becoming used to regular headline statistics about the number of electric vehicles sold each month/year. These are shouted about in the trade as though they are a sensible measure of the speed of the EV transition. However, this figure provides a very limited view of progress when it comes to assessing the environmental impacts of vehicles, not least because ownership matters much less than usage.

Consequently, the RAC Foundation has developed the Green Fleet Index (GFI)[1] – a regularly updated measure, not of new EV sales, or even the proportion of EVs in the UK vehicle parc, but the percentage of car miles done in the UK by zero emission (at tailpipe) vehicles. Set alongside modelling work (Lam & Wengraf, 2023[2]) which suggests that, without a decrease in overall vehicle mileage, the UK needs to aim for this figure to be a minimum of 37% by 2030 for the UK to meet its climate targets. The current GFI value (June 2023) of 2.87 highlights the scale of the challenge.

The GFI is supported by a range of auxiliary statistics which emphasise that when it comes to decarbonising the vehicle fleet, it is NOT new vehicle registrations that count so much as it is how long ICE vehicles remain in the parc and in regular use. These statistics describe both the age distributions and characteristics of the vehicle fleet, as well as the rate at which vehicles tend to leave the fleet.

One particular challenge highlighted by the GFI, is the current tendency for cars to remain in use for much longer than they used to. The presentation will include a discussion on a range of structural and behavioural reasons why this might be happening and some consequent challenges for policy, including cost of living, vehicle quality, public transport.

[1] https://www.racfoundation.org/data/green-fleet-index
Smart depot charging: current perspectives on commercial fleets

Marvin Helferich, Fraunhofer ISI, Germany
Josephine Tröger, Fraunhofer ISI, Germany
Annegret Stephan, Fraunhofer ISI, Germany
Patrick Plötz, Fraunhofer ISI, Germany

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
technology acceptance, smart charging, corporate strategy, commercial fleets

Vehicle electrification presents companies with (large) fleets with a variety of challenges. For example, vehicle deployment and charging times must be coordinated and the necessary charging infrastructure must be available. Smart charging can play a central role in this context. For companies, it offers the opportunity to save electricity costs or even create new revenue streams by providing flexibility services. Furthermore, it can facilitate coordinated depot charging by optimizing energy demand, efficiently integrating an increasing number of electric vehicles into the grid. This way, companies can contribute to grid stability through load management and synchronizing the charging process with times of high renewable energy availability. In this study, we analyze the challenges, opportunities and influencing factors for smart charging deployment within commercial fleets with different levels of electrification. We focus on two research questions:

• For which companies and fleet use cases can smart charging be particularly attractive and in what ways?
• What insights can we gain from companies that have successfully adopted smart depot charging for those that haven’t? Which policy implications can be derived?

We survey approximately 100 fleet managers from German companies owning vehicle fleets with high potential for electrification (i.e., passenger cars, light and medium duty vehicles, and busses). Using an online questionnaire, we collect their opinions on regulatory and technological boundary conditions, company- and fleet-level factors such as corporate (innovation) culture, corporate strategy, vehicle applications, schedules or on-site infrastructure, as well as personal attitudes towards smart charging. This will enable us to acquire comprehensive insights into the adoption of smart charging across various commercial fleets, leading to implications for decision-makers in industry, policy and other stakeholders.
Grid-connected mobility: estimating financial incentives and minimum required charge for V2G tech

Milad Mehdizadeh, Norway
Christian A. Klöckner, Norwegian University of Science and Technology, Norway

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
electric vehicles, mobility, energy policy

Electric vehicles (EVs) can play an ancillary role in energy and electricity system management. Vehicle-to-Grid (V2G) technology allows EV batteries to be discharged back into the grid. This technology enables charging when electricity prices are low and there is abundance of electricity in the grid and discharging when electricity costs are high and there is high load in the grid. The current study estimates the combination of financial compensation (FC) (reduction in monthly electricity bill) and the minimum guaranteed charge (MC) that would be needed to increase the acceptance of V2G technology among Norwegians.

Estimating a multi-equation econometric model, we investigate how socioeconomic, geographical, and psychological exogenous variables predict the level of FC and required MC, as well as the relationship between FC and MC. We found that there is a mutual and negative relationship between FC and MC. Based on the MC-FC economic relationship, the V2G system is more likely to be accepted by older people, people who perceive the V2G system as more useful, people who have EV experience, and individuals with a higher level of trust in the V2G system.

The group with strong trust in V2G demands less FC for a given value of MC. When MC is reduced, younger age groups (18–22) are more likely to demand higher FC. Our estimations also show that people demand an average reduction in electricity bills of 144 USD (72% of the average monthly electricity bill) as compensation for V2G investment while they would also use V2G if their electric car’s battery had a minimum level of 71% power.

Monetary incentives based on socioeconomic status, options in the interface allowing the user to easily override the standards, and trusted methods of calculating the revenue may be considered in order to reduce financial expectations and concerns regarding minimum battery charges.
Net zero societies: the role of transport and mobility in achieving net zero pathways

Christian Brand, ECI – Environmental Change Institute, University of Oxford, United Kingdom

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
transport, long-term scenarios, co-benefits, modelling, mobility

Future societal norms and behaviours will have a significant impact on how emissions are reduced, but they are also highly uncertain. Society in 2050 is likely to be very different from today. This paper explores the role of transport and mobility in achieving net zero societies. Using the UK as a case study, we show how different societal drivers and levers of change influence mobility patterns, transport systems dynamics and associated energy use and air pollution impacts in a net zero world.

A set of four plausible scenarios was designed to stretch thinking about how society might change, developed through workshops with stakeholders from different sectors, followed by detailed modelling of the transport-energy-environment system to assess the effects of shifts in travel patterns, avoided demand, technological adoption, and infrastructure requirements on energy use and emissions. Our findings reveal varied transport and mobility patterns across scenarios.

The Atomised Society experiences increased personal mobility with a technological thrust, while the Self-Preservation Society relies on traditional transport modes. The Slow Lane Society encourages sustainable transport practices, and the Metropolitan Society shows a divide between advanced urban and underdeveloped rural transport systems.

The Atomised and Metropolitan Societies rely more heavily on unproven carbon removal technologies needed to fulfill demand for aviation and long distance freight. The analysis shows the importance of investing in and promoting zero carbon tech, supporting the transition to shared, active and public transport systems, encouraging community-based sustainable transport, and ensuring equitable transport policies and plans in both urban and rural areas.
Estimating the marginal carbon abatement effect of EV supports in Ireland

Joel Franklin, Sustainable Energy Authority of Ireland, Ireland
Andrew O'Callaghan, Sustainable Energy Authority of Ireland, Ireland
Rory Geary, Sustainable Energy Authority of Ireland, Ireland

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
electric vehicles, impact evaluation, evaluation methods, car transportation

To reach its carbon abatement targets in the transport sector, Ireland’s 2023 Climate Action Plan has set KPIs to deploy 845,000 private EVs by 2030, which would then comprise 30% of the total private fleet. To support this, Ireland has implemented a grant of up to €5,000 towards purchase of Battery Electric Vehicles, reduced to €3500 in July 2023 (BEVs up to a maximum value of €60,000); grants of up to €600 towards a home charger; Vehicle Registration Tax relief of up to €5,000 for BEVs, due to end in January 2024; motor taxation at the lowest band of €120 per annum; and a 50% tolling reduction, due to end in January 2024.

As several of these supports are reduced or eliminated, questions remain as to the overall effectiveness of these schemes in reducing carbon emissions, and the prospects for the overall offer going forward. While these supports have very likely driven an increase in EVs on Irish roads, it is uncertain whether newly purchased EVs are substituting or complementing ICEVs; whether they are used more intensively than the ICEVs they replace; and whether the rates of replacement are greater for low-travel households than for high-travel households, affecting the average displaced kilometres travelled.

This paper presents the results of a study carried out by the Sustainable Energy Authority of Ireland, combining EV grant recipient data with National Household Travel Survey data and National Car Testing Service data to estimate the patterns of replacement and usage for new EV registrations across Ireland, taking into account differences across household types and geographic areas. Preliminary findings suggest that EVs on average are used less intensively than ICEVs, but that this is likely explained by a disproportionately high interest in EVs in geographic areas and households with lower average automobile use, and that this difference is gradually diminishing, likely due to the broadening interest in EVs.
Creating a multi-insight energy-transport poverty indicator

Samuele Livraghi, IECCP, The Netherlands
Mara Florina Oprea, IECCP, The Netherlands
Marco Peretto, IECCP, The Netherlands
Stefan Bouzarovski, IECCP, The Netherlands
Vlasis Oikonomou, IECCP, The Netherlands

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
energy poverty, fuel poverty, car transportation, household consumption, household electricity, broader social context, accessibility, climate, Vulnerability, indicators, energy policy, railways, Rurality

Energy and transport poverty are challenges that impact millions in the European Union (EU), and they are specifically understudied across vulnerable groups in rural areas. For instance, transport energy, the basic energy requirements for transportation, is a prominent need in this area. In rural regions, where public transport might be scarce, reliance on personal vehicles can intensify energy consumption, creating a more complex situation within energy and transport poverty. Also, the costs associated with transport energy can strain already limited resources, exacerbating the hardships of accessing affordable energy solutions. Despite their relevance for the livelihoods of many, an overarching awareness of these intertwined issues remains limited.

This research, in collaboration with the Institute of European Energy and Climate Policy (IEECP) in Amsterdam, wants to address a particular nuance of this knowledge gap by developing an energy-transport poverty indicator. Accordingly, this study is better suited to discern in which EU regions hardships faced by rural EU households can be more common, and it has been carried out for the cases of Italy, Croatia, and The Netherlands. The Composite Energy and Transport Poverty Indicator (CETPI) integrates aspects of traditional metrics, as well as introducing new ones: it emphasizes not just expenditures or service availability but also accessibility for transport use, vulnerability implications, and potential elementary climate pattern influences on energy consumption. The findings reveal regional disparities, highlighting the impact of urbanization, determining accessibility scores, and observing the role of climate in energy consumption. By offering a more holistic and context-sensitive approach to assessing energy and transport poverty, the research promises to guide the development of more effective interventions and policies tailored to rural communities’ needs.

After the indicator’s development, a Social Practice Theory (SPT) perspective supported the understanding of the underlying framework of energy and transport poverty as it also allows to
present a critique of current characteristics and components of indicators, with a clear focus on the built indicator. In doing so, it allows for a more capillary understanding of how energy and transport practices are embedded in broader socio-economic fragilities, particularly in rural settings. Hence, the leading research question is the following: "what components can build a robust energy-transport poverty indicator to observe which rural areas within the EU might need targeted policy interventions, considering the interconnection between transport poverty and energy poverty through a critical SPT perspective?"

Ultimately, this study aims to support policymakers and stakeholders with a tool that can potentially more closely resonate with on-ground realities, learning from a SPT lens, enabling them to craft interventions that genuinely make a difference in the lives of rural EU residents. As the availability of data allows now, the current outlook of the indicator can support mainly regional and national policymakers, as well as EU level experts, in pinpointing areas of concern, recommending and even implementing targeted measures to empower vulnerable rural areas against energy poverty.
Greening the drive: unpacking the impact and equity aspects of Germany's EV subsidy programme

Swaroop Rao, Fraunhofer Institute for Systems and Innovation Research, Germany
Marc Blauert, Technopolis Deutschland GmbH, Germany
Barbara Schloemann, Fraunhofer Institute for Systems and Innovation Research ISI, Germany
Jan Stede, Technopolis Germany GmbH, Germany
Julian Schaper, Technopolis Germany GmbH, Germany

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
electric vehicles, car transportation, distributive effects, additionality, subsidies

Public subsidies for the purchase of electric vehicles (EVs) have been introduced in various countries as a means of incentivising consumers to shift away from fossil-fuel powered personal transport. In Germany, as in many other European countries, the shift towards E-Mobility has gained particular attention due to the transport sector's increasing need to decarbonise for the country to meet national and European climate neutrality targets.

In this paper, we use data from the country's national EV subsidy programme (the Umweltbonus) and a survey of the recipients of the subsidy to determine the free rider, rebound, and spill over effects, which have become indispensable to consider in the design and evaluation of contemporary energy policy. In addition, the distributive aspects of the subsidy programme are analysed, notably concerning income and regional inequalities.

Our study suggests that there might be substantial inequalities in terms of the demographics of the recipients of the subsidy, whereas the rebound effects are smaller than what the literature might suggest. Future efforts to promote EV adoption might benefit if the corresponding subsidy programmes are better targeted towards recipients from economically disadvantaged groups and regions.

The insights from this study contribute to the growing literature on the effectiveness of EV subsidy programmes using observed microdata as well as stated data. In addition, concrete lessons such as about the distributive effects of the policy can be gathered from this experience in Germany that might find application in transport policy in other jurisdictions.

Further redesign of the subsidy should also consider including a corresponding disincentive for...
buyers to buy fossil-fuel driven cars, in addition to a subsidy towards EVs, which might increase distributional fairness as well as be more neutral towards the burden on state finances.
Cass 2024 What is an e-cargo bikable trip?

Noel Cass, University of Leeds Institute for Transport Studies, United Kingdom

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
individual mobility, means of transport, lifestyle, everyday life, E-micromobility, Cycling

E-micromobility and specifically e-bikes have great technical or theoretical potential for substituting car trips for climate change mitigation (Bourne et al. 2022), even or especially in under-researched non-urban areas (Behrendt et al. 2021; Philips et al. 2022, 2024). We know that a huge proportion of empirical car trips are short enough to be feasibly (especially electric) cyclable. In the 2022 UK National Travel Survey (DoT 2022), ~30% of all car trips were <=10 miles (16km). In addition, e-cargo bikes in particular can share key perceived benefits of cars that aid substitution potential (Riggs 2016). These include their ‘cargo function’ (Mattioli et al. 2016), capacity for carrying children as passengers (Carracedo & Mostofi 2022), and weather-proofing (Lopez et al. 2017, Faxér et al. 2018).

However, technical potential is necessary but not sufficient to achieve adoption and use. The real-world potential for substitution relies either on a household or individual being able to replace many, most or all of their regular car trips with e-cargo bike usage. Discovering to what extent this is true, and it what ways, under what conditions, for which households, individuals and geographies, remains an under-researched topic (Bourne et al. 2022), although reviews of research on e-cargo bikes (Carracedo & Mostofi 2022) investigate trip purposes and characteristics. Bjørnarå et al.’s (2019) three-month loans of e-bikes (with trailers) and longtail e-cargo bikes in Norway is the closest comparable study, although it focused on health impacts, while Faxér et al.’s (2018) study of weatherproof e-cargo bikes focuses on commuting/business uses.

Using travel diary and particularly interview data from 49 month-long household trials of e-cargo bikes, we compared the users’ actual usage and their reasons and explanations of use and non-use for (especially anticipated) trips. Before the trials, participants almost all expected to use the e-cargo bikes for shopping and carrying children, with many expecting to commute. They almost all expected to replace car journeys. At the end of the trials, participants explained why they did not use the e-cargo bikes as expected. Taking children, or grandchildren, e.g. for “fun trips”, was difficult because they did not like it or were unenthusiastic, there was no room to carry a pushchair, or the weather was bad. School runs were avoided as children were ‘too young’. Large food or supermarket shopping failed, because of not enough room, not being as easy as a bike and trailer, or shops being too close to bother. Using the bike at all was difficult for a too-busy father, was seen as too big, unsafe, and wobbling, or as not comfortable enough for long (e.g. 34 miles) trips. Another felt they over-estimated their cycling competence, and
found it hard to use on the road. However, trips unexpectedly added to these routines included (including multi-modal) commutes, leisure, sport and visits. And ‘secondary’ male users frequently took over use from their female partners if they were perceived as too big. The most prolific users of the e-cargo bikes tended to share certain characteristics, too. In particular, they had flexible working arrangements, e.g. being able to choose when to work in the office, were keen or proficient cyclists already, and were committed to reducing car usage as a general principle or for environmental reasons. A small number of participants used the e-cargo bikes to substitute all their car usage, although some had a partner whose use of a car was non-negotiable – typically for longer commutes or work trips. Car abandoning and car-free households were in this group of prolific users.

These findings suggest that support, advice and free trial loans of e-cargo bikes could be targeted to e.g. 2-car households and those whose characteristics and regular car trips match those of our most prolific sample, to maximise the potential to reduce car trips.
The adventures of cars through space and time

Malcolm Morgan, University of Leeds, United Kingdom

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
car transportation, CO2 emissions, big data, car buying patterns

This paper reports on three interrelated and ongoing projects to improve understanding of the use of cars in the United Kingdom. Personal vehicles are the main source of transport carbon emissions and energy consumption, which in turn is the most polluting sector of the UK economy.

The first project, “Connecting Administrative vehicle data for Research on Sustainable transport” will link two administrative datasets: the register of vehicle owners and the cars’ MOT test history, including annual mileage. Which will enable a detailed spatiotemporal analysis of vehicle ownership and use.

The second project is the Big Car Count, a crowd-sourced survey of parked cars. A web app lets users enter car number plates and identify the type of parking (driveway, road). The app adds the time, GPS location, and looks up technical information about the vehicle (e.g. model/age/mileage). The survey is being piloted with 80 Leeds University students, and it takes a person 15 minutes to survey a street. In 2024, the survey will be opened to the public.

The third project is to scrape data from AutoTrader, a popular website for new and second-hand car sales with over 450,000 monthly listings. AutoTrader provides over 100 variables about each car and captures them at an interesting moment in their “lives”. Location is provided as a dealership address or approximate location of private sellers (+/- a mile). As this data gathering is automated, it can be done nationally for a long period. Thus, a significant proportion of the UK’s 33 million cars will likely be captured over the next few years.

The paper will present some early results from each project and discuss how the synthesis of these projects can produce a detailed and nuanced understanding of the UK’s car fleet over space and time.
Where is my bike? a review of bike parking policies in Swedish municipalities

Frances Sprei, Chalmers, Sweden
Devon McAslan, Chalmers, Sweden

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
biking, parking, individual mobility

Car parking often gets quite a lot of attention – but what about bike parking? With cities moving toward climate neutrality and the 15-minute city, bikes will play a crucial role in the transport system. Still, bike thefts have been identified as one of the barriers to larger adoption of bike usage, especially when more expensive bikes such as e-bikes are introduced. It is thus important to provide good and safe bike parking at multi-dwelling houses and commercial buildings. Providing good bike parking and other biking service, such as bike-sharing, can also be a tool to reduce the need for car parking.

In this paper, we collect data from 56 municipalities of varying sizes in Sweden on requirements for bike parking in new multi-dwelling houses and commercial buildings. Data is collected through a survey, interviews as well as workshops with civil servants in charge of parking regulations.

Analysis of parking regulations documents is also included. Factors studied are the number of parking spaces regulated, specification on quality (such as locking possibilities and weather protection), as well as the provision of shared bikes. 86 % of the studied municipalities have some kind of regulations regarding bike parking at new multi-dwelling houses and 73 % at new commercial buildings. We find that medium-sized municipalities (>50,000 inhabitants) have worked the most with bike parking, especially compared to municipalities of similar size that are commuting municipalities to the three largest cities in Sweden. We also find that quality is an essential issue, however, municipalities feel unsure about how to regulate and follow up on the issue. Insights from the study can help municipalities either considering developing regulations about bike parking or considering revisions of current regulations.
Contribution of shared micromobility to intermodal travel in outskirts of cities. A case study from Hamburg

Elem Güzel Kalayci, Virtual Vehicle Research GmbH, Austria
Kevin Kulle, Virtual Vehicle Research GmbH, Austria
Manfred Rosenberger, Virtual Vehicle Research GmbH, Austria
Stefan werland, Wuppertal Institute for Climate, Environment, Energy Urban Living Lab Center (ULLC), Germany
Dominik Radzuweit, Hamburger Hochbahn AG, Germany

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
mobility, public transports, urban transport, intermodal shared micromobility, e-kick scooter, decarbonisation, accessibility

This presentation investigates the impact of shared micromobility on intermodal transportation in suburban areas in Hamburg as part of the SOLUTIONSplus project. E-scooters were introduced, accompanied by parking at metro stations and various incentive schemes integrated into Hamburg’s ‘hvv switch’ mobility platform.

Despite motorized private transport dominating urban transport at 36% in 2017, suburban areas maintained a constant 60% modal share of private car use. Therefore, the challenge is shifting private motorized mobility to public transport and micromobility, particularly in the suburbs.

The demonstration aimed to understand e-scooter usage in suburban contexts, focusing on their role as first- and last-mile connections in areas with weak public transport. It explored the impact of parking zones, app integration, and incentives on intermodality. Data collected from e-scooters, mobility providers, and a user survey provided insights into changes in travel behavior, resulting GHG emissions, and public transport accessibility. This research contributes valuable insights into sustainable urban mobility solutions.

The project challenges the typical placement of shared micromobility services in urban areas, exploring their potential in suburban regions with high car usage. It investigates whether extending shared e-scooters to these areas can encourage intermodal travel, reduce reliance on private trips, and assesses the effectiveness of designated parking and incentive schemes. The study also questions the financial viability, considering whether ongoing public subsidies are necessary.

The results show that extending shared micromobility beyond city centers can boost intermodal
travel, reducing private motorized trips and GHG emissions. Initial public subsidies may be used as catalysts but aren't permanently required. Integration into public transport apps and designated parking zones are crucial, while incentive schemes hold less importance.
Vulnerability structures across the EU-27: Assessment of 17 transport and energy poverty indicators using EU-wide microdata

Nelly Unger, Öko-Institut, Institute for Applied Ecology, Germany
Johanna Cludius, Oeko-Institut e.V.
Viktoria Noka, Oeko-Institut e.V.
Katja Schumacher, Oeko-Institut e.V.

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
indicators, transport poverty, EU Emission Trading Scheme (EU ETS), microsimulation

Energy and transport poverty and vulnerability are central in the debate around many energy and climate policy issues and have gained firm hold in central EU directives and regulations, such as the Energy Efficiency Directive, the Energy Performance of Buildings Directive, and the Social Climate Fund (SCF) Regulation. For many purposes, both related to EU policy, but also to policy at the national level, national governments need to establish indicators for both energy and transport poverty and vulnerability, e.g. to report on in their NECPs and to include in their Social Climate Plans under the SCF. While a number of established energy poverty indicators exist at EU level, the discussion about transport poverty indicators in the EU is only just gaining traction.

The goal of our study is to identify "vulnerability structures" in the EU by providing a comparison of vulnerable groups across European borders. We do this by looking at a selection of ten “representative” Member States from different corners of the EU and studying vulnerability structures within and across these Member States by applying 17 indicators (some of them composite) for both energy and transport poverty, using both traditional indicators such as 2M, M/2, keep home warm and arrears on utility bills, as well as indicators on Forced Car Ownership (FCO) and availability and accessibility of public transport. We employ the microsimulation model SEEK-EU based on Eurostat microdata sets for HBS 2015 (inflated to 2022/23) and several waves of the EU-SILC. The number of households identified as vulnerable differs widely depending on the specific indicators applied. We find a high degree of heterogeneity within and between Member States, highlighting the different focus of each indicator.

For the transport poverty indicators, no clear pattern emerges when comparing results across European regions – we rather find country-specific effects. Between indicators, we observe a
large range from 1 % to 43 % of households identified as vulnerable in the transport sector. For heating, the expenditure-based indicators show on average higher shares (up to 26 %) of vulnerable households than the self-reported indicators (1 %–32 %). We observe that self-reported indicators are particularly high in Southern Europe and in some Central and Eastern European countries. We also find that including an income threshold (in our case “at risk of poverty”) into the expenditure-based indicators, reduces the share of households identified as vulnerable considerable. Indicators without an income threshold may therefore overestimate the share of vulnerable households especially in high-income Member States.

When targeting policy measures at vulnerable households, it is important that households can prove they are in the vulnerable group and authorities can confirm this, e.g. through income tax statements or social security benefits. A “policy indicator” is therefore likely to be based on information on household income. We estimate being “at risk of poverty” as one possible policy indicator. This indicator identifies a higher share of vulnerable households compared to many other indicators in both sectors. This points to the fact that an indicator purely based on income is not able to take into account may of the other important drivers of vulnerability in transport and heating. Governments should therefore expand their ability to identify households based on other important drivers of vulnerability, e.g. the energy performance of the building of a household or a household’s access to essential services.

Based on the results on vulnerability patterns across the EU, we evaluate the means available to support vulnerable households, taking the SCF as an example. The amount of funding that will be available per vulnerable household in heating and transport is directly related to the indicator chosen to identify those households. The funding per household will be higher if the targeting is very concise and the group of recipients is small. The funding per vulnerable household can also be increased if additional, national resources are available to support vulnerable households in the context of the ETS-2. This is particularly important for those countries that are not identified as vulnerable according to the Social Climate Fund, i.e. most Northern and Western European countries. Making additional funds available to vulnerable households (e.g. from national auction proceeds) allows the funding of more households or of more impactful measures. In keeping with the ETS Directive, national auction proceeds can be used to this end. In many countries, national auction proceeds will dwarf funding from the SCF.
Using impact chains for a feasibility assessment of sufficiency policies in the mobility sector

Carina Zell-Ziegler, Öko-Institut, Institute for Applied Ecology, Germany
Johannes Thema, Wuppertal Institut, Germany
Kaya Dünzen, Oeko-Institut, Germany

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
energy sufficiency, mobility, decarbonisation, emission reduction policy analysis, domestic policies and measures, impact chains, feasibility assessment

Energy savings through modal shift and demand reduction (avoid) are key to decarbonising the transport sector. This is the aim of transport sufficiency policies. Some of them are already implemented and serve as best practice examples, and there are many planned and proposed policies, e.g., in the National Energy and Climate Plans (NECPs) of EU Member States and in the literature on decarbonisation of the transport sector.

The European Sufficiency Policy Database of the Energy Sufficiency junior research group (EnSu) currently contains 120 sufficiency policies for passenger transport, grouped into seven different policy strategies and covering different types of policy instruments. In this paper, we take a closer look at 74 of them.

Methodologically, we refer to the concept of impact chains as developed by Zell-Ziegler and Thema (2022) and analyse the chain from policy stimulus to impact with a particular focus on those factors that seem relevant to the feasibility of policy implementation.

In our feasibility assessment, we seek to answer the following questions: 1) How do particular policy instruments work from cause to effect and what can we learn from them for implementation feasibility? 2) Within a particular policy strategy, how do individual policy instruments differ in terms of implementation feasibility? 3) Does implementation feasibility vary between instrument types?

Regarding the first question, we take the impact chain of the good practice example of "superblocks" in Barcelona – neighbourhoods with restricted car access – as an example of a policy that could also be implemented in cities in Germany as well. We conclude that this can work well if good public transport is available and administrations are flexible in their urban planning. However, barriers and risks such as the risk of gentrification or protests from local shopkeepers should not be neglected and must be taken seriously. All of the other 73 impact
chains, which cannot be described in such detail, are provided in a supplementary table.

Regarding the second question, we focus our analysis on the enabling and hindering factors of policy instruments. We find that policies with many supporting factors often also have many barriers and risks. This is mainly because they are meta-level policies with more diverse relevant factors. The policy strategy “Reduce trips: local supply” has the most risks and the promotion of active transport has the least, suggesting a no-regret policy. Another pattern we see is that pull policies (such as incentives or infrastructure) have fewer barriers than push policies (such as banning air travel and converting road space to cycling and walking).

