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Understanding the social dynamics of consumer energy choices – some lessons learned from two H2020 projects (ECHOES, SMARTEES)

Christian Klöckner, NTNU, Norway

Panel

1. The dynamics of limiting (energy) consumption

Keywords

group behavior, agent-based modelling

This paper presents analyses based on data from two H2020 projects coordinated by the author. In ECHOES, energy choices of consumers are studied from a multilevel perspective, including particularly the question, how choices framed as group choices (e.g., choices people living in a particular region, city or country) differ from choices framed as individual choices. Results from a representative multinational survey with more than 18,000 respondents conducted in all EU member states plus Switzerland, Turkey, and Norway are presented.

In the survey, an online experiment was conducted manipulating if predictors of energy saving behavior were introduced as a choice with a connection to other people in the region, the country, or the European Union. The analyses show that intentions to support the Energy Transition by energy saving behavior are impacted by the degree a person embraces an environmental identity, the feeling of being morally obliged (personal norms), the feeling of individual efficacy, but also social norms and the degree of identification with the people in the respective geographic entity (municipality, country, EU).

Citizens of the different countries differ strongly in the degree they identify with their municipality or the EU in relation to their country and the degree of how strong they perceive the social norms and individual efficacy in their municipality or country in relation to the EU. Whereas identification with the EU is usually rather low in most countries, social norms to save energy are experienced to be stronger on the EU level than on the lower levels. Also, efficacy is perceived to be higher on the EU level. These findings are supplemented by preliminary findings from the SMARTEES project, which studies the diffusion of five types of social innovations in energy (inclusive mobility planning, energy autonomous islands, introducing car-free "superblocks" in cities, city quarter revitalization through energy effectivization, fighting fuel poverty through participatory energy efficiency plans).

For this paper, first findings of the ongoing social network analyses in the social innovation cases are presented, outlining who key actors in such innovation cases are - again underlining the important function of communication, interaction and decision-making in groups. Two cases were

selected (the Danish “Energy Island” Samsø and the Swedish eco-neighbourhood Augustenborg in Malmö). In both cases, it becomes obvious that successful social energy innovations require the collaboration of a complex network of actors sitting at key positions in the social networks. Long term restructuring of local societies requires individuals that have the ability to engage larger fractions of the diverse network of different actors. Across both projects, this paper makes a strong case for studying consumer-driven energy choices towards energy sufficiency and innovation from a social systems perspective, rather than a technological or overly individualistic perspective.

“Energy visualization” as a tool to influence the energy use in a municipality kitchen

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Panel

1. The dynamics of limiting (energy) consumption

Keywords

Sweden, energy use, visualisation, displays

In Sweden, municipalities' own and operate the kitchens that cook food for pre-schools, schools and the elderly care facilities. There are 68 kitchens in the municipality of Umeå and providing feedback to the kitchen staff on energy use could facilitate them to reduce the energy use in these facilities. Accordingly, an “energy visualization” project was initiated in one of the kitchen: Nordstjärnan, which is a newly built kitchen equipped with separate meters for appliances that continuously record the energy use.

For the “energy visualization” project, a visualization design software called “Siemens Control Point” is used. The software is integrated with the existing steering and control system and connected to almost all sensors/meters in the building. The electricity use data from the kitchen was collected for 5 months prior to installation of the “energy visualization” project to establish a base line for the energy use. The average electricity use is referred in this paper as “Electricity budget”, which is calculated for each kitchen appliance that has an electricity meter.

A trial was started in the kitchen from December 2018 onwards, wherein a display unit was designed to project the electricity use of the kitchen. The display unit, which is a large television screen, has different “slides”. For example, one of the slide is modelled to energy labelling. The energy labelling in the display has a rating from A+++ to D, which is calculated continuously based on the daily electricity use and the electricity budget. If the kitchen uses more electricity than budgeted then the rating will drop, and if the electricity use is less than the budget then the rating will increase. Furthermore, depending upon the energy performance of the kitchen the visualization screens also display “smileys” which are used as injunctive norms.

A review of the residential efficient lighting programme rollout in South Africa

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Panel

1. The dynamics of limiting (energy) consumption

Keywords

LED, energy efficiency policy, residential lighting, incentive mechanisms

Through its tremendous progress in electrification and with the Free Basic Electricity social program, South Africa provides the most elementary benefit of electricity –lighting- to most households in the country. Transitioning to super-efficient technologies, such as LED, can therefore have a profound impact. For low income consumers reducing the consumption of lighting has the potential to provide access to extended usage or secondary applications. For the national utility still struggling to provide reliable service, reducing the peak load (18h00 to 20h00) brings greater stability. And, for national government, it delivers the benefits of large-scale energy savings and emissions reduction in South Africa, where electricity is mostly produced from coal. Yet, residential lighting is at a crossroads in South Africa. Eskom’s highly successful rollout of over 60 million CFL’s cemented consumer perception that the technology is the de facto energy saver for lighting, resulting in limited consumer appetite or interest towards LED’s.

Indeed, the market may be regressing - recent research undertaken by the authors has found that low income consumers are reverting to illegally imported but significantly cheaper incandescent lightbulbs now that the utility CFL rollout programme has ended. Policy makers are grappling with how best to adopt policies that will accelerate the transition to more energy efficient lighting technologies for the benefit of consumers, industry and the society as a whole. In this paper, we will provide an overview of the residential lighting market, review recent changes in technology, consumer trends and then assess the potential benefits and costs of moving to more efficient technologies. The paper will conclude by recommending a policy implementation approach which could be considered by national government in its quest to accelerate the transition to more efficient lighting technologies in South Africa.

Challenging conventions towards energy sufficiency: ruptures in laundry and heating routines in Europe

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Charlotte Louise Jensen, Aalborg University Copenhagen, Denmark

Patrick Naef, University of Geneva, Switzerland

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Panel

1. The dynamics of limiting (energy) consumption

Keywords

household consumption, household electricity, sufficiency, collective conventions

This contribution proposes to address a central question in social science approaches to household energy studies: “how do conventions around energy services evolve, how do they alter over time, and how can they be changed once they are cemented?” (Sovacool 2014: 19). Drawing from a social practice theoretical framework, we posit that energy usage at the household level is tied up with forms of routinized and habitual activities in and across consumption domains, embedded in socio-cultural, and technical and material arrangements.

We begin by proposing a definition of energy sufficiency which accounts not only for absolute reductions in resource usage, but also changes in everyday and habitual practices – which implies challenging collective conventions around energy usage in the home, as well as setting upper limits to consumption. Drawing from the ongoing ENERGISE research project (H2020), with its focus on laundry and heating, we then provide an overview of the literature on collective conventions related to these two consumption domains, noting the lack of a systematic review and easily accessible data.

We follow with a review of over 1,000 initiatives aimed at reducing energy usage in the home or promoting renewables, relating these initiatives based on a typology that reflects our conceptual framework around the notion of ‘sufficiency’. We discuss how and why energy consumption continues to be framed in terms of individual action and technological change, often blind-sighted to social norms and collective conventions – necessary towards achieving the normative goal of sufficiency.

In a fourth section, we outline the ENERGISE Living Lab approach, designed towards setting upper limits to consumption and engaging households in a participative process towards creating ruptures in everyday routines – with an explicit focus on collective conventions. On this basis, we

conclude with a discussion around the need for further developments around conspicuous and symbolic consumption, towards amplifying social change. We consider the opportunities that this represents, and how such an approach to uncovering, contesting and amplifying challenges to collective conventions can be relevant to practitioners and policy-makers alike.

How simulation may help communities to set a sustainable course

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Patrycja Antosz, University of Groningen, The Netherlands

Panel

1. The dynamics of limiting (energy) consumption

Keywords

simulation, agent based modelling, transition, social networks

Whereas linear models are capable of predicting human behavior in relative stable situations, this predictive capacity drops when communities enter the turbulent process of transition towards sustainable practices. In some communities successful changes have been realized, e.g. in generating sustainable electricity or making neighborhoods bike and pedestrian friendly, in other communities such intended changes failed.

In the EU project SMARTTEES we focus on unravelling the social dynamics underlying the success or failure of such community efforts. SMARTTEES aims at identifying strategies that support communities in making a change. To do so, we develop agent-based simulation models of social networks of local communities. We use the Consumat framework to simulate the habitual behavior of satisfied people, and social strategies such as inquiring and imitating if people become uncertain and/or dissatisfied.

The Consumat approach is capable of simulating a population of people having different perspectives, motivations and interests. Also, well-connected opinion leaders and their influence on other people can be modelled.

This allows for simulating cascade effects and tipping points in social systems of new (socially contagious) behaviors.

In SMARTTEES we develop simulations of a variety of existing empirical cases from the EU using available quantitative population data and qualitative narratives data on critical events and the role of opinion leaders. Running many simulations with slightly different settings reveals how likely the success of the empirical cases was. Experimenting with different policies in the simulations may demonstrate how the chances of success can be influenced. Inviting representatives of the communities and policy makers to play with simulations of their own community is expected to help communities to set a sustainable course.

Three forms of energy prosumer engagement and their impact on time-shifting electricity consumption

Anders Rhiger Hansen, Aalborg University, Denmark

Freja Friis, Danish Building Research Institute, part of Aalborg University, Denmark

Kirsten Gram-Hanssen, Danish Building Research Institute, Housing and Urban Research Division, Denmark

Mette Hove Jacobsen

Panel

1. The dynamics of limiting (energy) consumption

Keywords

prosumers, energy consumption, photovoltaics, solar energy, practices, everyday life

Focusing on households' micro-generation, in this case solar photovoltaic (PV) systems, and the role as prosumers, this paper identifies three distinctive forms of engagement as energy prosumer.

These forms are based on responses to statements on being prosumer, and refer to becoming:

- (1) more environmentally conscious,
- (2) focused on own financial gain, and
- (3) less concerned about electricity consumption.

By applying an ordered logistic regression, we investigate how these different types of engagement influence the self-stated tendency to time-shift electricity consumption according to peak loads in the energy system and to own electricity production.

We find that prosumers, who state that being prosumer make them more environmentally conscious, are more likely to time-shift electricity consumption according to peak demands in electricity grid as well as to own production. Prosumers, who express focus on own financial gain, seems more likely to time-shift according to own production, whereas prosumers, who state that they have become less concerned with own consumption, tend to time-shift less according to own production.

Furthermore, the results show that the accounting scheme ('hourly or immediate accounting' or 'annual accounting') has a strong impact on the tendency to time-shift. As could be expected, prosumers with hourly or immediate accounting, are much more likely to time-shift energy consumption to own production compared to prosumers with annual accounting.

This paper contributes with new knowledge on the extent to which having PVs, and being an energy prosumer, change and reconfigure the everyday practices of households. The findings

suggest that how people see themselves as prosumers and engage in energy-consuming activities have an impact on the tendency to time-shift everyday electricity practices. Moreover, the results also problematize that the present available accounting scheme encourage prosumers to adjust everyday practices to own production, whereas from a system perspective, it would be more sustainable to adjust to the peak loads of the electricity grid.

Experimenting with resource-intensive practices and related energy consumption levels

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Panel

1. The dynamics of limiting (energy) consumption

Keywords

delegation of responsibility, energy consumption, experimentation, social practices

It is widely accepted that the well-being of humans and other species now and in future generations is vulnerable to the effects of climate change and that urgent mitigation measures are required (IPCC, 2014, 2018). Ecological and environmental crisis and severe resource depletion mandate a need for fundamental social change in systems of production and consumption (e.g. COP 21, Paris Agreement).

Despite significant efforts by the EU as well as national and municipal governments to reduce domestic energy consumption over the last 20 years, traditional problem framing (which has typically relied on a mix of rational consumer choice models, efficiency measures and information-based behavioral change theory) has failed to deliver anticipated reductions (e.g. EEA, 2013). New problem-framings are needed to understand and engage with the challenge of high levels of energy consumption. In the EU-funded research initiative ENERGISE, practice-theoretically inspired ways of understanding and challenging current resource intensive, domestic practices are developed and tested.

This paper presents:

- 1) the role of social scientific enquiry in developing such new ways of understanding and challenging resource intensive practices as well as
- 2) the role of related methods in rolling out experiments, which seek to reduce energy consumption accordingly.

This paper discusses and exemplifies these dynamics by presenting the process of conducting ENERGISE 'Living Labs' involving Danish households to challenge their resource intensive practices related to home-heating and laundry routines.

Applying the efficiency first principle to photovoltaic self-consumption

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Jan Rosenow, The Regulatory Assistance Project (RAP), Belgium

Panel

1. The dynamics of limiting (energy) consumption

Keywords

photovoltaics, efficiency first, retrofits, dynamic windows, financial incentives, efficiency standards

Self-consumption from photovoltaic (PV) rooftop installations is an important driver for private investment in renewable energy in Germany.

Financial incentives for PV provided by the feed-in tariffs are now so low that an investment in rooftop PV only makes sense if the benefits of self-consumption, including the avoided cost of buying electricity from the grid, are fully considered. In addition, ongoing battery support schemes for PV installations continue to increase the amount of renewable electricity consumed by the owner of the installation (“self-consumption”).

The incentives provided by this approach encourage fuel-switching to electricity in the heating and transport sectors, too.

This paper argues, however, that the incentives to maximise PV self-consumption discourage electric efficiency improvements, as those would lower the share of self-consumption and thus the financial rewards. Also, the window of opportunity created when renewable energy investments are considered, is not being used for energy efficiency interventions. This is contrary to the Efficiency First principle, which states that, whenever solutions on the demand-side, such as energy efficiency improvements, deliver higher economic net benefits than the generation, transport, and consumption of energy, these measures should be implemented first.

In this paper, we demonstrate how the proper support for PV self-consumption can become an important mechanism to fund energy efficiency improvements for inefficient homes. One need only to look to Europe and abroad for examples of renewable support schemes that prioritise self-consumption and incentivise energy efficiency improvements. We show how this experience can offer important lessons for EU member states, such as Germany, that provide strong incentives for self-consumption of on-site renewable generation.

Nature in Your Face: framing co-creative visioning

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Christian Klöckner, NTNU, Norway

Panel

1. The dynamics of limiting (energy) consumption

Keywords

eco-visualization, participation

More and more experts are explicitly talking about the need to limit consumption, on both an individual and a societal level. It is time for a shift away from the current path of nudging us into new consumption patterns without it requiring major changes in our way of life. Eco visualization, or eco-feedback, has proven useful in helping individuals to act in accordance with their (pro-) environmental values/identities.

The project Nature in Your Face (NiYF) develops a versatile methodology for participation designed to help us take a leap forward and mobilize communities and resources in solving pressing issues. NiYF uses eco-visualizations to reconnect humans with the eco-system. At the core of the methodology lies the idea of challenging our current way of doing things by confronting us with nature, or representations thereof, accentuating our dependence on it. By using art inspired, technology supported eco-visualizations that wilfully put us out of our comfort zone, we stimulate creativity, debate and engagement.

In order to not only create discomfort and question the current status quo, this confrontative approach is part of a structured three step process that is designed to harvest engagement, and open up for innovation and creativity, and finding new ways of doing things.

This paper describes the first NiYF case, Kristiansund, where the methodology has been used in a Climate-KIC funded ideator-project to support an ambition of plastic-neutrality. The methodology consists of three interdependent pillars to develop the future city together:

- 1) Framing,
- 2) Twisting, and
- 3) Using.

The first pillar involves a confrontation or challenge addressing the problem to be solved. In Kristiansund, this challenge was “the growing amount of plastic in the ocean”, while thematically framing it to specific practices or contexts. The second pillar opens up for co-creative visioning in which alternative ways of doing things are developed. In Kristiansund, this was kick-started by presenting potential radical changes in local conditions, such as local plastic-bans (twisting) in each of these practices and contexts. The final pillar involves testing these ideas and concepts in practice (using). Using Kristiansund as test case, this paper demonstrates how the NiYF methodology offers a framework for helping communities to mobilize resources, unlock innovation

potential and support cooperation between municipalities, citizens and (local) businesses in solving pressing issues in their community. The case has been used to fine-tune the methodology and to establish a proof of concept of the NiYF methodology. It provides a new approach to meet the challenges of creating a future (city) that invites citizens to experiment, explore and debate together with municipalities, universities and businesses.