On the third question, we find out that regulatory instruments do not have the most risks (but do have the most barriers) and even have the most supporting factors compared to economic and fiscal instruments. In conclusion, this analysis supports a detailed consideration of decarbonisation options for passenger transport and paves the way for further research on a comprehensive policy mix in this sector.
Transport Poverty: Towards an EU-wide conceptualization framework

Viktoria Noka, Öko-Institut, Institute for Applied EcologyÖko-Institut, Germany
Johanna Cludius, Oeko-Institut e.V., Germany
Nelly Unger, Oeko-Institut e.V., Germany
Karen Lucas, University of Manchester
Hairul Sharani Mohd Radzuan, University of Manchester

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
transport poverty, vulnerability, energy poverty

In addition to energy poverty, the Social Climate Fund has renewed attention to the issue of transport poverty. Addressing transport poverty is particularly important within the EU, as the right to access essential services, including transportation, is a fundamental principle of the European Pillars of Social Rights. In this paper, we consolidate existing work on the phenomenon to contribute to the development and implementation of a comprehensive definition and indicators for transport poverty at the EU level.

Through our literature review, it becomes evident that transport poverty is a complex phenomenon with multiple dimensions, closely linked to concepts such as mobility justice, mobility poverty, transport disadvantage, transport justice, accessibility poverty, and transport-related social exclusion. The report identifies and defines three fundamental aspects – availability, accessibility, and affordability – that are crucial for understanding transport poverty. These dimensions are influenced by and experienced differently based on socio-economic dimensions that include income, gender, age, employment (status), housing (status), ethnicity, and disability, health, and wellbeing. A final aspect of transport poverty, closely related to the socio-economic cross-cutting issues, is that of acceptability, which this paper also defines. Equally important are spatial dimensions that determine how groups are affected by and experience transport poverty differently based on location and the scale of study.

Based on an overview of the existing literature, this paper provides an overarching conceptualization of transport poverty and definitions of key dimensions that are a necessary basis for the development of indicators and policies and measures.
Double vulnerability of households: portraits of the energy and transport poor

Lilia Karpinska, Krakow University of Economics, Poland
Nelly Unger, Germany
Johanna Cludius, Germany

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
energy poverty, households, clusters, transport poverty, Europe

Both climatic and new geopolitical risks have increased the pressure on EU Member States to reduce their dependence on fossil fuels. In this study we focus on households and explore two aspects of households’ fuel dependency: (i) energy poverty, which receives much attention from policymakers and academia, and (ii) transport poverty, which is under-studied in the current research. The study aims to conduct a comparative analysis of and provide new insights into profiles of energy- and transport-poor households in the EU. Our previous research about hidden energy poverty in Central and Eastern Europe reveals that energy-poor groups are characterised by extra floor area, dependent children, tenure status, or single-family living. In the present paper, we broaden the time horizon, geography, and scope to cover the issues of transport accessibility, and car mobility in all EU countries.

We rely on several waves of micro-level data from Eurostat’s EU-SILC to draw the portraits and track changes over time. Our vulnerability indicators include the inability to keep home warm, car ownership, income poverty and accessibility of public transport with emphasis on households inhabiting thinly populated areas. We consciously limited our energy poverty sample only to at-risk of poverty persons due to the subjective nature of the inability to keep home indicators. Similarly, people who cannot afford a car and live in remote places can be genuinely defined as the transport poor. The profiles are constructed based on a set of demographic and housing variables, such as gender, age, health, education, employment, household size and type, and dwelling type. We use partitioning around the medoids clustering procedure and apply robustness checks to obtain the optimal number of clusters. To track changes in time, we include the same 27 EU countries in both 2012 and 2022, such as Austria, Belgium, Bulgaria, Cyprus, Czechia, Germany, Denmark, Estonia, Greece, Spain, Finland, France, Croatia, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Poland, Portugal, Romania, Sweden, Slovenia, and Slovakia.

According to our results, the weighted sum of households in energy poverty, which is a combination of inability to keep home warm and at-risk of poverty indicators, in 2012 and 2022...
were respectively 8,472,672 (4.8%) and 6,622,172 (3.86%). Transport poverty, which is defined as unaffordability of a car and inhabiting rural areas, affected 4,320,926 (2.45%) and 2,096,882 (1.22%) households in the same examined years. Consequently, individuals suffering from energy and transport poverty simultaneously represented 772,612 (0.44%) and 405,336 (0.24%) of the sample.

The results show that retired people in bad health living alone in large single-family buildings are part of both energy- and transport-poor groups. Profiles of the transport poor also include households without dependent children represented by working men and women in good health, and low or secondary education. To better capture regional specificity of profiles, we divided our sample into four geographical sub-groups, Central and Eastern Europe (CEE), Western Europe (WE), Northern Europe (NE), and Southern Europe (SE). Interestingly, double vulnerability profiles in CEE are characterised by owners living in single-family buildings, having basic level of education and a different employment status, pointing at in-work poverty inter alia.

The profiles for double vulnerability in WE are similar to those in CEE with the striking exception that described individuals usually rent their home. In SE, the profiles of double vulnerability are characterised by living in large houses. A mixture of tenants and owners is identified in both NE and SE profiles as being doubly vulnerable to both energy and transport poverty. The composition of groups is relatively stable across years, hinting at the presence of distinct target groups common to all countries in specific regions.
Driving sustainable urban development: smart mobility toward SDGs alignment

Ines Jaroudi, Fraunhofer ISI, Germany

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
sustainable development, climate policy, urban transport, Shared Automated Vehicles, Mobility as a Service, integrated transport and land use policies

The role of transport in advancing Sustainable Development Goals (SDGs) necessitates collaborative efforts to address its challenges. A paradigm shift in mobility, particularly the introduction of smart mobility like Automated Vehicles (AV), is seen as a disruptive innovation that could resolve these issues given the right conditions. AV, self-driving vehicles navigating with limited human control, offer configurations like Automated Minibuses (AM) integrated into Mobility as a Service (MaaS) systems, promising significant impacts on transportation systems and cities.

This study investigates if AM in MaaS aligns with Sustainable Urban Development (SUD) and SDGs using policy document analysis, Integrative Propositional Analysis (IPA), and a case study in Geneva. The analysis delves into the complex interactions between transportation policies, sustainability goals, and urban development strategies, aiming to understand the synergies in integrating AM into existing urban transportation frameworks. Policy document analysis focuses on 11 documents and 32 policies, providing insights into the strategic priorities and policy instruments employed by Geneva. Integrative Propositional Analysis (IPA) offers a systematic framework for analysing the interconnections between policy propositions, causal relationships, and overarching goals within the realm of sustainable urban development. By mapping out transportation policies and their implications for urban sustainability, IPA helps identify key leverage points and transformative pathways that could drive positive change in cities. The case study in Geneva serves as a concrete example of how AM in MaaS can be implemented within the context of a real-world urban environment. By examining the policy landscape, infrastructure developments, and stakeholder engagement strategies in Geneva, the study provides insights into the opportunities and challenges associated with integrating AM into existing transportation networks.

The results of the policy analysis reveal a significant alignment between Geneva's mobility policies and SDG 11, which focuses on sustainable cities, SDG 13, which focuses on climate change, and SDG 3, which focuses on health and well-being. Key policy instruments include infrastructure development and urban planning initiatives. However, there is a notable emphasis on infrastructure development, indicating a reliance on traditional approaches rather
than digital tools and stakeholder engagement. IPA identifies leverage points such as decreasing car modal share, increasing public transport modal share, promoting efficient vehicle usage, and reducing emissions. These leverage points highlight the potential for AM in MaaS to drive systemic changes in urban mobility patterns and contribute to SDG targets. Policy recommendations emphasize the importance of clean energy adoption, digital platform integration, infrastructure compatibility, and stakeholder engagement in advancing sustainable mobility initiatives.

By advocating for the integration of AM into existing transportation frameworks, the study underscores the transformative potential of smart mobility solutions in shaping the future of urban transportation and advancing sustainable development goals.

In conclusion, this study explores the role of AM in MaaS in fostering sustainable urban development and aligning with the SDGs. Through policy analysis, IPA, and case studies, the study provides valuable insights into the potential synergies and challenges associated with integrating AM into urban transportation systems. By emphasising the importance of strategic alignment with city policies and global sustainability objectives, the study offers actionable recommendations for policymakers, urban planners, and transportation stakeholders seeking to leverage smart mobility solutions for sustainable urban development.
Call for reinforcements: the impact of energy demand reduction policies on energy infrastructure needs

James Dixon, University of Strathclyde, United Kingdom
Connor McGarry, University of Strathclyde, United Kingdom
Christian Brand, University of Oxford, United Kingdom
Waqquas Bukhsh, University of Strathclyde, United Kingdom
Keith Bell, University of Strathclyde, United Kingdom
Stuart Galloway, University of Strathclyde, United Kingdom

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
energy demand, infrastructure, electrification

Demand electrification, system flexibility and energy demand reduction (EDR) are three central tenets of energy system decarbonisation in high-income countries. Their combined impacts on local energy systems, however, remain understudied. Here, we investigate the impact of energy demand future scenarios on the loading of local electricity networks, and the ability of demand to act flexibly in (i) mitigating the need for network reinforcement and (ii) shifting demand in time according to variable tariffs reflecting wider system needs. We demonstrate the method on a case study network in Scotland, representative of a great many energy systems in Europe.

In this case study, we find that EDR-focused energy futures reduce peak demand by up to 16% versus the business-as-usual trajectory. We find that EDR and demand flexibility are best used in tandem in minimising the impact of demand electrification on networks, in this case reducing evening peak demand by up to 69% versus the baseline when employing bi-directional charging from electric vehicles under energy futures with EDR. Therefore, promotion of EDR – particularly through policies targeted at excessive energy consumption – should be jointly prioritised with enabling system flexibility in promoting least-cost options for rapid decarbonisation at scale.
Charging at the workplace: boosting acceptance for electric mobility on the go? Empirical evidence from a pre-post-design study in Germany

Josephine Tröger, Fraunhofer Institute for Systems and Innovation Research, Germany
Sabine Preuß, Fraunhofer ISI Karlsruhe, Germany

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
electric vehicles, transition, infrastructure, technology acceptance, mobility, attitudes

Studies indicate that the availability of sufficient charging infrastructure plays a crucial role in the acceptance of electric mobility. The lack of charging stations and concerns about limited range are perceived as barriers to purchase and use electric vehicles, particularly for non-users. Charging at the workplace appears promising for addressing these challenges. Specifically, it can contribute to a higher perceived compatibility for individuals (e.g. for those without home charging options), potentially increasing interest in electric vehicles. Additionally, the increased visibility and accessibility of charging stations could contribute to overall acceptance. Hence, we investigated if (recently installed) charging stations at the workplace can influence attitudes and behaviours related to electric mobility.

Between 2019 and 2022, new charging stations were installed in four German cities, in close proximity to research institutes. Before (N = 1183) and after the installation (N = 522) of the charging stations, employees of the research institutes participated in an acceptance study. About 270 individuals participated in both online surveys. The statistical analyses reveal that the installation of charging stations makes the purchase of an electric vehicle more appealing to employees. The new charging stations appear to be a significant factor associated with an increased perception of compatibility of using an electric vehicle with people’s everyday life. In addition, we find that general attitudes toward electric mobility became more polarized. Overall, the study suggests that establishing charging stations within organizational settings can be a driver for the transition to electric mobility. However, we discuss additional factors that impact attitudes toward electric mobility – especially for individuals that are particularly sceptical – such as hands-on experiences with the technology, concurrent societal discourses and relevant policies.
The life cycle carbon emissions effects of household e-cargo bike ownership and use: evidence from three UK cities

Ian Philips, University of Leeds, United Kingdom
Christian Brand, University of Oxford, United Kingdom
Labib Azzouz, University of Oxford, United Kingdom
Jillian Anable, University of Leeds, United Kingdom

Panel
6. Energy-efficient and low-carbon mobility and transport

Keywords
e-cargo bike, mobility, CO2 emissions

E-cargo bikes show potential for energy demand reduction in household contexts (Carracedo and Mostofi, 2022): like standard e-bikes they have greater range than normal bicycles for day-to-day transport. They also have considerably greater capacity to carry children, shopping and other items than conventional bikes and e-bikes (though e-bike to e-cargo bike is a continuum rather than discreet categories) allowing them to replace previously car dependent trips. They are becoming popular in several EU nations, however domestic uptake in the UK whilst increasing is very low (Garidis, 2023).

We trialled e-cargo bikes with participants for 1 month (mimicking personal ownership) in provincial UK cities (Leeds, Brighton and Oxford) using a variety of e-cargo bike types. Via a survey we were able to compare general pre-trial travel habits and demographics of our participants and others in the neighbourhood.

Using travel diaries we establish a measure of the distance travelled and the mode substitution by the e-cargo bikes for each participant. It is well reported how travel diaries typically underreport and miss trips (Aschauer et al., 2021). Following this we estimate the lifecycle per km CO2 emissions of each e-cargo bike and the mode substituted. Initial estimates use emissions factors from the literature, but we illustrate how we can improve estimates using vehicle data gathered from participants. Additionally, we describe steps being taken to calibrate travel diary data using GPS trace data. We report the variation in emissions reduction and how our participants may be classified by city, bike type and socio-demographic characteristics.

Our participants were chosen with an (intended) selection bias for car owning (and multi car) households; the need to reduce the demand for car travel in the UK is well established (e.g. Barrett et al., 2022; Winker et al., 2023). Our recruitment and approach also takes the view that that no single technology is a panacea so may not work equally well for all people in all...
Prior to taking part, on average our summer trial participants own more cars than other people in their neighbourhoods, and they use their cars more often. Trial participants achieved lifecycle CO2 emissions reductions through trip substitution, we also examine whether participants achieve a reduction in overall car use. Based on travel diaries, e-cargo bikes were used to substitute for car trips far more often than any other mode (Figure 1).

Using emissions factors from the literature and the travel diary data we get an initial estimate of a mean CO2 saving per person year of use 170kg. However, calibration with GPS traces will likely increase this figure and we discuss the reasons for this. There is considerable variation in use, substitution and carbon savings between individuals. Identifying common characteristics of the high carbon saving group within our trial participants may help to identify the places people and transport energy consumption segments where e-cargo bikes may make a considerable difference to transport energy demand.

Our paper contributes to better understanding of the fact that the net effects on mobility-related climate change emissions are complex and under-researched. Studies of e-cargo bike suitability for domestic contexts is also less researched than e-cargo bike freight applications and our paper makes a useful empirical contribution: data gathered in the context of specific places provides insights to place-based approaches to decarbonisation. Our focus on car owning households means our results may contribute to understanding whether e-cargo bikes may help reduce the demand from particular transport energy consumption segments.
Moving new construction to net zero: progress and lessons learned from Europe and North America

Steven M. Nadel, American Council for an Energy Efficient Economy (ACEEE), USA
Rod Janssen, Energy Transition Consultant, France

Panel
7. Policies and programmes for better buildings

Keywords
building codes, energy efficiency programmes, zero-carbon houses, zero carbon buildings

In order to meet the Paris Agreement and other decarbonization targets, new homes and buildings will need to be net zero emissions. It is much easier to build efficiently at the time of new construction than having to retrofit these buildings later. Getting new construction to net zero energy and/or net zero greenhouse gas emissions will likely require a mix of building code upgrades and voluntary programs. In Europe, the Energy Performance of Buildings Directive (EPBD), obligates EU member states to steadily improve the energy performance of their buildings, both new and existing, and sets out how the EU can achieve a zero-emission and fully decarbonised building stock by 2050.

But implementation of the EPBD varies widely between countries, even regarding new construction which is the subject of this paper. Activities are also underway in non-EU member states including Norway, Switzerland and the UK. Likewise, in North America, Canada (driven in part by the province of British Columbia) has made great strides in establishing a code pathway to zero energy ready new construction. In the U.S., ASHRAE, the organization that develops the model building code for commercial buildings has established a goal to require net zero energy and emissions by 2030.

Some states have made great strides in their codes (e.g. California and Massachusetts). There are also new federal tax incentives that reward zero energy ready new construction and more than a dozen utilities offer technical assistance and incentive programs targeting net zero energy. In this paper, jointly written by European and American experts, we report on and contrast net zero new construction efforts in Europe and North America, identify lessons learned, and discuss some needed next steps.
Transaction costs for acquiring building-mounted solar PV systems – insights from Sweden

Sofie Sandin Lompar, International Institute for Industrial Environmental Economics (IIIEE), Lund University, Sweden
Lena Neij, IIIEE, Lund University, Sweden

Panel
7. Policies and programmes for better buildings

Keywords
Climate-neutral buildings, Building-applied PV, barriers, transaction costs, solar energy

Central to the European Green Deal is the decarbonisation of buildings to realize a zero-emission building stock by 2050. In this process of decarbonisation, the deployment of building-mounted solar photovoltaic (PV) systems will be essential. Still, electricity generated from solar PVs is marginal in the EU, and several studies have presented barriers to the deployment of PVs, including for example a lack of objective information, complex administrative processes, and finding trustworthy installation companies. Such barriers can also be understood and addressed in terms of transaction costs (TCs), i.e. costs that go beyond the market price of the PV system, arising from tasks related to the acquisition of solar PVs. Knowledge on the magnitude and distribution of TCs will advance our understanding of barriers to deployment of solar PVs, and will be valuable in the design of effective policy interventions.

In this study, which is financed by the Swedish Energy Agency, we quantify TCs carried by Swedish households acquiring PVs. TCs are expressed as hours spent on 14 tasks across the PV acquisition as illustrated below. Data was collected using online surveys with 264 respondents, encompassing residential single-family house-owners who acquired a building-mounted PV system between 2015-2020.

The results reveal that the magnitude and distribution of TCs across the PV acquisition vary substantially between respondents, with individual processes ranging from 2-677 hours. The rounded average distribution of the TCs across the 14 tasks is as follows:

Preparing for the solar PV acquisition
1. Searching/assessing information related to PV system design, technical/construction limitations, placement, etc. (37%)

Selecting and maintaining contacts with suppliers and installers
2. Searching for information about PV suppliers/installers (14%)
3. Asking for/evaluating quotes (5%)
4. Negotiating/contracting with firm(s) (4%)
5. Contacts with PV installers during mounting/installation of PV (7%)

Applying for required permits
6. Searching for information about building permit regulations (2%)
7. If required, preparing a building permit application (9%)
8. Contacts with the grid operator for a connection permit (3%)

Planning and securing finance and insurance
9. If a loan is required, search and compare banks (1%)
10. Searching for information about financial support schemes (6%)
11. Applying for financial support schemes (7%)
12. Searching and comparing insurances (1%)
13. Searching for information about the sale of excess electricity (4%)
14. Contracting with utility about the sale of excess electricity (3%)

The largest share of TCs lies in the preparation of the acquisition, where adopters are tasked with finding and processing information on constructional, technical, and regulatory aspects, followed by identifying PV suppliers and installers. Other tasks that are experienced as burdensome include complicated bureaucracy related to subsidies and building permits, and problematic installations. Conversely, aspects surrounding insurances are generally of minor concern along with acquiring bank loans. However, it is important to stress that average values sometimes hide important results, as in the case of the task "asking for and evaluating quotes". This task shows a rather high average time spent, while also having one of the highest numbers of unique respondents spending no time at all. This points to important differences in the individual PV acquisition experiences, where 38% of the adopters accept a bid without further assessment or comparisons.

The policy environment surrounding PVs in Sweden has undergone several changes over the investigated period, yet with only marginal improvements in overall TCs discernible. The wide range of reported time spent on the entire acquisition, however, suggests that there are opportunities to further streamline the acquisition process and thereby reducing TCs carried by PV adopters.
Carbon price or installation ban - decarbonising space heating in the EU

Robin Hasse, Posdam Institute for Climate Impact Research, Germany
Ricarda Rosemann, Potsdam Institute for Climate Impact Research
Robert Pietzcker, Potsdam Institute for Climate Impact Research
Gunnar Luderer, Potsdam Institute for Climate Impact Research

Panel
7. Policies and programmes for better buildings

Keywords
space heating, decarbonisation, policy instruments, scenario study

Current sales of heating systems are still dominated by fossil fuel boilers. These new boilers could lock-in substantial future CO2 emissions due to their long lifetime, putting the decarbonisation of the residential sector at risk. Carbon pricing and an installation ban for fossil fuel boilers are among the most discussed policy instruments. Some member states (MS) have introduced carbon pricing instruments for heating fuels, but the coverage and the prices are mostly low. The EU-wide emission trading systems will not cover direct emissions in the building sector before 2027 and the future price levels are highly uncertain. The installation of new fossil heating systems is banned in some of the EU MS, but more than 70% of the current heating demand is not covered by phase-out policies.

In this study, we use the new building stock model BRICK to compare the effect of a strong implementation of either and both of these policy instruments on the decarbonisation of space heating in the EU. In one scenario, we set a carbon price on heating fuels of 150 €/tCO2 until 2030 rising linearly to 400 €/tCO2 in 2050. The second policy scenario prohibits the installation of coal and oil boilers after 2025 and of gas boilers after 2030. Electricity is assumed to reach zero emission intensity in 2035 and district heat in 2040. We compare the results to a policy scenario combining both instruments and a baseline scenario without policies to enforce heating decarbonisation and only minor emission intensity reduction of electricity and heat until 2050.

Preliminary results show that the stock development differs considerably between the two scenarios. The carbon price leads to an immediate and persistent switch towards clean heating technologies whereas the installation ban only takes effect after the effective date but then leads to a faster phase out of fossil fuel boilers.

In the scenario with carbon price, natural gas boilers remain an important technology in both new construction and the renovation of existing buildings but they lose their dominance in installation for the benefit of non-fossil technologies. Clean heating technologies serve more than 60% of the residential building stock in 2050.

Following the installation ban of fossil fuel boilers, the market of heating technologies drastically shifts and is dominated by heat pumps and district heating after the ban. Installed
fossil fuel boilers phase-out as they reach the end of their technical life time but still make up 20% of the stock in 2050. The carbon price scenario reaches an emission reduction of around 70% until 2050 compared to 2020. After new gas boilers are banned in 2030, the installation ban scenario is faster to reduce emissions cutting around 80% of 2020 emissions until 2050. Both policies combined can reduce the emissions even faster with a reduction of almost 90% within the same period. Only the sensitivity scenarios with shorter lived fossil fuel heating systems get close to full decarbonisation around 5% residual emissions in 2050 compared to 2020.

Our results seem to indicate that a high carbon price in 2030 and beyond leads to a switch towards clean heating technologies immediately as it increases the heating cost for all fossil fuel boilers in use. In the installation ban scenario, emission reductions only happen after the ban is implemented, but emissions then reach lower levels after 2040 compared to the carbon price scenario, as the ban completely rules out the installation of fossil boilers. Combining both policies leads to a comparable pace of emission reduction as the installation ban alone but takes effect immediately just like the carbon price alone and suppresses anticipatory effects before an installation ban. The fact that only sensitivity scenarios with shorter lived fossil fuel heating systems come close to full decarbonisation until 2050 might indicate an entry point for additional policies encouraging the exchange of very old fossil equipment.
Local authority capacities for strategic action on energy efficiency and heat decarbonisation – a Scottish case study

Faye Wade, University of Edinburgh, United Kingdom
Janette Webb, University of Edinburgh

Panel
7. Policies and programmes for better buildings

Keywords
institutions, social innovation, local authorities, local and regional energy planning, governance, local government initiatives

Existing approaches to energy efficiency and low carbon heat in buildings are failing to deliver change at the speed and scale necessary to meet climate targets. Local and regional planning is a potential route to faster action, but innovative policy instruments are needed. We examine the emerging innovation in Local Heat and Energy Efficiency Strategies (LHEES) in Scotland.

The intention is to create area-based, costed and prioritised, 20-year strategies for upgrading energy efficiency and decarbonising heat in all buildings. Scottish Government have positioned local authorities as key agents of change through the proposal to make LHEES a statutory duty, with all councils having a comprehensive Strategy by 2023. This paper analyses empirical material collected in a 3-year (2017-2020) evaluation of LHEES pilots. It presents original data from interviews with local authority officers coordinating the pilots, alongside analysis of the LHEES reports generated.

A capacities framing is used to explore the potential for effective institutional innovation through this proposed local responsibility. The analysis considers how political authority, finance, personnel and knowledge capacities shape and constrain local authorities’ ability to deliver. The paper highlights the inter-linkages between different local authority capacities and the tensions that may restrict councils’ ability to deliver LHEES. This shows that innovations in governance are essential to achieving net zero emissions from buildings, and area-based strategies are likely to be one effective instrument. However, central government intention to innovate through new local responsibilities is insufficient when local capacities are weakened by long term reductions in public finances. Only through concerted interaction across central and local governments, and across sectors and building owners, to plan, and to organise the essential resources, will innovation happen.
Integrating sufficiency policies in National Buildings Renovation Plans: an unmissable opportunity

Laetitia Aumont, EEB European Environmental Bureau, Belgium

Panel
7. Policies and programmes for better buildings

Keywords
sufficiency, policies and measures, national building renovation plans, Energy Performance of Buildings Directive (EPBD)

The ECEEE Summer Study will take place a few months before the start of national implementation of the EPBD, which will include drafting National Building Renovation Plans (NBRPs). Considering that sufficiency is an element to which the overview of implemented and planned policies and measures in the NBRPs may refer to, we would like to present our work on the potential of sufficiency measures in the built environment to tackle both the high environmental impact of the sector and the current housing crisis.

Although efficiency improvements and the increased use of renewables have reduced CO2 emissions in the use phase of residential buildings by 29% over the period of 1990-2018, because new construction has led to an increase in the living space per person (especially in the wealthiest countries), the energy demand per capita has remained rather stable. This ‘rebound effect’ clearly underlines that the EU cannot reach its objective of a climate neutral building stock without considering the implementation of sufficiency policies.

In addition, this session would also encompass how sufficiency policies can deliver a fair and just transition of the building sector, tackling current challenges such as rising cost of living, housing shortage, poor housing conditions, and growing homelessness. In 2021, 17% of the EU population lived in overcrowded households and 8.3% of the population was overburdened by housing cost. However, this does not solely reflect an insufficient number of buildings. In fact, most countries have a substantial number of vacant buildings. On average, 16% of European dwellings were not occupied in 2011, and 35% were underoccupied. This represents 30 million empty dwellings, and yet, 15 million new ones were built between 2011 and 2020.

Turning towards sufficiency measures in the built environment would allow national governments and local authorities to address environmental and social issues at the same time. To illustrate our point, we have gathered a number of best-case examples of implemented sufficiency measures and policies proposals related to the existing building stock (addressing issues of wrong-sized space, vacancy and misuse of existing space) and unbuilt land (addressing issues of inner-city densification and urban sprawl). We would like to emphasise that sufficiency measures do not only apply to the energy use of buildings but also
to our consumption of water, land and materials when building new.

“The greenest building is the one already built”, particularly since reusing an existing building can reduce emissions by 50%-75% compared to an identical new-build. We argue that monitoring the use of the existing building stock would allow for better housing policies such as targeted fiscal measures and economic incentives for renovation and moving schemes, facilitated through a close collaboration with local authorities and the wider public. Finally, making use of the existing building stock by transforming unused office spaces into social housing for example, would also allow to avoid further inner-city densification or the sealing of unbuilt land and reduce urban sprawl.

We would provide the audience with concrete examples of where these measures were put into action. These will include public policies - such as taxing vacant housing based on potential rental income, already successfully implemented in France – but also functioning private initiatives that deserve upscaling. For instance, the renovation of unused offices spaces in Ireland, where a 7,500 square meters office space was converted to 86 one- or two-bedrooms apartments, allowing for a 62% reduction of carbon emissions compared to a new build in a whole life carbon assessment and 82% reduction of embodied carbon. Finally, we will cover best-practice examples of financial support schemes, such as the German state-owned investment and development bank KfW supporting co-living projects through reduced interest rates.
Tracking Ireland's National Retrofit Plan: progress and prospects

Andrew O'Callaghan, Sustainable Energy Authority of Ireland (SEAI), Ireland
Joel Franklin, Sustainable Energy Authority of Ireland, Ireland
Rory Geary, Sustainable Energy Authority of Ireland, Ireland

Panel
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Keywords
building retrofitting, domestic energy efficiency, climate action plan, energy efficiency policy

Ireland's National Retrofit Plan serves as a cornerstone in its efforts to meet the Climate Action Plan (CAP) objectives, specifically within the built environment sector. This plan delineates a dual approach: achieving energy efficiency through comprehensive retrofitting initiatives and transitioning to decarbonised heating systems. It sets forth ambitious goals—retrofitting 500,000 homes to a specified Building Energy Rating (BER) standard and installing 400,000 heat pumps in existing residences—projected to result in a reduction of 3.5 Mt CO2eq by 2030.

Our analysis leverages a dataset of retrofit measures implemented under the Sustainable Energy Authority of Ireland (SEAI)'s grant schemes, alongside Energy Performance Certificate data within the Irish BER framework. This study interrogates the dynamics of retrofitting practices across various households, scrutinising their potential to meet the outlined retrofit targets.

Five years into the plan, an incremental increase in both the scope and intensity of retrofits facilitated by SEAI grants has been observed, alongside a marginal rise in heat pump installations. Installations of solar photovoltaic (PV) systems have seen strong growth and now represent the most popular retrofit measure.

Despite these advancements, the overall improvement in the energy efficiency and carbon footprint of the national building stock remains limited. Notably, the adoption of heat pumps is disproportionately low, even among homes retrofitted to the minimal fabric standards required for such installations. At the beginning of 2024, 2% and 7% of the heat pump and BER retrofit targets for 2030 had been achieved respectively. Moreover, should the current annual increase in retrofit rates continue throughout the decade, Ireland will still fall significantly short of its CAP targets.

Through regression analysis, we identify key dwelling and socioeconomic factors influencing the likelihood of higher efficiency gains and heat pump adoption. Detached, older homes in affluent locales emerge as prime candidates for significant efficiency improvements, while
similar urban homes are more inclined towards heat pump installations. The initial heating fuel type is related to the propensity for decarbonisation and efficiency upgrades, with homes originally using oil and gas showing reluctance towards cleaner fuels and efficiency enhancements compared to their electric or solid fuel counterparts. Of note, solar PV is negatively associated with efficiency uplift relative to homes that install other measures, suggesting that homeowners are less likely to accompany such installations with other fabric upgrades.

The findings highlight that, despite some modest progress, existing policy measures are unlikely to adequately ensure the achievement of CAP targets. A significant change in policy strategy is crucial, requiring a level of policy innovation that is unprecedented. Our study provides valuable insights for policymakers, suggesting targeted interventions to foster retrofit uptake and mitigate disparities in access to cleaner energy solutions and energy efficiency improvements.
Implementing the new EPBD: the devil (and the beauty) is in the details

Hélène Sibileau, Buildings Performance Institute (BPIE), Belgium
Denisa Diaconu, BPIE - Buildings Performance Institute Europe, Belgium

Panel
7. Policies and programmes for better buildings

Keywords
Energy Performance of Buildings Directive (EPBD), EU policy, transposition, implementation, clarity, impact

Achieving the EU’s energy and climate targets requires an improved and more ambitious policy framework, notably for buildings. In 2021, the European Commission published its proposal for a recast Energy Performance of Buildings Directive (EPBD), the key EU level legislation for building renovation and decarbonisation. More than two years later, after intense political debates in Brussels, the time has come to look at the adopted text, clarify the new measures in view of transposition, assess the situation at national level, provide a stock take on the EU renovation ambition and start looking beyond.

First, based on the official EPBD text, the presentation will describe some of the new provisions: updated standard for new buildings (ZEB – Zero Emission Building), Minimum Energy Performance Standards (MEPS) for non-residential buildings and national trajectory for the residential stock, national building renovation plans (NBRPs), renovation passport scheme, new provisions for Energy Performance Certificates (EPCs), and heating & cooling decarbonisation measures. The presentation will explain how to interpret the new provisions and give clarity to help fast-tracking EPBD transposition and implementation at national level. The approach will not be to highlight new provisions one-by-one in all details, but to underline how they interact, build on each other, overlap and compete. Furthermore, links between EPBD and other adopted EU policies relevant for the building stock (such as EED, RED, ETS2 and Governance Regulation) will be drawn to get a coherent picture out of the EU-level landscape.

Second, the presentation will look at the situation at national level, with a focus on the Central and Eastern European (CEE) countries’ building stock, specifically Bulgaria, Hungary, Romania, and Poland. As shown in the first part, the new directive has the potential to trigger powerful policy packages to enhance the renovation and decarbonization of the built environment. However, its effectiveness will strongly depend on the implementation of the provisions at national level and how the new policies interact with the existing national framework. This part of the presentation will analyse the policy conditions as well as the current institutional set up within the selected countries and show how to better accommodate the new EPBD provisions and facilitate their effective implementation.
Third, the presentation will put the recast EPBD into perspective, and question its ambition level compared to objectives from the start of the policy cycle (Renovation Wave Strategy, 2030 climate targets). These aspects will inform EPBD implementers about which measures to focus their effort on to achieve the maximum impact. As a conclusion, considering what the new EPBD is expected to bring, the debate will be opened regarding what should be the new topics and policy measures that should be promoted at EU level, in view of the next mandate of EU institutions, starting in summer 2024.
The cumulative energy demand of buildings - a life cycle assessment

Jana Deurer, IREES - Institute for Resource Efficiency and Energy Strategies, Germany
Jan Steinbach, IREES GmbH, Germany
Lennart Bunnenberg, IREES GmbH, Germany

Panel
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Keywords
Sustainable Construction, life cycle analysis, building design, data collection, Embodied emissions

Current climate protection measures focus on the building's final energy demand during its use phase. The legal framework emphasizes efficient operation of buildings by incentivising efficiency measures on the building envelope and the installation of heat supply technologies based on renewable energies. It does not yet address the ecological effects over the entire life cycle of buildings. However, the operation of buildings only causes around 15 % of GHG emissions in Germany, while manufacturing, construction and maintenance of buildings cause another 15 to 25 %. Therefore, this paper analyses the Cumulative Energy Demand (CED) and Global Warming Potential (GWP) for various new buildings and renovation of existing buildings.

For the life cycle assessment, a new model is developed to calculate the environmental impact of the building construction and technical building equipment in a highly detailed manner. The model is used to analyse the effects of different construction variants and building materials both at the level of individual buildings and for the entire building stock in Germany.

Different construction methods are compared in the variants considered, e.g. solid and lightweight construction with concrete, brick and wood. Different construction methods are defined for each building component – roof, exterior wall, windows, basement, heating system – which are linked to the ÖKOBAUDAT building materials database. For each given energy efficiency standard and associated U-value, the weight, volume and environmental impact of the material required for each building variant are calculated. The CED and the GHG emissions of the building operation are modelled according to the standard DIN 18599 for the energy demand for space heating and ventilation.

As a result, recommendations are derived for considering the embodied energy and carbon in the building materials in funding instruments and energy standards. The comparison of different construction methods shows the potential for saving GHG emissions by reducing the embodied energy and compares its relevance for different building types and energy standards.
In-use home thermal performance metrics: the value for householders in supporting increased take up of retrofit

David Kenington, University College London, United Kingdom
Kevin Gornall, Department of Energy Security and Net Zero, United Kingdom

Panel
7. Policies and programmes for better buildings

Keywords
smart metering, energy performance certificates, energy demand side, behavioural change

This paper explores future benefits of new information opportunities to engage householders in improving home energy performance, derived from the roll-out of smart meters. SMETERs (smart meter enabled thermal efficiency ratings) are an example of a housing & energy system-level innovation that offers opportunities to improve delivery and reduce costs of Net Zero homes. From an informational perspective, these systems offer significant opportunities such as more accurate EPCs, personalised and property-specific information, which can improve retrofit decisions.

Developing in-use data-derived systems can enable retrofit by a) providing greater understanding and agency for householders to understand the actual performance of their homes and b) in doing so overcome informational barriers to action.

Such systems do not yet exist so it is not possible to accurately predict their impacts, however this review of behavioural psychology literature indicates that real, in-use measured performance information will likely enable significantly greater householder interest and engagement in retrofit activities, especially given increases in interest as a result of recent energy, cost of living and climate crises.

There are many opportunity areas where in-use information can support decision-making at key stages in the retrofit customer journey, and at trigger points where customers are more likely to consider retrofit works. In-use metrics crucially also enable householders to have greater agency over the retrofit supply chain by enabling in-use performance assessment post-installation. Householders currently have to rely principally on trust to deliver quality installations, which is a key barrier to action.

Increasing interest in Net Zero indicate that the retrofit market would utilise such information by innovating to help householders visualise and understand home energy performance – making what is currently invisible and immeasurable, visible and measurable.
What drives sustainable buildings (SB) into the mainstream? Despite a long-standing awareness of emissions, and resource and ecological impacts of buildings, recent reports show building emissions are rising, not falling.

The built environment is responsible for nearly 40% of global annual fossil fuel-related Greenhouse Gas (GHG) emissions, equating to around 13 Gt per year. To have any chance of keeping global warming to 1.5 °C, emissions need to halve by 2030 and be net-zero by 2050. Mainstreaming sustainable buildings has never been more urgent. It is therefore important to recognise what drives the adoption of sustainable buildings in developed and developing countries, accounting for different geographical regions and stakeholders of the built environment. This study conducted a systematic review and meta-analysis of the literature to identify generic drivers of sustainable building adoption.

Following the review of 49 selected publications, 69 drivers of sustainable building adoption were identified. They were classified into seven categories using the “Race to zero built environment map”. These were Government/policy/regulations, Technical/professional, Social/culture, Financial/economy, Technology/data, Knowledge/training and Environmental related drivers.

Pareto analysis identified the most significant drivers for sustainable building adoption within each category. The results showed differences in the significance of the drivers depending on their dynamics with the socio-economic status of a country (developed/developing), geographic region, and the relevant stakeholders, which is critically discussed. Timelines for each driver category presenting their evolution are included. These results are anticipated to support the formulation of policies for sustainable building adoption in countries and identify the most relevant drivers for their context and incorporate them to devise feasible strategies to promote sustainable building.
iBRoad2EPC: Enhancing EPCs with BRP elements to accelerate deep renovation – alignment with national plans and incentive programmes and implementation

Peter Mellwig, Ifeu – Institute for Energy and Environmental Research
Heidelberg, Germany
Florian Maiwald, Ifeu, Germany
Marianna Papaglastra, Sympaxis Team, Greece
Emily Bankert, BPIE, Belgium

Panel
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Keywords
energy performance certificates, deep renovations, action plan, indoor environment, building codes, building envelope, heating systems

The recast of the Energy Performance of Buildings Directive (EPBD) recognises Energy Performance Certificates (EPCs) and Building Renovation Passports (BRPs) as essential tools to promote transparency and information, accelerate deep renovation and facilitate access to finance. However, the renovation recommendations and their presentation in most EPCs across the EU do not inspire confidence that they will trigger sufficient levels of deep renovation. They often do not clearly specify the decarbonisation and financing measures needed to align individual building upgrades with long-term policy goals (e.g. Long-Term Renovation Strategies (LTRS)). BRPs have the potential to address this issue due to their specificity and enhanced data consideration.

The Horizon 2020-funded iBRoad2EPC project integrates BRP elements into existing EPC schemes. This means that every EPC issued can become a “light version” of a BRP, giving building owners a long-term and focused perspective on the renovation of their buildings.

This paper introduces the iBRoad2EPC concept and shows how it could accelerate deep renovation by adapting the existing EPC schemes to the needs of Member States, through deeper and more targeted consultation, linkage with existing energy-related programmes and instruments, and incentive schemes. It examines the current use of EPCs in incentive programmes and how can the iBRoad2EPC approach help in designing better incentive programmes in the six iBRoad2EPC pilot countries - Bulgaria, Greece, Spain, Poland, Portugal.
and Romania, based on a literature review and qualitative input from country experts.

Findings show that the integration of the iBRoad2EPC approach into current EPC schemes and incentive programmes could enhance their effectiveness by (1) presenting clear guidelines to public authorities on what renovation interventions should be incentivised with priority, (2) enabling informed decision-making by investors by tying the exact amount of funds to specific and measurable energy improvements, and (3) providing building owners with clear, reliable and actionable information, thus making renovations more accessible. In the crucial phase of EPBD implementation, the results of this analysis can inform the drafting of the next version of the LTRS which should include clear targets and measures to incentivise renovation. It also informs how to benefit from the uptake of iBRoad2EPC when designing incentive programmes.
Low carbon materials (steel and concrete) uptake in built environment

Harsha Pallerlamudi, RMI India Foundation
Aun Abdullah, Lodha
Tarun Garg, RMI

Panel
7. Policies and programmes for better buildings

Keywords
carbon emissions, thermal insulation, Embodied Carbo, public procurement, business models, energy label

Building-related embodied emissions are often overlooked. Embodied emissions are indirect emissions associated with procurement, manufacturing, construction use, and end-of-life disposal of materials over the life cycle of a building. India's buildings sector emits nearly 500 million metric tons of carbon dioxide (CO2) in embodied carbon annually, a rate that, if unabated, could nearly double amid the growing urbanisation. As embodied emissions occur particularly at the beginning of a building's life cycle, they will be responsible for around half of the total emissions from new buildings. This will significantly impact India's energy transformation and the global fight against climate change.

On the other side, the interest in low-embodied-carbon materials is growing significantly. This transition also comes at a time when industrial firms are quickly recognising the importance of aligning their business models with the urgencies of climate change and associated climate risks. Given the low-embodied carbon infrastructure's cost, risk, and durability, stakeholders are understandably cautious about adopting new practices. The efficacy of these strategies can be demonstrated through pilot projects, which can then influence standards by design professionals and portfolios.

Hence, this paper aims to present a case study and demonstrate the embodied carbon reduction potential and corresponding cost impacts of a residential building in the Indian context. This paper also provides a broad range of strategies that can be adopted at various stages of project execution to reduce embodied carbon and evaluate policy and institutional mechanisms at the national and state/city levels for driving the adoption of the identified strategies. The paper will also focus on various procurement strategies for creating and sustaining a market for low-carbon materials in India.
MEPS for non-residential buildings: how to define the worst performing buildings in a heterogeneous stock?

Malte Bei der Wieden, Öko-Institut, Institute for Applied EcologyÖko-Institut, Germany
Sibylle Braungardt, Öko-Institut e.V.
Michael Hörner, Institut für Wohnen und Umwelt (IWU)

Panel
7. Policies and programmes for better buildings

Keywords
Energy Performance of Buildings Directive (EPBD), efficiency, minimum energy performance standards (MEPS), non-residential buildings, energy efficiency policy, lessons learned

The Energy Performance of Buildings Directive (EPBD) is currently being revised. The negotiating parties agreed on MEPS for non-residential buildings. To this end, Member States will now have to identify the “worst performing buildings”, specified as a percentage of the total buildings stock. The energy demand of non-residential buildings varies considerably, mainly depending on the use of the building. This poses the challenge to define MEPS that account for these differences by reflecting different building uses. Our aim with this paper is to provide answers for upcoming questions in the national implementation of MEPS for non-residential buildings.

First, we draw lessons learned from existing MEPS for non-residential buildings in terms of design, thresholds, and compliance. Second, we discuss different indicators and their effectiveness. Thirdly, we present two approaches for Member States to transfer a theoretical share of the worst performing buildings (e.g., worst 16 %) into practical requirements for individual buildings (e.g., in kWh/m2a): 1) different thresholds per use category, 2) comparison with a virtual reference building. Fourth, we use Germany as a case study for both approaches and derive threshold-values. We conclude that the implementation of MEPS can play a vital role within a comprehensive policy mix. However, it is important to design a MEPS scheme which takes into account the heterogeneity of the non-residential building stock in a fair manner.

This paper is based on findings of a comprehensive study conducted by the authors (Bei der Wieden et al. 2023).
Energy performance certificates in Europe – their differences and why that matters

Mahsa Sayfikar, Heriot-Watt University, United Kingdom
David Jenkins, Heriot-Watt University, United Kingdom

Panel
7. Policies and programmes for better buildings

Keywords
energy performance certificates, energy standards, survey

The Energy Performance in Buildings Directive (EPBD) implies a level of harmonisation in how energy ratings are generated for buildings across Europe. However, whilst central tenets of standardisation and replication are seen across different countries, the details of how Energy Performance Certificates (EPCs) are calculated and applied vary considerably with geography. This has implications on how different assessors are trained, how those EPCs are (or should be) used in policy, and raises questions around whether EPC ratings from different countries are comparable.

The Horizon-funded crossCert project has the aim of highlighting these differences, and investigating what this means for “next generation” EPCs. As new innovations (e.g. metrics, consumer information, alternative methodologies) are being tested for upgrading EPCs, the ability to do this with equal effectiveness for all countries is questionable for such divergence of methods.

This paper reports on a cross-comparison of EPC methodologies, to ascertain differences in numerical outputs and subsequent recommendations for buildings. This provides a holistic overview of how EPC approaches differ, and where and why this might be important. Furthermore, with the project aiming to engage with a range of stakeholders who interact and/or use EPCs, the paper reports on a survey of different groups of end-users. The survey gauges the perceptions of various EPC users in the respective countries, focusing on the trustworthiness of the certificates and the information they provide. By collecting insights from users, the project aims to gain a holistic understanding of the perceived reliability of EPCs across different methodologies and form a foundation for next-generation EPCs.

The results suggest that, whilst there are similarities in some countries, significant differences in EPC frameworks produce very different interpretations of building energy efficiency depending on selection of EPC approach. Faced with such differences, the paper questions whether it is possible to design EPC innovations that are country-agnostic and stimulated purely by central, Europe-wide guidance. It is concluded that the different frameworks identified
require tailored and country-specific treatment to ensure effective evolution of next-generation EPCs, such that they can accommodate new technologies and applications to different areas of zero-carbon policy. Finally, the paper discusses how the need of the user of EPCs should be a central part of this design process.
Relight my fire or scatter the ashes? 
The economic and health costs of woodburning stoves

Gesche Margarethe Huebner, UCL BSEER, United Kingdom
Donal Brown, Sussex Business School, United Kingdom

Panel
7. Policies and programmes for better buildings

Keywords
biomass, homes, cost benefit, air pollutants, health, domestic policies and measures, woodburner

Recent winters have seen a huge increase in energy prices, prompting a renewed interest in woodburning stoves as an alternative and presumably cheaper form of heating. However, domestic combustion – including wood burning – is the biggest source of fine particulate matter (PM 2.5) in cities like London. Wood is classified as a renewable energy source; however, this is only appropriate with strict forest management techniques.

Here, we report the results of a study done together with the environmental charity “Global Action Plan” and the not-for-profit organization “Impact on Urban Health”. We undertook energy simulation modelling of a typical 3-bedroom London mid-terraced house. We assumed two occupancy scenarios, a higher occupancy scenario based on a family of four, and a lower occupancy scenario based on a retired couple with no children at home. We modelled five different heating system options: (A) Existing gas boiler providing 100 % of heat. (B) Newly installed Defra-compliant woodburning stove led heating (80 %) with gas secondary heating (20 %). (C) Existing gas boiler (80 %) with newly installed Defra-compliant wood burner secondary heating (20 %). (D) Existing gas boiler (80 %) with existing wood burner secondary heating (20 %). (E) Newly installed Air Source Heat Pump (ASHP) providing 100 % of heat. Analysis showed that gas boilers and heat pumps are cheaper options for home heating than the wood burner options in either scenario. Only for those who can largely source their own wood for free, woodturners might become cost competitive. The public health costs of wood burning are substantial, in the long-term contributing to chronic health conditions, e.g., cardiovascular, and respiratory diseases, and in short-term to acute health outcomes, such as exacerbation of asthma.

Hence, we argue that burners are not a cost-effective, healthy or sustainable alternative to other forms of heating, notably heat pumps, and should not play a critical role in the transition to net-zero.
Rethinking retrofit: relational insights for the design of residential energy efficiency policy

Donal Brown, Research Fellow/ Ashden Climate Solutions, United Kingdom

Panel
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Keywords
building retrofitting, energy efficiency policy, existing housing stock, sociology

The ‘retrofit’ of energy efficiency, low carbon heating and renewable microgeneration measures in homes is a major focus for energy and climate policy. Yet, despite policy interventions, few countries are achieving their residential decarbonisation targets.

In this paper, we argue a core reason for this failure is the mainstream ‘rational actor’ framing of households, which guides energy efficiency policymaking. We introduce an alternative ‘relational’ framing, to re-examine the assumptions surrounding the retrofit ‘customer journey’ and the accompanying policy framework. In doing so, the study draws on three United Kingdom (UK) case studies, exploring the customer journey of households, self-funding renovations and retrofit, via (n=40) semi-structured interviews.

We argue that by paying attention to relational dynamics, we can better design policies that work with the grain of existing household practices and social relations. This includes: 1) Leveraging existing entry points such as when renovating or moving home 2) Aligning with how households currently seek advice and procure renovation services 3) Developing solutions which factor broader motivations than simply cost savings 4) Designing inclusive and long-term financing models and 5) Building trusted ongoing relationships between contractors and communities. Consequently, we argue a paradigm shift in retrofit policymaking towards a relational approach is now required.
An installer survey of the state of the UK’s private housing retrofit market

Alice Owen, Sustainability Research Institute, School of Earth and Environment, University of Leeds, United Kingdom
Gavin Killip, Nottingham Trent University, United Kingdom

Panel
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Keywords
retrofit, existing housing stock, construction industry, market barriers, installers

Residential energy efficiency and heating system upgrades have long been important elements of the UK’s strategy for decarbonisation. With over 80% of UK homes being privately owned, the development of a viable and thriving market for owner-occupiers and private landlords is key to achieving climate targets. However, the market is still very small and past policy failures are known to have undermined industry confidence.

A telephone survey was carried out in November 2023 with 200 small to medium-sized enterprises (SMEs), all members of a UK construction trade association, the Federation of Master Builders. Firms were asked their views on the current state of the energy retrofit market and on the confidence they had in their own ability to answer customer questions and carry out energy efficiency projects.

Smaller firms tend to focus predominantly on repair, maintenance and improvement (RMI) projects, while larger firms do both RMI and new construction. Compared with the larger firms in the survey, the smaller firms reported lower levels of confidence in their ability to answer customer questions on energy efficiency, and their ability to carry out energy efficiency projects. Across all respondents, the self-reported confidence to respond to customers exceeds the level of customer demand encountered.

Cost of materials was perceived to be the single largest barrier to energy efficiency, followed by labour costs and lack of demand. Other perceived risks and uncertainties relate to uncertain supply chains, policy, time-consuming administration and an aversion to using new materials and technologies.
Better living from housing renovation?  
The perspective of tenants in Sweden

Paula Fermenias, Chalmers University of Technology, Department of  
Architecture and Civil Engineering ACE, Sweden

Panel  
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Keywords  
renovation, Energy Efficiency Directive (EED), existing social housing, tenants, consumer  
involvement, energy efficiency policy, everyday life

This paper explores the impact of the outcomes of housing renovation on the experienced  
quality of life among tenants in municipally owned housing. The paper is based on extensive  
empirical data from renovations conducted across three municipally owned companies in  
Göteborg, the second-largest city in Sweden, between 2018 and 2021. This includes all  
renovation projects (n=42) carried out by the companies during the study period affecting 6,339  
rental apartments.

The renovation projects varied in approach and ambitions regarding energy efficiency, some  
are extensive all-at-once renovations while others are incremental or stepwise renovations.  
The paper integrates results from interviews with 187 tenants who decided to relocate after the  
renovations, and 405 filled-in questionnaires from tenants who either stayed or moved in after  
the renovation.

Findings show that tenants are divided, while some tenants are satisfied with the results of the  
renovation, there is also widespread dissatisfaction. Respondents to the questionnaire are  
mainly satisfied while among the interviewees there are almost as many that give positive and  
negative comments, or both. Positive comments concern a general satisfaction with the  
refreshed standards but also improved indoor comfort.

What the tenants are dissatisfied with is linked to the functionality and the floorplan after the  
renovation, the indoor comfort, the quality of materials and appliances as well as the  
craftsmanship and execution of the renovation. For 19 tenants, the dissatisfaction was a  
motivation to relocate after the renovation. Several of the negative experiences of the  
outcomes can be traced back to energy-saving measures, for example, losing apartment space  
to new installations, dissatisfaction with indoor comfort, the experience of overheating in  
summer but also the functionality of low-flowing taps. The study also shows that tenants lack  
information about energy issues and may resist measures that compromise their comfort.

The study wants to highlight that insufficient attention has so far been given to the potential  
adverse impact on people’s quality of life following a renovation. Tenants are especially  
vulnerable in housing renovation as they have little possibility to influence decision-making.
Furthermore, they are not sufficiently informed about their role in the energy transition. The study calls for more holistic studies on housing renovation that look at the intersection between energy savings, social welfare, and quality of life of people, with special attention to the vulnerable situation of residents in tenanted housing.
What's behind the label: how an EPC label change hides the full range of possible retrofits

Marie-Hélène Laurent, EDF R&D, France
Dominique Osso, EDF-R&D, France
Najlae Bouhi, EDF Energy, United Kingdom
Catherine Grandclément, EDF R&D - Département SEQUOIA, France

Panel
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Keywords
energy performance certificates, building retrofitting, deep renovations

The French Energy Performance Certificate (EPC) is used to define long-term energy performance targets for residential buildings: improving the energy label to at least the B label.

However, these objectives described in terms of EPC label do not allow us to describe and quantify the extent of energy renovation that is required. The aim of this study is to explain the kind of retrofit and its cost using a statistical approach, with two explanations: the nature of the technical measures and their cost. As an example, we will present the results for achieving high-efficient renovation (label A or B) for all the initial EPC labels.

To do this, we use the French EPC method in its 2021 version to determine all the possible combinations of retrofit package described as compatible with all the possible EPC label changes. For each retrofit package, the calculation determines the energy consumption after retrofit, based on the standard EPC calculation, the new energy label obtained, and the investment required per retrofit measure.

To study label changes, the calculations are based on 2,300 homes described in a public survey. With a maximum of 8 retrofit measures per renovation package studied, we have a combination leading to a total of around one million calculations for all the dwellings studied. We then carry out a statistical study of the costs of the retrofit package calculated in this way.

Overall, the cost of high-efficient renovation is in the range of €200 to €350/m² of living space (direct cost), depending on the type of property, the initial EPC class and the final level achieved. As expected, the lower the initial performance of the building, the higher the cost of high-performance renovation.

For given label changes, there is therefore a "home retrofit package" configuration for which the investment costs are minimal and configurations with very high costs, but which correspond
to rare combinations. The knowledge of what is behind the EPC label change clarifies energy efficiency policy objectives in terms of technology and the type of retrofit possible and/or necessary, particularly for the building industry and the introduction of targeted financial incentive.
Addressing the split-incentive dilemma: how to share heating costs fairly while maximising the incentive for both residents and housing associations to save energy

Simon Moeller, Ludwig-Maximilians-Universität München, Germany

Panel
7. Policies and programmes for better buildings

Keywords
energy efficiency policy, domestic energy efficiency, split incentive, building refurbishment, existing housing stock

One of the main problems for increasing energy efficiency investments in the existing building stock in Germany is the split incentive dilemma. Property owners, such as housing associations, have little incentive to invest in energy efficiency measures because mainly the tenants benefit from the reduction in energy costs. However, tenants will not invest unless it is their own property. Although there are currently regulations in place to address this dilemma, they often do not work as intended. Not only do renovation rates remain too low and energy demand in the existing stock too high, but refurbishments can also lead to social problems such as strongly increasing rents and a displacement of residents.