Nudgeathon for encouraging energy behaviour

Alina Mia Udall, NTNU, Norway

Daniel Read, Warwick Business School, United Kingdom

Umar Taj, Warwick Business School, United Kingdom

Panel

1. The dynamics of limiting (energy) consumption

Keywords

nudgeathon, participatory design, built environment, sustainability, heating, consumer behaviour, design process, home energy audits, energy use, conservation

Humans are generating many environmental problems and our behaviours are not sustainable over the long term. According to an Intergovernmental Panel on Climate Change (IPCC) special report on the impacts of global warming by Allen and colleagues in 2018, encouraging pro-environmental energy behaviour is most likely to reduce carbon emissions, which is essential in order for the UK to reach the 2050 target of a 60% reduction in CO₂ emissions.

Pro-environmental heating behaviours in contexts where there is little economic incentive to conserve energy, such as in our context (Higher Education Institutions [HEI]), is one of the key contexts for the UK to reach its goal. Many attempts have been made to encourage these behaviours, using design-thinking, participatory design, and choice architecture, however, each approach alone has its limitations. To overcome these challenges in order to optimally change behaviour, we combine these three approaches, and propose a new comprehensive behaviour change model, namely, Nudgeathon.

Nudgeathon proposes seven consecutive stages that can lead to any type of behaviour change, including pro-environmental heating behaviours, and in any contexts, including university accommodation.

These stages are as follows: Define, Empathise, Ideate, Present (Figure Out Phase), Refine, Prototype and Test (Follow Through Phase). This seven-stage process has been successfully tested at an Institution level, where we observed positive behaviour change – that of pro-environmental heating behaviours in university accommodation. Finally, we suggest questions to be addressed in future research in behaviour change, and for pro-environmental heating behaviours.

Walking with Energy: increasing energy visibility through research participation

Aimee Ambrose, Sheffield Hallam University, United Kingdom

Panel

1. The dynamics of limiting (energy) consumption

Keywords

district heating, qualitative study, citizens

Cities face challenges to rapidly decarbonise and the engagement of citizens is critical to this. Yet, our relationship with our domestic energy consumption has been said to suffer from a 'double invisibility' in the sense that energy is now rarely tangible and seen and is so embedded in our lives that we no longer appreciate the connections between it and our everyday actions (Hargreaves et al, 2010). This invisibility distances us from our consumption and its consequences- a problem in the context of urgent pressure to be more conscientious resource consumers.

Goodchild et al (2017) found that those that had experienced the transition from open fires to gas central heating felt that their own heuristic experience of household heating (handling and rationing fuel such as coal and building fires) was far removed from that of their children who are detached from practices of warming the home. Therein lies a set of risks associated with the disconnect between several generations and their energy consumption at a time when energy is more scarce than ever.

'Walking with Energy' considers the existence of energy invisibility within the home, its consequences and possible means of reconnecting households and their energy consumption that extends beyond the technological realm. The project employs participative methods to help understand contemporary relationships with energy and to reconnect us with energy (specifically heat) production through research participation itself.

We report findings from a study which involved walking with members of the public along the pipelines of a district heating system to their source at an incineration plant. The aims were twofold;

- 1) to gather- whilst walking and thus being embedded in the energy landscape- an oral history of how participants' relationship with energy has changed over time and
- 2) to reconnect them with the environmental and ethical debates around heat production.

Closing the (conceptual) energy efficiency gap

Tessa Dunlop, European Commission Joint Research Centre (JRC), Ispra, Italy

Panel

1. The dynamics of limiting (energy) consumption

Keywords

methodology, indicators, concepts, Energy Justice, Philosophy, rebound effects

Energy efficiency represents an important policy strategy among governments across the globe to reduce energy consumption, secure energy supply, and reduce greenhouse gas emissions. Despite this however, evidence shows that worldwide neither energy consumption nor climate mitigation targets are being met.

Given the pressing ‘energy trilemma’ regarding climate change, energy security and social welfare, there have been renewed calls to disentangle what is meant by energy efficiency, including, critically, its conceptual foundations and practical applications. Specifically, research has shown that the way that the concept of energy efficiency is applied to the physical, material world is a value judgement that brings with it a raft of societal trade-offs that are not fully understood.

This conceptual review of the energy efficiency literature shows that a major gap exists in knowledge, at the nexus between concept, technical methodology and sociological understanding. That is, in order to understand the underlying values inherent in energy efficiency actions, it is necessary to observe how the concept is represented and manifested in its practical quantification and what effect this has on society, policy implementation and energy practices. In investigating this point of intersection between values, a theoretical concept, and its application to the real world, one can then begin to see what and where are the social and environmental trade-offs inherent in its use.

To this end, this article observes energy efficiency through a new lens by reviewing its conceptual and methodological foundations together in a multidisciplinary way, taking into consideration cultural and technological change over time. Building on the research of historians and social scientists, this research shows that more efforts need to be done to integrate energy efficiency issues more into sociological frames of energy justice, philosophy and history.

Better off with less (energy)? Household activities during interventions

Marina Diakonova, ECI - Energy Group. Environmental Change Institute, University of Oxford, United Kingdom

Philipp Grünewald, ECI - Energy Group. Environmental Change Institute, University of Oxford, United Kingdom

Panel

1. The dynamics of limiting (energy) consumption

Keywords

demand response, household consumption, electricity, activity patterns, energy demand side

The dominant supply side perspective in energy research tends to focus on the downsides of (energy) consumption, its costs and the environmental impact. We seek to inform this debate with a reversal of perspective. What are the benefits of energy for the users and how does demand reduction affect them? We have collected over 18,000 simultaneous records of UK household activities, enjoyment and electricity consumption. These data give us novel and nuanced insights into the relationship between what we do, how much (electricity) we consume at the time and how this affects our sense of enjoyment.

Three broad and interrelated trends emerge:

1. Periods of high activity coincide with high demand
2. Periods of high demand coincide with greater enjoyment (!)
3. Interventions to reduce demand can lead to reductions in demand, but also affect activities and enjoyment

Our ongoing research on demand interventions found that requests to reduce demand during peak periods (5-7pm) led to 15% reduction in load. Food related activities have been identified as particularly relevant during peak demand. They tend to get shifted or suppressed and substituted with other activities to compensate. For some, this can lead to increases in enjoyment, while others have their enjoyment reduced, especially where 'quality time' activities are sacrificed during such interventions.

While the overall trend is for periods of high consumption to be more enjoyable, there are important nuances to consider. We will present high-energy low-enjoyment patterns as well as low-energy high-enjoyment activities. Interventions to reduce the former or increase the latter may hold the key to more acceptable public policies and may even increase well-being. Three activities that stand out as the most enjoyable are reading, socialising and sleeping. These are also among the least energy consuming. Instead of denying or penalising energy use, encouraging activities like reading, socialising and sleeping could bring about a wide range of benefits, aside from displacing less enjoyable, costly and environmentally harmful demands.

Non-energy benefit evaluation: the experience of a multi-utility

Dario Di Santo, FIRE, Italy

Stefano D'Ambrosio, FIRE, Italy

Margherita Cumani, HERA S.p.A., Italy

Fabio Roveda, HERA S.p.A., Italy

Livio De Chicchis, FIRE - Italian Federation for Energy Efficiency c/o Centro ENEA Casaccia, Italy

Panel

1. The dynamics of limiting (energy) consumption

Keywords

multiple benefits, non-energy benefits (NEBs), energy management system, ISO 50001, decision-making process

Multiple benefits of energy efficiency are a topic of growing popularity, also thanks to many related initiatives and projects, such as Combi, Odyssee-Mure, and, more recently, M-Benefits. The importance of multiple benefits assessment was clearly highlighted by IEA already in 2014, and a better understanding of their impact on energy efficiency projects is expected to help both policy makers in delivering better policies and companies in improving their business. Until now, however, their evaluation has been mainly confined to research studies.

In 2017, after four years of promotion of the non-energy benefits (NEBs) concept among energy managers, ESCOs and utilities, FIRE launched a survey trying to understand how companies and authorities were working to catch the opportunity offered by NEBs to increase the implementation rate of energy efficiency projects. Interesting results emerged and are here presented: the industrial sector is the most active (around 50% of companies are already evaluating multiple benefits, at least qualitatively) and the buildings sector is trailing behind. However, only a few companies are effectively evaluating NEBs in a quantitative way and following detailed procedures.

The presentation also illustrates the interesting case study of HERA, the Italian multi-utility which is certified ISO 50001 as whole organisation and very active in the energy management field. HERA promotes energy efficiency at corporate level and within client industrial companies, acting within the white certificate scheme. In 2018, HERA developed, with the involvement of all business units, methodologies and criteria to quantify NEBs for some energy efficiency projects. Results are quite interesting and demonstrate the feasibility and added value of NEBs evaluation at company level for decision making. Furthermore, a structured cooperation among business units, built over the years throughout the energy management system, turned out to be a key success factor.

Case study feedbacks to accelerate and strengthen the energy transition

Patricia Gorin, SIG - Services Industriels Genève, Switzerland

Cédric Jeanneret, Services Industriels de Genève - SIG, Switzerland

Panel

1. The dynamics of limiting (energy) consumption

Keywords

Case Study Feedback, Learning by using, energy systems, innovation, best practice

What have we learned from all these magnificent energy transition projects in our territories since decades? Are we humble enough to recognize our trials and errors? How to structure these lessons in order to avoid repeating mistakes? What tools to facilitate this « learning by using? »

Geneva Industrial Services (SIG) has been working with the University of Geneva for more than 15 years in the field of energy innovation on thermal, real estate renovation and energy efficiency projects, stimulated through the "learning by using", a powerful feedback process, between academics and practitioners (incremental innovation process). The recent publication "Energy transition and innovation, feedback from experience" tries to capture the entire process by sharing a summary of methods for evaluating and value energy systems.

As part of a large exploratory geothermal drilling campaign, a pilot project is underway to create several Case Study Feedbacks based on the above collaboration and methodology. The objective is to allow a public and systematic access to the data to help the actors of the energy transition (project leaders, public authorities, consulting firms, decision-makers, etc.) to remove the technical and financial barriers to new projects. Based on a common desire for centralization, exchange and sharing of knowledge, this project is supported by the national public energy institution which shows an interest in the launch of Case Study Feedbacks to strengthen and accelerate the energy transition. This concrete pilot project could be replicated on a larger scale to other areas of the energy transition and form a neutral and dedicated structure which would produce Case Study Feedbacks, facilitate training and research, inform and sensitize, and bring together stakeholders. Elements of answer on "how can we capitalize on successes of Case Study Feedbacks cumulated from the previous years?" would be generated through the debate between academics, policy makers and practitioners. This will bring new views on how to explore, research, envision, intervene, monitor and evaluate energy sectors and their limits to finally improve behaviours and practices.

Exploratory analysis of family-related activities during peak electricity periods

Máté Lőrincz, University of Reading, United Kingdom

Timur Yunusov, School of Built Environment, University of Reading, United Kingdom

Jacopo Torriti, School of Built Environment, University of Reading, United Kingdom

Panel

1. The dynamics of limiting (energy) consumption

Keywords

time use, work time, peak savings, sufficiency, flexibility, practices, sequences

Price-based interventions (such as Time of Use tariffs) are designed to shift the timing of certain everyday activities to mitigate peak electricity demand. On the one hand, it is argued that timing activities outside the peak hours would decrease the demand, easing the stress on the grid. On the other hand, recent literature suggests that householders are more likely to ignore timing of activities - due to convenience or due to activities considered 'non-negotiable' during peak hours. One way to address this conundrum is to investigate how family-related activities during the peak times hang together and what is important about performing them together at a specific time of the day.

The starting point of this research is that working hours and school times shape the dynamics of peak hours, leaving less time for families to do more during these time periods and also making it difficult to shift activities to other times of the day. Drawing on the insight of our preliminary analysis, using UK Time Use Survey 2014-2015 diaries, we diagram family-related activities (such as homework, food preparation, cleaning, washing, bathing or playing) which constitute the outside peak electricity period, as well as those performed during the peak electricity period (4pm–8pm). We aim to explore the timing and duration of activities and how they vary at different temporal and spatial scales. Markov chain technique will be used to determine the probability of a certain electricity load to take place at a specific time of a day.

In conclusion, we argue that any effective shifting of family-related activities will need to look beyond the meter (such as de-synchronized effects of school holidays), potentially collecting information regarding both energy and non-energy data in order to understand the connection, coordination and organization between activities which constitute electricity demand.

How to engage households in energy demand response solutions?

Toke Haunstrup Christensen, Danish Building Research Institute, Aalborg University, Denmark

Simon Peter Larsen, Aalborg University, Danish Building Research Institute, Denmark

Henrik N. Knudsen, Aalborg University, Denmark

Panel

1. The dynamics of limiting (energy) consumption

Keywords

demand response, everyday life, households, social learning

Within the smart energy and smart grid field, Demand Response (DR) is expected to play an important role in balancing energy consumption with intermittent energy production from renewable sources in the future. This DR vision, in many cases, relies on active involvement of households in actions aimed at time shifting their energy demand. However, DR solutions targeted households have had a rather limited diffusion and impact so far, and it has proven difficult to ensure sustained user engagement.

Based on practice-theoretical approaches to residential energy demand, this paper takes as its starting point that new methods to involve households are required if we are going to design DR solutions that will be successful in engaging households in DR actions. As a contribution to this, the paper explores what role learning might play in realizing DR solutions based on active involvement of households. Here, learning is understood as both the self-reflection about own habits and the appropriation of new practices.

The role of learning is explored by, first, identifying and discussing the types of situations and dynamics in everyday life that can initiate processes of learning. Such situations or dynamics are termed “initiators of cultivation”, and examples include social feedback, encountering others’ ways of doing, embodied sensory feedback, etc. Secondly, we discuss to what extent existing DR approaches are employing these situations or dynamics in order to foster instances of learning in relation to moving everyday practices in time. The conclusion is that the scope of present DR approaches is quite narrow and only addresses a limited number of possible initiators of cultivation. Therefore, the paper provides some first ideas on how to make DR designs better at initiating processes of learning, which could lead to more engaging and successful DR solutions. This part informs policy-makers as well as DR solution designers.

The paper is based on a literature review. We are not necessarily implying that new learning approaches “by default” result in efficient DR solutions that are successful in changing the energy consumption profiles of households. This is an open question, which needs further theoretical and

empirical exploration to be answered, but we hope that our paper contributes to the foundation of such further investigation.

Energy sufficiency: how to win the argument on potentials?

Charline Dufournet, Association négaWatt - Antenne de Paris, France
Hannah Förster, Öko-Institut (Institute for Applied Ecology), Germany
Edouard Toulouse, NégaWatt Association, France
Yves Maignac, France

Panel

1. The dynamics of limiting (energy) consumption

Keywords

energy sufficiency, scenarios, acceptance, energy savings potential

In terms of energy demand, technical efficiency improvements alone may not be enough to tackle climate change and meet the 1.5°C target if we continue using a growing amount of energy-based services. Actions on behavioural and societal organisation changes - encompassed in the 'sufficiency' concept - are also required.

Energy sufficiency means efforts to rethink and redesign collective and individual practices in order to favour intrinsically low-energy activities and services, to keep us in line with the ecological limits of the planet. It requires reflecting on human needs, social equity, economic development, urban structures, social norms, consumption habits, as well as the role of policies to foster sufficiency.

There is an increasing number of contributions discussing how to take sufficiency into account in energy transition scenarios. Some energy models include quantifications of sufficiency potentials, and studies provide recommendations on how best to do it. Theoretical assessments of potentials are a key step; but making a convincing case as to the credibility and plausibility of these potentials appears to be another important matter. The reason is that sufficiency potentials are provoking specific doubts and sometimes reluctance, that may be due to their nature, limitations, and other (more or less subjective) reasons. In this paper, we propose an exploratory investigation and typology of these objections, and factors that are likely to aggravate them.

The analysis is notably based on the experience of the French négaWatt Association on the way its sufficiency-based energy scenario published 17 years ago has been received by various audiences since then. We then suggest and discuss ways to increase the trust in and acceptance of sufficiency potentials, through recommendations on how to improve their robustness and how best to communicate them (supporting explanations, effective arguments, importance of co-benefits, use of narratives, etc.).

From Paris to local government action: implementing territorial carbon budgets

Martin Mickelsson, Uppsala University; Dept of Education; Swedish International Centre of Education for Sustainable Development, Sweden

Helena Lindquist, LightSwitch AB, Sweden

Martin Wetterstedt, Uppsala University; Centre for Environment and Development Studies, Sweden

Panel

1. The dynamics of limiting (energy) consumption

Keywords

territorial carbon budgets, scaling, climate change mitigation, local authorities, local and regional energy planning, sufficiency

The Paris agreement states that the signees have a shared responsibility of limiting global temperature increase to well below 2,0, and aim for 1,5 degrees. Acknowledging that a major percentage of global warming stems from energy related carbon dioxide emissions, a method has been developed for expressing the global temperature goal as local territorial carbon budgets.

We argue that the method is novel in three ways;

- 1) it provides a bridge between a global temperature target and a local emission pathway;
- 2) it inherently communicates the fact that fossil carbon emissions are cumulative to their nature, implying that the current paradigm of setting climate targets is flawed;
- 3) and it gives fuel to the discussion on sufficiency due to the combination of the high calculated reduction rates the method generates, and how emissions are distributed among countries and people.

To be effective in contributing to the Paris climate goals, carbon budgets need to be implemented on a large scale while retaining depth in context. The aim of this paper is to enquire into the conditions for implementing the Carbon Budget (CB) framework into municipal practice. Using Kotter's theory of change and the conceptual framework on scaling-as-learning, we understand implementation as a change process, integrating and adapting certain content in practice.

Consisting of three parts, the paper first introduces the CB framework and describes its application and possible interpretations by local stakeholders in a municipal setting. Second, we draw on the change theory to explore change conditions needed for a successful implementation. Finally, we outline processes guided by the conceptual framework of scaling-as-learning as possible support mechanisms for the change conditions of this implementation.

Energy equality and energy sufficiency: new policy principles to accelerate the energy transition

Giuseppe Pellegrini-Masini, NTNU Norwegian University of Science and Technology,
Norway

Panel

1. The dynamics of limiting (energy) consumption

Keywords

energy equality, energy justice, energy sufficiency, energy policy

Energy equality (EE) is a novel concept, and its tentative definition was recently presented as follows: “Providing all individuals with equal opportunities of using energy services, energy technologies, and consuming energy and embodied energy for satisfying personal needs and holding capabilities” (Pellegrini-Masini, 2018, p. 13).

The complexity of the concept and its relation to widely used concepts such as “needs”, “capabilities”, “energy justice”, “environmental justice”, “distributional justice” and “energy sufficiency” deserve to be analysed and discussed.

Nevertheless, EE appears as a concept that is susceptible to inspire energy policies pursuing higher levels of distributional equity and the reduction of CO₂ emissions. Distributional policies though, are known to be contentious and often raise debates on the opportunity of interfering with the free market allocation of goods in capitalistic economies. Whether EE inspired policies might be considered feasible and implementable depends on their expected social acceptance. In this paper, we discuss the interrelation of EE with other concepts at the core of energy consumption policies and we discuss the profile of social acceptability of the policies that might be informed by EE.

Play the game: learning about energy efficiency can be fun – seriously!

Catherine Cooremans, Université de Lausanne, Groupe Ecologie Industrielle, FGSE / IDYST, Switzerland

Clemens Rohde, Fraunhofer Institute for Systems and Innovation Research, Germany

Dominique Jaccard, Haute Ecole d'Ingénierie et de Gestion du Canton de Vaud (HEIG-VD), Switzerland

Jarle Hulaas, Haute Ecole d'Ingénierie et de Gestion du Canton de Vaud (HEIG-VD), Switzerland

Panel

1. The dynamics of limiting (energy) consumption

Keywords

training, serious game, communication, multiple benefits of energy efficiency projects

Industrial and service sectors offer potential for cost-effective energy-savings. But under-investment in energy efficiency is observed in all EU countries. This is called the «energy-efficiency gap». In order to be implemented by companies, energy-efficiency measures have to be analysed and communicated taking into account the various professional interests and cultures prevailing in a corporate context.

Well beyond the mainstream energy-saving analysis, a multidisciplinary approach is needed, which requires training of energy-efficiency engineers.

Classical training for energy engineers focuses on lectures in combination with individual exercises. This training has several shortcomings:

- exercises usually focus on simple techno-economic assessments;
- the variety of information sources and interests in a company are improperly represented;
- strategic concepts, such as competitive advantage or core business, are not included.

Therefore classical training does not develop the skills needed to deal with the multidisciplinary aspects of energy-efficiency measures. It is also well known in pedagogical sciences that, in professional training, the motivation for learning increases when participants can directly apply what they are taught.

By providing a virtual training environment, serious games offer the opportunity to manage complex problems and to directly apply any theoretical framework in a fun and collaborative way. Our paper first part discusses serious games general concepts and methods. Secondly it presents a new serious game developed as a training tool for a capacity-building program on the multiple benefits of energy efficiency. This game puts the participants in the context of an industrial company. In this virtual company, participants play the role of an energy manager who

wants to get an energy-efficiency project approved by the investment committee. In order to succeed participants have to virtually interact with the company's staff members to collect the relevant information to set up their project. The paper's third part presents first results of training sessions using this serious game.

Energy sufficiency: are we ready for it? An analysis of sustainable energy initiatives and citizen visions

Edina Vadovics, GreenDependent Institute, Hungary
Lidija Živčič, Slovenia

Panel

1. The dynamics of limiting (energy) consumption

Keywords

energy sufficiency, sustainable energy initiatives, citizen visions

The aim of this paper is to bring together knowledge and experience about energy sufficiency from two European projects. On the one hand, relying on a database of sustainable energy initiatives we investigate whether the concept of energy sufficiency is present in projects designed to make energy consumption more sustainable. On the other hand, based on an analysis of visions created by citizens, we explore whether energy sufficiency, or sufficiency in general, appears in citizen visions of a sustainable future.

The paper starts by defining energy sufficiency, or more accurately, 'energy sufficiency within limits' that the authors describe as consumption that ensures that everyone has access to a sufficient amount of energy to satisfy their basic needs in a way that respects the ecological limits of the planet. Thus, energy sufficiency is understood as connecting the need to limit energy consumption with the need to make consumption and distribution more just, hence also introducing the concept of energy justice into the analysis.

Then, an analysis of the ENERGISE database of 1000+ sustainable energy consumption initiatives (SECIs) from 30 European countries is introduced, using an energy sufficiency framework. This is followed by a study of citizen visions from the CIMULACT project. CIMULACT developed a participatory methodology that involved more than 1000 citizens from 30 European countries in a consultation process during which visions of a desirable future were created. These citizen visions are analyzed from the point of view of sufficiency: namely, does the latter term (or similar terms) appear? If yes, in which contexts, and in relation to which objectives? What, if any, are the aspects that are currently missing? The paper closes with reflections on what the findings from the analysis mean for putting energy sufficiency more firmly on the research, action and policy agenda.

1-331-19:

Limiting energy consumption using different methodologies: carbon clubs, energy neighbourhoods and living labs. A comparison of methods and results

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

Panel

1. The dynamics of limiting (energy) consumption

Keywords

household consumption, group-based change, energy saving assessment, living laboratory

This presentation introduces and analyzes three sustainable energy initiatives implemented in Hungary, all focusing on limiting household energy consumption. They all started as a part of larger European research or action projects: a local carbon club called the Gödöllő Climate Club initiated as a pilot project in the Changing Behaviour project (FP7), a small groups based energy saving programme called EnergyNeighbourhoods (IEE), and the ENERGISE (Energy) Living Labs (H2020). The first two of these have been implemented for many years, beyond their originally planned project timelines, while the Living Labs are recent, and have been conceived to be short-term.

The presentation first describes and compares the theories of change and problem framings underlying the three initiatives (theory of interpersonal behaviour, group-based behaviour change, social practice theory), with particular attention to similarities and differences between them. Resulting methodologies, including intervention strategies and tools, individual vs. group methodology elements, communication tools, etc., are also compared.

Following this, the results and outcomes of the three initiatives are analyzed. All initiatives applied a mix of qualitative and quantitative evaluation methods such as interviews with participants, pre- and post-intervention surveys, energy and carbon saving calculations, etc. The outcomes of these are synthesized with the objective of drawing out success and challenge factors, including those that are specific to all three initiatives. It is also examined how the methodologies applied in the three initiatives could be combined to create more effective sustainable energy projects in terms of limiting energy consumption and creating long-term change. Finally, the authors reflect on more systemic factors that need to be present or to change in order to create more favourable conditions for the change in everyday behaviour and practices achieved through similar initiatives to persist in the long run.

What's the magic word? What we talk about when we talk about energy efficiency

Jens Petter Johansen, NTNU Social Research, Norway

Jens Røyrvik, NTNU SR, Norway

Gudveig Gjørund, NTNU Social Research, Norway

Panel

1. The dynamics of limiting (energy) consumption

Keywords

media discourse, energy efficiency action plans, industrial energy saving

Energy efficiency has become an integrated concept in modern language and public discourse, yet definitions and effects of energy efficiency and reduction is still an ongoing debate within academic discourse. This article investigate how industrial energy efficiency is framed and features in media narratives.

Media discourses both reflect and shape public opinion and essentially the political sphere, calling for an improved understanding of how energy efficiency features in public discourse. The paper is based on a media analysis of 309 articles featuring “industrial energy efficiency” in a selection of Norwegian newspapers in the period between 2013-2017.

We find numerous different framings of energy efficiency in the articles, where the authors draw on various notions of relative and absolute reduction in consumption, indicators and system boundaries. Even more common is the tendency to frame energy efficiency generically without explicit or implicit assumptions about reduction in consumption.

The analysis show that energy efficiency is rarely an object of contention or controversy and often not even the topic of the articles itself. Rather it figures in arguments within transition narratives of climate change mitigation and economic stability and growth. The paper outlines the underlying structures of how energy efficiency serves as a legitimizing concept in these narratives, as well as ammunition on both sides of heated controversies regarding development of renewable wind or hydro-parks, transmission lines and oil & gas industry.

The combination of a multitude of framings and generically use of the concept essentially lead to a black-boxing of the relationship between energy efficiency and reduction. Consequently, the associative equation between “energy efficiency” and “reduction” contributes to establish energy efficiency as a magic word in media narratives, suitable to legitimize almost every thinkable argument within transition narratives.

Gamification as a way to involve young adults in energy efficiency and sufficiency – a case study

José Luís Sousa, Polytechnic Institute of Setúbal, Technology School of Setúbal and INESC Coimbra, Portugal

Carlos Henggeler Antunes, INESC Coimbra - Department of Electrical and Computer Engineering, Portugal

Marta Lopes, INESC Coimbra, Portugal

Inês Reis, INESC Coimbra, Portugal

Joao Sousa, University of Coimbra, Portugal

Válter Gonçalves, Polytechnic Institute of Leiria,, Portugal

Alexandre Silva, Polytechnic Institute of Coimbra, Portugal

Luís Marcelino, Polytechnic Institute of Leiria, Portugal

Rúben Pereira, Polytechnic Institute of Leiria, Portugal

Licínio Moreira, Polytechnic Institute of Leiria, Portugal

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Jorge Cabral Júnior, Politechnic Institute of Setúbal, Portugal

Carla Henriques, Polytechnic Institute of Coimbra, Portugal

Dulce Costa, Polytechnic Institute of Setúbal, Portugal

Dulce Coelho, Polytechnic Institute of Coimbra, Portugal

Diogo Correia, Polytechnic Institute of Leiria, Portugal

Rodrigo Dionissa, Federal Institute of Santa Catarina, Brazil

André Vieira, Polytechnic Institute of Leiria - ESTG, Portugal

Luís Neves, Polytechnic Institute of Leiria, Portugal

Panel

1. The dynamics of limiting (energy) consumption

Keywords

games, domestic energy efficiency, energy sufficiency, app, behavioural change

Today, social and environmental concerns make energy efficiency a matter of common concern, for both domestic consumers, industry, services and other entities. This paper discuss gamification as a tool for behavior changes in young adults (higher education students). The work was carried out as part of a research project that aims to characterize domestic energy consumption behaviors, seeking to contribute to greater energy efficiency and cost reduction, disseminating good practices as a form of retribution for consumers' collaboration. The project involves students and researchers from three higher education institutions in Portugal, a research institute and three energy agencies.

A mobile application (app), "Minha Energia" (My energy, in Portuguese), was created to reach younger adults, although it is available to the population in general, with the intention of helping the development of energy efficiency programs targeting energy efficient behaviors. The objective of the app is to characterize consumers' behaviors, giving suggestions and advices as a reward to participants. The more recent version of the app has been released recently and the gathering of data has just started.

The project is expected to contribute to a more detailed knowledge regarding energy use in the residential sector, with particular focus on three cities, and to disseminate good practices in terms of energy behaviors.

The use of mobile apps as an inquiry and best practices dissemination tool, through gamification, allied to the involvement of circa 200 students as research helpers, has the potential to achieve a notable effect, namely when it refers to changing energy consumption behaviors of younger generations.

Using digital interventions for behaviour change towards energy efficient behaviour

Annette Roser, IREES – Institute for Resource Efficiency and Energy Strategies, Germany

Edith Chassein, IREES, Institute for Resource Efficiency and Energy Strategies, Germany

Karin Schakib-Ekbatan, IREES GmbH – Institut für Ressourceneffizienz und Energiestrategien, Germany

Panel

1. The dynamics of limiting (energy) consumption

Keywords

behavioural change, awareness, technological intervention, digitalisation, co-creation labs

Energy is consumed by people rather than by buildings. However, most of the strategies to achieve energy efficiency in buildings focus on technical mitigation measures.

The EU Interreg Alpine Space project 'THE4BEES' with partners from Slovenia, Italy, Austria, Switzerland, France and Germany aims at reducing GHG emissions and energy consumption in buildings through more efficient behaviour.

According to the extended model of normative decision making, awareness raising is the first step towards behavioural change. Together with users, energy managers, technical experts and scientists, ICT tools have been developed and are currently tested.

Four specified target groups are part of seven pilots: alpine huts, schools, work places and private households. In the end it is the behaviour of students, workers, tourists and residents that will create the impact.

The ICT tools should support soft approaches to raise awareness and change energy relevant behaviour. For this purpose, a mix of intervention strategies has been discussed and implemented within the project: feedback, comparison, hints and tips, unusual usage alerts, additional information and storytelling.

The intervention methods are integrated in two digital ICT tools designed in co-creation labs:

1) For energy managers, a dashboard was created that is fed by sensors in all rooms of the building. The monitored measurements are, for example, power consumption, room temperature, room luminosity, window opening time.

2) An app has been developed, especially for students, with elements like consumption overview, comparison with last week, hints and tips and an option to rate the current comfort level (happy-neutral-not happy).

The tools are currently tested and continuously developed together with the users within the seven project pilots. This co-creation process demonstrated the high relevance of participation in terms of involving the target group of a specific intervention to foster positive effects.

Facilitating joint action towards energy efficiency in business and industry

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Stefan M. Büttner, Institute for Energy Efficiency in Production (EEP) - University of Stuttgart, Germany

Panel

1. The dynamics of limiting (energy) consumption

Keywords

initiatives and solutions, energy efficiency policy, corporate strategy, industry, facilitation

A lot is already done in energy efficiency - so what is the issue? The potential is clear, the barriers are identified, good approaches exist, but widespread implementation still remains slow! Pursuing energy efficiency projects, particularly in business and industry, involves many internal and external stakeholders and often leads to many communication gaps: financial institutions, ESG ratings/reporting, research, NGOs, IOs, policy makers but also corporate management on the one side and engineering on the other side. However, Energy Efficiency is not difficult. It is just complicated. Making energy efficiency part of the core business strategy can help making efficiency happen - particularly as energy efficiency easily fits into the digitalized industry model.