To address these issues, the current government in Germany has agreed to consider regulations where the rent includes heating costs (warm rental models). A major challenge for such models is how to increase the incentive for housing associations to invest in energy efficiency while maintaining a strong incentive for tenants to use energy sparingly, as required by the EU Energy Efficiency Directive 2012/27.

In a current research project, we are investigating different models. There are several issues to be addressed, such as how to share the responsibility for energy consumption between landlords (building structure and technologies) and tenants (comfort behaviour). Another question is how to deal with the problem of rebound effects in energy-efficient buildings and prebound effects (Sunnika-Blank & Galvin 2012) in old buildings, and make the change from the current system to a warm rent system socially acceptable, i.e. not to cause a sudden increase in costs for previously economical tenants. We make a conceptual proposal for a new warm rent model that addresses these issues. The research builds on living labs in residential buildings where we have investigated occupant-building interactions and how a fair and reliable distribution of heating costs could look like.
Flattening the peak demand curve through energy efficient buildings: a holistic approach towards net-zero carbon

Martha Maria Frysztacki, Open Energy Transition, Germany
Salvatore Fantoni, Eurima (European Insulation Manufacturers Association)
Ekaterina Fedotova, Open Energy Transition
Yerbol Akhmetov, Open Energy Transition

Panel
7. Policies and programmes for better buildings

Keywords
electrification, peak load, peak savings, renovation, energy model, electricity grid, demand side management (DSM), energy security, building envelope, energy-economy model, energy efficiency policy, security of supply, energy supply and demand, space heating

In response to the electrification rate across Europe, challenges posed to the power grid infrastructure stemming from instances of peak electricity demand become increasingly prominent. Addressing these challenges is important in the pursuit of achieving net-zero emissions and reducing overall costs. This study employs a top-down, sector-coupled European model with a carbon dioxide emissions constraint to examine the impact of energy efficiency measures in buildings, specifically targeting the significant 40% of final energy consumption in the European Union attributed to space and water heating.

The study utilizes a holistic model that combines supply and efficiency considerations, offering insights into mitigating space heating demand peaks. Examining the competition between various supply technologies, including thermal energy storage, and hybrid heat pumps, results unveil a competing perspective on the role of building renovation measures that reduce heat demand. We demonstrate that efficiency measures in buildings dominate reductions in total costs by approximately 15% on the overall system. Renovating the thermal envelope of buildings can flatten electricity prices, resulting in more evenly distributed prices across Europe, in contrast to the considerable variations observed between countries when these measures are excluded. Building renovation also enables the removal of individual gas boilers from the energy system without significant additional costs.

On the policy front, the collaboration with stakeholders from the energy sector, both demand- and supply-side, enabled refining and scrutinizing model assumptions. By openly sharing models and data, stakeholders actively contributed to the review of model assumptions,
promoting transparency and validity of the modelling approach. The collaboration aligned model scenarios with policy objectives, offering insights for policymakers on how to improve Europe’s energy system resilience and efficiency.
Building practices through the lens of sufficiency and adaptability

Migena Sula, Linnaeus University, Sweden
Krushna Mahapatra, Dept. of Built Environment and Energy Technology, Linnaeus University, Sweden
Brijesh Mainali, Dept. of Built Environment and Energy Technology, Linnaeus University, Sweden

Panel
7. Policies and programmes for better buildings

Keywords
sufficiency, efficiency, sustainable communities, climate change mitigation, climate policy, energy policy, flexibility, adaptability

The increasing urbanization and influx of people into cities urge the need for sustainable living solutions, pressing on natural resources and environmental sustainability. This study explores how integrating principles of sufficiency and adaptability to varying occupant needs can enhance the adequacy and optimization of space and resource consumption. Building upon an integrative review of existing literature, it investigates these concepts’ interconnectedness within the built environment, aiming to clarify adaptability's potential in facilitating space-sufficiency interventions.

A synergetic linkage of the principles of adaptability and sufficiency in buildings is needed to adapt to evolving needs and reduce environmental impacts. Such an approach stresses a user-focused strategy and views buildings as dynamic systems capable of adapting to technological changes, environment, and society. This manuscript leverages an integrative literature review to propose a conceptual framework to enhance building space utilization.

Drawing inspiration from the 5R Hierarchy, traditionally applied to waste management, it reimagines underutilized space as a form of waste, suggesting intervention steps such as rethinking, reducing, reusing, and repurposing. These steps target spatial rearrangements to tackle the complexities of space optimization.

Aligned with the "Intervention Steps," a series of Key "Intervention Parameters" are outlined to boost the effectiveness of interventions across Shearing Layers, considering the immediate and future needs of occupants. This framework provides a strategic approach to managing space and promoting environmental sustainability and occupant well-being effectively, with the potential to yield economic and social advantages in built environments. The proposed "Intervention" Framework is based on an extensive literature review, but real-world applications are needed to refine and validate this approach. Further exploration is necessary to identify regulatory and policy frameworks to facilitate and incentivize its implementation.
Energy Performance Certifications: current status, challenges, and opportunities

Jerson Amorocho, BPIE, Belgium
Sheikh Zuhaib, BPIE, Germany
Xerome Fernández Álvarez, BPIE, Belgium

Panel
7. Policies and programmes for better buildings

Keywords

Energy performance certificates (EPCs) contain information on the energy performance of individual buildings and are one of the main sources of bottom-up information on the performance of the EU building stock. EPCs also remain a reference information tool for citizens and other stakeholders to support decision-making (e.g. buy/sell transactions, renovation trigger/recommendations, etc.) and the implementation of key policies (e.g. minimum energy performance standards, building renovation passports). Nevertheless, diverse barriers such as the scarcity, incompleteness, and low frequency of updates of data publicly available, the limited comparison across member states, and absence of a well-established common reporting framework at the EU level hinder the role of EPCs in the transformation of the EU building stock towards a more sustainable sector.

This paper reviews the available national data and characteristics of EPCs across EU Member States to provide a comprehensive overview of the status, challenges, and opportunities of this sector.

The paper analyses the differences between the EPC classes across 22 Member states. Moreover, an extensive data collection exercise was conducted for the EPC data available from 20 Member States until 2023. In conjunction, a normalisation procedure was applied to compare the relative share of EPC classes in Member States in reference to the whole EU building stock. It is important to note that data for the service sector is not available for all the Member states. Therefore, the data collected focuses only on the residential sector.

The paper summarizes the challenges and opportunities for next-generation EPCs to play their role in decision-making and policymaking within the transformation of the EU building stock, including their relation to the current recast of the Energy Performance Buildings Directive (EPBD), the deployment of renovation strategies, among other paradigms.
An innovative investment plan for decarbonisation of the European Union residential buildings

Paolo Bertoldi, European Commission, Joint Research Centre (JRC) Ispra, Italy
Luca Castellazzi, European Commission Joint Research Centre, Italy
Carmen Maduta, European Commission Joint Research Centre, Italy

Panel
7. Policies and programmes for better buildings

Keywords
deep renovations, building envelope, EPBD, Renovation Wave, Directive on Energy End-use Efficiency and Energy Services (EEES)

The majority of buildings in the European Union (EU) are expected to remain in use by 2050, with many having poor energy performance, especially those constructed before the Energy Performance of Buildings Directive. Residential buildings account for about 25 % of final energy consumption in the EU, with approximately 65 % dedicated to space heating. Achieving climate neutrality by 2050 requires urgent action to thermal retrofit residential buildings and adopt low-carbon technologies. However, the EU’s building renovation rate in 2020 was low, at just 1 %, with many renovations being light energy renovation.

To understand the gap and necessary efforts for decarbonisation, this article investigates the potential reduction of final energy consumption in residential buildings at EU level by 2030, based on national targets outlined in the 2020 EU Member States Long-Term Renovation Strategies (LTRS).

The analysis reveals varying levels of ambition among Member States, with potential 12 % reductions in final energy consumption by 2030 compared to 2019. This projection is compared with the necessary target in households to achieve the new energy efficiency target in the 2023 recast Energy Efficiency Directive, revealing a significant gap of over 50 %. This highlights the urgency to realign national energy renovation targets for the building sector with the more ambitious overall objectives.

Despite the ambitious targets, several barriers hinder deep renovations, including financial, technical, and social obstacles. Policies at both EU and national levels aim to address these barriers, such as energy-saving obligation schemes. However, the substantial need for higher annual rates of deep energy renovations and extensive financing highlights the necessity for a new EU investment plan for building renovation.

This paper proposes a new EU investment plan to accelerate deep renovations, building upon
the Renovation Wave initiative. The plan includes obligations for Member States to renovate a
growing proportion of the worst-performing buildings, increased support for end-users, targeted
district renovations, blended financing, and the aggregation of projects. Additionally, the plan
aims to enhance the supply industry and ensure a skilled workforce.
How can the next European Commission best support buildings sector decarbonisation?

Samuel Thomas, Regulatory Assistance Project, Belgium
Louise Sunderlan, Regulatory Assistance Project, Belgium

Panel
7. Policies and programmes for better buildings

Keywords
European Commission, thermal insulation, electrification, demand response, local and regional energy planning, decarbonisation, energy poverty

2024 is a year of change for the European Union. The new European Commission will start its 5-year term with a new agenda and the European Parliament elections in April introduce a new set of representatives. In this presentation we set out goals for the building sector; the extent to which the Fit-for-55 Package delivers on those goals; the constraints within which the next Commission will likely operate; and the resulting priorities for the remainder of the 2020s.

Meeting the EU’s climate goals requires rapid decarbonisation in the buildings sector. To meet the net zero target by 2050, the buildings sector will need to be almost fully decarbonised by 2040, with much of the effort taking place in before 2030. Russia’s war on Ukraine and the resulting fossil fuel price increases require the EU to make further significant reductions in fossil fuel imports over the next seven years. Heat in buildings is still 75% reliant on fossil fuels and the residential sector is EU’s largest gas user. Increasing energy poverty across Europe reinforces the urgent need for action.

We identify four key themes for delivery: (i) phasing in clean heat to reduce emissions rapidly; (ii) targeting fabric improvements in the worst performing buildings to make transition-ready and alleviate energy poverty; (iii) integrating buildings as energy system resources, unlocking their flexibility potential; and (iv) coordinating planning for the infrastructure we need across networks and policy programmes.

The Fit-for-55 Package provides the basis for significant Member State policy development across these themes, while the political context is likely to limit the scope for new EU legislation. As a result, implementation, of the Fit-for-55 Package will be central to the next Commission, through guidance, good practice sharing and enforcement. Nevertheless, the gaps in the current EU policy framework motivate us to propose the development of new regulations on heating appliance manufacturers and an energy efficient buildings fund as part of the next multi-annual financial framework.
In summary, we see a need for the Commission to provide:
(i) Coherence, updating the Systems Integration Strategy, aligned with an ambitious EU Heating and Cooling Plan designed to deliver the deep cuts in emissions needed during the current decade;
(ii) Prominence for the buildings sector, elevating its transition through the institution of a Commissioner for buildings;
(iii) Coordination across multiple Directives and initiatives, focusing implementation where it can make most difference; and
(iv) Legislation to fill the gaps in current EU law.
Exploring acceptability of sufficiency policies in the housing sector and the role of vulnerability – findings from a multinational survey in five European countries

Hannah Janßen, Fraunhofer Institute for Systems and Innovation Research ISI, Germany
Elisabeth Dütschke, Fraunhofer Institute for Systems and Innovation Research ISI
Sabine Preuß, Fraunhofer Institute for Systems and Innovation Research ISI

Panel
7. Policies and programmes for better buildings

Keywords
sufficiency, policy acceptability, housing, energy demand side, vulnerable groups

Sufficiency choices in the housing sector such as the reduction of living space can lead to a decrease in energy demand and thus, can be an important element in working towards decarbonisation. However, currently, the opposite development can be observed: The increase in living space per capita makes a change in housing choices necessary. These changes in housing choices can be supported by policy measures, making them one important aspect in the reduction of living space. Since decisions in the housing sector can have significant financial and long-term effects for individuals, it is crucial to pay special attention to different societal groups as they could be affected differently. Therefore, we investigate how individuals perceive these sufficiency policy measures and which factors are related to policy acceptability, while considering differences across societal and particularly vulnerable groups.

Using representative survey data from five European countries (Germany, France, Italy, Denmark and Latvia), we conduct regression models to examine the impact of various explanatory variables on the acceptability of two hard policy measures: (1) a ban on the construction of new single-family homes that are standard-sized or larger or (2) an annual financial fee for dwellings with an above-average living area. A special focus lies on analyzing the results for different societal groups, specifically vulnerable groups, defined by income and intersecting dimensions such as wealth.

For most countries, higher policy acceptability of both hard measures is associated with
familiarity with the policy measure, higher problem awareness regarding sustainable housing and higher trust in national politicians. In addition, we examine respondents' preferences to combine these hard measures with soft policy measures in a policy program. In all five countries, incentives for renovation of old houses or flats was preferred to be part of the program, followed by the participation of citizens in designing the policy.

We will discuss the results' relevance for sufficiency policies as well as the importance of considering different societal groups and vulnerability.
Regenerating an architecture pedagogy of sufficiency and equity: radicalizing architecture academia in India through ‘trojan horse’ curriculum change

Vivek Gilani, CBALANCE SOLUTIONS PVT. LTD., India
Hasan Khan, cBalance Solutions Hub, India
Savitha Narayanmurthy, cBalance Solutions Hub, India
Kirti Makhija, cBalance Solutions Hub, India

Panel
7. Policies and programmes for better buildings

Keywords
education, building design, behavioural change

Additive curricula change (i.e. adding sustainable architecture content through electives, design competitions, or taught subjects) has been attempted in Indian architecture academia since the genesis of its ‘green building movement’ in 2000. Outcomes of this incremental approach are sobering; students emerging from the inert ‘factory’ education model have inadequate motivations, skills and ethical grounding required to practice an architecture that fosters equity and ecological balance.

While additive approaches minimize conflicts with the status quo and healthy ‘competitive’ components are a mobilizing force that legitimates marginal ideas and aids gradual diffusion into the mainstream, our grassroots curricula change program has identified its compelling limitations as a system change theory. It leaves the norms and hubris of the construction industry’s contempt for natural and social limits that produces the problematic system in the first place, largely intact. The marginal shift in student's capacities to be socially relevant change agents is not commensurate with the daunting scale of the existential crises. This warrants a pedagogy that responds to climate emergency not as a ‘value addition’ valorized by the market but instead as a non-negotiable value that forms the scaffolding of the academic structure. We present the evolution of our 8-year long evidence-based educational policy and practice advocacy program, unpack its principles and methodologies, hinging on engaging with humanities and architectural theory, alongside technical and design subjects, that shape the intellectual, socio-cultural, and ethical climate of undergraduate students.

We will be presenting a reassuring case study wherein a major Indian university (that regulates
curriculum on 50 campuses graduating ~ 2000 architects per year) has been transformed and 2 co-created pedagogy training centers are operational to train the entire cohort of ~ 1,000 architecture teachers over 3 years. The case study will detail the entire process of bringing about this transformation, which included roundtable with board of studies authorities, curriculum study of different universities to identify gaps, consultation with stakeholders from the university to understand the lacunae, the horizontal and vertical integration of the topics and capacity building among the architecture faculty through the master training programs under 4 themes - Design, Humanities, Technical, Theory. The case study will also present the knowledge resources developed to support capacity building, which encompasses content on Building Physics concepts like Solar Geometry, Psychrometry, Passive Design Strategies, Sustainable Cooling Principles; an online Learning and Re-Training Course (MOOC), Sustainable Cooling Animation videos, Climate Crisis Responsive Pedagogy Handbook, a real-time exchange forum for Architecture Professors that permits them to engage & contribute their own pedagogy techniques and templates, downloadable activities and implementable lesson plan; Building Physics Ready-to-Assemble Classroom Learning Aids Kit, manual and demonstration videos.

Vision for Europe: Through local partnerships with contextually-embedded academic institutions in Switzerland, the program is currently interrogating means through which this bottom-up participatory-designed curricula transformation method can be replicated through a pilot-test approach in a Western European context. Learnings from these pilot tests will generate insights related to necessary modifications of pedagogy resources, including classroom learning aids, to account for the pedagogy of contextually relevant passive design, sustainable cooling/heating techniques etc. for an increasingly warmer Western Europe, which is likely to witness a drastic rise in deployment of climate-harming ACs if the academic apparatus does not respond to this compelling need of its built space economy while averting climate breakdown.
Life cycle carbon emissions of the EU building stock: Policy needs for embodied carbon reductions

Zsolt Toth, Buildings Performance Institute (BPIE), Belgium
Judit Kockat, Buildings Performance Institute Europe, Belgium
Dagmar Sibyl Steuwer, BPIE, Germany

Panel
7. Policies and programmes for better buildings

Keywords
decarbonisation, EU policy, Whole Life Carbon, building stock, emissions scenarios, life cycle analysis

Embodied carbon plays an increasingly important role in achieving decarbonisation. Estimates suggest that the embodied carbon already accounts for around 10–20% of buildings' total greenhouse gas emissions, though the relative importance is expected to grow as more buildings are constructed and renovated to higher efficiency standards.

This highlights the fact that embodied emissions in buildings need to be tackled soon for them not to undermine the carbon reductions achieved from the energy saving measures in the building sector. Furthermore, reducing embodied carbon emissions is an effective and immediate way to take climate action, as the majority of emissions occur before buildings start being used and operated. Effective decarbonisation therefore requires quantifying and regulating emissions over the whole life cycle of buildings. The paper presents the main findings of a study initiated by the European Commission's Directorate-General for Environment (DG ENV) aimed at supporting the development of an EU-wide roadmap, outlining how all building-related emissions (both operational and embodied) can be mitigated by 2050.

The study provides an indication on the dynamics and evolution of whole life carbon emissions due to market and policy developments. The study illustrates the reduction potential resulting from using whole life carbon information to influence choices for new buildings and renovation and provides insights on the role of various low carbon solutions/strategies at both building and stock levels. Building on a short review of the context and relevance of the topic, as well an overview of the general approach, three aspects will be addressed in more detail: (1) results for the baseline year 2020 (2) business-as-usual projections and (3) two decarbonisation scenarios. The paper concludes with a list of recommendations addressed to EU and Member State policymakers, as well as relevant market actors.
How to deal with rising energy prices: financial compensation for all VS targeted energy efficiency and renewable energy measures for low-income households

Tilman Hesse, Öko-Institut, Institute for Applied EcologyÖko-Institut, Germany
Sibylle Braungardt, Öko-Institut, Germany
Emma Kreipl, University of Bayreuth, Germany
Katja Schumacher, Öko-Institut, Germany
Viktoria Noka, Öko-Institut, Germany
Nelly Unger, Öko-Institut, Germany
Andreas Müller, e-think, Austria
Lukas Kranzl, TU Wien, Austria

Panel
7. Policies and programmes for better buildings

Keywords
ergy poverty, fossil fuel, building retrofitting, window replacement, heat pump, photovoltaics, campaign

In view of the current high energy prices, many EU countries have spent considerable amounts of public funding to support households' energy bills. We quantify the impact of shifting part of the funding for such compensatory measures to targeted investment support for low-income households and address the question of how such approaches can contribute to long-term solutions to the energy security and climate crisis. Countries included in our study are France, Germany, Greece, Hungary, Italy, Romania, and Spain.

For the sets of energy efficiency and renewable energy measures considered, we find that measures targeted at low-income households and rolled out within a two-year period could lead to final energy demand reductions in low-income households of between 9.5 percent (Italy) and up to 17.4 percent (Hungary).

The need for public investment support to help low-income households to invest in the set of measures considered ranges from around 2 bn Euros in Greece to up to 17 bn Euros in Germany, when considering a subsidy rate of 80% of the total investment costs. The resulting energy cost savings over the measures' lifetime are of the same order of magnitude reaching more than 2.5 bn Euros on Greece and up to 20 bn Euros in Germany.
We conclude that targeted support for low-income households for investing in energy efficiency and renewable energy is essential to address energy poverty, whilst at the same time contributing to marked reductions in energy use and greenhouse gas emissions in the EU. Additional benefits include a lower need for compensatory measures as well as a lowered dependency on fossil fuel imports. This calls for governments to focus on structural energy efficiency and renewable energy measures with both short-term and long-term savings that can be rolled out quickly, and to use compensation only for those households that are most vulnerable.
Policy measures for energy efficiency of data centres

Hans-Paul Siderius, Netherlands Enterprise Agency, The Netherlands
Fiona Broklehurst, Ballarat Consulting, United Kingdom
Adriana Diaz, Ecodesign Company, Austria

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
data centres, energy efficiency policy, energy saving potential

In light of the increasing demand for data centre services, and their associated energy consumption estimated for Europe at 54 TWh/year in 2030, policy makers and industry are exploring ways to reduce data centres' energy consumption and/or greenhouse gas emissions. This paper first presents a set of specific metrics to define and assess energy efficiency of data centres, which could be used to design energy efficiency policies.

The approach for developing these new metrics and improving efficiency moves away from directly quantifying the useful computing or service provided by the data centre, to look instead at avoiding energy losses in data centres, i.e., focusing on quantifying the energy spent not delivering any useful performance. Although power usage effectiveness (PUE) is still the dominant metric used in the sector, it does not capture the magnitude of losses in the IT equipment of a data centre. The authors introduce the server energy loss coefficient (SELC) to assess the losses of IT equipment, focusing especially on the servers.

This paper shows how the SELC can be calculated from standardised server operational parameters. In addition to this new metric, the paper presents a short overview and analysis of policies for energy efficiency of data centres, which range from MEPS (Ecodesign) and labelling to procurement criteria, incentives, and reporting requirements.

Finally, the paper provides an estimate of the associated energy savings from such measures, which in Europe could be 15 TWh/year in 2030. Half of these savings would result from decreasing PUE to 1.20; and the other half would result from lowering losses by increasing the utilization of servers, an accelerated shift to cloud computing, and switching off equipment at periods of low utilization.
Energy consumption in higher education buildings: bridging the performance gap using digital twin technology

Laurence Peinturier, University of Oxford, United Kingdom
David Wallom, Department of Engineering Science, University of Oxford, United Kingdom

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
energy consumption, energy efficiency gap, energy performance, building design, simulation, digital twin

Limiting global warming to 1.5°C necessitates a significant reduction in energy demand and increase in energy efficiency, particularly in the building sector, responsible for 26 % of global energy-related emissions and 25 % of UK emissions in 2022. Among UK buildings, higher education institutions (HEIs) rank second in energy intensity, due to their diverse array of activities, spaces, and age. To reduce this elevated energy demand, new methodologies are required to analyse HEIs energy use and uncover potential performance gaps.

Well understood digital twin energy simulations are valuable for this purpose, to identify the causes of these gaps and allowing interventions to be tested virtually before modifying buildings’ controls or equipment. The Andrew Wiles Building (AWB), home to the Mathematical Institute at the University of Oxford, serves as a case study to demonstrate the effectiveness of digital twin energy simulations in closing performance gaps during the operational phase of a recently constructed building. Several control and equipment failures have caused the AWB’s energy consumption to exceed expectations.

A digital twin has been built using DesignBuilder with two different configurations. The first is derived from construction documentation and originally intended operations. The second configuration is calibrated to reflect the AWB’s metered consumption and operational methodologies. Differences in simulated energy consumption between the first and second configurations are used to understand the building’s performance gaps. Proposed interventions result in a 22 % reduction in electricity usage for the year 2022, aligning the AWB’s energy performance with best practice standards according to the 2021 CIBSE TM46 benchmarks. This study highlights the value of accurate digital twin energy simulations to allow building operators to gain understanding of intervention impacts prior to implementation.
Assessing building performance in a low carbon home: a comparative study of the energy modelling representing design and as-built phase

Xinyi Zhang, School of Science, Engineering and Environment, United Kingdom  
Richard Fitton, Energy House 2.0, the University of Salford, United Kingdom  
Heidi Diaz Hernandez, Energy House 2.0, the University of Salford, United Kingdom  
Grant Henshaw, Energy House 2.0, the University of Salford, United Kingdom  
Anestis Sitmalidis, Energy House 2.0, the University of Salford, United Kingdom  
Christopher Tsang, Energy House Labs, the University of Salford, United Kingdom  
William Swan, Energy House Labs, the University of Salford, United Kingdom

Keywords  
low/zero carbon homes, energy performance, energy model

Buildings, as the second-largest carbon emitter, play a significant role in decarbonising efforts to achieve net zero in the UK. The proposed Future Homes Standard aims to ensure a 75–80% reduction in carbon emissions by increasing the building energy efficiency including decreasing U values and use of more efficient services for all new homes constructed from 2025, as compared to the current regulations. As a result, there is a need to assess the operational energy use of newly built homes that meet the criteria of the Future Homes Standard.

Due to the limited scope of energy monitoring systems in homes, the current residential assessment reports from the building industry mostly rely on building energy modelling. Existing research has demonstrated that for non-net-zero homes, significant differences persist between in situ energy measurements and energy simulation results, despite accurate modelling based on the design stage. The extent of such discrepancies in net zero homes (low carbon homes) is still uncertain and requires further investigation.

To address this issue, this study focuses on low carbon homes. It compares the building performance resulting from two energy models representing the design and as-built phases. The building energy modelling aims to replicate the test house in DesignBuilder, a dynamic
building energy modelling software, as closely as possible, considering both the design and as-built phases. Parameters representing the as-built phase are obtained from in situ measurements. Measurements are carried out under controlled conditions at Energy House 2.0 at the University of Salford, a unique research facility with two environmental chambers capable of simulating a wide range of weather conditions. The low carbon home eHome2 is built in one of these environmental chambers. The study examines this low carbon home through four metrics: energy use, operational carbon emissions, thermal comfort and energy costs.
Decarbonization of the construction sector in Sweden – exploring barriers to and drivers for increased use of wood-based materials in the construction industry

Pardis Niknafs, Linköping University, Sweden
Maria Johansson, Linköping University, Sweden
Patrik Rohdin, Linköping University, Sweden

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
decarbonisation, barriers, drivers, Timber building materials, Wood material flow

The European Union intends to reach climate neutrality by 2050, which will require substantial reductions in greenhouse gas emissions. Construction is an energy and carbon-intensive sector, which needs further decarbonization. The use of wood in buildings can be effective measures for decarbonization in the sector compared to conventional building materials, such as concrete and steel. Despite Sweden’s long history of building with wood-based products and extensive forest cover, the share of multi-storey buildings manufactured with wood frames are low. Wood-based building materials offer a potential for decreasing carbon emissions, storing carbon in buildings for a long-time span and offering high cascading potential.

As wood resources are limited, it is important to examine the possibilities of utilizing wood in long-lasting products and plan the use of them to contribute to decarbonization. Therefore, it is important to map and analyse the wood flow from forests to various wood industries and to the building sector. In this study, the wood material flow is mapped based on the mass conservation principle and the availability of wood resources for wood-based building material is investigated. The results show that gross and net felling is predicted to be relatively constant in the coming years, but that the view is that the market for high value wood products, such as wood-frames, textiles etc, will increase and thereby increase competition for the raw material.