So what needs to be addressed to make it really happen: Understanding energy efficiency, making sense of what's already available, have industry as a leader rather than a follower and establish collaboration for better policy? The answer is connecting the dots and providing both a clear forum and an overview for stakeholders.

With the newly established UNECE Task Force on Industrial Energy Efficiency and the UNIDO Industry working groups, business and industry leaders find a platform for open exchange, enabling industry leadership on Industrial Energy Efficiency (IEE) and access the entire value chain, getting a unified and clear summary of IEE, as well as an independent review of IEE initiatives and policies to enable better matching of initiatives to companies and identify areas of for future focus of policy action.

Building energy consumption quotas: a policy tool toward sufficiency?

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Adam Hinge, Sustainable Energy Partnerships, USA

Shan Liu, Division of Building Energy Efficiency, Center of Science and Technology & Industrialization Development, Ministry of Housing and Urban-Rural Development, China

Siyue Guo, Tsinghua University Building Energy Research Center, China

Bin Hao, Shenzhen Institute of Building Research, China

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Panel

1. The dynamics of limiting (energy) consumption

Keywords

new paradigm, energy sufficiency, building energy quotas

As the level of building construction has grown in China over the past decade, with annual building construction levels surpassing two billion square meters of new construction each year, China has been investigating new regulatory mechanisms to reduce building energy use. One method being considered as part of the government policy to reduce the growth rate of building energy consumption (and resulting greenhouse gas emissions), is the development of “energy consumption quotas” for buildings, essentially setting an energy intensity limit for different building types within a given climate zone.

Experts and regulators in China have been investigating limits, or quotas, on the amount of energy that can be used by the building sector; then a target is set for total building energy use in a province or city, which can then be extended down to apply to individual buildings. The building energy quota concept has been advanced into a Chinese National Standard promulgated in 2016 (the National Standard for Civil Building Energy Consumption, GB/T 51161-2016).

This paper focuses on how quota consumption limits have been applied in other industries, methods for developing appropriate quotas for different building types, potential compliance mechanisms for enforcing the quotas, and prospects for implementation in the near future.

Making more of middles: advancing the middle-out perspective in energy system transformation

Kathryn Janda, Energy Institute, University College London, United Kingdom
Yael Parag, School of Sustainability, Interdisciplinary Center (IDC), Israel
Yann Blumer, ZHAW School of Management and Law, Center for Innovation and Entrepreneurship, Zürich University of Applied Sciences, Switzerland
Faye Wade, International Institute for Industrial Environmental Economics (IIIEE), United Kingdom
Katharina Reindl, Sweden

Panel

1. The dynamics of limiting (energy) consumption

Keywords

middle-out perspective, cities, middle-out approach, building design, building refurbishment

Social and technological innovations are commonly seen as either being induced from the ‘top-down’ — e.g., by policymakers—or evolving from the ‘bottom-up’— e.g., by consumers. Instead, a ‘middle-out’ perspective (MOP) focuses on agents of change that are located in the middle, between the top and the bottom. Janda and Parag (2013) and Parag & Janda (2014) describe how middle actors include (but are not limited to) such groups as building professionals, religious congregations, and commercial property owners (Janda & Parag 2013; Parag & Janda 2014).

In recent years, these and other authors have further developed the MOP to address providers of housing refurbishment (Janda, Killip & Fawcett 2014), heating engineers (Wade, Hitchings & Shipworth 2016), community-based organizations (Hamilton et al. 2014), facilities managers (Goulden & Spence 2015), social housing providers (Cauvain & Karvonen 2018), and actors involved in energy storage (Devine-Wright et al. 2017).

This paper focuses on recent advances in the ‘middle-out perspective’. It considers several new middle actor groups, including an energy committee for orthodox Jews in Israel (Parag 2018), code officials in India (Janda & Khosla 2018), formal social groups in Swiss cities (Blumer et al. 2018; Frick et al. 2017), professionals working with housing providers in Sweden (Reindl 2017), local authorities and delivery agents in Scotland (Bush, Wade & Webb 2018), and housing developers in the USA (Agee et al. 2018).

These cases demonstrate new applications of the MOP, bring additional theoretical perspectives to bear (such as practice theory) and further develop the use of perspectives already recognized within the MOP (e.g., system of professions). By looking across these, this paper develops the

MOP with respect to other work on intermediaries, professionals, and communities of practice. To increase practical use of the MOP, the paper encourages future authors to clarify both the direction and scale of middle-actor impacts.

The development of energy efficiency policies in developing countries

Erwin Cornelis, Tractebel Engineering S.A., Belgium

Landry Grossin, Tractebel Engie, Belgium

Paula De La Fuente, Tractebel ENGIE, Chile

Panel

2. What's next in energy policy?

Keywords

developing countries, national energy efficiency action plans (NEEAPs)

The study analyses the energy efficiency policy making in developing countries. A desktop research was carried out to find National Energy Efficiency Action Plans (NEEAP) for the fifty most populated non-G20 countries. Half of these countries (25) are African, 18 are Asian, the remainder countries are Latin-American and one European one. The selected sample represent 30.8% of the world's population and 8.1% of the global GDP (2017 data). To compare, the G20 represents 63.3% of the world's population and 86.4% of the global GDP.

First, the existence of a NEEAP in these countries was investigated. For 34 countries of the sample, a NEEAP was found. The 16 countries for which no NEEAP was found are mostly African. International collaboration has fostered drafting some of these NEEAPs; ECOWAS supported West-African countries in developing their NEEAPs and APAEC reviewed NEEAPs of countries around the Pacific. In total 20 of the 34 identified NEEAPs date from 2014 and can be considered as recent. Overall energy savings targets are included in 22 of the 34 NEEAPs. The time horizon for the targets varies from 3 to 22 years. Half of the plans set targets for the short term (for the next 3 to 10 years); the other half for the longer term (for the next 15 to 22 years).

As a next step, the proposed policies and measures (PAM) were recorded from these 34 NEEAPs and categorised according to sector (lighting, appliances, buildings; other PAMs in residential, tertiary, industry, transport and energy sector) and type (prescriptive, supportive and economic).

– PAMs targeting lights, other appliances and buildings are found in respectively 21, 31 and 25 NEEAPs, mostly MEPS or building codes. 8 countries combine these with awareness campaigns or distribution of efficient lamps; 5 countries with subsidies.

– PAMs, other than those above and targeting the residential, are found in 21 NEEAPs, mainly supportive ones (information campaigns). Some countries also included actions for a more efficient use of biomass in (rural) households.

– PAMs targeting the tertiary sector are found in 21 NEEAPs, 14 countries proposed supportive PAMs, such information and training campaigns, and 13 countries proposed economic ones (various instruments). Energy management for public or commercial institutes is requested by 7 countries.

– PAMs targeting the industry are found in 30 NEEAPs. A wide variety of PAMs is proposed:

energy management standards, MEPS for equipment, energy audit campaigns; technical assistance, subsidies and loans. The implementation of voluntary agreements and learning networks is intended by respectively 2 Asian and 2 African countries. 7 countries intend to support the ESCO market: 5 Latin-American ones and 2 Asian ones.

– PAMs targeting the transport sector are found in 18 NEEAPs, mainly standards for vehicles, often in combination with awareness campaigns and subsidies. 6 countries include investments in infrastructure (road; rail).

– PAMs targeting the energy sector are found in 22 NEEAPs, mainly performance criteria for power plants followed by training campaigns and investments in grids (mostly power grids; district heating grids in Central-Asia). Two countries intend to implement an energy efficiency obligation scheme.

This analysis indicates that energy efficiency policy making in development countries is maturing. This conclusion is supported by the observation that two third of the assessed countries have included energy efficiency in their policy agenda, a wide range of sectors is covered by the NEEAPs and a variety of policies and measures is proposed. International collaboration and coaching by more developed countries can foster this development, as already demonstrated in the past.

Fundamentally rethinking - yes, but surprise us!

Hans Nilsson, FourFact AB, Sweden

Panel

2. What's next in energy policy?

Keywords

cost efficiency, carbon-neutral housing

We need to be far better in making use of the energy efficiency to its full value. To put energy efficiency first requires a fundamental rethinking that goes beyond the traditional policies. It is not enough to only make it an issue about informing customers or providing financial means but understanding the way customers think and providing different means to facilitate action. Maybe we could learn from Nobel Prize awards that have surprised us.

The potential of improved energy efficiency is tremendous, but does not seem to be released anywhere close to its capacity. We need to find new ways to make energy efficiency happen. We may need to be more innovative and we may need to be surprised! Nudges could be built into the products, rules for purchasing could be reformed to address the customer mind-set rather than a rigid view on competition. Service (including recycling) could be the focus for the transition, business models should be adapted to the conceptual design with a long-lasting perspective rather than only address and fix the momentary situation.

Facts are useless – without a story

Hans Nilsson, FourFact AB, Sweden

Panel

2. What's next in energy policy?

Keywords

economic analysis

Energy efficiency is a bargain for most actors in all sectors of the economy. They can reduce their energy use and at the same time increase the quality of the service. The cost to do so is normally a small fraction of the price of energy. It would amount to huge savings for them and for the society as whole. The tragedy, however, is that it does not happen.

This fact has been well documented by the energy efficiency community for decades. Lately it has also been shown by prestigious parties both in the private sector, e.g. the consultancy company McKinsey, and by international organisations such as the EU and in particular by the IEA. The latter has also verified that the lion's share of the profitable potential will remain unharvested for decades to come - unless there will be a change of game.

Standard economic thinking says that eventually the market will mature. Behavioural economists and cognitive science has shown that mere facts about these opportunities are not sufficient as arguments to convince the actors responsible for operations and maintenance in industry and far less so individuals to act and realise the potential for efficiency improvements that they have. We must reconsider our approach and tell a better story that appeal to people in all sectors and to find narratives that encourage the necessary mobilisation of the efficiency market actors.

This is assumed to be presented as a display (=poster).

The importance of efficiency in the building sector for the achievement of long-term climate protection targets

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Martin Pehnt, Ifeu – Institute for Energy and Environmental Research Heidelberg, Germany

Alexandra Langenheld, ifeu - Institute for Energy and Environmental Research, Germany

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Alexander Ladermann, ifeu - Institut für Energie- und Umweltforschung, Germany

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Sebastian Blömer, Fraunhofer Institut für Energiewirtschaft und Energiesystemtechnik, Germany

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Christian Linke, Germany

Panel

2. What's next in energy policy?

Keywords

sector coupling, PtX, efficiency, building envelope, heating systems, scenario study

The study assesses how climate targets can be achieved at the lowest possible cost and what role building efficiency plays in the energy system. To these ends, we analysed the cross-sectoral effects of building efficiency measures and their impact on the total economic cost of energy supply by linking four calculation models. The study also shows scenarios which compensate less efficiency by more renewable energy, heat pumps or synthetic fuels. One main focus of the analyses is how the scenarios can realistically be implemented. The study also examines the susceptibility of development paths to lock-in situations and the potential of flexible approaches to achieve more ambitious targets.

Key findings:

- 1) Higher efficiency in the building sector is more cost-effective than the alternative approaches (up to 8.2 billion per year). It is also a more feasible way to meet the climate targets.
- 2) Efficiency increases multiple benefits like higher building quality, better thermal comfort, which improves health and performance of the inhabitants, reduced dependence on energy imports,

relieved renewable energy sources and higher gross domestic product.

3) Efficiency reduces risks. The greater the energy savings are in general, the more flexibility there will be – for both, technical supply solutions and ambitious climate protection targets.

4) Efficiency opens the door to all kinds of technologies. All available technologies need to be ramped up steeply to meet the mandatory targets at least. Efficiency, however, provides the greatest potential, is broadly present in today's market and in many cases enables the use of renewables. Synthetic fuels are likely to be too expensive to be burned in inefficient buildings.

5) Purposeful action: building investments follow a multi-decade cycle. Sudden course changes always cause high additional costs. It takes a purposeful approach to transform the building sector. Today's decisions have to consider the targets from the outset.

Non-energy benefits in energy audit and energy efficiency network policy programs for industrial SMEs

Ida Johansson, University of Gävle, Sweden
Patrik Thollander, University of Gävle, Sweden

Panel

2. What's next in energy policy?

Keywords

non-energy benefits (NEBs), networks, energy audit, industrial SME, policy programme

Improved energy efficiency is a key component towards sustainable and climate-neutral industrial energy systems. The potential for industrial energy efficiency varies between sectors and processes but is stated to be high. Implementation of energy efficiency measures and activities could also result in benefits in addition to energy cost savings, benefits that are more difficult to quantify in economic terms.

Research shows that additional gains from investments are underestimated as non-energy benefits (NEBs) are often neglected when the financial attractiveness of energy efficiency investments are evaluated. In the literature, great attention has been given to realise industrial energy efficiency potential through industrial energy policies and programs, in order to promote investments and implementation of new, more efficient technologies and processes. The most internationally common industrial energy policies for industrial SMEs are energy audit programs, but energy efficiency networks have also received increased attention from policymakers.

However, there is a scarcity of studies exploring NEBs in relation to industrial SME energy audits and energy efficiency network policy programs. The aim of this study was to identify and compare NEBs from two key energy efficiency policies: energy audit and energy efficiency network programs. Semi-structured interviews were conducted with executives at two groups of industrial companies: companies that participated in the regional Swedish energy efficiency network policy program, and participants from the national energy audit program, Swedish Energy Audit Program (SEAP).

Commonly mentioned NEBs were related to production, such as increased lifetime of equipment and more reliable production. However, while participants from the energy audit program related these NEBs mainly to technical installations, network participants also saw these types of NEBs from energy management practices. If NEBs were to be included in energy audit programs the benefit of the audits could be increased, but will then particularly affect the technical installations. NEBs in terms of network participation were shown to lead to an increase in the general benefits of the networks, and for network companies NEBs are also linked to measures related to operation

and maintenance, i.e., energy management practices.

One difference between the two groups was that NEB improved the company's environmental image. Two of the companies participating in the network policy program had presented their participation on their public webpage perceiving this as a very important benefit, while respondents from the energy audit program could not relate their company image to their energy audit.

One additional NEB that was found, not previously mentioned in the scientific literature on NEBs, was that among the network participants, establishing contacts with other companies in the region was considered of great importance, and further contacts that would not have been established outside of the network. Results even found new customer relationships as a result of the network. This finding is of a general nature, thus apart from the other commonly known NEBs, an additional NEB that primarily relates to participation in energy efficiency networks that this study found is establishing new relationships with other companies in the region.

New business models enabling higher flexibility on energy markets

Klemens Leutgöb, e7 Energie Markt Analyse GmbH, Austria

Christof Amann, e7 Energie Markt Analyse GmbH, Austria

Dimosthenis Ioannidis, CERTH/ITI, Greece

Dimitrios Tzovaras, CERTH/ITI, Greece

Panel

2. What's next in energy policy?

Keywords

DR service providers, market facilitation

Energy markets – and particularly electricity markets – are faced with a strong need for more flexibility, mainly due to the fact that the share of renewable energy sources in energy supply is steadily increasing. The current model of ensuring demand-supply match mainly by investments into supply and transmission infrastructure needs to be complemented by demand-centric solutions – usually summarised under the term demand response (DR).

Due to digitalisation the technical possibilities to integrate small- and medium-sized prosumers (residential, tertiary, decentral power and heat storages, micro-grids etc.) into DR activities are continuously expanding: innovative platforms allow for bundling of small/medium-sized capacities; transaction cost are reduced through automated dispatching; communication with switchable, “smart” appliances is becoming cheaper; new technologies are available to ensure secure data handling for easier forms of “smart contracts”; etc. But hand in hand with expansion of DR potentials, there is also a need to adapt and further develop current DR business models to cope with new challenges.

Against this background, this paper

- gives a brief summary on the most current technological developments that will lead to a continuous expansion of DR potentials over the next decade
- presents an overview on the core elements of the regulatory framework in EU countries which are relevant for DR activities
- describes business models that are currently applied on the market and analyse the limitations of these business models
- derives from there new business models that enable increasing demand-side flexibility , including a clarification of roles and responsibilities of future DR service providers and their position as a market facilitators.

The paper is based on research work currently implemented in the frame of a bundle of national and European projects dealing with the development of suitable business models for future DR markets.

Energy efficiency in the energy transition

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Panel

2. What's next in energy policy?

Keywords

energy transition, electrification, energy demand

The energy transition to a zero carbon energy system will require both a shift to renewable energy and a major increase in energy efficiency. These are usually treated separately, but are not independent. Where renewable electricity replaces other fuels in heat and transport, there is a fundamental shift in energy supply from sources of heat to sources of work. This allows technologies such as heat pumps and electric vehicles to deliver large improvements in energy efficiency.

Where new energy sectors such as hydrogen are required, there are more complex implications for energy efficiency, depending on the details of the energy conversion processes. The paper sets out a scenario for the UK where energy is provided solely by solar and wind energy. It makes plausible assumptions about which end uses of energy can be supplied directly by electricity, and assumes others will be supplied by electrolytic hydrogen. It shows that reductions of final energy demand by 50% and primary energy demand by 60% from current levels.

The main driver is the improvement in conversion efficiencies at the point of energy use. This has major implications for the levels of renewable energy needed, which could be supplied entirely by UK indigenous resources. These types of changes to energy demand not fully captured by many global energy models and scenarios used to inform climate policy. They may therefore be unreliable and significantly over-estimating likely energy demand. The findings have important implications for policymakers in terms of lower and more realistic expectations of future energy demand.

Energy efficiency and renewable energy in a decarbonized electric power system

Hans-Paul Siderius, Netherlands Enterprise Agency, The Netherlands

Panel

2. What's next in energy policy?

Keywords

renewable energy, electric power system, decarbonisation

For long time energy efficiency and renewable energy have been treated separately, but the need to decarbonize the (electric) power system brings them together. In a decarbonized power system any demand must be met in a sustainable, zero-carbon way. Therefore the relation could be simply formulated as follows: energy efficiency is about reducing demand so that this can be met by electricity generated by renewable energy sources.

However, competing claims from the two sides arise. The renewables claim that with the abundant availability of renewable energy there is less or no need to focus on efficiency. On the other hand energy efficiency claims it is the “first fuel” that is much cheaper than renewable energy (or any other energy source) and therefore should get priority. It seems that both claims are rooted in the current situation in which the power system in most countries is still highly carbonized and centralized, and efficiency is deployed in a modest way only.

This paper provides a framework to explore the relations between energy efficiency and renewables in the electric power system. The elements of the system – generation, connection, storage, control and efficiency – are in competition with each other. Different system designs will put emphasis on different elements; however, simple, single focused solutions will not realize a decarbonized power system. By looking at the extreme situation – an electric power system with renewable generation only – the consequences for energy efficiency will become clearly visible. The paper concludes with recommendations for further research.

How can Germany reach its 2030 sectoral emissions targets? Energy efficiency, renewable energy or reduction of energy consumption? An impact assessment of different pathways

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Tobias Fleiter, Fraunhofer Institute for Systems and Innovation Research, Germany
Oliver Lösch, IREES, Institute for Resource Efficiency and Energy Strategies, Germany
Katja Schumacher, Öko-Institut (Institute for Applied Ecology), Germany
Luisa Sievers, Fraunhofer Institute for Systems and Innovation Research, Germany
Dominik Rau, Prognos AG, Germany
Nils Thamling, Prognos AG, Germany
Matthias Pfaff, Fraunhofer ISI, Germany
Axel Worz, FIBL

Panel

2. What's next in energy policy?

Keywords

environmental impact, emissions scenarios, climate policy, renewable energy

Germany's Klimaschutzplan 2050 provides a long strategy to decarbonize Germany but also contains sectoral interim emissions targets for 2030 to ensure consistency and to avoid structural breaks. A comprehensive ex-ante evaluation (impact assessment) of these interim targets has been commissioned to serve two main purposes: i) to provide information and create a dialogue with affected and concerned stakeholders (e.g. social partners, parties, unions etc.). ii) to derive recommendations for the development and implementation of comprehensively sound policies and measures.

In a first step, we develop two sets of possible pathways for each sector with which the sector targets set for 2030 can be achieved. While set A is mainly focused on energy efficiency, electric mobility and demand reduction, set B is less efficiency oriented but primarily targets renewable energy and alternative fuels (PtX). In a second step, we assess the environmental, economic and social effects including external costs for each set of pathways (or combination of sets from each sector). We also assess the interaction of different policy targets (within Germany and the EU).

The assessment is based on sectoral, macroeconomic and microsimulation modelling and shows that set A with its focus on efficiency is preferable from an economic perspective. However, it requires substantial investment and innovation which need to be stimulated early on and also well scheduled to make optimal use of investment cycles and avoid lock-in effects. The transition towards a decarbonized economy requires new technologies, structural changes, changes in employment as well as adjustment of consumer behavior.

All these provide substantial challenges, a particular one for Germany relates to managing the lignite coal phase out which will help to achieve climate targets while at the same time putting a burden on regions which are economically weak and politically challenging.

Metering energy savings: insights from the “Energy Savings Meter” funding scheme

Mandy Werle, ifeu - Institute for Energy and Environmental Research, Germany

Uta Weiß, Ifeu Institute for Energy and Environmental Research, Germany

Carsten Ernst, ÖKOTEC Energiemanagement GmbH, Germany

Laurenz Hermann, co2online gGmbH, Germany

Panel

2. What's next in energy policy?

Keywords

digitisation, innovative business models

Achieving the German primary energy saving targets requires increased efforts: for 2020, there is a foreseeable shortfall of at least 1,400 PJ (BMW 2014). To help narrow this gap, the Federal Ministry of Economics and Energy (BMWi) launched the pilot funding scheme “Energy Savings Meter” in 2016. The scheme is designed to tap the benefits of digitisation for energy savings. Companies offering smart energy services to customers in all sectors – targeting energy savings through installing metering technology, providing data analyses and feedback, and supplying additional energy efficiency services – are eligible for financial support. Notably, the “Energy Savings Meter” enters new territory: as the subsidy is performance-based, metered and proven energy savings will be remunerated. Thus, the “Energy Savings Meter” introduces a unique funding scheme in Germany.

This paper compiles new insights from the programme’s progress. Demand from companies that want to realise an innovative pilot project under the funding scheme is high – with the result that the overall funding volume had to be increased from 30 to 69 million Euro in 2018.

First, the paper analyses why the scheme is particularly attractive for both companies and policy makers, given that there is less demand for other funding programmes within the field. Second, considering the conceptual challenge to meter something that is not there, this paper highlights improvements towards measuring energy efficiency made within the accompanying research. Metering methods to determine energy savings that are reliable and feasible in practice have been developed. Third, the paper analyses to what extent the objectives of the pilot scheme have been met by now, based on qualitative data and first quantitative results on energy savings. Finally, related to the design of energy efficiency policies, the paper identifies strategic options to effectively develop the scheme further.

Is efficiency + sufficiency sufficient for Iran?

Faraz Sojdei, Ministry of Petroleum, Iran
Ali Khodamoradi, Freelance Consultant, Iran

Panel

2. What's next in energy policy?

Keywords

climate vulnerability, Middle East

The Middle East will be very vulnerable to climate extremes according to different references including World Bank, and this raises urgency for more severe actions in this region, based on the decisions to stay in 1.5°C limit. Many Oil and Gas producers with some common challenges are in this region, Iran being an influential country among them who is and a member of OPEC is increasingly vulnerable to climate change.

On the other hand, Iran's high energy intensity put it as 8th place in the top 10 GHG emitters. Meanwhile economic and energy security concerns made Iran set different policies to improve its energy intensity including flaring reduction, the transition to lower carbon fuels, improvement of efficiency by implementing energy management systems in energy-intensive Industries, and development of renewables. These undoubtedly have co-benefits towards reducing carbon footprints and may improve Iran's position in GHG emitting ranking.

Due to the big amount of subsidies that Iran pays for energy, the concept "Efficiency First" has not been sufficiently attractive to make it "First" during the last decades, and the government needs to act to incentivise movement towards low carbon economy. Meanwhile, different barriers like economic blockade have put limits on Iran to access to technology, capacity building facilities (including cooperation with experienced efficiency companies) and finance for improving efficiency.

Despite the barriers, the strong will to combat its carbon footprint and eminent progress in fuel switching from oil products to natural gas in different sectors exists, but political difficulties could cause a rollback in this way. On the other hand, because of the young and extensive middle class and appetite for using luxury and wasteful use of energy, paying attention to sufficiency is important too. While being efficient has severe barriers on its way, every effort must be facilitated. The mitigation policies against climate change shall not face hurdles in any way for any country (especially Iran who has a special situation from this point of view) in a way that can adversely influence climate change. The climate impacts are something that won't stay in the borders.

Policies for opening up new markets for the passing on of additional costs of breakthrough technology innovation: the case of direct reduced iron ("green steel")

Oliver Lösch, IREES, Institute for Resource Efficiency and Energy Strategies, Germany

Panel

2. What's next in energy policy?

Keywords

technological innovation system, steel, energy and climate policy development, product policy, labelling, climate change mitigation, value chain stakeholder cooperation, electrification

Direct reduction of iron ore with hydrogen could considerably reduce the specific GHG emissions of pig iron and subsequently crude steel production. Also, it would be a measure to enhance energy efficiency of industry production and its electrification. However, under the given economic conditions, it is not economically viable compared to the blast furnace process. Therefore, the operation of a demonstration plant seems very unlikely, even if substantially subsidised. The question arises whether the additional costs could be passed on, to at least enable the operation of a demonstration plant. To achieve this, product /market differentiation would have to take place.

First, possibilities for product/market differentiation need to be identified. For the case of Germany, the automotive sector seems to be a promising candidate: the production of automobiles is highly relevant for crude steel demand, and it is of high significance for the German economy. Assuming the material costs for the crude steel used in a typical passenger car with 1000 €, high additional costs for crude steel of 50 %, and a retail price of 20,000 €, this would add up to retail prices rising by 2.5%. This rough calculation shows that the price increase in the automotive sector would be in the single-digit percentage range.

Next, it should be analysed under which conditions a market niche for "green steel" could be created. The design of product/market differentiation could, for example, be aimed at image enhancement (labelling). Moreover, the supply relationships with regard to the structure of the value chain as well as with regard to the usual relevant contractual arrangements (risk protection, etc.) need to be assessed. This idea for a possible innovation policy approach is an outcome of analysis performed by IREES, commenced by the German Federal Ministry for the Environment (BMU). During the forthcoming process up to the summer study, it will be further developed.

Understanding the optimal timing and the social benefits of energy efficiency measures for designing an effective climate policy

CHRYSO SOTIRIOU, Cyprus University of Technology, Cyprus
Theodoros Zachariadis, Cyprus University of Technology, Cyprus
Apostolos Michopoulos, Cyprus University of Technology, Cyprus

Panel

2. What's next in energy policy?

Keywords

energy efficiency measures, climate change mitigation, climate policy, optimisation, optimal abatement strategy, timing

Governments around the world are facing strict energy- and climate-related targets, and decision makers need to decide an appropriate set of policies and measures for this purpose. In this paper we explore the contribution of energy efficiency measures to the formulation of policies designed to simultaneously achieve decarbonisation targets in both the medium and the long term.

We develop a multi-objective constrained optimization model to examine least-cost greenhouse gas (GHG) emission abatement pathways, taking into account:
a) emission reduction objectives for two years: 2030 and 2050;
b) the potential speed of implementation of each measure, which expresses technical and behavioural inertia in the deployment of a measure; and c) environmental side-benefits of these measures expressed in monetary terms, i.e. the avoided damage costs because of lower emissions of GHG and air pollutants NO_x and SO₂.

We focus on economic sectors that are not subject to the EU Emissions Trading System, analysing measures such as energy renovations in residential and commercial buildings, promotion of public transport, switch to fully electric cars and CNG-powered trucks, and co-generation.

We perform two types of optimisation runs with our model. One is a 'joint optimization' for both target years 2030 and 2050. In other words, the model is forced to solve the dynamic abatement problem satisfying both emission constraints. This enables policymakers to design a decarbonization policy that meets the 2030 objective as well as the 2050 commitment. In the second type of run, which we call 'split optimization', the model is initially solved for the period 2021-2030, with the 2030 emissions target as the only constraint; then at a second stage, the model solves for annual abatement in the period 2031-2050, taking into account the solution of 2021-2030 and having as a constraint the 2050 emissions target. We derive relationships

between 2030 abatement targets of varying ambition and the possibility for a country to achieve a strong 2050 decarbonization target.

Our results demonstrate the importance of taking into account long-term energy and climate targets even when formulating a medium-term decarbonisation strategy, in order to avoid lock-in effects. Our simulations offer evidence that, if the 2030 objective is unambitious, the decarbonization target of 2050 can only be met if a policymaker deciding in 2020 solves jointly the optimization problem for both 2030 and 2050. Conversely, if a policymaker designs a strategy in 2020 keeping in mind only the 2030 target, deep decarbonization of year 2050 cannot be achieved.

Our findings also highlight the substantial social benefits of most energy efficiency measures, which can change the priorities of policy makers if properly quantified in monetary terms. If air pollution costs are taken into account, strong decarbonization by 2050 has lower social costs than less ambitious policies. Although this study is conducted for the economy of Cyprus, a Mediterranean EU member state, its methodology and results are relevant for any country seeking appropriate decarbonisation strategies.

Going beyond policies focused on building energy efficiency technologies – evidences and lessons from China

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Siyue Guo, Tsinghua University Building Energy Research Center, China

Da Yan, Tsinghua University

Panel

2. What's next in energy policy?

Keywords

rebound effects, building codes, energy labelling, building energy certification, quotas

Improper implementation of energy efficiency policy exist and caught concerns on how should energy policies go beyond energy efficiency. The problem this study is trying to discuss it the limitation of energy efficiency policy in energy consuming sector, specifically building sector. This study gathered several practices of energy efficiency policies in China's building sector and analyzed the target design, implementation and actual effect of these policies, including building energy efficiency standard/code, green building labeling, and incentives to energy efficient home appliance and lighting bulbs, solar water heater and so on. Through analytical evidence, reasons of limitation of energy efficiency policies in building sector is deeply dug and concluded. Experience from China's building sector is finally given as a policy reference to step out dilemma and achieved energy consumption and emission reduction.

By large scale of building energy information survey and case study on typical buildings, reasons for failures of these policies are concluded and summarized as two: one is unsuitable utilization of high efficient technology, such as very low-load ratio, or unnecessary system circulation and heat dissipation; the second is demand boost caused by energy efficient system and rebound effect of demand by energy efficiency policies, or rebound effect. The essential reason is, product of building sector, indoor service, is not standard and uniformed as industry sector. Therefore, the solution to step out dilemma is move policy target from process control to outcome management, from energy efficiency of system while operation to result of final energy consumption. The experience from China's building sector is to switch building energy policy from energy efficiency standard, energy efficiency product, to energy consumption quota(standard) and conduct energy consumption management.

Multiple benefits of energy efficiency at the firm level: a literature review

Gavin Killip, ECI-CREDS, University of Oxford - Environmental Change Institute, United Kingdom

Catherine Cooremans, Université de Lausanne, Groupe Ecologie Industrielle, FGSE / IDYST, Switzerland

Tina Fawcett, ECI-CREDS, University of Oxford - Environmental Change Institute, United Kingdom

Wina Graus, Fraunhofer Institute for Systems and Innovation Research, The Netherlands

Fabian Voswinkel, Utrecht University, Germany

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Panel

2. What's next in energy policy?

Keywords

multiple benefits, organisation behaviour, business strategy, non-energy benefits (NEBs), energy efficiency investments

The multiple benefits of energy efficiency for individual businesses have not received sufficient research attention. For firms, these non-energy benefits may be critically important to their investment decisions. This paper presents initial results from a project investigating the firm-level strategic benefits of energy efficiency.

Using a rapid evidence assessment method, the literature on multiple benefits in firm-level energy efficiency decisions was reviewed. This encompassed academic, conference and grey literature, with thousands of items scanned, leading to 31 documents being read in detail.