A significant role in achieving the decarbonization goals can be played by stakeholders in the building industry by choosing low-carbon technologies, including wood-based building materials. It is important to review the perspective of experts with experience of working with wood-based buildings or material from different disciplines within the construction process such as building material companies, architects, designers, and construction companies to identify
barriers and drivers associated with the selection of wood as building material. Therefore, in addition to a wood-flow study semi-structured interviews were conducted with a group of these experts in the field to investigate their perspectives of using an increased amount of wood products in buildings and the potential for decarbonization. The main conclusion from these interviews is that the experts see an increase in semi-high-rise wood-framed buildings, and that local initiatives and clear sustainability goals are important drivers. The respondents also emphasize the learning process as well as a continuous need for good examples of successful projects.
Where and how do people live?
Modelling the occupation of the German building stock by households

Johannes Thema, Wuppertal Institut for Climate Environment and Energy, Germany
Luisa Cordroch, Europa-Universität Flensburg, Germany
Johannes Parschau, Wuppertal Institut für Klima, Umwelt, Energie, Germany
Georg Graser, Europa-Universität Flensburg, Germany
Frauke Wiese, Europa-Universität Flensburg, Germany

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
sufficiency, buildings, simulation, choice model

Living space needs to be heated in winter and partially cooled in summer and the construction of new buildings requires high amounts of energy and materials. Total living space is increasing, driven by continuously rising average per-capita spaces. The reasons for this are numerous and include the trend to smaller households who live in larger flats, increasing numbers of single-family houses, elderly people remaining in oversized dwellings, e.g. after their children moved out, the unavailability of adequately sized and priced dwellings on the market, and ongoing construction of new buildings even in regions with shrinking or stagnating populations.

Prospective scenarios for a sustainable transition of the building stock thus need to account for these factors, in order to be able to endogenously model impacts of different policy measures and other influencing parameters on the distribution and amount of living space.

This paper presents the approach of the INHABIT model for the German building sector which is currently under development. Based on Socio-Economic Panel (SOEP) data, we model dwelling occupancy, by matching the German population to the dwelling stock.

Historical data shows that dwelling space is increasing for older and wealthier households, even more so in single family homes, and that under-occupation of dwellings concerns exactly these groups: over 50 % of households aged >60 live in under-occupied dwellings.

Finally, we find that also moving rates follow similar patterns and are on average lower for these groups, perpetuating the situation. The proposed model will aim at a simulation of the future of possible occupancy pathways, also as a function of policies that may address prevailing inequalities and inefficiencies in German dwelling occupation.
The impact of adaptive thermal comfort on energy savings in office buildings under various insulation levels

Hui Ben, EDRC, University of Birmingham, United Kingdom
Sara Walker, University of Birmingham, United Kingdom

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
thermal insulation, comfort, comfort norm, energy saving potential, offices

Efficient heating and cooling systems are central to sustainable building practices, as they significantly impact energy consumption. For office buildings, where shared spaces are common and individual control over temperature is limited, achieving net-zero energy use is critical. This challenge necessitates a rethinking of conventional thermal management and highlights the importance of adaptive thermal comfort strategies, which allow occupants to acclimatise to changing conditions, thus conserving energy while maintaining comfort.

Traditional methods in office buildings often enforce strict temperature settings, disregarding the advantages of adaptive comfort. However, this concept suggests that a flexible approach to temperature can result in energy savings. Previous research has focused on single building types, which limits applicability. Our study addresses this by evaluating adaptive comfort's effect on energy savings across a variety of building fabrics.

We examine the relationship between occupant behaviour, comfort preferences, and energy use in different building types, from modern skyscrapers to retrofitted historic sites. This comprehensive approach aims to shed light on the practicality of adaptive comfort strategies in promoting sustainable building operations. The goal is to guide architects, building managers, and policymakers in adopting adaptive comfort for energy savings in office buildings, influencing future design and policy.

The research is grounded in a detailed model of an office building, inspired by the Civil Engineering building at Cambridge University. Dynamic Modelling Simulation with DesignBuilder and EnergyPlus software provides an intricate representation of the building's thermal behaviour. The model is calibrated against actual data, including energy usage, sensor readings, and historical performance, ensuring accurate simulations.

We then explore 40 different insulation scenarios, examining their impact on the building's energy demand. This allows us to understand the role of the building envelope in energy consumption and how adaptive comfort strategies can respond to insulation changes.
The study methodically investigates the energy savings potential of adaptive comfort by examining the effects of different insulation materials and occupant behaviour. The findings from this research are expected to inform building design and energy management, promoting an energy-efficient and occupant-friendly environment.

Our results show a consistent energy savings range of 11% to 15% with adaptive thermal comfort, despite various insulation setups. This stability suggests that adaptive comfort is a reliable method for reducing energy use. Such consistent savings are significant for facility managers, providing a benchmark for expected energy reductions and aiding in the implementation of efficiency strategies that also prioritise occupant comfort.

These findings also offer practical insights for facility managers, suggesting that adaptive comfort can achieve consistent energy savings regardless of the building fabric. This knowledge supports more precise planning and decision-making in energy efficiency efforts.

Overall, this study provides a comprehensive understanding of how adaptive thermal comfort strategies can lead to stable energy savings, serving as a solid foundation for future research and discussions on sustainable building practices. It emphasises the effectiveness of adaptive comfort in various office building types, setting the stage for smarter energy use and sustainability in the built environment.
Evaluating non-domestic building stock simulation based on single-zone models with multi-zone average usage profiles

Christian Karczewski, Institute for Building Energetics, Thermotechnology and Energy Storage (IGTE), University of Stuttgart, Germany
Julian Bischof, Institute for Housing and Environment, Research Institution of the State of Hesse and the City of Darmstadt, Germany
Michael Hörner, n/a, Germany

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
building stock, non-domestic, usage, energy model, single zone model, building category

Building stock models are valuable tools for the determination of building stock-related efficiency impacts on greenhouse gas reduction strategies. The building stock is often simulated based on building models with a single usage zone to cope with missing information and computational expenses. Especially in the case of non-domestic building types that combine very different uses under one roof, such as production buildings for instance, the attribution of a single standardized usage profile can lead to considerable uncertainties in the calculation of energy demands.

The aim of this work is twofold. The first goal is to determine average usage profiles that are specific to non-domestic building categories and their typical zoning. The second goal is to evaluate these profiles’ capability to reduce uncertainties in single-zone models.

In recent work, the floor area shares of typical usage zones for non-domestic building categories in Germany were determined. In this work, these building categories are matched to the building categories of the German non-domestic building research database. Averaged profiles with weighted parameters are determined for these building categories by combining the typical floor area shares with the standardized DIN V 18599 usage profiles. Next, demand benchmarks for heating, cooling and lighting are calculated based on a multi-zone building model (M), considering the typical zoning in each building type. These demands are compared to the results of single-zone building models with one predominant usage (S) as well as to the results of single-zone building models with averaged usage profiles (S+).

The comparison shows that the S+ results closely align with the M results, while the S results show significant deviation. Consequently, the averaged usage profiles provide a simple way of
reducing the usage-based uncertainties for single-zone building stock models. The developed building category-specific usage profiles are publicly available on GitHub.
Embodied and operational carbon of construction products: an evaluation of the impact of using double or triple glazed windows with coatings in the EU

Justin Loup, Glass for Europe, Belgium

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
average carbon emissions, building envelope, double glazed window, triple glazed window, CO2 assessment, life cycle

To reduce overall CO2eq emissions in the EU, one route pursued by authorities is to move towards zero-emission buildings. The emissions from heating/cooling a building (operational CO2) and the emissions during its construction (embodied CO2eq) thus need to be minimised. This entails evaluating which construction products minimise whole-life carbon emissions (WLC) considering both factors. In this contribution, high-performance windows are taken as a case study.

Relying on preexisting models, the embodied and operational carbon impacts of various windows on a residential building model in different EU climates are calculated. This shows that using low-e coated triple glazed windows in the studied buildings generally results in the least CO2eq impact. The performance of these windows permits CO2 savings during the operational phase of the buildings that are high enough to compensate for the incremental CO2eq emitted for their production when compared to low-e double glazed windows. In Southern EU countries, for the studied models, solar control triple glazed windows generate fewer embodied and operational carbon than low-e double or triple glazed windows.

These conclusions cannot be used to choose windows for a given building project but they provide general information on windows’ WLC in Europe. After displaying the methodology and findings, the paper presents a calculation tool developed to obtain results with bespoke parameters and enable a more thorough evaluation of window-related carbon emissions in Europe.
The potential of waste water heat recovery systems in reducing the energy need for water heating in the EU in a cost-efficient way

Pavel Sevela, Austria
Pavel Sevela, University of Innsbruck, Austria
Johannes Frenger, University of Innsbruck, Austria
Jürgen Schnieders, Passive House Institute, Germany
Rainer Pfluger, University of Innsbruck, Austria

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
heat recovery, domestic hot water, energy saving technologies, Directive on Energy Performance in Buildings (EPBD), greenhouse gas emission reduction, cost effectiveness, showers

After extensive research, Waste-Water Heat-Recovery (WWHR) technology was identified as the most promising technology to unlock the under-addressed potential in reducing the energy need for domestic hot water heating.

Particularly interesting application of WWHR is for showering, which accounts for about 70 to 82% of the daily residential hot water tapping profile. Shower-wise installed heat-exchangers offer a cost-effective way of utilizing otherwise wasted heat for preheating cold fresh water, thus reducing the temperature span covered by the water heater. The savings on delivered energy for water heating can be up to 40%. The unique advantage of WWHR, is achieving high thermal energy savings without compromising on user comfort with low material and monetary needs. The cost-effectiveness of WWHR is best in climates with cold ground temperatures and in cases where showers are used extensively.

At European level, the WWHR itself is theoretically capable of surpassing the energy savings targets planned in the "Fit for 55" climate action in the hot water sector, if all buildings are equipped accordingly. If between 2022 and 2030, every second anyways renovated or newly constructed building in Europe were equipped with the WWHR system, 35.7 TWh less energy would have to be generated and 6.6 Megatons of CO2e emissions less emitted.
Micro heat pumps: Are they ready for the big show?

Aniruddh Roy, Energy Solutions, USA
Tim Minezaki, Energy Solutions, USA
Aniruddh Roy, Energy Solutions, USA
Pradeep Bansal, Energy Solutions, USA

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
heat pumps, airconditioner, decarbonisation, efficiency

Most major economies, including the European Union (EU), the United States (US), China and Japan have established aggressive goals to significantly increase the uptake of heat pumps in buildings. These policies provide strong signals to worldwide markets that the current business as-usual approach to decarbonization technologies is insufficient to meet climate goals. Innovative programs and policies are necessitated to enhance the speed and scale of technology deployment.

In the pursuit of rapid decarbonization, micro heat pumps (MHPs) are emerging as innovative solution for multi-family buildings and could be a game changer particularly for the European market which has almost half of residents living in multi-family buildings. These next generation packaged window, wall or ceiling mounted heat pumps have the potential to rapidly displace polluting in-unit fossil-fuel heating systems, inefficient window air conditioners, and electric resistance space heaters and eliminate cost barriers associated with the design and installation of traditional HPs.

New MHPs are small, efficient, capable of proving both heating and cooling, designed for urban environments, and fit in most window frames without extensive installation procedures. Various versions are now commercially available. These offer several features such as the ability to being plugged into electric wall socket, space heating operation down to -21°C without any electric resistance heat backup, and enhanced part-load efficiencies via a variable speed compressor.

These MHPs have garnered immense interest in the US for their multifamily market applications. This paper will spotlight this technology and efforts that are currently underway to accelerate the market viability of these MHPs through stakeholder coordination among various energy efficiency organizations, manufacturers, and standards and regulatory bodies. For any new technology, the question remains to be answered- Are they ready for the big show?
Taking a closer look at technical energy efficiency potentials using an integrated bottom-up and top-down model for the German tertiary sector: results and calibration issues

Sonja Arnold-Keifer, Fraunhofer Institute for Systems and Innovation Research, Germany
Simon Hirzel, Germany
Clemens Rohde, Germany

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
tertiary sector, technical innovation, energy efficiency potential

Germany's tertiary sector accounts for 15% of the country's total energy consumption. To achieve international climate goals, greenhouse gas savings must be achieved in all sectors including the tertiary one. Energy efficiency remains particularly important for this. Identifying energy efficiency potentials helps to show how processes, products and services can be made more energy efficient and thus save energy.

Different energy efficiency potentials can be achieved through technical and economic energy saving opportunities. Although there have been studies on energy efficiency potentials in the past, the tertiary sector with its sectoral aggregate is still a little considered area. For this purpose, different specific energy applications of the German tertiary sector are analysed in this paper using an integrated bottom-up and top-down approach. One key factor here is the required calibration of the calculated bottom-up values to the top-down data.

This paper aims to contribute to a more detailed knowledge of the special characteristics of the calibration and to the different methodological approaches to include technical energy efficiency measures to the top-down and bottom-up model. This yields insights into future energy saving potentials but also underlines how dependent energy efficiency potential calculations can be on the input data and methodological choice. Depending on the savings potential, the assessment may vary according to the method used. It is therefore important to understand how the calculation works.
Knowledge to action – strategies for market adoption of super-efficient fans

Akhil Singhal, RMI India Foundation
Aun Abdullah, Lodha
Tarun Garg, RMI

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
comfort, low-energy cooling, carbon emissions

The cooling sector, whether air conditioning, process cooling, or cold-chain has been somewhat of a climate change blind spot – partly due to its initially small share. However, over the last two decades it has been growing dramatically and is now approaching 7 % of all GHG emissions globally. The IEA estimates that there are currently 3.6 bn cooling appliances in the world and full access to cooling for those that need it is estimated to result in a total of 14 bn cooling appliances by 2050. Within the cooling sector the largest contributor now – and in the future – is air conditioning in buildings.

Whilst we need better buildings that can naturally and passively prevent heat gain, we also need better air conditioners, fans and coolers that have a lower climate impact such that the emissions impact of cooling can be flattened even as its adoption grows. Providing thermal comfort to the millions of people is critical during extreme heat conditions. About 35 % of the urban population living in slums and informal settlements cannot protect themselves from extreme heat and mostly depend on low-cost ceiling fans for thermal comfort under the intense heat – devices which are currently inefficient.

The paper will focus on informing novel strategies based on Knowledge to Action (KTA) framework that helped in transforming the market of super-efficient cooling appliances, mainly fans, across one of the largest real estate developers in India. The paper will focus on the case study from the real estate company “Lodha Developers” on how a multi-pronged strategy in a city inhabited by 1 million people by 2030 can be adopted for diffusion of energy efficient technologies. The proposed strategy consists of designing a mass awareness campaign, conducting in-person interviews, strategic partnerships and engagement with manufacturers and resident associations.
Old and wise? How to combine smart new technologies with traditional solutions

Noam Bergman, University of Sussex, United Kingdom

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
digital, best available technologies (BATs), built environment, energy policy, traditional knowledge

We are currently undergoing two global transitions: digitalisation and decarbonisation. There are (often implicit) assumptions that digitalisation is both necessary for decarbonisation, and that it will inevitably catalyse the decarbonisation transition. Smart technologies promise to deliver clean energy when and where it’s needed, enable energy efficiency in all sectors, and maintain – or enhance – existing lifestyles while delivering economic growth.

However, while digitalisation can deliver energy savings in many areas, the current trajectory of the digital transition is focused on consumerism and enhancing growth. This could lead to higher energy use: First, directly, as digital technologies spread and require more electricity for new devices, data flow and data centres, and the high embodied energy (and emissions) from smart devices, appliances and infrastructure. And second, through a variety of rebound effects as newer smart devices carry the expectation of new services and functionalities, creating new demand.

Meanwhile, others question the ubiquity of smart solutions, from engineers calling for “excellent dumb cities”, to architects calling for “high science, low-tech” developments, and transport research calling for “low mobility” future transport systems. Many of these approaches call for making use of existing technologies alongside traditional knowledge and solutions, rather than rely on future, unproven developments.

This paper is a thought piece, considering what principles might guide us in combining new and old to ensure necessary energy savings and environmental impact reduction through rapid change, and questioning narratives relying on future technologies that lack engagement with complex behavioural and societal effects.

I draw on two approaches. The first is digital sufficiency, that considers what minimum level of digitalisation can deliver environmental benefits and social wellbeing, rather than pursuing maximal digitalisation in every sector [1,2]. Digital sufficiency enables to consider both energy and resource use of digitalisation versus alternatives, and societal impacts of ICT, including the wellbeing of users. It demands rethinking ICT from the design stage, with roles for
communities, ICT developers and policymakers. Digital sufficiency could counter techno-optimism, allowing room for more traditional, less technology focused solutions.

The second is Max-Neef's [3] needs theory, that distinguishes between fundamental human needs, satisfiers that can meet them, and artefacts that facilitate satisfying needs. Satisfiers and artefacts can be culturally specific. Applying this theory allows us to consider how ICT impacts quality of life, transcending the division of needs and wants. ICTs’ contribution to satisfying needs depends on how they are embedded in socio-technical systems. Research suggests that configurations of optimal need fulfilment, in line with environmental sustainability, align with reduced use of ICTs [4].

These two approaches together could help us consider digitalisation both as it impacts individual well-being and its potential to achieve broader societal goals including decarbonisation. By embedding digitalisation in a socio-technical system, behavioural and societal effects can be considered, and ICT impacts can be better compared to other ways of satisfying our needs.

Overlooked pitfalls and perks of automation unearthed through a living lab trial

Emilie Vrain, ECI - Energy Group. Environmental Change Institute, University of Oxford, United Kingdom
Charlie Wilson, Environmental Change Institute, United Kingdom

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
digital, time use, energy consumption, households, smart appliances, societal impacts

Automation of daily life activities promise energy efficiency gains, demand reduction and a more integrated, decentralised, and flexible energy system. Much research investigates the direct impacts on energy from technologies offering automation such as smart learning thermostats and other internet of things (IoT). However, indirect and systemic social impacts are often overlooked but can have detrimental consequences on energy and climate.

This study investigates the overlooked impacts of automation through a mixed methods experimental research design as part of a UK living lab. A sub-sample of 10 living lab households trialled the automation of floor cleaning through smart vacuum cleaners for one month. Detailed activity specific data was collected pre, during and post-trial to measure the effects of floor cleaning automation on not only energy consumption but also time-use, household members’ roles and responsibilities, behavioural norms and expectations.

The trial revealed a range of impacts from automation: 1) reduced time spent by household occupants on both planning and executing floor cleaning tasks, increased multi-tasking and notable ‘time rebound’ effects; 2) substantial shifts in household responsibilities, with the move from traditional human-centric chores to automation-driven tasks alleviating mental stress and family pressures, illustrating a positive shift in household dynamics; and 3) increased household tidiness and cleanliness, accompanied by heightened expectations for cleaning frequency.

While there were positive shifts in time management and household dynamics, these were accompanied by altered cleaning norms and increased energy consumption (dependent upon factors such as floor space, and the digital skills of the users). These findings underscore the importance of considering broader societal and behavioural effects when evaluating the impacts of digital automation.
Mapping and quantifying the impacts of digital applications on energy use

Charlie Wilson, ECI – Environmental Change Institute, University of Oxford, United Kingdom
Vlad Coroama, Roegen Centre for Sustainability, Switzerland
Hazel Pettifor, Environmental Change Institute, United Kingdom
Maureen Agnew, Environmental Change Institute, United Kingdom

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Keywords
digital, rebound effects, visualisation, meta-analysis, impact

The impacts of digitalisation on energy use are potentially large but uncertain. In this paper, we map, visualise, and quantify the impact mechanisms linking digital applications in buildings to outcomes that explain estimated reductions or increases in energy use.

Digital applications provide functionality through different mechanisms. As examples, they coordinate supply and demand and so better integrate energy use into networks or systems of provision (e.g. demand response). They substitute for energy-intensive activity (e.g. teleworking). They control or optimise performance (e.g. building energy management systems). They reduce friction or effort (e.g., smart heating).

Which mechanisms have the largest impacts on energy use?

We synthesise evidence from the literature to compile a dataset of 40 quantitative impact estimates for seven different digital use cases in buildings ranging from energy management systems and smart lighting to disaggregated energy feedback and peer-to-peer platforms for trading goods.

First, we propose a set of seven mechanisms and five outcomes that explain the variety of ways digital applications impact energy use. We then develop impact pathways linking specific mechanisms to outcomes for each digital application. For example, smart heating provides control (mechanism) that helps avoid energy waste (outcome), but also reduces effort (mechanism) that rebounds in the form of more heating (outcome).

Second, we visualise the impact pathways in wire diagrams that demonstrate the complexity of linkages, and the dominance of certain mechanisms such as the integration of building energy use into networks which is a distinctive feature of digitalisation.

Third, using a larger more diverse sample of impact estimates for 23 digital applications not
just in buildings but also in transport and food domains, we use meta-analysis to quantify which mechanisms have the largest impact on energy use, controlling for differences between types of digital application and variation in study design. Across all digital applications, we find the substitute mechanism results in the largest reductions in energy use (median of -45 %) and the optimise mechanism leads to the largest increases in energy use (median of +2 %).

Understanding the mechanisms through which digitalisation impacts energy use in buildings helps guide innovation activity towards functionality linked to energy savings, and emphasises the need to tackle rebound outcomes for certain types of digital application.
A cross-sectoral sufficiency strategy for Germany

Frauke Wiese, Europa-Universität Flensburg, Germany
Johannes Thema, Wuppertal Institut, Germany
Carina Zell-Ziegler, Öko-Institut, Germany
Luisa Cordroch, Europa-Universität Flensburg, Germany
Jonas Lage, Europa-Universität Flensburg, Germany
Benjamin Best, Wuppertal Institut, Germany

Panel
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Keywords
sufficiency, energy sufficiency, multiple benefits, policy measures, barriers, strategy, indicators

No European country has formulated an integrated sufficiency strategy yet. Political strategies for sustainability transitions so far rely on technological means like renewables, energy efficiency or the very prominent example of hydrogen strategies, and respective strategy documents are formulated and wide-spread on EU, national and federal, sometimes even on local level. As a multi-solving strategy, sufficiency has the potential to make an important contribution across and within sectors, not only to achieving climate targets but also to other sustainability goals in conjunction with a fairer distribution of resources.

As a concrete example, we formulate a national sufficiency strategy for the country of Germany. In this contribution, we outline dominant trends per sector that are problematic from a sufficiency perspective and analyze the status quo based on main indicators on energy service level. Against climate mitigation needs, we derive a target vision for each sector, where possible with a quantified potential for energy demand reduction. We additionally outline the multi-benefits of sufficiency as a multi-solving strategy, such as distributional effects, resilience and other sustainability dimensions.

The sufficiency strategy addresses main barriers in German legislation that currently hinder progress towards demand reductions and suggests promising policy options for harnessing sufficiency potentials.

This work builds on prior research of the energy sufficiency research group and distills the insights regarding practical policy relevance. Preliminary work includes the identification, clustering and classification of sufficiency policies including respective indicators, resulting in the sufficiency policy database (https://energysufficiency.de/en/policy-database-en/), quantitative analysis of sufficiency potentials and the identification of legislative barriers to sufficiency.
Demand and potential for seasonal heat storage in urban district heating systems in aquifer thermal energy storages

Benjamin Köhler, Öko-Institut, Institute for Applied EcologyÖko-Institut, Germany
Irina Ganal, Öko-Institut e.V.

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Keywords
district heating, heat storage, geothermal, Aquifer Thermal Energy Storage (ATES)

District heating is gaining importance in the decarbonization of the heat supply of buildings across Europe. Therefore, district heating systems must be expanded and at the same time decarbonized. To increase the use of renewable and waste heat, the efficiency of renewable heat generation and the primary energy efficiency of the overall district heating system, seasonal thermal energy storage are important. Surplus heat, which might be available in summer, can hereby be stored and used during the heating season. The aim of this paper is to assess the seasonal thermal energy storage demand of three urban district heating systems in Germany as well as the potential role of Aquifer Thermal Energy Storage as one option for seasonal thermal energy storage in these systems. The three analysed district heating systems are in the geothermal regions of the Upper Rhine Graben, the South German Molasse Basin and the North German Basin. The networks differ in terms of flow temperatures and the available renewable and waste heat potential in the summer.

We quantify the thermal energy storage demand based on the current and future heat demand and generation characteristics. The focus is on available surplus heat from zero-/low-emission heat sources during the summer in terms of power and energy. In addition, the possibilities and potentials for storing the surplus heat in aquifers at high temperatures of up to 90 °C are assessed in a detailed analysis of the underground conditions. As 90 °C is often not a sufficiently high enough temperature for the supply of district heating systems, possibilities for efficiently raising the temperature to the required level with high temperature heat pumps are developed. The availability of the storage system is thereby increased and the non-renewable primary energy demand in the overall district heating system can be minimized.

Through the detailed assessment of existing district heating systems with differing characteristics, the potentials and the limitations of seasonal thermal energy storage in district heating are determined. The results show that the seasonal thermal energy storage demand is
mainly determined by the available generation surplus, especially in larger district heating systems. The contribution of the stored heat to the overall heat supply can significantly differ as the possible thermal power of seasonal thermal energy storage is limited and can be low compared to the high thermal powers in large district heating systems. Conclusions are drawn from the results for other district heating networks with similar characteristics. They help to raise the use of zero-/low-emission heat sources in district heating.
Exploration of qualitative scenarios towards climate neutrality of the German building sector

Mahsa Bagheri, Fraunhofer Institute for Systems and Innovation Research, Germany
Ewa Dönitz, Fraunhofer Institute for Systems and Innovation Research, Germany
Songmin Yu, Fraunhofer Institute for Systems and Innovation Research, Germany
Heike Brugger, Fraunhofer Institute for Systems and Innovation Research, Germany

Panel
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Keywords
modelling, building stock, participatory process, energy demand, scenarios, foresight

Scenario modelling is widely applied to quantify the development of energy demand and GHG emissions in a given time horizon. Transformation scenarios, on the other hand, are primarily qualitative visions of the future that align with energy transition objectives. Including current policies, technological developments and societal trends in the scenarios allows considering a wide range of possible future developments. Combining descriptive scenarios with quantitative modelling results provides rich insights and contextual understanding that enhance the overall robustness of the analyses.

This paper develops a methodological approach for combining qualitative scenarios and quantitative modelling to analyse the future of energy consumption in the German building stock, which aims to become climate neutral by 2045. It describes a participatory process that was followed to develop different transformation scenarios, taking into account technical, social, political and economic aspects. The process included defining the geographical, content-related specification and the timeline of the scenarios, identifying relevant scenario factors, trends and uncertainties that could affect the German building sector, and describing underlying factors and assumptions regarding their future development.

The paper then briefly presents an agent-based framework for quantitatively modelling the qualitative scenarios. By modelling the representative buildings as agents, the model can capture the details of individual buildings at the micro level, such as the efficiency of building components and renovation decisions, heating systems and technologies and their replacement, and occupant behaviour. Through an iterative exchange between scenario description and modelling, the qualitative scenarios representing different narratives are then
translated into the mechanisms and parameters in the model. The presented approach will be used to quantify the developed scenarios for the energy demand of the German building stock until 2045.
Can Swedes learn from North Americans?

Åsa Wahlström, CIT Renergy, Sweden
Maria Jangsten, CIT Renergy, Sweden

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
procurement investigation, learning curves, energy efficiency

Installation of air-to-air heat pumps is a common way to improve the energy efficiency of heating in Swedish single-family houses with electric resistance heating. However, the coverage of the house's floor area is often no more than 50 percent.