This process confirmed that relatively little has been published on the topic. Nevertheless, there is evidence that strategic non-energy benefits do exist, e.g. reduced production down-time, increased product quality or improved productivity. These benefits can positively and significantly influence the financial assessment of energy efficiency projects. However, such benefits are generally not reported, quantified or included in project assessment.

Of the existing studies, most seek to monetise non-energy benefits in order to expand the scope of conventional cost-benefit analysis. However, some take a radically different approach, based on the observation that energy efficiency and energy payback are often not salient to firm-level decision-makers, who have other priorities and ways of evaluating project proposals.

Instead of taking energy efficiency as the starting point (and cost-benefit as the assessment method), these studies seek to understand the priorities of investment decision-makers and to propose means by which energy efficiency can be integrated into their decisions in ways which are

more salient. The work involved can be time-consuming and places a responsibility on researchers to understand topics and business practices that may be new or only partly understood by experts in energy efficiency.

There is very little evidence and work done in support of the 'salience approach', but what there is suggest that it holds promise for increasing the take-up of energy efficiency at the point of firm-level investment decisions. There is a need for further research to take forward this idea, both in terms of providing more case-study evidence, but also in refining the idea itself.

An integrated PV system analysis tool for households incorporating battery storage, energy-efficiency measures and electric car charging

Sebastian Albert-Seifried, Büro Ö-quadrat GmbH, Germany

Dieter Seifried, Büro Ö-quadrat GmbH, Germany

Vicky Albert-Seifried, Büro Ö-quadrat GmbH, Germany

Panel

2. What's next in energy policy?

Keywords

photovoltaics, batteries, energy saving potential, tool, electric vehicles

Residential sector has been a key driver for photovoltaics (PV) applications in Germany. Over 80% of new PV systems installed in 2017 were smaller than 10 kWp and every second newly installed residential PV system was combined with a battery. The investment decision on PV installations is largely based on analysis of solar potential and collector area.

The role of energy efficiency measures and its effects on the costs and CO₂ emissions are rarely considered. Additionally, battery electric vehicles (BEVs) that exhibit significant growth in recent years are expected to have a profound influence on the energy system in the future. However, their impact on the CO₂ footprint of households is not fully understood. In view of these shortfalls, an integrated energy analysis tool has been developed to enable calculations of the economic performance and carbon balance of PV installation with battery storage, energy-saving measures and BEV charging. The Excel-based tool was developed in collaboration with the Öko-Institut and a local utility. It is publicly available and intended for energy consultants and interested households.

Using a typical 3-person household in Germany as an example, an analysis over 15 years shows that the implementation of energy-saving measures at the time of PV installation can reduce the overall costs and increase the internal rate of return. The application of PV-battery systems is not profitable with the current system price of about 1500€/kWh. Nevertheless, considering the current rate of decline in battery costs, it is anticipated that solar battery systems will become cost-effective in the coming years. In contrast to the common belief, the use of BEVs leads to an increase in CO₂ emissions compared to conventional gas-powered cars. BEVs can reduce the carbon footprint only if they are coupled with a PV system. The full paper will present the energy analysis tool and results of various scenarios that will shed light on future energy policies.

Auctioning revenues to foster energy efficiency: status quo and future potential within the European emissions trading system

Catharina Wiese, Technical University of Denmark, Denmark

Richard Cowart, Regulatory Assistance Project (RAP), Belgium

Jan Rosenow, The Regulatory Assistance Project (RAP), Belgium

Panel

2. What's next in energy policy?

Keywords

EU Emission Trading Scheme (EU ETS), auctioning revenue use, energy efficiency programmes

Auctioning revenues in the European Union's Emissions Trading System (EU ETS) are likely to increase in the future. This projection is driven by recent changes within the system's framework, addressing the current surplus of emission allowances and reducing the overall cap. More specifically, the Market Stability Reserve starts operating in 2019 and the linear reduction factor increases from 1.74 percent to 2.2 percent annually from 2021, increasing scarcity and allowance prices. Considering the growing amount of auctioning revenues projected, it becomes ever more important to assess the use of these revenues and their potential contribution to accelerate decarbonisation efforts.

While there are various opportunities to invest auctioning revenues to drive emission reductions, we argue that strategic investments in energy efficiency programmes provide opportunities for realising multiple dividends: additional emission reductions from both ETS and non-ETS sectors, lower economic and societal decarbonisation costs, and support for the political process to further tighten the ETS cap.

Our assessment of the status of auctioning revenue use at EU Member State level shows that Member States have made only limited use of these multiple dividends in recent years. In 2017, no more than 22.4 percent of total revenues have been strategically invested in energy efficiency programmes, as Member States have officially reported to the European Environment Agency's reporting obligations database.

However, evidence from efficiency programmes funded by auctioning revenues in Ireland, Germany and Czech Republic illustrate that these programmes deliver energy savings and emission reductions, cost savings to consumers, tax revenue to the national budgets, employment and economic growth.

We conclude that the EU carbon price can provide important signals to investors and energy users, but auctioning revenues can also be a powerful tool in the energy transition and the strategic use of revenues needs to be accelerated in all Member States.

Dressing for the anthropocene: mitigating climate change through cooler clothing

Deborah Poskanzer, USA

Alan Meier, Lawrence Berkeley National Laboratory, USA

Chinmayee Subban, Lawrence Berkeley National Laboratory, USA

Margarita Kloss, Lawrence Berkeley National Laboratory, USA

Panel

2. What's next in energy policy?

Keywords

air conditioning, climate change mitigation, behavioural change, clothing

Dressing for the Anthropocene: Mitigating Climate Change through Cooler Clothing

Deborah Poskanzer*, Alan Meier†, Margarita Kloss†, and Chinmayee Subban†

Wearing cooler clothing could reduce the energy used for mechanical cooling.

As the world gets hotter, we are caught in a dilemma between the need to maintain thermal comfort, while at the same time reducing the use of air conditioning (AC) as a source of GHG emissions. AC has been, and will continue to be, a major driver of growing electricity demand. Space cooling in buildings accounts for 10% of world total electricity use and 12% of building CO₂ emissions.

A threefold growth in emissions for space cooling by 2050 is projected, an increase that will be difficult to offset even in optimistic efficiency/decarbonisation scenarios. This growth rate need not happen. Forecasts of energy demand, and climate policy in general, have ignored the energy savings potential of changing the way we dress. Dressing in cooler clothing would allow thermal comfort at higher indoor temperatures, mitigating the anticipated growth in electricity demand. The impacts of these modest changes should not be underestimated: every 1°C higher AC setting saves about 10% of a building's cooling energy budget, or about 4% of a building's total energy use. Japan's Cool Biz initiative asked office workers to dispense with ties and jackets during the warm season, and set AC temperatures at no lower than 28°C. Despite enforcement only in government owned buildings, these measures are estimated to have avoided 2.2 million tonnes of CO₂ emissions in 2012, or about 0.15% of Japan's baseline scenario emissions.

The Japanese private sector is also adopting these practices, and Cool Biz has nearly become the baseline. But even greater savings are possible: a recent study estimated that the introduction of 'localised thermal management systems', such as advanced thermo-adaptive textiles, could lower

US GHG emissions by at least 2% by reducing the need for building cooling.

Unfortunately, government, research, and commercial sectors are not aligned to realize the energy saving potential of cooler clothing. For example, although there are a number of ‘thermo-adaptive’ or ‘meta-cooling’ textiles coming to market in the near future, these materials are marketed towards productivity or athletic performance rather than general use. Textile manufacturers and apparel makers have not widely recognized that advanced cooling textiles could be marketed more widely as an energy savings measure (allowing higher indoor temperatures while maintaining thermal comfort), thereby increasing sales.

Governments actively regulate and label energy consuming appliances, but there is no mechanism for conveying apparel energy information to the consumer. Finally, apart from a few studies, rigorous data connecting the dots between individual thermal comfort, building energy savings, and overall GHG reductions is scarce. Our display depicts a future scenario in which the energy saving potential of cooler clothing is realized. Its central feature is a timeline of events and initiatives—occurring between now and 2050—that move the world towards a different way of dressing.

The transformation occurs on two fronts, both a change of materials— that is, familiar styles rendered in different textiles— and a change of fashions, in terms of less formal clothing, or less clothing altogether. Recognizing that broad and enduring social change is usually more difficult than technological change, we pay particular attention to the use of social policy levers, market restructuring, and cultural leadership in promoting new, cooler fashions.

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Energy sufficiency: how can research better help and inform policy-making?

Edouard Toulouse, France

Anja Bierwirth, Wuppertal Institut for Climate Environment and Energy, Germany

Sylvia Lorek, SERI, Sustainable Europe Research Institute Germany e.V., Germany

Marlyne Sahakian, University of Geneva, Switzerland

Katharina Bohnenberger, Wuppertal Institut für Klima, Umwelt, Energie, Germany

Leon Leuser, Europa Universität Flensburg, Germany

Panel

2. What's next in energy policy?

Keywords

energy sufficiency, research, policy-making

The concept of sufficiency – reducing energy uses beyond technical efficiency – is far-reaching and requires a reflection on human needs, energy services, urban structures, social norms, and the role of policies to support the shift towards lower-energy societies. In recent years, a growing body of literature has been published on energy sufficiency in various disciplines. However, there has been limited exchanges and cooperation among researchers so far, hindering the visibility and impact of this research.

This paper presents an assessment of where sufficiency research stands, especially in the perspective of policy-making. It is the first overview paper issued in the context of the newly-founded ENOUGH network – International network for sufficiency research & policy, established in 2017.

In the first part, we provide a condensed literature review on energy sufficiency, based on dozens of recent references collected through the network. Through four main themes (the nature of sufficiency, the challenges of modelling it, the barriers to its diffusion, and the approaches to foster it), we summarise the key issues and approaches.

We then present what the scholars themselves see as the priorities for future research, promising sufficiency policy options, and key barriers that research should help overcome. We collected their views through a questionnaire completed by more than 40 knowledgeable authors and experts from various disciplines.

We finally build on the previous parts to draw some recommendations on how sufficiency research could increase its impact, notably in relation to policy-making.

Investigating the energy efficiency first principle – whose idea of energy efficiency is coming first?

Tessa Dunlop, European Commission Joint Research Centre (JRC), Ispra, Italy

Panel

2. What's next in energy policy?

Keywords

energy efficiency first, energy efficiency policy, policy implementation, discourse analysis, EU policy

Over the past decade, the concept of energy efficiency has increasingly been conceptualized as a metaphor, as a tangible 'fuel' in its own right – including the invisible fuel, the fifth fuel and most recently, the 'first' fuel. This clarification of the concept as something tangible has been boosted by the fact it is now quantifiable in monetary terms, worth some USD \$231 billion in 2016.

Since the expression 'energy efficiency first' was coined, however, the seemingly straightforward and rational terminology has taken on multiple meanings in various contexts. The European Union, for example, promotes what it calls the 'principles' of energy efficiency first, denoting that energy efficiency is a strategic priority. Whilst the concept of energy efficiency first has achieved valuable political consensus over an idea with which to solidify meaningful action, it has also caused political fractures.

During the trilogue negotiations of the EU's Clean Energy Package in 2018, there was political disagreement between the Council and European parliament over how the "energy efficiency first" principle should be treated – whether as a legal requirement in national energy and climate plans, or as a slogan to honor the 'cost-efficiency first' principle.

Through examining the parliamentary discussions and other materials related to the Energy Efficiency Directive 2012/27/EU as a case study, this research uses discourse analysis to observe the evolution of the term energy efficiency first over time, to understand the diverse meanings and values it reflects according to the multiple contexts in which it is used, by different actors. In doing this, the analysis traces these political struggles and how they weave together policy objectives, meanings of energy efficiency and different ideas about how to implement energy efficiency policy. This presentation thus reveals both the potential as well as the dangers of the different conceptualizations of the energy efficiency first principle.

Implementing the efficiency first principle in the UK

Jan Rosenow, The Regulatory Assistance Project (RAP), Belgium

Richard Cowart, Regulatory Assistance Project (RAP), Belgium

Panel

2. What's next in energy policy?

Keywords

energy supply and demand, energy efficiency policy

The principle of “Efficiency First” has been adopted by the EU in the various parts of the Clean Energy for All Europeans package. It is a principle applied to policymaking, planning, and investment in the energy sector. Put simply, it prioritises investments in customer-side efficiency resources (including end-use energy efficiency and demand response) whenever they would cost less, or deliver more value, than investing in energy infrastructure, fuels, and supply alone.

Efficiency First has gained traction at the European Union (EU) level since the launch of the Energy Union Communication in February 2015 and the publication of the Winter Package, but also in some European countries such as Germany, where it has become an energy policy principle and is now an underlying principle of Germany’s Energiewende.

What is unclear so far though is how the Efficiency First principle should be applied across the energy system and what the implementation would look like.

In this paper, we identify key areas where we see opportunities for the Efficiency First principle to play an important role. We use the United Kingdom as a case study as there are many existing policy areas that demonstrate how Efficiency First could be applied. In particular, we assess the potential for Efficiency First in the context of policy decisions that will be made over the next years, including the design of a new able-to-pay energy efficiency programme, energy network regulation, infrastructure spending, revisions of the capacity mechanism, and the levy control framework.

Energy efficiency or energy demand?

Noam Bergman, University of Sussex, United Kingdom

Panel

2. What's next in energy policy?

Keywords

narratives, techno-optimism, energy sufficiency

Energy efficiency has long been hailed as a central pillar in climate change mitigation through its role in reducing energy demand – not least by eceee. However, some now question whether the energy efficiency narrative is sufficient for emission reduction goals.

This is a welcome development, as this narrative has often been synonymous with improving technical efficiency, while obscuring the question of reducing demand for energy services – as opposed to delivering those same services more efficiently.

Further, it carries an implicit techno-centric bias, overlooking non-technological solutions.

A classic example is the EU's estimates of potentially large energy savings that could be achieved by more efficient tumble dryers – a study measure which could encourage dryer purchase, significantly increasing energy use over hanging clothes to dry.

This paper draws on conclusions from three research projects at the Centre on Innovation and Energy Demand (CIED), including one finding that a shift to electric cars risks maintaining high travel demand, preventing a deeper transition to a more sustainable transport system, and another forecasting significantly lower household energy savings from the UK smart meter rollout than previously estimated.

I conclude that the energy efficiency narrative might lock us in to high energy lifestyles through seeking ways to maintain, rather than disrupt, business as usual behaviours. I suggest that a complementary energy demand reduction narrative could highlight the limits to (technical) efficiency savings, and open a way for policy to engage with the deeper changes needed to our demand for energy services.

Energy sufficiency in policy and practice: the question of needs and wants

Tina Fawcett, ECI-CREDS, University of Oxford - Environmental Change Institute, United Kingdom

Sarah Darby, ECI - Energy Group. Environmental Change Institute, University of Oxford, United Kingdom

Panel

2. What's next in energy policy?

Keywords

energy sufficiency, energy efficiency policy, EU policy, energy justice

Transformation of energy demand is one of three pillars for action identified in the IPCC's 1.5°C report. To deliver emissions reductions of the scale required, this transformation will need to be radical. While policy approaches of 'energy efficiency first' and 'multiple benefits of energy efficiency' have the potential to increase action and reduce carbon, a more ambitious framing is needed.

Sufficiency, or energy service sufficiency, could be a strong framework to deliver energy services equitably, while respecting planetary boundaries. But the concept of sufficiency cannot be separated from judgements on what is 'enough' or from principles of distributional justice: it steps outside conventional energy policy boundaries.

This paper explores the possibility of distinguishing between needs and wants – a debate with a long history – and considers whether and how such distinctions may be embodied in policies such as rising block and demand-based tariffs, energy labels based on consumption, product bans and building standards to reduce and prevent energy / fuel poverty. Ideas from the literature on distributive and procedural justice will be presented and interrogated in the light of European experience and debates on energy sufficiency and fuel poverty, and a model for reaching a national consensus on basic needs will be offered.

Energy policy based around access to sufficient services will involve questioning expectations and norms about what 'enough' means and who gets to decide. Moving to a sufficiency framing will involve challenging social and political debates, and technological advances will not allow us to side-step these. The energy policy community is a good place to start these discussions, because we already have some socio-technical options to offer, along with experience in defining services and standards, which can be developed on the path to much-reduced use of fossil fuel.

Is 1+1 more than 2? The German-Japanese Energy Transition Council (GJETC), a role model for bi-national cooperation

Stefan Thomas, Wuppertal Institute for Climate Environment and Energy, Germany

Peter Hennicke, Wuppertal Institut for Climate Environment and Energy, Germany

Naomi Gericke, Wuppertal Institut, Germany

Wilhelm Meemken, ECOS Consult, Germany

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Masakazu Toyoda, Institute of Energy Economics, Japan, Japan

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Panel

2. What's next in energy policy?

Keywords

energy transition, bi-national cooperation

In spite of differences in energy policies and supply, Japan and Germany have to master similar challenges: To reorganize the energy supply system towards—in the long term—being reliable, affordable, low in risks and resource use, and climate-neutral. At the same time, the ecological modernization should maintain or even strengthen international competitiveness. To better address these challenges, a bi-national expert council has been established between the two high-tech countries in 2016 – the GJETC.

The aim of the GJETC is to show that despite different starting points, a national energy transition can be more successful, if both countries learn from their strengths and also weaknesses, to avoid the latter. If the implementation of an energy transition in the two countries is socially and economically sound and advances technology innovation and deployment, it may not only double success, but can also serve as blue prints for other countries, especially due to learning from similarities and differences. For example: Why is per capita energy consumption higher in transport in Germany, but energy intensity higher in Japan's building sector? How can variable renewable energies be integrated in an efficient energy system at lowest costs?

'The Council meets twice a year, holds stakeholder dialogues and outreach events, and prepares policy papers on strategic topics of mutual interest. Four comprehensive studies, each in cooperation of a German and a Japanese research institute, have been the basis for 15 joint key recommendations during the 1st phase. The 2nd phase to 2020 will study the role of hydrogen and

digitalisation for the energy transition, as well as other topics. The paper presents the findings and recommendations of the GJETC of the first phase 2016-18 as well as first results of the second phase. It also reviews the setup of the GJETC and the way it works, to assess if and how it can serve as a role model of bilateral cooperation on the energy transition.

The relevance of multiple impacts of energy efficiency in policy-making and evaluation

Johannes Thema, Wuppertal Institut for Climate Environment and Energy, Germany

Jana Rasch, Wuppertal Institut for Climate Environment and Energy, Germany

Felix Suerkemper, Wuppertal Institute for Climate, Environment and Energy, Germany

Stefan Thomas, Wuppertal Institute for Climate Environment and Energy, Germany

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Stefan Bouzarovski, School of Environment, Education and Development, University of Manchester, United Kingdom

Johan Couder, Advanced Buildings and Urban Design, Belgium

Nora Mzavanadze, Copenhagen Economics, Lithuania

Souran Chatterjee, Advanced Buildings and Urban Design, Hungary

Martin Bo Hansen, Hungary

Diana Ürge-Vorsatz

Panel

2. What's next in energy policy?

Keywords

multiple impacts

Improvements in energy efficiency have numerous impacts additional to energy and greenhouse gas savings. This paper presents key findings and policy recommendations of the COMBI project (“Calculating and Operationalising the Multiple Benefits of Energy Efficiency in Europe”).

This project aimed at quantifying the energy and non-energy impacts that a realisation of the EU energy efficiency potential would have in 2030. It covered the most relevant technical energy efficiency improvement actions in buildings, transport and industry.

Quantified impacts include reduced air pollution (and its effects on human health, eco-systems), improved social welfare (health, productivity), saved biotic and abiotic resources, effects on the energy system and energy security, and the economy (employment, GDP, public budgets and energy/EU-ETS prices). The paper shows that a more ambitious energy efficiency policy in Europe would lead to substantial impacts: overall, in 2030 alone, monetized multiple impacts (MI) would amount to 61 bn€ per year in 2030, i.e. corresponding to approx. 50% of energy cost savings (131 bn€).

Consequently, the conservative CBA approach of COMBI yields that including MI quantifications to energy efficiency impact assessments would increase the benefit side by at least 50–70%. As

this analysis excludes numerous impacts that could either not be quantified or monetized or where any double-counting potential exists, actual benefits may be much larger.

Based on these findings, the paper formulates several recommendations for EU policy making:

- (1) the inclusion of MI into the assessment of policy instruments and scenarios,
- (2) the need of reliable MI quantifications for policy design and target setting,
- (3) the use of MI for encouraging inter-departmental and cross-sectoral cooperation in policy making to pursue common goals, and
- (4) the importance of MI evaluations for their communication and promotion to decision-makers, stakeholders, investors and the general public.

Quantifying the health and performance gains of enhanced indoor environmental quality in offices, schools and hospitals

Jonathan Volt, BPIE, Belgium

Dan Staniaszek, The Buildings Performance Institute Europe (BPIE), Belgium

Vivian Dorizas, BPIE, Belgium

Judit Kockat, Buildings Performance Institute Europe, Germany

Panel

2. What's next in energy policy?

Keywords

multiple benefits, deep renovations, health, productivity, air quality, lighting, control

Buildings we live and work in are a key determinant for our physical and mental health, our wellbeing and even our professional performance. People spend on average 90% of time indoors and one in six Europeans live in unhealthy buildings. Buildings also have a key role to play in combatting the impacts of climate change. In Europe, buildings are responsible for 40% of energy consumption and nearly 36% of CO₂ emissions. Despite this, the European renovation rate remains low.

Most investors (public and private) look solely on the potential energy savings and tend to overlook the multiple non-energy benefits. In most renovations, the value of these benefits, such as fewer sick days, shorter length of stay at hospitals or higher performance at work, heavily outweigh the energy savings realised. The paper contributes to the understanding of multiple benefits in schools, hospitals and offices and how they can be valorised.

The methodological approach covers a (i) systematic review of existing literature (>250 studies) based on the key indoor environmental indicators, (ii) monetisation of the quantified benefits and an (iii) extrapolation to a European level. In a final stage, the findings are scrutinised by leading experts. The initial finding shows the performance increase due to a holistic renovation, is expected to amount to 11-16% in offices and 13-20% in schools. The number of sick-days in schools and offices are expected to drop 15-20%, while the length of stay in hospitals is predicted to decrease with 15-30%. The monetised value of shorter length of stay in hospitals alone, amounts to €58-117bn on a European level.

Renovations must improve the energy performance of the building but also be designed to optimise the acoustic environment, thermal comfort, air quality and light, while empowering the residents with control. The results suggest that indoor environmental quality can become a driving force for energy renovation and proper implementation across Europe.

Demand response as a tool of the power system flexibility – insights from Singapore's electricity market

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Panel

2. What's next in energy policy?

Keywords

demand side management (DSM), demand response

Demand side management now alter our economic fundamentals of the electricity market in many ways. It blurs the distinction between supply and demand, and enables the interaction with consumers to balance supply and demand in real time. Thus, it is important to identify future opportunities and challenges to unlock the energy system-wide efficiency potential. By applying an electricity dispatch and investment model to Singapore's long-term electricity technologies portfolio, this study investigates the power system value of demand response and power storage at the high penetration level of variable solar energy.

The system value in our study captures the various roles that power storage can play in reducing electricity generation costs, through merit order value associated with renewables integration, arbitrage value shifting electricity from periods with low marginal generation costs to periods with higher costs, reserve value related to the provision of balancing reserves, and capacity value related to the reduction of peak capacity.

We find that demand response and power storage contribute to saving 1% of the system cost in 2035, equivalent to around 100 million SGD.

In the absence of storage technologies, installed capacity of CCGT will increase from 11 GW to 12 GW in 2035, with the total installed capacity remaining almost unchanged compared with the baseline scenario. With the support of these findings, this study suggests the implications on business models, regulatory framework, and market design to enable demand response investments.

As the U.S. considers “the utility of the future”, what will be the role for utilities regarding energy efficiency and climate?

Martin Kushler, ACEEE - American Council for an Energy-Efficient Economy, USA

Panel

2. What's next in energy policy?

Keywords

utilities, climate change, U.S., energy efficiency

The electric utility industry in the U.S. is facing many challenges. These include: aging infrastructure needing major investment; economic pressure from slow demand growth; the need to integrate new technology; competitive pressures from alternative suppliers and customer-sited resources; and societal obligations from environmental, equity, and other policy objectives. There is much discussion going on about how the electric utility industry is headed for major transformation, and several leading states have begun processes to consider changes toward “the utility of the future.” (In the U.S., regulation of electric utilities is largely left up to the individual states.)

Overlaying this context is a growing awareness of the urgency of taking bold action to address climate change. The new IPCC report tells us that we have barely a decade to make dramatic changes. This highlights the critical importance of what emerges from these discussions in the U.S. Quite simply, there is no way the U.S. can hope to achieve the necessary GHG reductions without the full-fledged participation, and indeed leadership, by our utility companies in promoting energy efficiency. In the U.S., given our state-oriented regulatory structure, what states may do in this regard is of central importance. In spite of the unfortunate current lack of commitment to climate at the federal level, states can still have a tremendously important impact. In this project, we selected 7 states that have been identified in the trade press as among the leading states in terms of examining the issue of “the utility of the future”. Those states include: Hawaii, Illinois, Massachusetts, New York, Ohio, Minnesota and Rhode Island.

For those states, we reviewed key documents and talked to industry experts, to gain a good understanding of each state’s approach. We focused in particular on two key areas: the extent to which their discussions are motivated by climate concerns (if at all); and the extent to which their discussion has focused on a role for utility companies in pursuing energy efficiency objectives. We also reviewed nearly a dozen reports and articles on the subject of the ‘utility of the future’ by key organizations and industry experts, to examine the prevailing thinking on this subject in the U.S. today.

To briefly summarize: concern about climate change is rarely mentioned as a motivation for the discussion about the utility of the future. Rather, the motivating factors are much more traditional:

aging infrastructure; economic threats to the traditional utility business model; the need to integrate exciting new grid technology and distributed (customer-sited) resources; and the desire to maintain a reliable and affordable electricity grid.

In fairness, some of the states and industry experts do put some emphasis on integrating renewable energy into the grid (although not necessarily with an explicit climate connection). Disappointingly, however, a desire to increase utility achievements regarding energy efficiency is essentially absent from the discussions.

During the past century, the fundamental goal of the U.S. electric system has been to bring “reliable, affordable electricity” to everyone. While those traditional factors being focused upon so far in these discussions of the utility of the future are worthy objectives, they essentially ignore what arguably should be a (perhaps ‘the’) primary objective of energy utilities going forward: being leaders in the effort to mitigate climate change. Reducing GHG emissions needs to be a defining mission for utilities in the 21st century, and energy efficiency should be major emphasized strategy for achieving that. Unfortunately, what one sees so far in the U.S. in discussions of the utility of the future is primarily the application of new 21st century tools to pursue 20th century objectives.

Multiple benefits of energy efficiency and renewable energy in ASEAN

Jose Antonio Ordonez, Fraunhofer Institute for Systems and Innovation Research, Germany

Matthias Reuter, Fraunhofer Institute for Systems and Innovation Research ISI, Germany

Wolfgang Eichhammer, Fraunhofer ISI, Germany

Panel

2. What's next in energy policy?

Keywords

multiple benefits, ASEAN, decomposition, CO2 savings, energy supply and demand, Kaya Identity

The Association of South East Asian Nations (ASEAN), comprised by Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Singapore, the Philippines, Singapore, Thailand and Vietnam is home to approx. 630 million inhabitants and one of the fastest growing regions of the world. As a consequence of its strongly rising energy demand, ASEAN's member states have stipulated ambitious targets in Energy Efficiency (EE) and Renewable Energy (RE) in order to cope with rising energy supply and environmentally related challenges.

Based on the modelling results of the 5th ASEAN Energy Outlook, we provide a comprehensive analysis of energy-related multiple benefits of transforming the energy system towards the achievement the EE and RE targets. In particular, we present on the primary- and final energy savings, as well as the effects on import dependency and supplier diversity regarding fossil fuels. We provide a Kaya-decomposition analysis on avoided CO2 emissions, thereby highlighting the nexus between EE and RE targets.

Beyond energy and emission related multiple benefits, we provide first estimates of health related impacts of reaching EE and RE targets. In view of the great benefits of reaching EE and RE targets, our results highlight the importance for ASEAN Member States of putting stronger efforts in implementing adequate and necessary policy measures to reach the stipulated targets and thereby harvest the multiple benefits of EE and RE penetration.

High and low energy efficiency companies: is there a competitiveness gap? An empirical investigation on Italian manufacturing firms

Corine Nsangwe Businge, Ricerca sul Sistema Energetico SpA, Italy
Franco d'Amore, Italy

Panel

2. What's next in energy policy?

Keywords

industrial energy saving, energy efficiency investments, energy intensity, competitiveness, energy efficiency gap, energy efficiency policy, behavioural change, co-benefits

Energy efficiency is considered a key policy option to meet different strategic energy targets, including decarbonisation, security of supply and energy cost reduction. In spite of the pledged benefits, energy efficiency potential is still largely untapped. The energy efficiency gap in the industrial sector is a well-known issue due to several barriers including economic/financial, awareness, behavioural, firm size, sector and competitiveness environment.

The aim of the present work is to investigate the correlation between energy efficiency investments and the competitiveness of firms belonging to medium energy intensity sectors in the Italian manufacturing landscape.

Medium energy intensity sectors have been chosen since they are less extensively studied compared to energy intensive ones and because the correlation between energy efficiency and competitiveness can be less obvious and straightforward.

Firstly, the existence of differences in the Competitiveness Indexes between high and low energy efficiency companies is analysed, with a special focus on where these differences are stronger among the different sectors and within company size.

Second, the presence of statistical correlations between the implementation of energy efficiency measures and the increase in economic performances of companies is investigated.

The study reveals an overall statistically significant positive correlation between energy efficiency investments and the competitiveness of firms. The results have interesting implications both for policy makers, who need instruments to tackle the energy efficiency gap in medium energy intensity industries, and for the top management within companies, who need, on the one hand, to raise internal awareness and knowledge about co-benefits of energy efficiency measures.

Implications of appliance efficiency in energy access cost modelling

Sam Grant, Kenya

Iain MacGill, UNSW (University of NSW), Australia

Anna Bruce, UNSW, Australia

Lauren Gardner, UNSW, Australia

Panel

2. What's next in energy policy?

Keywords

household appliances, economic model, distributed energy resources (DER)

The electricity grid in much of East Africa has yet to be built. Kenya is taking this partially filled canvas as an opportunity to innovate and design an energy system that meets the needs of its population and the challenges of its geography. Kenya's rapid electrification is taking place on two main fronts: through grid expansion and distributed solar home systems. Arguably Kenya's most promising utility models are being developed outside of the traditional grid system and have attracted telecoms and banks as principal actors leading to 4 million solar home system and solar lantern sales since 2012. These solar sales have coincided with a rapid expansion of the centralized grid where heavily subsidized connections have more than doubled in the same period.

This paper attempts to create a nuanced optimization model that compares how cost effective these two approaches have been and provides guidance for future electricity infrastructure investment decision making. Previous energy planning models have failed to account for appliance efficiency gains in future load demand scenarios. This model allows adjustments in appliance efficiency for both on and off grid households.

The resultant modeling strengthens the economic justification for greater reliance on distributed energy solution over grid expansion when trying to increase energy access at least cost. An honest assessment of appliance efficiency in electricity infrastructure planning across East Africa would improve the efficiency of government expenditure and would bring the region closer to achieving Sustainable Development Goal 7.

Energy efficiency and flexibility – the dynamic duo of the energy transition

Katharina Wohlfarth, Fraunhofer Institute for Systems and Innovation Research, Germany

Panel

2. What's next in energy policy?

Keywords

demand response, synergies, energy efficiency

In the EU's energy policy, energy efficiency and the increased share of renewable energies are key elements to meet the requirements of sustainability and climate protection. However, improved energy efficiency aims to reduce energy demand while volatile renewable energies require flexibility of demand. Both concepts will play an important role in the energy transition, but in some cases, they may counteract - e.g. demand flexibility can increase energy demand. Solutions to promote both – energy efficiency and flexibility – would be most favorable.