In the US and Canada, it is common to have a significantly higher coverage rate, often up to 100 percent. How can it be that we don't do better in Sweden? The market is large, with up to 200,000 single-family homes with electric resistance heating that use a lot of electricity.

Through a literature study and interviews in the United States and Sweden, the difference between the practice of installation in North America compared to Sweden was analyzed. It was found that if we can get a better collaboration between ventilation technicians and heat pump installers in Sweden, we could get a higher coverage rate. Products are currently available to combine ventilation duct systems and air-to-air heat pumps or the use of multisplit indoor units, but the knowledge of how to do this is limited to few installers.

In a theoretical case study, the energy efficiency potential and the homeowner's profitability of an air-to-air heat pump with a high degree of coverage were analyzed. The results show that the profitability is about the same as traditional heating system alternatives, which should be considered together with other factors such as the possibility of cooling, thermal comfort, noise disturbance and aesthetics.

However, it is noted that conditions are in place for both air-to-air heat pumps in combination with ducting or the use of multisplit indoor units to be further developed and adapted for typical single-family houses with electric resistance heating and thus reduce investment costs. It can be concluded that the conditions are in place for an innovation procurement to get more adopted technical solutions on the market together with actors that can offer “one-stop-shop” possibilities.
Taking stock of our ability to project a consistent ecological transition of the French building stock

Albane Gaspard, ADEME, France
Yves Marignac, Institut négaWatt
Thierry Rieser, Enertech
Noé Delargilliere, Institut négaWatt

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
energy model, econometric models, choice model, buildings, energy supply and demand

Our ability to adequately project the evolution and use of the building stock is key to reaching carbon-neutrality by 2050, and, more broadly, to decrease its environmental impacts. The models used in this field are central to establish pathways, in particular to validate the required level of efficiency- and sufficiency-related options. While a wide range of models has long been developed in France to support such strategic environmental policies, no review of the modelling community existed. To which extent are models able to capture the multiple dimensions of the transition of the building stock (energy, carbon, materials, resources, stock value…), what are the main gaps and what could be improved to make foresight more robust?

This paper presents an analysis of the existing French community of models related to the building sector. Based on interviews with model developers, four original cartographic views of the community, and two workshops, it covers 47 models or tools developed by a large array of research institutes, public bodies, private consultancies and NGOs.

In-depth results show that models representing the energy-building nexus form the backbone of the community and enable to capture a wide array of technical and economic challenges ( electrification, job creation, etc.), together with an emerging set of models on resource demand. However, the study clearly points to needs for further development. Some, such as variations in demographic projections, projections beyond 2050, etc. require only minor adjustments for the models to capture them. Others would require stronger development, e.g. to integrate a wider array of environmental impacts, or to introduce feedback loops between models that better reflect the interplay between demand and supply (jobs, resources, etc.). Ultimately, the modelling community needs to strengthen its ability to help reflect upon resilience to crisis or major social and economic trends (digitalization, shifts in real estate markets, etc.).
How to assess glazing performance for optimum building energy efficiency

Adrien Carton, Glass for Europe, Belgium

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
glass, building envelope, energy balance

The recently revised Energy Performance of Buildings Directive (EPBD) mandates the European Commission to develop a "guidance on the calculation of the energy performance of transparent building elements that form part of the building envelope and the consideration of ambient energy". By providing tools to correctly assessing the energy performance of transparent elements, this non-binding document aims to support Member States or regions in developing appropriate performance-based policies. This presentation will examine why transparent building elements are the only ones covered by such a guidance and which methods are currently available for consideration by the European Commission.

As stated in the Commission Recommendation on the modernisation of buildings (2019), the influence on the energy performance of buildings of some elements depends on the calculation methodologies applied. In this respect, glazing has a specific characteristic, transparency, which directly affects its energy performance in a different way from other building elements. Glazing transparency allows it to capture or repeal free heat gains provided by the sun. Solar gains (calculated with the g-value) can help to further reduce heating and cooling – the main source of energy consumption in buildings.

The presentation will explain why focusing only on thermal transmittance - as is the case in most Member States that have set minimum performance requirements for windows (with a minimum U-value to be achieved) but also in some European legislation (EU taxonomy) - can lead to the use of inadequate or sub-optimal products with a more limited impact on reducing energy consumption. Double or triple glazing are not the only relevant categories for assessing the thermal performance of glazing, as invisible innovations have been incorporated into insulating glass units to improve performance and reduce heat transfer, regardless of the number of panes.

Based on the example of different Member States, we will look at existing solutions (energy balance, g and U values adapted to geographical locations and building characteristics...) to show the different directions the European Commission could take with its guidelines and the role it can play in helping to reduce CO2 emissions from the EU building stock, considering that windows account for up to 30% of energy losses in buildings.
Key approach to decarbonising buildings: efficient and needs-based allocation of housing

Jonas Lage, Europa-Universität Flensburg, Germany

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
energy sufficiency, housing, climate policy

In Europe, there is only one push policy for efficient and needs-based allocation of housing: minimum occupancy requirements for apartments in Swiss housing cooperatives and some municipalities. Efficient and needs-based allocation of housing is necessary to achieve social and environmental goals. In Germany, for example, about 10% of all people live in overcrowded dwellings, despite the fact that living space per person has increased by about 30% in the last 30 years. This increase in living space has completely cancelled out efficiency gains over the same period, so that residential heat demand has remained more or less stable. Similar trends can be observed in most European countries and call for changes in housing practices.

However, policies to enable and shape such changes are rare. We know from research on mobility, for example, that a successful change in social practices requires a combination of pull and push measures. The only existing push policy, the minimum occupancy requirement in Switzerland, is therefore of particular interest. In most cases, minimum occupancy means that the number of occupants in each dwelling may only be one less than the number of rooms. If this is no longer the case, people have to move into alternative accommodation. This means that housing is much more directly linked to changes in life stages.

The study of this policy offers many insights into the transformation of housing practices (through regulatory measures), far beyond the specific policy itself. On the basis of an analysis of more than 20 qualitative interviews and additional documents, I would like to explore questions about the processes, conflicts and achievements associated with the necessary move, the effects on life planning and family constellations, and the perception of how much living space is perceived as sufficient. Finally, I draw general conclusions for energy sufficiency policies in the housing sector.
The role of biomass and synthetic energy carriers in the building sector – from a sectoral to a cross-sectoral perspective

Charlotte Senkpiel, Fraunhofer Institute for Solar Energy Systems (ISE), Germany
Connor Thelen, Fraunhofer ISE, Germany
Hannah Nolte, Fraunhofer ISE, Germany
Kost Christoph, Fraunhofer ISE, Germany
Jan Steinbach, Institut für Ressourceneffizienz und Energiestrategien, Germany

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
allocation, biomass, energy model, cross effects, hydrogen

Explorative bottom-up models simulate possible development paths from a sectoral perspective. Aspects such as decision-making, intermediaries and the impact of policy instruments can be mapped. In comparison, cross-sectoral energy system models can find the cost-optimal system solutions and inherently generate the minimum cost solution for the individual sectors. What effects in the cross-sectoral energy system arise when the results of an explorative simulation for the buildings sector are fixed in a cross-sectoral energy system model, taking a policy mix into account?

For this purpose the results of the final energy consumption of the Invert/ee-Lab simulation model were determined for a "policy scenario" in the cross-sectoral energy system model REMod. This means that the buildings sector is not optimized in terms of heating system replacement and refurbishment, as is the case in the normative approach.

The emerging results allow interesting conclusions. When restricting the solution space in the energy system model, it first becomes apparent that the mathematical model cannot determine a solution under standard boundary conditions. The reason for this is that the high shares of biomass in the heating systems resulting from the bottom-up simulation exert pressure on the overall energy system. In the normative case, the optimizer can freely optimize the use of biomass between the sectors. A bottleneck is created that can only be solved by increasing the assumptions for biomass potential. The analysis with regard to sectoral effects is presented here. These results show a high political relevance with regard to the distribution of limited
available climate-neutral energy carriers, as without sectoral attributions, higher system costs and resource bottlenecks can result, which in turn impair the achievement of climate protection targets.
How to bring intelligence to legacy equipment at our places and actively manage it?

Ana Soares, INESC Coimbra / University of Coimbra, Portugal
Ricardo Rodrigues, DEEC - University of Coimbra, Portugal
Alvaro Gomes, INESC Coimbra / University of Coimbra, Portugal

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
ergy management system, renewable energy, automatic control, flexibility

Considering the expected growth of wind and solar power generation on the journey to the decarbonization in the European Union (EU), the ability of power systems to adjust to fluctuating energy generation and consumption plays a key role. This ability, called flexibility, is clear on the proposal to improve the EU’s electricity market design and can be seen as solution to better accommodate variable renewables. At the individual level, flexibility can be defined as "the modification of generation injection and/or consumption patterns in reaction to an external signal (price signal or activation)" to provide energy system supporting services. The main difficulty here is harvesting flexibility at the individual level when no technology is yet in place but assuming that local generation is available.

This paper aims at presenting an economical viable home energy management system (EMS) architecture which can be easily deployed for bringing intelligence to non-smart controllable home equipment and appliances – the so called legacy equipment. This solution will allow endowing legacy equipment typically available in most houses with technology which can be further integrated in an EMS and used to i) maximize the integration of local generation based on renewables, ii) decrease the end-user electricity bill and iii) provide flexibility services to the electricity network if needed. The targeted loads are air conditioning systems, electric water heaters, dishwashers, washing machines, electric vehicles and cold appliances. The intelligence embedded in the EMS is based on mixed-integer linear programming models using CPLEX as the solver and coded in Python. Next step foresees the implementation of this system in a Raspberry Pi using Home Assistant. Preliminary results show that the EMS can attain significant savings and maximize self-consumption, actively contributing to the energy transition and decarbonisation of the electricity supply and building sector.
What's the ETA for heat pump adoption? Assessing barriers and opportunities with the Energy Technology Adoptability framework

Sarah Outcault, University of California-Davis Western Cooling Efficiency Center, USA
Eli Alston-Stepnitz, University of California-Davis Western Cooling Efficiency Center
Angela Sanguinetti, University of California-Davis Western Cooling Efficiency Center
Emily Searl, University of California-Davis Western Cooling Efficiency Center

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
heat pump, adoption, residential customers

Air-source heat pumps (ASHPs) are a keystone technology to electrify and decarbonise buildings. Despite an abundance of programs to promote their adoption, uptake lags behind targeted rates in many regions. Research has highlighted a range of factors that hinder heat pump adoption, but it tends to focus on known barriers such as high initial costs and lack of awareness among potential customers. This paper takes a systematic approach to exploring barriers to heat pump adoption, using the Energy Technology Adoptability (ETA) framework. This framework is a rating system that can be used to assess how adoptable a given energy technology is based on its economic, technical, and informational characteristics and when taking into account externalities (i.e., environmental and non-energy impact). Fourteen characteristics are rated on a simple three-point (low/medium/high) scale and arranged in a matrix that provides an easy-to-interpret representation of the technology’s adoptability.

Twenty-nine heating, ventilation, and air conditioning (HVAC) experts from around the United States completed the ETA rating scale for ASHPs via an online survey platform. They rated each characteristic in comparison to gas furnaces, the most common heating equipment in the United States. Ratings were aggregated across the sample by calculating the median response for each characteristic. Heat pump adoptability ranked poorly on economic characteristics (operating costs, return on investment, market availability), particularly on the initial investments required which were rated “high” compared to gas furnaces. The technical characteristics of ASHPs ranked fairly well, rating “high” on performance, ease of use and maintenance, and technical compatibility with home infrastructure; and “medium” on ease of
installation and energy savings. Heat pumps were rated as having “low” negative environmental impacts, but only “medium” non-energy benefits to users. Finally, while the visibility of residential ASHPs and their performance were reported to be moderately good, the ability to gain experience with them without making a significant investment (i.e., their trialability) was rated “low.”

Since the assessment of some technology characteristics is driven by local policies and market conditions, variations in responses among respondents from regions with different levels of heat pump adoption were explored and patterns suggested the expected regional differences. Initial investment, market availability, and observability, as well as technical compatibility with other home equipment, performance, and ease of installation and maintenance, were rated more favourably by respondents from higher prevalence regions. Across regions, respondents generally agreed that heat pumps are easy to use, generate few negative environmental impacts, require moderate operating costs, and offer moderate energy savings. The limited trialability of heat pumps was also noted across regions.

This paper illustrates the utility of the ETA framework in facilitating a systematic assessment of technology characteristics and summarising the outcome with a simple visual representation. The tool identifies attributes of residential ASHPs that hinder adoption, such as “low” trialability and “high” initial investments, as well as their characteristics that favour adoption, such as “high” performance and ease of use and maintenance. The resulting assessment provides a lens through which to explore efforts and opportunities to address barriers to adoption and leverage the relative advantages ASHPs have over alternative technologies.
Developing a regionalized representative building Stock model for Germany

Şirin Alibaş, Fraunhofer Institute for Systems and Innovation Research, Germany
Songmin Yu, Fraunhofer ISI, Germany

Panel
8. Products, systems and technologies to decarbonise buildings

Keywords
building stock, modelling, open data, regionalization

According to statistics, the German building sector is directly responsible for 16 % of the GHG emissions in the country (Federal Climate Protection Act), as well as roughly 40 % of the total final energy consumption. More than 70 % of heating rely on fossil fuels.

The building sector is a key pillar of the green energy transition in Germany. To model the decarbonization of the sector and support policymaking, a reliable and consistent representation of the heterogeneous buildings and technologies in the stock is needed.

In this study, we develop a regionalized representative building stock model for Germany by making use of different sources, incl. (1) Census survey data at various geographic levels, (2) findings from the TABULA project about residential buildings, (3) non-residential building stock dataset (dataNWG) developed by the Institute for Housing and Environment (IWU), (4) built environment data from the Global Human Settlement Layer (GHSL) varying from 10 m to 1 km geographic resolution, and (5) data from research papers and the public reports by IWU and the German Energy Agency (dena).

As a result, the building stock model includes a population of “representative buildings” (RBs), each of which has detailed information on its sector, type, construction period, geometry (surface area and orientation) and thermal efficiency (U-value) of components, heating system and technology, and location in terms of the NUTS 3 region and settlement types (e.g., urban center, sub-urban, rural cluster, etc.).

The number of buildings that each RB represents is also estimated for aggregating the results to different regional levels. Finally, the energy demand of the building stock model is calculated according to the simple hourly method of the DIN EN ISO 13790. The energy demand is then updated with user behavior parameters such as internal set temperatures, occupancy profiles etc. and heating system conversion efficiencies to obtain the final energy consumption. The final energy consumption is compared with the statistics in a base year at the national level.
This representative building stock model can serve as the foundation for developing agent-based energy demand projection models for the German building sector. Based on the high geographic resolution, such models have the potential to analyze the effects of the development of infrastructure, e.g., district heating network and gas grid, on the transformation of the building stock.
Decarbonising basic materials for buildings – exploring circular economy scenarios for the EU

Meta Thurid Lotz, Fraunhofer Institute for Systems and Innovation Research, Germany
Matthias Rehfeldt, Fraunhofer Institute for Systems and Innovation Research ISI, Germany
Andrea Herbst, Fraunhofer Institute for Systems and Innovation Research, Germany

Panel
9. Energy efficiency and sustainability of industry

Keywords
circular economy, decarbonisation, buildings, industry, material demand, material production

In 2020, 6% of greenhouse gas (GHG) emissions in the European Union (EU) were caused by the production of construction materials including basic materials. To meet the climate targets, it may be necessary to reduce this basic material demand, given high production quantities and significant emission shares. However, the potential to reduce this demand is closely interlinked with the future development of the building stock. On the one hand, it could increase due to a rising demand for building-related services, such as comfortable living, education or workspace. On the other, it could be reduced by implementing circular economy strategies, such as designing and constructing buildings more efficiently, extending the lifetime of buildings or re-placing conventional construction materials. Consequently, a circular economy for buildings gains momentum for reducing basic material demand and contributing to achieve EU climate targets. However, the material demand for buildings cannot be completely avoided. Thus, it is necessary to analyse further options for decarbonizing the basic material production. Building on this research interest, this contribution aims to answer a two-part research question: (1) What is the potential impact of a circular economy in EU buildings on material demand and (2) how does a circular economy for EU buildings affect the decarbonization of basic material production in the industry sector?

To answer this question, we applied a stock-driven material flow model of steel, concrete, glass, insulation and wood in EU buildings. Within this model, we determined the potential impact of a circular economy in buildings on material demand for five scenarios: (1) Increased re-cycling focusing on activities that improve the reuse and recycling of building elements and building materials; (2) Material efficiency including activities to reduce material use by design and to reduce emissions-intensity of the used materials; (3) Demand reduction especially during the use of buildings by extending their lifetime and using space more efficiently; (4) Material substitution with timber for structural applications; (5) Mix of all above-mentioned
activities.

Scenario 5 (Mix) was selected for analyzing the basic material production in the industry sector. For this, we applied the bottom-up model FORECAST, which simulates future GHG emissions and assesses industry transformation pathways. The tool aims to model the decarbonization of the industry sector based on techno-economic assumptions. It considers a broad range of GHG mitigation options like energy efficiency or switching to carbon neutral energy carriers and processes.

The results of the stock-driven material flow model show that all scenarios reduce the demand for the materials by up to 65% except for wood. The wood demand increases in scenario 4 (Material substitution) and 5 (Mix) by 207% and 83%, respectively – as it is used as a substitute for conventional, emission-intensive materials. Scenario 5 (Mix) achieves the highest reduction through an ambitious combination of all circular strategies. For instance, the concrete demand for EU buildings in 2050 is reduced by more than 160 megatons (-47%).

Overall, the decarbonization of basic material production in the industry sector in 2050 is achieved by using electricity as the main energy carrier followed by hydrogen. In this scenario, a circular economy for buildings primarily reduces energy and feed stock demand. Consequently, the demand for hydrogen is lower than in comparable industry decarbonization scenario – lowering costs for renewable energies, grid expansion and the import of secondary energy sources.

In conclusion, decarbonizing the basic material production for buildings is achievable and can be facilitated by a circular economy. Further research should investigate other products with high relevance in terms of basic material demand and circular economy potentials, such as vehicles or plastic products.
Prospective Life Cycle Assessment of renewable hydrogen import in the European political context

Vanessa Schindler, IREES GmbH, Germany
Nele Friedrichsen

Panel
9. Energy efficiency and sustainability of industry

Keywords
hydrogen, regulation, prospective life cycle assessment, integrated assessment modeling, decarbonisation

Hydrogen plays a major role for the phase out of fossil fuels especially in industry to reach the 1.5 °C target from the Paris Agreement. Carbon intensity of hydrogen production very much depends on the production route and supply chain. To provide early decision support for hydrogen electrolysis as an essential future technology, we conduct a prospective Life Cycle Assessment (LCA) analysing the overall and future environmental impacts.

Our analysis encompasses six scenarios for electrolytic hydrogen production in Algeria as a representative for the Middle East-North Africa (MENA) region and probable hydrogen exporter to Europe where hydrogen is transported via the European Hydrogen Backbone to Germany in 2030 and 2050. LCA-foreground and background systems are transformed in line with IPCC scenarios to future states.

We find that power consumption is a main driver for the impacts, despite considering the future increase of renewable electricity generation. Compression for transport accounts for 17 % to 38 % and the PV power consumption for electrolysis for 26 % to 49 % of the total global warming potential. Impacts are decreasing in all scenarios over time driven by the assumptions on decarbonising the EU electricity mix and efficiency increases of all relevant processes in the future. This underlines the importance of decarbonising the power system for low-carbon hydrogen transport.

Overall, we find our results of the environmental impacts to be coherent with similar studies. Except for the baseline scenario in 2050, all scenarios lead to a carbon intensity below the current EU threshold for Renewable Fuels of non-biological origin (RFNBO), calculated according to the EU delegated act defining the methodology of emissions accounting of the hydrogen supply chain to spur further reduction of emission intensity and efficiency improvements, the EU should review the thresholds in due time.
Evaluating net-zero emission pathways for China’s cement industry

Hongyou Lu, Lawrence Berkeley National Laboratory, USA
Hon Leung Curtis Wong, Lawrence Berkeley National Laboratory, USA
Nan Zhou, Lawrence Berkeley National Laboratory, USA
Xian Zhang, The Administrative Center for China’s Agenda 21, China

Panel
9. Energy efficiency and sustainability of industry

Keywords
cement, circular economy, net zero emissions, China

China’s cement industry emits over 1 Gt of carbon dioxide (CO2) annually, or 3% of global CO2 emissions. Urgent decarbonization efforts of the Chinese cement industry are needed to meet China and global community’s climate commitments. Prior studies on this topic primarily relied on supply-side technologies and end-of-pipe solutions, presenting one singular pathway to net zero without exploring multiple trajectories.

This study adds value to the existing research by constructing and evaluating two different pathways toward net-zero emissions in China’s cement industry: the Energy Technology Pathway (ETP) and the Circular Economy Pathway (CEP). Both pathways aim for net-zero emissions but diverge in their prioritization and emphasis. The Energy Technology Pathway focused on supply-side technologies such as green hydrogen and CCS, while the Circular Economy Pathway focused on demand-side strategies, centered on materials and resources.

The study showed both pathways can achieve a comparable level of emission reduction, reducing 94–95% of CO2 emissions by 2060 from the 2020 level. Notably, the role of CCS is limited in the CEP, contributing only 5% and 22% of total emission reductions by 2030 and 2060, respectively. The majority of the emission reductions in CEP are achieved through a combination of material-focused innovations and circular economy strategies, such as increasing the use of supplemental cementitious materials (SCMs), advancing alternative cements, integrating material efficiency practices in product lifecycle phases, and adopting alternative fuels (e.g., industrial wastes and agricultural byproducts). Policy support on materials and the circular economy will be critical. We recommend updating codes and standards to allow performance-based cement products, providing R&D support on alternative cements, developing implementation guides to disseminate material efficiency practices, and improving material/waste collection, sorting, and recycling systems.
Can green hot briquetted iron trading help steel decarbonization and achieve NDCs and the Paris agreement? Evidence from eleven countries

Zhenxi Li, Lund university, Sweden
Max Åhman, Lund university
Lars J Nilsson, Lund university
Jonas Algers, Lund university

Panel
9. Energy efficiency and sustainability of industry

Keywords
Asian steel, HBI trading, decarbonisation

The steel industry accounts for 7-9% of global greenhouse gas emissions. To meet the Paris agreement, the decarbonization of the steel industry is urgent. Most of the steel production nowadays is in Asia, who accounts for 73% of global steel production in 2022. The top eight Asian steel producers in 2022 are China, India, Japan, South Korae, China-Taiwan, Vietnam, Indonesia, and Malaysia. Their total steel production accounts for 99% of the total Asian steel production. Thus, their ambitions on steel decarbonization will hugely affect the CO2 reduction of the global steel industry. Even if all of those countries/region have announced their carbon neutral time in their Nationally Determined Contributions (NDCs), between 2050-2070, none of them have detailed long-term climate target and plan for their steel industry.

Decarbonizing the steel industry in those countries/region is not easy since they already have have huge amount of blast furnace – basic oxygen furnace (BF-BOF) capacity which is carbon intensive. In addition, most of them have recently announced that they plan to invest heavily in new blast furnaces. To mitigate the CO2 emissions caused by producing BF-BOF steel, carbon capture and storage (CCS) may be an option. However, CCS has caused a lot of discussion that it is not an optimal choice to mitigate emissions.

One way to solve this problem is to import green Hot Briquetted Iron (HBI) from, for example, Australia, Brazil or South Africa –countries with large iron ore reserves and a large renewable electricity potential. No research systematically study how HBI trading can affect national steel production pathway for those Asian regions and how HBI trading can contribute on achieving NDCs and the Paris agreement. Here, we interpret the NDCs as the time of carbon neutrality and the Paris agreement as the cumulative CO2 emissions before carbon neutrality. In addition, none of them consider how HBI trading will affect the HBI exporters annually, from the perspective like annual green H2 consumption and job opportunity. In addition, no study
focuses on emerging economic, like Vietnam, Indonesia and Malaysia who will be also emerging in steel capacity in the future.

Thus, we build a long-term cost minimal optimization model to study the steel production pathway of the eight Asian countries/region under the goal of achieving their own NDCs or the Paris agreement, and most importantly, the impacts of green HBI trading on both HBI importer (the top eight Asian steel producers) and exporters (Australia, Brazil, South Africa). Four scenarios are built, based on the presence or absence of HBI trading, the timeline for grid power decarbonization, and the strength of climate target. From there we assess how HBI trading and varying reduction ambitions on both the grid power and steel industry can affect: the total cost, CO2 emissions, future steel production pathway, directed reduced iron demand, green electricity and H2 demand, the risk of standard capital and employment opportunity. Finally, we end by discussing the geopolitical difficulties of doing HBI trading and giving associated policy recommendation.

Our main conclusions are: 1) HBI trading can reduce 5-10 Gt total cumulative CO2 emissions, but can not advance the carbon neutrality time: the neutrality of grid power is the key for when the steel industry can be carbon neutral. 2) HBI trading can lead to 2764 Mt less BF-BOF steel production and accelerate the phase out of BF-BOF steel capacity1-7 years earlier, but HBI trading can cause more standard capacity. 3) The best strategy for steel decarbonization in different countries/region is different. In China and south Korea, HBI trading is the most efficient way to reducing CO2. In India, setting stronger NDC is the most efficient way to reduce CO2 emissions; in Japan, Taiwan, Vietnam, Indonesia and Malaysia, the most efficient way is to decarbonize grid power as quick as possible.
Highway to corporate energy efficiency: extending the VBN theory to predict leaders' sustainability behavior

Maike Keil, RWTH Aachen University – Junior Professor for Risk Perception and Communication, Germany
Katrin Arning, Junior Professor for Risk Perception and Communication, Germany

Panel
9. Energy efficiency and sustainability of industry

Keywords
Corporate investment decisions, corporate strategy, sustainability, quantitative survey, norms, environmental attitudes, environmental awareness, sustainability leaders, organizational citizenship behavior for the environment

One of the key challenges in addressing climate change is the corporate transformation towards sustainability, as industry and commerce account for over 40% of the primary energy consumption in Germany. Current literature highlights the pivotal role of leaders in shaping the corporate sustainability transformation in their respective companies through their individual pro-environmental behavior. However, little research has investigated the specific traits or psychological factors that define managers as effective sustainability leaders. Therefore, the present study aimed to explore and model the relationships among various individual factors influencing leaders' Organizational Citizenship Behavior for the Environment (OCBE).

A quantitative online survey with 108 German managers responsible for sustainability and energy efficiency decisions was conducted. Based on Stern et al.'s (1999) Value-Belief-Norm (VBN) theory, a structural model (partial least squares, PLS-SEM) was developed, and additional individual factors were integrated to predict the psychological determinants driving managers' OCBE. The model results confirmed the VBN model's causal chain, where general eco-consciousness impacts specific beliefs about climate change, which then influences personal responsibility and activates personal norms, leading to OCBE. The inclusion of additional factors like locus of control, innovativeness, and sustainability interest significantly enhanced the model's explanatory power.

Our model validates the VBN theory as a foundational framework for understanding environmental behavior within corporate leadership and confirms the significant influence of additional factors closely linked to managerial characteristics. Furthermore, the study yields recommendations for fostering Organizational Citizenship Behavior for the Environment (OCBE) within companies, specifically through strategic personnel selection and targeted leadership training.
Policy recommendations to accelerate the replacement of old electric motors

João Fong, ISR-University of Coimbra, Portugal
Fernando Nuño, ECI
Erik Faassen, IEECP
Bruno Dewachter, ECI
Diedert Debusscher, European Copper Institute

Panel
9. Energy efficiency and sustainability of industry

Keywords
electric motors, motors, Energy Efficiency Directive (EED), energy efficiency policy, energy policy, policy recommendations, electricity savings, energy saving potential, Motor Replacement, industrial process equipment, Equipment Replacement, ecodesign, Ecodesign Directive (EuP/ErP), evaluation

The EUropean MOtor REnovation initiative (EU-MORE), co-funded under a LIFE grant agreement, aims to accelerate the replacement rate of old, inefficient motors through the development of new policies. Enterprises and public services tend to operate electric motors for much longer than their intended lifespan, typically opting for replacement only when failure occurs and repair is no longer feasible. Through swift action, the replacement rate of old motors by high-efficient ones can be raised significantly. The resulting energy savings can be counted under the new Energy Efficiency Directive (EED), which came into effect in October 2023. Regulatory programmes that accelerate motor replacement fulfil the condition of Art.8 of the EED to create energy savings with proven additionality and tap into a savings potential of 70 to 130 TWh per year.

In January 2024, EU-MORE will have reached its 4th milestone with the publication of its Policy Review. A total of 61 existing policy measures that directly or indirectly aim at accelerating motor replacement have been identified and analysed for their approach, impact and lessons learnt, leading to an initial set of general observations. These observations will be used to derive concrete policy recommendations, which will be listed in a first draft report in spring 2024.

The Policy Review reveals, among other conclusions, that support measures of a financial kind comprise the large majority, while it could be questioned whether these are still the most effective. The lack of information is a major barrier that is much less addressed. Moreover, most of the policy measures target industry, while service companies, municipalities and buildings are much less aimed at, despite the abundant presence of motors in those organizations.
At the ECEEE Summer Study, EU-MORE will discuss its Policy Review with a European-wide public and will, as a premiere, shed a light on potential policy recommendations resulting from the review.
Beyond industrial energy efficiency: defining the multiple roles that businesses can play for climate-positive action

Hannah Bamford, University of Oxford, United Kingdom
Sam Hampton, ECI - Energy Group. Environmental Change Institute, University of Oxford, United Kingdom

Panel
9. Energy efficiency and sustainability of industry

Keywords
business strategy, industrial SME, industrial energy saving, SME, business models, role model, citizens

In the last three decades, significant research and policy attention across OECD countries has focused on how to encourage greater energy and resource efficiency in industry. This has been justified on the basis of cost, energy and emissions savings, and productivity improvements that can accrue to both large enterprises and SMEs. However, with the increasing urgency of climate change and in response to the energy crisis which has affected millions of businesses, there is a need to look beyond efficiency and consider the multiple roles that businesses can (and must) play in accelerating the transition towards net-zero.

In focusing on efficiency, researchers and policymakers have tended to frame industrial organisations primarily as (1) consumers of energy and resources, with interventions to reduce these whilst maintaining output (productivity).
There has also been a focus on 'eco-innovation' policies that address a second role that businesses play in energy transitions, as (2) enablers of low-carbon consumption (e.g. developing green products and services).

Using findings from a two-year research study on the governance of SMEs and climate change, including 76 interviews with industry stakeholders, expert workshops, and a narrative literature review, we discuss the effectiveness of these dominant role-framings, and highlight three additional roles that warrant attention and analysis: businesses as (3) adopters of critical low-carbon technologies and services including demand-side flexibility; (4) citizens with the power to influence policy agendas and contribute towards local placemaking efforts; and (5) social influencers, creating and embedding social norms around consumption choices and environmental responsibilities.
This paper seeks to widen the discourse of industrial decarbonisation, challenging researchers and policymakers to reconsider their assumptions about the role of business in the energy system, and to forge new approaches which capitalise on their potential for climate-positive action.
Unlocking energy efficiency in SMEs: overcoming challenges and realizing savings

Bo Shen, Lawrence Berkeley National Laboratory, USA
Virginie Letschert, Lawrence Berkeley National Laboratory
Nan Zhou, Lawrence Berkeley National Laboratory

Panel
9. Energy efficiency and sustainability of industry

Keywords
industrial SME, energy efficiency policy, climate change mitigation, developing countries, sustainability

Small and medium-sized enterprises (SMEs) in manufacturing are pivotal for the economies of developing nations, fostering job creation, economic growth, and industrialization. However, SMEs often face hurdles in fully embracing energy efficiency, despite its potential for cost savings and environmental sustainability. Challenges include high upfront costs, limited financing, insufficient awareness of benefits, technical expertise gaps, resource constraints, and inadequate governmental support.

In addressing the barriers hindering SMEs from embracing energy-efficient practices, we present five compelling case studies that exemplify promising strategies for advancing energy efficiency within manufacturing SMEs. These cases include a range of initiatives, such as an energy performance benchmarking and rating program to promote sustainability in SMEs, a supply chain eco-partnership between a multinational corporation and SME suppliers aimed at enhancing collective sustainability, voluntary decarbonization agreements aimed at decarbonization and rewarding outstanding achievements in reducing carbon emissions, a program establishing industry assessment centers partnering with universities to identify efficiency opportunities for SMEs while simultaneously cultivating the next generation of energy professionals, and market-based approaches utilizing third-party financing and energy performance contracting to facilitate the implementation of efficiency measures, expand the ESCO sector, and achieve scale in energy efficiency adoption.

To tackle the SME challenges holistically, we propose a "closed-loop strategy" that integrates the most effective elements from these case studies to create an enabling ecosystem for SMEs in developing countries pursuing energy efficiency. This strategy starts with SMEs making voluntary commitments to reduce their carbon or energy intensity, establishing a baseline for progress. Following this commitment, tailored energy efficiency and decarbonization performance metrics are developed. This data pinpoints areas for improvement and allows for the tailoring of support programs to effectively address the unique needs of each SME.
Simultaneously, supply chain eco-partnerships are forged to motivate and support manufacturing SMEs. These partnerships leverage the expertise and resources of larger corporations within the supply chain, helping to overcome barriers to adoption faced by smaller players.

Next, university-partnered industry assessment centers (IACs) are established. These centers serve as hubs of expertise, identifying energy efficiency opportunities and providing cost-saving solutions for SMEs. Market-based solutions, such as energy performance contracting and third-party financing, are then deployed to scale up the actions recommended by IACs and catalyze growth in the ESCO sector. Finally, an "SME Champion" recognition program and incentive policy are introduced to reward top-performing SMEs and incentivize companies to surpass their targets. This effort completes the loop by encouraging SMEs to push further and cultivate a culture of continuous energy efficiency improvement.

The adoption of this closed-loop strategy requires tailored policy recommendations. We therefore recommend a comprehensive set of policy actions that complement and reinforce the closed-loop strategy. These recommendations will be tailored to empower SMEs and accelerate the adoption of energy-efficient practices within the sector. Through the implementation of this closed-loop strategy and the recommended actions, SMEs are empowered to drive meaningful change, contributing to a more sustainable future while enhancing their own competitiveness and resilience.
Resource efficiency: a new element in Germany's funding program for companies

Karsten Weinert, Prognos AG, Germany
Simon Hirzel, Fraunhofer ISI, Germany
Lisa Neusel, Fraunho, Germany

Panel
9. Energy efficiency and sustainability of industry

Keywords
resource efficiency, program design

Resource efficiency has gained increasing attention as a complement to energy efficiency in recent years and it will likely grow in relevance in the future. The sparing use of resources can make a substantial contribution towards energy efficiency. Its relevance is also mirrored in funding schemes for enhancing energy efficiency: in Germany, companies may request financial support for the implementation of resource efficiency measures under the Federal Funding Scheme for Energy and Resource Efficiency in the Economy (EEE) since November 2021.

Since it is the first extension of this kind in a German funding scheme, this paper aims to provide a high-level overview of funding activities in the first year. To this end, application data for the funding and energy saving concepts submitted by the companies were analyzed in more details. The results show that material substitution measures play a particularly important role. These projects, particularly in the cement, metal and plastics industries, are characterized by high absolute greenhouse gas reductions. On the other hand, a significant proportion of these types of projects are not economically viable in terms of material costs. From a methodological point of view, it is not always clear where the greenhouse gas reductions were achieved in resource efficiency projects. Due to the LCA approach, it is conceivable that some of the savings are imported.
Can you have your cake and eat it (later)? Decoupling power from service to support flexibility and security

Michael Fell, University College London, United Kingdom

Panel
9. Energy efficiency and sustainability of industry

Keywords
demand patterns, energy services, demand response, flexibility capital, security

Electricity is used to provide energy services like heating and lighting, which in turn enable further services or states such as comfort and productive work. Societal rhythms influence timing of demand for these services, and lead to variations in electricity use. Such variations cause challenges for grid management, like congestion or suboptimal use of renewable generation. There is a tension between the demands of the electricity system (for efficient operation) and of its users (for services) over time. Demand-side flexibility interventions aim to address this tension. The ideal outcome would be one where power demand could be managed entirely according to the needs of the system, while users’ receipt of services was unaffected.

The extent to which this power-service decoupling is possible depends on two key linkages: between power delivery and energy service delivery; and between energy service delivery and end service experience.

An example of the first linkage is delivering electricity from the grid to a battery, and only later using it to deliver an energy service such as heating. An example of the second is delivering the energy service of heating (an oven), and only later experiencing the end service (eating cake). While both linkages have sociotechnical elements, the former is principally a technical one of energy storage. The latter is primarily social, can be framed in terms of “service storage”, and varies with the nature and quality of the service. This presentation will expand on this framing and consider its possible implications for different households using the lens of flexibility capital. It will also consider the energy security implications, with a focus on service security.
Towards a sustainable industrial transition: analysing the incorporation of resource and energy efficiency measures into the UK's local industrial decarbonisation plans

Imogen Rattle, University of Leeds, United Kingdom
Peter Taylor, University of Leeds, United Kingdom

Panel
9. Energy efficiency and sustainability of industry

Keywords
industry, governance, local or regional energy efficiency measures, qualitative study, research

Energy intensive industry is responsible for a quarter of global GHG emissions and the sector is considered hard to abate due to its heterogeneity, high capital costs, long investment cycles and low profit margins. Enhanced resource efficiency and energy efficiency (REEE) measures have the potential to achieve significant reductions in industrial emissions. However, globally, the main focus of recent policy efforts has been on developing business models and securing support for large-scale infrastructure projects related to low carbon hydrogen and carbon capture and storage. The effectiveness of these interventions is likely to most pronounced when applied to existing clusters of heavy industry, such as those found around the ports of North-West Europe. Addressing the diverse challenges and opportunities associated with emission reduction strategies in other, less carbon intensive regions, however, will require a broader approach that will almost certainly involve embedding REEE measures into regional initiatives to decarbonise industry. At present, there remains a considerable knowledge gap about how best to effectively decarbonise these regions and achieve a sector-wide industrial transition.

Using the UK as its case study, this paper examines developments in the recent Local Industrial Decarbonisation Plans (LIDP) competition. Starting in January 2024, the initiative has provided grants to twelve industrial "mini-clusters" to develop local decarbonisation plans tailored to their specific regional conditions. Through stakeholder interviews with industry representatives, policymakers and local authorities, combined with qualitative document analysis, the presentation will provide an analysis of the LIDP process to date. Key questions include understanding why certain consortia decided to bid, identifying the barriers and enablers influencing participation, examining the goals of the proposed LIDPs and the types of interventions envisaged. The research aims to understand which approaches are most conducive to encouraging decarbonisation efforts in areas of dispersed industry, how
mini-clusters understand the issues they face, and what determines the type of interventions they consider.

As the industrial transition shifts from planning to implementation, this research contributes towards a practical foundation for developing a comprehensive policy framework for decarbonising dispersed industrial sites.
Redefining industrial efficiency. How could EU industries transform by 2050?

Khaled Al-Dabbas, Fraunhofer Institute for Systems and Innovation Research, Germany
Tobais Fleiter, Fraunhofer ISI

Panel
9. Energy efficiency and sustainability of industry

Keywords
energy-intensive industry, circular economy

The EU's commitment to the Paris Agreement and its own ambitious becoming a climate neutral society by 2050 necessitates a far-reaching transformation of the whole economy, covering energy supply and demand. To navigate this complex system transformation, models and scenarios play a fundamental role. The industry sector, a cornerstone of the EU's economy, is a major contributor to greenhouse gas emissions responsible for 26% of the total final energy demand and approximately 22% of the greenhouse gas (GHG) emissions corresponding to 721 Mt of CO2 equivalent in 2020.

This study's objective is to explore different pathways for decarbonizing EU industry. For that, a reference scenario (RRef) and two target scenarios were developed and modelled. The two target scenarios illustrate different pathways of reaching GHG-neutrality. order to have a high level of detail for the industry sector, we first use the bottom up model FORECAST to calculate transition pathways for the industry sector. These resulting energy demands are then fed into the ENERTIL model to assess the impact on the overall energy system. The first target scenario (RTgt) has a stronger focus on technical solutions and is more technology-open. The second scenario (EUGS) presents a pathway which includes highly ambitious assumptions regarding sustainability. It includes strong assumptions on sufficiency and circularity and limits technologies available.

Results show that renewable electricity and sustainable hydrogen are needed in large quantities to enable domestic low-carbon production. From a techno-economic perspective, renewable energy sources have the potential to meet Europe's energy demand at competitive costs. EU Industry Energy demand in 2050 is dominated by electricity (43% in RRef, 49% RTgt and 55% in EUGS). Strong diffusion of hydrogen as an alternative energy carrier in energy-intensive industries in climate-neutral scenarios (150 TWh in RRef, 1430 TWh in RTgt and 737 TWh) in EUGS).
High-temperature heat pumps unleashed: cracking the code on waste heat recovery in industry and overcoming commercialization hurdles

Ammi Amarnath, Electric Power Research Institute EPRI, USA
Baskar Vairamohan, EPRI, USA
Pradeep Vitta, Southern Company, USA

Panel
9. Energy efficiency and sustainability of industry

Keywords
industry, heat pump, commercialization, financial incentives, environmental policies

This paper focuses on the commercialization of high-temperature industrial heat pumps designed for the recovery of waste heat in the U.S. industrial sector. According to estimates by the U.S. Department of Energy, a significant portion, approximately 35%, of energy input for process heating in industrial applications is lost as waste heat in various forms, including exhaust gases, cooling water, and product heating losses. Harnessing this waste heat emerges as a key strategy for improving energy efficiency and achieving sustainable industrial practices.

The paper explores the advancements in waste heat recovery through industrial heat pumps and the subsequent efforts to commercialize these technologies. The industrial sector's waste heat inventory, with a particular focus on high-temperature streams, is evaluated, revealing substantial untapped potential. The commercialization of industrial heat pumps capable of capturing and converting high-temperature waste heat into valuable energy resources is crucial for widespread adoption and impact.

The paper also discusses technological innovations, economic considerations, incentives and regulatory frameworks in the USA, which influence the commercial viability of such industrial heat pumps. It also highlights the role that low GWP refrigerants play in successful commercialization.

Additionally, the paper emphasizes the environmental benefits of such technologies, contributing to reduced greenhouse gas emissions and fostering a more sustainable industrial landscape. Finally, the paper details a successful prototype developed under a California Energy Commission funded project and industry-specific applications where such heat pumps can play a pivotal role.
In summary, the paper aims to provide insights into the current state of these technologies in the USA, challenges faced during commercialization, and the potential for widespread implementation across various industrial sectors.
Techno-economic analysis of the potential of hydrogen and electric heating technologies for the decarbonization of industrial processes: case study for downstream processes in metals industry

Christian Schwotzer, RWTH Aachen University, Department for Industrial Furnaces and Heat Engineering, Germany
Felix Kaiser, RWTH Aachen University, Department for Industrial Furnaces and Heat Engineering, Germany
Herbert Pfeifer, RWTH Aachen University, Department for Industrial Furnaces and Heat Engineering, Germany

Panel
9. Energy efficiency and sustainability of industry

Keywords
decarbonisation, hydrogen, electrification, metals industry

Energy-intensive industries such as steel, glass, ceramics and non-ferrous metallurgy, in which energy-related greenhouse gas emissions as well as process emissions play a role, are facing a variety of challenges and risks as a result of the energy transition and the associated increase in the use of renewable energies. New technologies, as well as climate protection policy targets relating to pollutant emissions and the use of fossil fuels, are changing the markets. This makes investment decisions in energy-intensive thermal process technology systems increasingly difficult. For a successful energy transition and decarbonization of industrial processes, thermal engineering systems and production chains must be designed for operation with electricity from renewable energies or other low-CO2 energy sources that will be available in the future. At the same time, energy and system availability, product quality and cost-effectiveness must be guaranteed.

This study focuses on the techno-economic analysis of the potential of hydrogen and electric heating technologies for decarbonizing energy-intensive industrial process chains, analysing downstream processes of the metals industry, showing the potential for the aluminium remelting process as an example. A model is used, that dynamically maps the key figures energy efficiency, greenhouse gas emissions and heat production costs over a period of
several decades and allows for a quantitative assessment of new technologies for process heat generation. This combination of different key performance parameters contributes to a better understanding of the possibilities for decarbonizing industrial processes. The results show possible process transformation pathways for electric and hydrogen heating technologies, that reach CO2 emissions reduction targets within the next decades.
Barriers and strategies in the engagement of SMEs in support and research projects on energy efficiency

Marta Maia, IEECP - Institute for European Energy and Climate Policy, The Netherlands
Axelle Gallerand, IEECP - Institute for European Energy and Climate Policy, The Netherlands
Ivana Rogulj, IEECP - Institute for European Energy and Climate Policy, The Netherlands

Panel
9. Energy efficiency and sustainability of industry

Keywords
innovation, stakeholder engagement, SME, EU project, stakeholder

Projects that support companies with implementing energy efficiency rely on the engagement of the same companies to produce innovation that is relevant, realistic, and scalable in market and industrial settings.

Although some research has been developed on the engagement capacity of academic institutions, less attention is paid towards challenges at an individual level. While organizations may adopt engagement policies, individuals working on the field must interact with heterogeneous stakeholders, navigating a landscape of unwritten rules and hierarchical dynamics that require sensibility beyond organizational protocols.

This research aims to identify common challenges of engaging SMEs and propose a series of coping strategies within the context of projects dealing with energy efficiency upgrades.

Initial literature review explores the concept of stakeholder engagement and the inherent diversity of SMEs. Accounts from a preliminary workshop with experts identify common challenges in the engagement of SMEs, such as geography and temporality. A subsequent co-creation workshop with researchers explores possible paths to overcome them, such as supply chain pressure and targeted communication. The outputs of both workshops are then discussed in the light of challenges faced by companies and reported in literature.

The development of coping strategies should build trust and facilitate collaboration between energy efficiency research teams and SMEs. An effective two-way knowledge flow would then increase the applicability of the outputs of projects, thus improving the overall relevance and impact of the research work.
Circular economy in hard metals production: energy and environmental impact of recycling processes

Anna Realini, UFFICI.A DI DAVIDE TEDESCHI SAS, Italy
Gian Pietro De Gaudenzi, FILMS S.p.A., Italy
Mattia Garabelli, FILMS S.p.A., Italy
Gian Carlo Marcheselli, FILMS S.p.A., Italy
Gian Maria Passoni, Uffici.A, Italy

Panel
9. Energy efficiency and sustainability of industry

Keywords
circular economy, hard metal recycling, industrial energy efficiency

Hard metals are a class of composite materials where a carbide-base skeleton, mainly tungsten carbide (WC), is embedded in a metallic binder, usually Co-based, being Ni a viable alternative for special applications.

The special characteristics of tungsten carbide alloys (hardness and wear resistance) allow them to be used in a wide range of sectors where previously inferior materials were used, allowing users to better manage industrial processes and increase production performance. They are also considered a strategic material at the base of industrial economy and societal welfare: geopolitical factors and the EU classification of WC and Co among the Critical Raw Materials, have highlighted the relevance to develop and/or optimize recovering processes of the raw material values along the whole hard metal life cycle.

A model was implemented to maximize the use of secondary raw materials in hard metal production process. The model includes five main sources of secondary raw materials: (a) the powders recovered along the industrial powder metallurgy production process; (b) the hard metal scrap collected at the end of the life cycle (urban mining) and selected in order to be processed by an oxidation/reduction/carburization thermal treatment; (c) the hard metal scrap and sludges, “urban mined” and treated by a third party chemical recovery process, comprising (d) toxic oil sludges regenerated by a thermal process; (e) the hard metal scrap treated by a third party Zn-based recovery process.

The aim of this paper is to quantify the energy saving potential and environmental impact of hard metal recycling through oxidation/reduction/carburization process (sources a) and b)), instead of chemical routes (sources c), d) and e)), compared with literature data that consider the impact of hard metal production from metallic ores.
The main results are the higher environmental impact of the pyrometallurgical process, in the case of recycling, but this is compensated by the lowest impact with regards to the whole process.
What can the mandatory energy audit database tell us about the potential of energy efficiency in Germany?

Paurnima Kulkarni, Prognos AG, Germany
Dominik Rau, Prognos AG, Germany

Panel
9. Energy efficiency and sustainability of industry

Keywords
Energy Efficiency Directive (EED), industrial energy saving, efficiency, energy audit, energy efficiency policy, evaluation

Enterprises, which carry out the mandatory energy audit according to German Energy Services Act, must submit an online declaration after completion of the audit process. Our team at Prognos AG analysed this database, comprising of approx. 24,000 declarations collected over a period of five years. Our aim was to gain insights about the potential of energy efficiency in German non-SMEs (larger than Small and Medium Enterprises) and assess the effectiveness of the mandatory energy audits.

The database was cleaned and unplausible entries were removed before analysis. On an average electricity and natural gas are together responsible for nearly 60 % of energy consumption of the audited companies. Only for a few sectors, more than 30 % of energy consumption comes from renewable sources. The most suggested energy efficiency measures are for illumination and heating systems. The company size (large or not large) influences the suggested measures accounting for highest energy savings and highest investment. Furthermore, the suggested measures and potential for energy savings differs depending on the business sector. While comparing the suggested efficiency measures for first and recurring audit, it is observed that during the recurring audit similar measures are suggested. This can mean, that the measures during the first audit were not or not completely implemented before the recurring audit, which takes place every four years.

This database offers significant insights into potential of energy efficiency as well as the required investment. This abstract is only a small glimpse into the total amount of results, which are shown in the paper. The results signify the importance of efficiency as a cornerstone of decarbonization of German enterprises. On the other hand, the results also suggest that energy audit is just a first step. The efficiency potential must be realized through implementing these measures to reduce demand and to achieve the efficiency targets.
Assessing the environmental impacts of policies on industrial electric motors: a stock model, material flow analysis and life cycle assessment approach

Antoine Durand, Fraunhofer Institute for Systems and Innovation Research, Germany
Robin Barkhausen, Fraunhofer ISI, Germany

Panel
9. Energy efficiency and sustainability of industry

Keywords
electric motors, product policy, life cycle analysis, industry, circular economy

Electric motors are significant contributors to energy consumption in the EU, accounting for more than half of the total electricity consumed. In order to reduce the environmental impact, there is a need to address the inefficiency of existing motors. This study explores how early replacement of inefficient motors can reduce environmental impacts at the system level and compares this strategy with a base case.

A combined material flow analysis and life cycle assessment approach is used to provide answers. Using a layered approach, material and environmental impacts are derived from product flows through a product database that defines physical properties for different product variants.

The study focuses on industrial electric motors in the EU and employs a scenario analysis from 2005 to 2050 to assess the long-term impacts of different policy alternatives. Specifically, the environmental impacts of early replacement of IE2 and IE3 motors with IE4 motors are compared to minimum energy performance standards and to a base case scenario with no change. This comparative analysis aims to highlight the potential environmental benefits of implementing different policy measures beyond mere energy savings.

The results of this study have implications for sustainability and energy efficiency policies in the EU. By understanding the environmental impacts of different policy measures on industrial electric motors, policy makers and industry stakeholders can make informed decisions to promote sustainable practices and reduce energy consumption in the long term.
Direct electrification of industrial process heat: Analysing the potential development of electric heating technologies, their applicability for industrial processes and the potential influence on the fuel demand

Simon Bussmann, Fraunhofer Institute for Systems and Innovation Research, Germany
Matthias Rehfeldt, Fraunhofer ISI, Germany

Panel
9. Energy efficiency and sustainability of industry

Keywords
electrification, electrical heating, energy-intensive industry, industrial processes, industrial process equipment, fuel consumption, efficiency

Fossil fuels are the main energy source for process heat generation in industrial applications, making the industrial sector a major emitter of greenhouse gases. This study examines the technical potential for direct electrification of industrial process heat in the EU27 and the barriers to electrification.

Based on a literature review and stakeholder interviews, this study assesses seven electric heating technologies that are currently available or expected to be available by 2035, such as electric boilers and resistance heating. We evaluate a range of processes, taking into account a variety of technical requirements. Of the 33 applications evaluated, 14 are fully quantified and analysed for electrification efforts, covering a significant proportion of high temperature process heat demand. The selected applications form a portfolio of process requirements to be met by electrification technologies.

Stakeholder interviews conducted for the study contribute to the findings and provide practical insights into technologies and processes, as well as barriers to electrification. Based on the process specific requirements and technologies, we estimate the overall electrification potential and the resulting fuel reduction potential.

We find that there is significant potential for direct electrification of process heat generation. Resistance heating can be applied to many processes, but an important limitation is the energy...
density achieved. Induction heating has potential in metals processing. Plasma technology is emerging as an alternative for high temperature processes. However, current limitations such as the short lifetime of plasma torches and low efficiency limit its current applicability. Novel technologies have the potential to increase the attractiveness and applicability of direct electrification. Such technologies are likely to improve over the next decade and extend the applicability of electrification to challenging areas. Electric boilers and heat pumps are suitable for applications requiring hot water or steam. Heat pumps offer significant efficiency gains. While sectors with low temperature process heat needs, such as food or pulp and paper, can be electrified to a very large extent with today's technologies, other sectors still face technical hurdles. In particular, in the non-metallic minerals sector, the production of cement, lime or glass requires further technological development to enable full electrification. In the steel industry, hydrogen is required as a reducing agent for the production of primary steel.

If fully realised, fuel demand could be reduced by 62% using technologies available today. Assuming an increased effort in the development of electric heating technologies and processes, technologies could be available by 2035 to reduce current fuel demand by 90%. However, a number of barriers have been identified that prevent the deployment of these technologies and slow down future technological progress.

Economic barriers include the price differential between electricity and fossil fuels and the additional capital required to replace equipment. In addition, organisational barriers hinder the spread of direct electrification: Local infrastructure favours fossil fuel technologies. Replacing equipment may require deep interventions in the entire production process. High uncertainty about grid connection, expansion and security of supply paralyses decisionmakers. Uncertainty also extends to knowledge of the availability of direct electrification technologies.

We conclude that, electric industrial heating technologies are central to the decarbonisation of industry. Policymakers should prioritise overcoming barriers and guiding technology development to enable a carbon-neutral production system, ensuring the availability of abundant and cost-effective carbon-neutral electricity. Demonstrating these technologies under industrial conditions will help mitigate risks and promote their market uptake.
Fostering energy efficiency investments in SMEs: the multiple benefits approach for energy audits and energy management systems

Ivan Sangiorgio, IEECP, Italy
Antoine Durand, ISI Fraunhofer, Germany
Ivana Rogulj, Institute for European Energy and Climate Policy, The Netherlands
Garyfallos Fragidis, International Hellenic University, Greece

Panel
9. Energy efficiency and sustainability of industry

Keywords
multiple benefits, energy audit, energy management, industrial SME

Investments in energy efficiency projects in SMEs face obstacles due to the perception of their limited relevance to business priorities and are often disregarded in favor of other investments with superior economic performance. Including the evaluation of Multiple Benefits (MBs) in the company’s decision-making process has proven to enhance the uptake of energy efficiency measures. The DEESME project, co-funded under the Horizon 2020 Programme, has the primary objective of creating a connection between energy efficiency investments and the company’s core business priorities.

This paper aims to present the methodology developed in the project and the results stemming from its application. The methodology consists of the incorporation of the MBs approach into both energy auditing and Energy Management Systems (EnMS). This paper aims to present the methodology developed in the project and the results stemming from its application. The methodology consists of the incorporation of the MBs approach into both energy auditing and Energy Management Systems (EnMS). The MBs approach for audits is structured in a four-stage methodology. This involves analysing the business model for value and efficiency, identifying opportunities for emission reduction through energy analysis, conducting a multiple benefits analysis to link energy decisions to business development, and advancing business model sustainability. Simultaneously, the EnMS methodology, fed by inputs derived from extended energy audits, seeks to underscore the correlation between the MBs approach and
ISO 50001 certification. Emphasis is placed on integrating the MBs approach into every aspect of the standard. These methodologies have been successfully applied to SMEs in Italy, Bulgaria, Poland, and Germany. The presented paper is based on the insights gained from 42 audits and 22 EnMS implementations, all incorporating the MBs approach, contributed to gathering valuable lessons learnt and best practices.
Better together? Exploring what can be achieved through real-world examples of innovative knowledge exchange partnerships between SMEs and universities

Richard Bull, Nottingham Trent University, United Kingdom
Rita Domingues, Sustainability Research Institute, School of Earth and Environment, University of Leeds, UK
Muhammad Mahzar, Nottingham Trent University
Gamze Yakar-Pritchard, University of Nottingham
Kate Ling, Nottingham Trent University

Panel
9. Energy efficiency and sustainability of industry

Keywords
SME, knowledge transfer, sustainability, partnering project

Ambitious and necessary climate change targets will not be achieved by working in silos. The literature around partnership and participation clearly outlines the benefits to be found, but all too often, organisations at the national or local level compete rather than collaborate. Local authorities struggle to engage the business community at the local and regional levels, notably small and medium-sized enterprises (SMEs), which comprise 99 % of organisations and nearly 50 % of carbon emissions. There is an emerging body of work focusing on the set of needs felt by these organisations struggling to improve their energy efficiency, and this points to the need for examples of what is working or not.

The ERDF-funded Sustainability in Enterprise (SiE) project presents a standout example of partnership working between local Nottingham-based SMEs and a University that engaged with over 200 SMEs and reduced their emissions by over 1000 tCO2e. This paper presents the impact of the SiE programme on SMEs, the university, and its students and explores what lessons can be learned for all parties involved. This research adopted a quantitative approach, using pre-and post-surveys to collect data from SMEs and students.

Specific examples of student consultancy are used to identify the drivers, challenges, and outcomes of such collaborations. Evidence shows that collaboration between universities and businesses can be mutually beneficial, supporting students in gaining sustainability competencies and offering businesses the expertise and resources they often lack to reduce
their carbon footprints. Utilising theoretical models of partnership working and knowledge exchange (KE), reflections are also presented from those directly involved in the management of the programme as the challenges, barriers and opportunities are discussed. Finally, recommendations are offered for policymakers, businesses, and universities.
Pathways to a GHG-neutral German industry: Assessing the role of direct and indirect electrification and demand reduction

Markus Kaiser, Fraunhofer Institute for Solar Energy Systems ISE, Germany
Charlotte Senkpiel, Fraunhofer Institute for Solar Energy Systems ISE, Germany
Patrick Jürgens, Fraunhofer Institute for Solar Energy Systems ISE, Germany
Christoph Kost, Fraunhofer Institute for Solar Energy Systems ISE, Germany

Keywords
sufficiency, scenario study, steel, electrification, hydrogen, chemical industry, cement, energy model

The German Climate Protection Act aims to reduce greenhouse gas (GHG) emissions by 65% in 2030 and by 100% in 2045. Normative scenarios from energy system models (ESMs) quantify transformation pathways in line with these targets. Scenarios for the industry often have a sectoral perspective, neglecting dependencies with the energy sector and other demand sectors. Moreover, scenarios often analyze consistency strategies, i.e. the replacement of fossil technologies by renewable ones, without focusing on demand reduction. Here, we answer two questions: What are the scenarios for industrial transformation that consider consistency and demand reduction? What structural changes occur in individual industrial sectors and how are they linked to other sectors?

Four scenarios are developed in an adapted Cross Impact Balance analysis. These scenarios are described by 12 different descriptors that contain both qualitative storylines and quantitative model assumptions for key areas that impact industrial decarbonization, such as the availability and prices of GHG-neutral energy imports. Two scenarios focus on consistency, either through direct or indirect electrification, and two focus on sufficiency, combining energy demand reduction with either less or more optimistic assumptions on technological change. The ESM REMod is used to calculate cost-optimal transformation pathways for the energy sector and the demand sectors industry, buildings, and transport. For the industry, REMod explicitly models production routes for the energy-intensive basic materials crude steel, ammonia, methanol, high-value chemicals, and cement. Each production route is implemented using specific energy consumptions and techno-economic parameters such as CAPEX and OPEX. The model takes production volumes of the basic materials as input. In contrast to other ESMs, REMod optimizes the transformation in all sectors at the same time and endogenously...
accounts for sector coupling. Despite the German focus, general conclusions can be drawn for industrial sectors and process heat supply.

Preliminary results indicate that final energy demand for industry including feedstocks reduces in 2045 to 90% of current levels in both consistency scenarios and to 66% in scenarios including demand reduction. This reduction of final energy demand is attributed to more energy efficient production routes and technologies. In addition, the sufficiency scenarios assume a reduction in consumption. Across all scenarios, direct electrification of process heat supply is important. By 2045, industrial electricity demand increases by 37-46% compared to current levels in the consistency scenarios. In the sufficiency scenarios, reduction of energy demand outweighs the increase of electricity demand by direct electrification of process heat supply resulting in a constant electricity demand in the industry. The availability of green hydrogen and hydrogen-derivatives is crucial as feedstock for the chemical industry, the production of crude steel and the supply of high-temperature process heat. In the consistency scenarios, over 90% of the demand for green hydrogen is for feedstock or energetic use in the industry. To supply this green energy, domestic variable renewable energy (VRE) capacities must be expanded.

Additionally, GHG-neutral imports of green hydrogen or derivatives are required. The imports are limited by scenario design. In the consistency scenario with focus on direct electrification, VRE capacities reach 790 GW, accompanied by 300 TWh of imports of synthetic energy carriers in 2045. In the consistency scenario focusing on indirect electrification, only 760 GW of VRE are needed, but 450 TWh of imports are used. In the sufficiency scenarios, demand reduction lowers those capacities to below 630 GW of VRE with only 200 TWh of imports. Demand reduction can play a significant role in the transformation of the energy system by slowing down the need for drastic technological changes.
Accelerating Industrial Energy Efficiency to support South Africa’s transition to a low-carbon economy

Onay Geylan, UNIDO, South Africa
Mchenge Nyoka, UNIDO
Karin Reiss, UNIDO

Panel
9. Energy efficiency and sustainability of industry

Keywords
energy efficiency, sustainable energy, decarbonisation, industrial energy saving, climate action plan

South Africa is one of the largest carbon emitters in Africa, driving 33% of the continent’s total emissions. As a signatory to the Paris Agreement, South Africa has committed to reducing its greenhouse gas emissions to contribute to global climate goals. Despite the recognized need to decarbonize, South Africa is facing other structural challenges, such as the ongoing energy crisis, which has significant negative impacts on productivity and safety. In 2022, there were 208 days of load shedding, a substantial increase from the 75 days recorded in the previous year, 2021. The average Eskom tariff grew by 333% between 2007 and 2017, according to research done by the South African Reserve Bank (SARB). Since 2007, it has grown by 450% by 2022. As a result of energy constraints and an unprecedented increase in electricity prices in South Africa, the cost of operating a business has been significantly impacted. With industrial companies having to compete with cheaper imports and rising operating costs amid a constrained economic climate, the role of industrial energy efficiency in reducing production costs cannot be overstated. Increased energy efficiency investments could potentially cut South Africa's need for additional electricity generation capacity by 18% by 2030, according to an analysis by the IEA.

To tackle this challenge, efforts need to be made to enhance industrial energy efficiency and bolster national energy security while ensuring the uninterrupted supply of electricity. It is crucial to encompass the introduction, piloting, and promotion of energy management systems (EnMS) and energy systems optimization (ESO), with a primary focus on implementing the ISO 50001 Energy Management Standard. Supporting SMEs to implement EnMS helps industry rethink how they use energy, increase asset values, and boost productivity.

This approach should involve collaborative efforts with diverse stakeholders, including government bodies, industries, regulatory entities, and educational institutions. The integrated approach sought to ensure the successful and sustainable implementation of energy efficiency measures, contributing to long-term improvements in energy performance and overall...
Industrial energy efficiency in South Africa not only supports the country's climate action but also generates positive social co-benefits by creating jobs, reducing costs for industries, improving air quality and enhancing energy security.
As-a-service solutions contributing to decarbonisation: key design and operational issues for SMEs

Dimitris Karamitsos, BASE - Basel Agency for Sustainable Energy, Switzerland
Livia Miethke, BASE Stiftung, Switzerland
Christophe Rynikiewicz, BASE – Basel Agency for Sustainable Energy, Switzerland

Panel
9. Energy efficiency and sustainability of industry

Keywords
industrial energy saving, circular economy, energy services, manufacturing

Away from the media and creative industries, servitisation has huge profit potential for sectors like manufacturing. This paper questions how as-a-service solutions may help addressing decarbonisation issues. In the EaaS - Efficiency as a service initiative, we have looked at how servitisation business model can be an enabler to accelerating the wider uptake of energy-efficient technologies in SMEs of various European countries. Applying the pay-per-use or outcome approach to critical but energy-intensive systems like heating, cooling or compressed air systems can have a significant impact on energy efficiency gains, decarbonising sectors such as SMEs, buildings and accelerate the shift to a circular economy.

Building on the benefits of the servitisation model from the perspective of technology providers and clients SMEs, we present some examples of successful as-a-service projects in terms of decarbonisation.

Following the energy crisis, industry is now even calling for “frugality” and many services/technology providers tend to position themselves as key enablers. While sufficiency often focuses on lifestyle change and individual behavior, and questioning services allows for thinking in terms of having enough and not using too much, the application of frugality or sufficiency in industry is not straightforward. We will present some key aspects along the servitisation contractual aspect (including pre-sales support, on-site assistance and maintenance) to avoid greenwashing or lock in in a specific solution.

Thirdly, this business model has a strong potential to align and promote circular economy principles. However, the details of any rewarding schemes (green VAT, CO2 incentives, subsidies) have still to be set.
Energy efficiency synergies in the dairy industry

Beatrice Marchi, Università degli Studi di Brescia, Italy
Simone Zanoni, University of BresciaUniversità degli Studi di Brescia, Italy

Panel
9. Energy efficiency and sustainability of industry

Keywords
heat pump, industrial energy saving, refrigerators

The European Union's dairy sector stands as the second-largest agricultural segment within the EU, comprising over 12% of the overall agricultural output. Dairies exhibit significant energy consumption, contributing to indirect emissions.

Conventional dairy processes necessitate heating for milk processing and refrigeration for storage, posing a challenge in optimizing energy utilization. In this context, the importance of energy efficiency measures (EEMs) and the utilization of renewable energy sources (RES) becomes pronounced when viewed holistically, considering a coordinated supply chain. This approach is crucial for advancing sustainability across economic, environmental, and social dimensions.

Among the various EEMs, heat pumps that generate both hot water and cold air emerge as a promising avenue for substantial energy savings. They play a key role in reducing dependency on fossil fuels, primarily oil and gas, and in curbing greenhouse gas (GHG) emissions. The heat pumps recover heat from the compressor used in the milk production process, which otherwise would be released as condensation heat into the air if a heat pump were not employed.

This contribution aims to show how integrating heat pumps enables the efficient utilization of waste heat from refrigeration systems to fulfill heating requirements, establishing a synergistic relationship between the two processes, moreover, a concept of a tool for the analysis of the potential implementation of heat pumps in the dairy industry will be presented.
A measure of control: About sensors, measurement and control equipment in German companies

Simon Hirzel, Fraunhofer Institute for Systems and Innovation Research, Germany
Lisa Nabitz, Fraunhofer ISI, Germany
Carmen Berger, Fraunhofer ISI, Germany

Panel
9. Energy efficiency and sustainability of industry

Keywords
energy monitoring, sensors, energy management, control, energy efficiency measures

Taking stock of energy flows is central for energy management activities within companies: It is needed to identify the most appropriate energy efficiency measures, to implement them and to monitor their impact. While the use of sensors, monitoring and control equipment helps to enhance transparency, few studies seem to provide empirical data about the use of these technologies and about the expectations for achievable energy savings across a larger sample of companies. Against this background, this paper aims to broaden the understanding of the use of measurement infrastructure and control technologies for enhancing energy efficiency within industrial companies based on a sample of German companies. The insights in this paper use survey results obtained from companies participating in a national funding programme for sensors, measurement and control equipment.

The analysis covers, among others, the expected savings associated with measurement infrastructure and control technology, how companies monitor energy flows and how they make use of this information. While the selection of companies is not representative and limitations apply, the results seem to underline that there are various ways how energy-related measurement infrastructure and control technologies are used and implemented in practice. Among others, the companies in the sample seem to monitor electricity more often than thermal or other properties, they have largely left the pen-and-paper era for data acquisition and data is kept in in-house storage systems. The assessment of data appears still seems to include a substantial amount of handiwork and AI-based automation was still rare at the time of conducting the survey. In general, expected triggered savings vary but tend to be in a range of 2 to 5 % of the covered energy demand.
Decarbonizing energy-intensive industries: Empirical insights into the aspirations for electrification and flexibilization of industrial processes

Jessica Berneiser, Fraunhofer Institute for Solar Energy Systems ISE, Germany
Johanna Kucknat, Fraunhofer Institute for Solar Energy Systems ISE, Germany
Felicitas Fornfeld, Fraunhofer Institute for Solar Energy Systems ISE, Germany

Panel
9. Energy efficiency and sustainability of industry

Keywords
electrification, demand side management (DSM), flexibility in energy sources, energy-intensive industry, industrial SME, social science research

The electrification of industrial processes is essential for achieving climate neutrality in the energy-intensive industry. However, various challenges impede the widespread electrification of industrial processes. Furthermore, literature emphasizes the significance of flexibility of electricity purchases and production processes in terms of temporal shifts. Flexibility provision can enhance the utilization of clean electricity, reduce energy costs, and contribute to grid stability by reducing peak demand. However, it is currently unclear to what extent energy-intensive companies adopt electrification strategies and pursue load-shifting measures, and this is likely to vary across industrial sectors. We present findings from interviews that were conducted in 2023 and an online survey among energy-intensive companies in February 2024 that sought to explore the potential and barriers of the electrification and flexibility of industrial processes from companies’ perspectives.

The challenges identified are clustered into different levels (macro, meso, micro) and categories (technological, financial, regulatory/political, organizational, social). Major constraints for electrification include, among others, high investment costs and long payback periods for process technologies, technological complexity and immaturity, a lack of stable policy frameworks, and transitional barriers related to operational procedures. Specific attention will be drawn to the general notions and named potential regarding flexibility provision, and further, the stated strategies regarding flexibility in energy source utilization. Challenges include the technical feasibility of flexibility measures, production-related factors and organizational factors such as personnel planning. In addition, we found that many companies already have climate neutrality strategies in place that often comprise scope 1-3 emissions.
Target years for climate neutrality vary. The most frequently mentioned methods for decarbonizing the company were energy-efficiency measures, the purchase of green electricity from the grid, waste heat utilization, but also the electrification of industrial processes. Biomass-based energy sources and, prospectively, the use of hydrogen were also considered as relevant decarbonization methods by 25% of our respondents. However, only few companies agreed that the flexibilization of industrial processes will be a relevant topic in the future. This is in contrast to the majority of companies that emphasized the goal of direct electrification measures.

Overall, the study’s strength lies in its allowance for a comparison of model assumptions and scenario outcomes with empirical data. The resulting implications for decarbonization scenarios and pathways will be discussed.
Revolutionizing industrial energy efficiency with a holistic approach to compressed air systems, unlocking 10% reduction in overall energy demand

Elvira Rakova, Direktin, Italy

Panel
9. Energy efficiency and sustainability of industry

Keywords
compressed air, audit guidelines, manufacturing

In the realm of industrial energy consumption, compressed air accounts for a formidable 20%, posing a significant cost burden. Despite the potential for a remarkable 60% reduction, prevailing systems only manage to achieve meager savings between 10 and 15%, primarily hampered by design constraints. This presentation advocates for a paradigm shift, underscoring the necessity of a comprehensive approach that addresses the entire supply chain.

The compressed air system, comprising generation, distribution, and demand sides, serves as the focal point. The key insight lies in prioritizing demand-side interventions before adjusting generation, necessitating a holistic problem-solving strategy. To illuminate this transformative approach, the presentation introduces a cutting-edge digitalized modeling method designed for cost reduction. Case studies from furniture manufacturing, steel production, and automotive factories underscore the versatility of this method, offering insights into reduction opportunities, multiple benefits, and adaptable action plans tailored to diverse industries.

A notable revelation emerges from the data: the demonstrated savings range from a substantial 20 to 40%, presenting a transformative potential within the broader industrial landscape. Beyond the immediate financial gains, this shift towards optimized compressed air systems carries profound implications. By unlocking the maximum potential savings, a consequential 10% reduction in the overall energy demand for the industrial sector becomes a tangible reality, fostering sustainability and environmental responsibility.
Increasing energy resilience, saving costs, and curbing emissions with systemic efficiency approaches

Stefan M. Büttner, Fraunhofer IPA / University of Stuttgart, EEP – Institute for Energy Efficiency in Production, Germany
Janniko Czeschlik, EEP - Institute for Energy Efficiency in Production, Germany
Werner König, REZ - Reutlingen Energy Center for Distributed Energy Systems and Energy Efficiency, Reutlingen University, Germany

Panel
9. Energy efficiency and sustainability of industry

Keywords
decarbonisation, cross effects, cost effectiveness, industrial energy saving, system optimisation, systemic efficiency

Systemic efficiency necessitates clarity about the aspired goal, available and feasible input factors for the desired outcomes and knowledge of the current state. This principle applies regardless of the sector or the level of flight. The common thread is that collaboration between the various stakeholders is of the essence. Beyond technological solutions, business model, education, training, and behavioural aspects must also be considered.

Increasing energy resilience, saving costs, and reducing emissions are thus inextricably linked to how effectively we integrate and optimise the interaction of the individual factors of any system technical, economic, organisational, and human, as well as the resources and specifics that exist or are available on site.

Electrification of industrial processes is an important step towards reducing dependence on fossil fuels, but challenges such as process changes and financial feasibility need to be addressed. Process heating and cooling, which account for a significant proportion of industrial energy consumption and are often fuelled by fossil fuels, are a key focus. However, the exploitation of unused waste heat potential is hampered by a lack of knowledge, so that large potentials remain unrecognised or neglected.

Overcoming this fateful barrier constitutes the biggest lever to reduce energy-related emissions from the industrial sector, eases the energy crisis and is the issue that is most important for achieving systemic efficiency: electrification or easier fuel switching both have an impact on one-off and ongoing costs, raise questions about ongoing security of supply, but also have a strong impact on systemic efficiency. This is due to the conversion efficiency in conjunction with the energy efficiency of the process. Due to the associated costs and availability, the identification of unnecessary consumption and utilisation of waste heat to reduce energy
demand represents a huge – often untapped or underestimated – opportunity for many.

Drawing from meetings, reports and documents around the Group of Experts on Energy Efficiency of the United Nations Economic Commission for Europe, as well as exchange with practitioners, researchers and conferences, the heuristic approach applied in this paper aims at shedding light on the concept of systemic efficiency, providing examples across numerous application areas and levels of flight to underline the broad relevance and applicability and thus enabling stakeholders to replicate the approach to various contexts.
Multiple benefits of energy efficiency: methodology and preliminary application on Italian plastics industry

Carlos Herce, ENEA, Italy
Enrico Biele
Enrico Biele, ENEA
Alessandra De Santis, ENEA
Chiara Martini, ENEA
Fabrizio Martini, ENEA
Claudia Toro, ENEA
Marcello Salvio

Panel
9. Energy efficiency and sustainability of industry

Keywords
Energy Efficiency Directive (EED), multiple benefits, industrial SME, energy efficiency policy, energy-intensive industry

The crucial importance of the “Energy Efficiency First Principle” has been recently underlined as a policy pillar at European level in the recast of the Energy Efficiency Directive (EED), with a specific article (Art.3). Energy efficiency is a key bridge among sustainability, climate neutrality and economic growth. The multiple benefits approach is focused on extending the direct benefits of energy efficiency (reduction of energy consumption and greenhouse gas emissions) to other dimensions, such as energy security, health and well-being, air quality, material resources efficiency, productivity, and other economic and social benefits, both at micro and macro level.

This is a topic of recent and growing interest from academia, policymakers, and the private sector because of its impact on the profitability of energy efficiency investments. However, despite its importance, quantifying the multiple benefits is still demanding and particularly challenging for small and medium-sized enterprises (SMEs).

In this work an analysis of multiple benefits (MB, also known in literature as Non-Energy Benefits or Co-Benefits) in the Italian plastics industry is developed. The work is divided in two sections.

Firstly, a general multi-sectoral characterization of MB has been carried out on the results of a wide scope survey targeted to both public and private stakeholders, where a gap was observed in the perception and role of MB by policymakers and enterprises.
Secondly, a framework was developed to quantify the MB associated to different Energy Performance Improvement Actions (EPIAs), with a focus on the plastics manufacturing industry. Based on this framework, the potential quantification of the impact of MB is explored at sectoral level. The results obtained in this analysis can help companies in quantifying the MB associated with energy efficiency and to invest more consciously in EPIAs. The findings can also be helpful to National Authorities during the transposition of EED Articles 3, 11(7) and in support of Articles 9 and 10.
Advancing energy resilience and decarbonization by unleashing the potential of energy storage and demand-side flexibility

Stefan M. Büttner, Fraunhofer IPA / University of Stuttgart, EEP – Institute for Energy Efficiency in Production, Germany
Ferenc-Paul Sawitzki, EEP - Institute for Energy Efficiency in Production, Germany
Leandra Scharnhorst, Institute of Industrial Production (IIP), Chair of Energy Economics, Karlsruhe Institute of Technology (KIT), Germany

Panel
9. Energy efficiency and sustainability of industry

Keywords
electric storage, heat storage, thermal storage, storage, dynamic efficiency, energy flexibility, systemic efficiency

Achieving the scalability of intermittent renewable energy hinges on robust energy storage solutions to optimize low-carbon resources and ensure energy security. Interconnected energy systems, along with storage at system and end-use levels, act as catalysts for both systemic and individual energy resilience, presenting numerous challenges and opportunities. In the medium to long term, demand-side flexibility and virtual storage from major energy consumers, coupled with various storage types should mitigate reliance on fossil-based generation unless rendered net-zero compatible. Recognizing that there’s no one-size-fits-all technology, emphasis is placed on identifying the right mix of technologies tailored to specific situations, contexts, and objectives.

This approach underscores the significance of disseminating knowledge on diverse energy storage forms, laying the foundation to determine the optimal technology mix for supporting energy access, building a stable, resilient, and progressively decarbonized energy system, and empowering end-users to achieve their desired outcomes. The energy storage types comprise mechanical, electrical, chemical and thermal storage technologies which can be differentiated into short-term or long-term storage, depending on the storage period. Considerations span across techno-economic specifications such as intended energy use, energy density, durability, space requirements, charge and discharge times, power output, temperature, available sources, conversion losses, costs, and critical raw materials.

The objectives for energy storage applicability are diverse and depend on the respective use
case, essentially applied to either system level storage and end-use level storage. On a system level, energy storage can mitigate the loss of surplus renewable energy that cannot be absorbed by the grid (curtailment), as well as mitigate energy bottlenecks and regional shortages, and stabilizing the grid and thus may reduce the need for baseload reserve power plants. On the end-use level, energy storage objectives can optimize (e.g. self-consumption, peak shaving, load shifting, integrating renewable energies), protect (e.g. increase self-sufficiency or ensure uninterrupted energy supply), and generate additional revenues (e.g. provision of balancing power or disconnectable loads). With regard to the objective of energy storage adoption, it also provides the means for increased demand side energy flexibility.

The energy storage allows to obtain and store energy in low cost windows and can provide the energy in times of expensive energy prices. The most effective way to realize goals such as energy resilience and decarbonization involves a combination of demand-side energy flexibility measures. This approach should integrate local and system-level storage options, power-to-X applications, systemic approaches, and policy measures tailored to both the energy system and end-users. The proposed framework aims to foster a macro- and micro-level low-carbon, accessible, affordable, and resilient energy system.
The quintessential win-win: Saving energy and eliminating PCBs in Southern Africa

Michael Scholand, M2S2 Energy Limited, United Kingdom
Haosong Jiao, UNEP Chemicals and Health Branch, Switzerland
Ludovic Bernaudat, UNEP Chemicals and Health Branch, Switzerland
Jitendra Sharma, UNEP Chemicals and Health Branch, Switzerland
Victor Hugo Estellano Schulze, UNEP Chemicals and Health Branch, Switzerland

Panel
9. Energy efficiency and sustainability of industry

Keywords
industrial energy saving, distribution transformers, Electric Power Networks, polychlorinated biphenyls

Polychlorinated biphenyls (PCBs) are highly carcinogenic compounds that were used in certain industrial products such as transformers and switchgear. The Stockholm Convention on Persistent Organic Pollutants, which came into effect on 17 May 2004, obliges countries to eliminate the use of PCBs in equipment by 2025 and to make determined efforts that lead to the environmentally sound management of PCB-contaminated waste liquids and equipment by 2028. Despite these deadlines being known about for two decades, there are still literally thousands and thousands of PCB-contaminated transformers and switchgear that remain in service across less developed regions in the world.

This paper presents an excellent opportunity to address the removal of PCBs while simultaneously saving energy and improving grid reliability and security of supply. The Global Environment Facility (GEF) initiated a project in Southern Africa that is working to capture public health, environmental and economic benefits from the removal of PCBs, part of which is derived from the application of energy-efficiency principles in the electricity sector. This paper presents the findings from the energy-efficient transformer component which found that upgrading old, PCB-contaminated equipment is highly cost-effective and can be a key driver in PCB eradication. The economic analysis demonstrated that the running costs of a transformer – the electricity lost in inefficient core/coil assemblies – is significantly greater than the purchase price of a new, more efficient unit – and thus, energy-efficient transformer upgrades...
offer an opportunity for cost-effective removal of PCB-contaminated units.

The software model was distributed to utilities in Africa to support national programmes of PCB removal from transformers. The model is adjustable by each utility, designed to take into consideration their installed stock of contaminated units and plan for their removal and replacement with new, more energy efficient models. Summarising the techno-economic model and key findings, this paper concludes that cost-effective industrial efficiency measures can be applied to electric power transformers to achieve economic and climate goals while simultaneously addressing public health objectives such as the elimination of PCBs.