To derive possible synergies between energy efficiency and flexibility, we compare aspects of the framework of both, like influencing factors on decision making including drivers, barriers and typical measures. Based on the existing policy instruments in Germany concerning energy efficiency, we categorize policy instruments and give policy recommendations on how to integrate or harmonize comparable policy instruments regarding energy flexibility. We assume that the successful instruments and policies for energy efficiency could also be applied for promoting energy flexibility. New flexibility policies built on established instruments deem to be more promising to be effective and might be less at risk to counteract efficiency policies.

Additionally, using existing instruments to integrate new aspects can save the effort to establish new tools and mechanisms. The results can help to strike a balance in policies affecting different aspects of the energy transition.

The role of different energy infrastructures in ambitious energy efficiency scenarios for the building sector

Jan Steinbach, IREES, Institute for Resource Efficiency and Energy Strategies, Germany

Lukas Kranzl, TU Wien - Energy Economics Group

Panel

2. What's next in energy policy?

Keywords

long-term scenarios, energy policy, building stock, renewable energy, network infrastructure

Climate reduction targets of 80 to 95 % GHG until 2050 compared to 1990 which are in line with two-degree Paris goal, requires very ambitious energy efficiency measures in all sectors and the decarbonisation of energy supply. One of the crucial challenges for energy policy making in the coming years is to decide which energy supply infrastructures are required and best suitable in a world with very low energy demand and which corresponding policies are needed today to support this transformation. In particular, the future role of gas networks and heating grids to achieve a complete decarbonized heat supply is of particular importance here.

This paper performs a scenario analysis for the building sector in Germany considering different sector coupling strategies and energy infrastructure to achieve a 95 % GHG reduction until 2050. Similar energy saving levels are combined with different policy strategies to support the transformation of heating supply.

The gas network exist scenario assumes regulation to prohibit new installations of gas boiler in all buildings from 2030 onward, whereas the power-to-gas scenario utilize gas infrastructures further until 2050 by assuming a feed-in quota for methane produced from renewable electricity. The scenarios are calculated with the bottom-up simulation model INVERT/EE-lab that allows not only a detailed depiction of the building sector, energy efficiency measures and supply technologies but also the simulation of the individual decision-making of different investors. By using a simulation model with an explorative scenario design, the analysis enables not only the comparison different infrastructure strategies but also an evaluation of required policies to achieve the targets. The paper elaborates on investments, costs and savings and the allocation to different actors in the different scenarios as well as on the impact of the energy efficiency policies.

Energy efficiency vision 2050: how do societal changes shape energy efficiency and energy demand?

Heike Brugger, Fraunhofer ISI, Germany

Ewa Dönitz, Fraunhofer ISI, Germany

Wolfgang Eichhammer, Fraunhofer ISI, Germany

Panel

2. What's next in energy policy?

Keywords

societal changes, trends, policy, scenarios, energy demand

New societal trends are currently unfolding, such as digitalization, the sharing economy and changing consumer awareness. All of which might highly influence future energy demand and depending on their realization might enhance or counterbalance projected energy efficiency gains. This work is a first attempt to analyse quantitatively how these societal trends might interact with energy efficiency gains. An extensive consultation with European experts identified 14 societal trends that are likely to shape future energy demand. Based on these trends three energy demand scenarios were developed for 2050. The EU Reference Scenario (2016) serves as the baseline (BAU).

A 'Removing Barriers Scenario' (S1) identifies the prospective decreases in energy demand based on (nearly) cost-effective potentials but excluding major impacts of such new societal trends. Through extensive review of existing studies as well as expert consultations the impacts of new societal trends on all sectors were evaluated in two additional scenarios taking explicitly these trends into account: In scenario 2 the techno-economic potentials are realized, but are counterbalanced by societal trends (e.g. cars might become more energy efficient, but the increased comfort of automation leads to an increase in the kilometres travelled and / or to larger vehicles). Scenario 3 assumes that the Energy Efficiency First Principle is widely established and guides individual and policy decision-making, thus shaping societal trends in a way that facilitates decreasing energy demand.

A current study by IEA (2017), based on Wadud et al (2016), shows that by 2050, digitalization might double or decrease transport energy demand by roughly 40%. This gives a rough idea of the spectrum of possible developments. This paper aims to open up the discussion of how societal trends will shape future energy demand. It explicates that solely relying on unregulated energy efficiency gains to reduce energy demand underestimates the complexity of the interplay of energy demand with changing behaviour through societal trends, while they may also bring about large reduction potentials.

Meta results in NEB/NEIs – progress in NEB values, attribution to measures, and state adoption into cost-effectiveness tests

Lisa A. Skumatz, Sera Skumatz Economic Research Associates Inc., USA

Lisa A. Skumatz, Sera Skumatz Economic Research Associates Inc., USA

Panel

2. What's next in energy policy?

Keywords

non-energy benefits (NEBs), cost benefit, energy efficiency programmes, measures

Domino-style, more and more states are incorporating NEBs into benefit-cost tests in various subsets and formats. NEBs can reduce bias in the cost-effectiveness tests, improving program and portfolio investment decisions. The paper summarizes the specific approaches states are taking in incorporating NEBs in tests including:

- Adders (and what they do/don't include)
- "Easy to measure" NEBs
- All NEBs
- A hybrid adder/estimation approach.

We examine collaborative procedures in states, and states that are incorporating NEBs through changes to the TRM – a process that is involving identifying and/or developing measure-based NEBs. The paper identifies those NEBs that are appropriate for inclusion, and the common ranges for values. We provide case studies and the similarities and differences, and ranges and patterns of values being applied in different states.

We update states that have taken basic adder approaches vs. more aggressive approaches in NEBs. We identify values of measure-independent NEBs and measure-based NEBs – and particularly identify the priority gaps that are being identified – in values and measure-specific NEBs – as part of the deliberations. The paper discusses treatments and values in B/C work in different states, implications related to bias, risk, and cost, and address directions and recommendations for the future.

The building battlefield: (in)consistencies in German policies for sustainable living

Oliver Wagner, Wuppertal Institut for Climate Environment and Energy, Germany
Anja Bierwirth, Wuppertal Institut for Climate Environment and Energy, Germany
Johannes Thema, Wuppertal Institut for Climate Environment and Energy, Germany

Panel

3. Policy and governance

Keywords

sustainable housing, building policy, broader social context

“400,000 new homes per year are needed in German cities.” This figure has been cited repeatedly in political discussions, media, and statements of different groups for a couple of years now. Living space is needed to mitigate the (further) inordinate increase of rents in some cities and regions and to ease finding appropriate flats at affordable prices for low- and medium-income households. But how to activate investors and the real estate market?

Having the triangle of sustainability in mind with its ecologic, social and economic cornerstones the discussion – metaphorically spoken – currently pulls the three corners: Which should have the highest priority?

The economically driven most favourable solution is lowering the requirements for new buildings such as the energy performance to make building cheaper. The social perspective prefers an increase of public social housing investments regardless of efficiency standards. And the ecological side argues that a high performance is needed to reach energy and climate targets in the buildings sector.

Starting at this point of discussion, firstly, the paper reflects the assumptions behind the numbers of new homes needed against a sufficiency background.

Secondly, it presents current changes in German building policies: a new legislation for energy supply and efficiency is currently in preparation.

It discusses the potential to integrate sufficiency aspects in building policies, focussing specifically on the new regulation, financial incentives, and energy advice.

The paper analyses if and to what extent it is likely to balance the three cornerstones of sustainability by integrating sufficiency aspects into efficiency policies. Household experiences with prepayment meters are used as an example to illustrate the potential for tapping efficiency and sufficiency potentials in low-income households considering social, economic, and ecological aspects. Based on the identified (in)consistencies, thirdly, it suggests further development in German policies to make better use of synergies between the ecologic, social and economic demands on buildings.

Energy efficiency first; sufficiency next?

Hannah Förster, Öko-Institut (Institute for Applied Ecology), Germany

Carina Zell-Ziegler, Öko-Institut (Institute for Applied Ecology), Germany

Daniel Eichhorn, Umweltbundesamt (UBA)

Panel

3. Policy and governance

Keywords

sufficiency, modelling, energy policy, mitigation potential, greenhouse gas mitigation

The European Union has committed to binding 2030 targets: to cutting greenhouse gases by 40 % compared to 1990, to decrease energy consumption by 32.5 % compared to a baseline scenario, and to increase the share of renewable energy to at least 32 % of gross final energy consumption. Energy efficiency first is the key principle of this climate and energy strategy.

For 2050, the EU's non-binding the ambitious long-term goal is to cut greenhouse gas emissions by 80-95% compared to 1990. There are many ways to approach climate protection. Increasing energy efficiency and the expansion of renewable energies are two relatively familiar ways and are regularly part of climate mitigation modelling exercises.

Sufficiency can also contribute to climate protection. Specifically if mitigation goals are very ambitious it could take some burden off technological mitigation options. However, sufficiency is seldom addressed explicitly in stringent climate protection scenarios due to several reasons.

Our study derives a first draft guidance that aims at motivating to systematically integrate sufficiency when modelling stringent climate protection scenarios. In order to do this we characterize German longer-term scenarios with stringent climate protection goals in place. We investigate whether, and if yes how, sufficiency is included in these scenarios. An exemplary look is also taken beyond Germany. We address how sufficiency can be addressed systematically across all sectors included in modelling exercises.

Further the derived draft guidance feeds from the results of an expert meeting that took place in 2018 at the Federal Environment Agency (UBA) in Dessau. 12 German organizations all familiar with modelling climate protection scenarios discussed theses about integrating sufficiency in modelling stringent climate protection.

White certificates in Italy: will it overcome the huge challenges it has been facing in the last three years?

Dario Di Santo, FIRE, Italy

Livio De Chicchis, FIRE - Italian Federation for Energy Efficiency c/o Centro ENEA Casaccia, Italy

Panel

3. Policy and governance

Keywords

white certificates, tradable white certificates, energy efficiency obligation, incentive mechanisms

The Italian White certificates scheme (WhC) was introduced in 2001 and has been effectively working since 2005. It has been characterised by rising targets, all sectors and energy efficiency solutions covered (at least in the first decade), and many flexibility options in place (e.g. non-obliged – a.k.a eligible – parties, tradable market for white certificates, bankability, flexibility on obliged parties targets, etc.). With more than 26 million tons of oil equivalent (toe) of energy savings cumulated by the end of 2017 it has contributed to the national energy efficiency targets.

The scheme underwent important changes first in 2012, then in 2017, both for the targets and the operating guidelines. These modifications, combined with energy market developments, resulted in a reduced capability of producing the expected certificates and in an increasingly shorter WhC market, thus putting at risk both the compliance with the targets and the operation of the scheme itself.

The paper will illustrate the main issues that affected the scheme over the years, in particular in the recent years, the effects produced by 2017 guidelines, and the need to adopt new rules in 2018 to avoid a collapse driven by skyrocketing market prices and an insufficient number of certificates to reach even the minimum targets (i.e. considering the flexibility given to the obliged distributors to postpone part of them for 1-2 years). An historical excursus which can be useful to understand the challenges that an Energy Efficiency Obligation scheme (EEO) with tradable market can pose to policy makers and also the potential in terms of results.

The paper will cover the main modifications and the issues arisen over the years and illustrate the effects of the new rules introduced in 2018, providing figures on the results in terms of issued certificates and market price. Besides, the cost-effectiveness of the scheme will be evaluated, considering the different phases (with and without the tau coefficient, the multiplier introduced in 2011 and abandoned in 2017).

Evolutions of the French EEO scheme through the ages according to emblematic measures: a testimony from within of a continuous work in progress

Dominique Osso, EDF-R&D, France

Marie-Hélène Laurent, EDF - R&D Département ENERBAT, France

Stanislas Nösperger, EDF - RD, Département TREE, France

Panel

3. Policy and governance

Keywords

energy efficiency obligation, residential buildings, evaluation, white certificates, energy savings certificates

The energy-saving obligation scheme in France launched in 2006 was revised each three-year period. The majority of EEOs issued are based on standardised action valued according to deemed energy savings. These revisions have made it possible to correct errors, to value new actions and to update eligible actions according to changes in the context and regulations.

After more than 10 years of operation, and a potential extension of the scheme beyond 2020, it is interesting to look at the lessons of the past. For this purpose, we look at the evolution of the system through the prism of iconic actions. The assessment of a renovation action in the EEO scheme consists of 2 parts: the technical part helps to calculate energy savings (calculation sheet), the second deals with the verification of the eligibility of the works (certificate on honour). Both have evolved over time.

The estimation of energy savings have evolved for technical reasons: reduction of the heating-degree-day, decrease of the space heating reference consumption and modifications of other coefficients. If these modifications were made for objective reasons, others have been made to explicit unexplained values. In addition, the EED directive has helped to modify energy saving to value only marginal savings (i.e. beyond the performance of Ecodesign). Recently, the problem of fraud has led to the simplification of modulating energy savings due to the impossibility of verifying certain criteria while adding constraints on the execution of work (proof, on site-visit).

Effectiveness of these changes should be studied to ensure this scheme still fosters energy retrofit of the building stock. This study could help to make a relevant trade-off between process simplification and the valuation of accurate energy savings. In summary, the EEO scheme will always be a work in progress and the preparation of the next period will not escape it but lessons from the past should enlight future developments.

Sharing experience to spread evaluation practices: evaluation does help to improve policies!

Jean-Sébastien Broc, IEECP (Institute for a European Energy and Climate Policy), The Netherlands

Barbara Schlomann, Fraunhofer Institute for Systems and Innovation Research, Germany

Fabian Voswinkel, Fraunhofer Institute for Systems and Innovation Research, Germany

Barbara Breitschopf, Fraunhofer Institute for Systems and Innovation Research, Germany

Lovorko Marić, Energy Institute Hrvoje Požar, Croatia

Gregor Thenius, Austrian Energy Agency, Austria

Panel

3. Policy and governance

Keywords

experience sharing, energy efficiency policy, evaluation

Experience sharing about evaluation of energy efficiency policies is often limited due to lack of time for stakeholders to disseminate or document their evaluation works, and to the many languages in Europe. This paper presents the findings from two resources developed to get a better view of current ex-post evaluation practices and facilitate experience sharing:

- a Knowledge Base that gathers 180 references encoded according to a set of criteria enabling various types of search;
- 23 case studies including detailed analyses of practical examples of evaluations.

The review of the Knowledge Base supports the thesis that methodological discussions precede empirical studies: an evaluation issue (e.g. rebound effect) is more likely to be taken into account in practice if clear guidance is available about it. The review gives evidence of a large variety of studies and approaches, but highlights the need to elaborate and use transparent and replicable evaluation methods.

Promoting a minimum level of documentation would be a first step in this direction.

Documentation may be tricky due to the variety of metrics/approaches used for quantifying energy savings.

The review thus discusses what metrics and factors to take into account for common evaluation criteria (target achievement, effectiveness, efficiency).

Expanding the scope of evaluation to include other impacts than energy savings (e.g., employment, health) also appears a promising way to enhance the added value of evaluation and improve policy design.

The review of the case studies drew practical lessons summarized in 11 messages structured along the evaluation process: from the no-brainer about early planning of evaluation, up to thinking ahead what evaluation results to communicate, how and to whom, as well as about the conditions for evaluation findings to be used. These 11 messages are based on feedback from stakeholders and illustrated by examples that show how evaluations have helped to improve policies.

Implementation status and effectiveness of Article 17 of the Energy Efficiency Directive

Nele Renders, Vito, Belgium

Erika Meynaerts, VITO, Belgium

Panel

3. Policy and governance

Keywords

effectiveness, Energy Efficiency Directive (EED), information, training, policy implementation, national energy efficiency action plans (NEEAPs)

The study "Assessment of the implementation status and effectiveness of Article 17 of the Energy Efficiency Directive" (accomplished under the authority of Directorate-General for Energy, <https://art17assess.vito.be/>) provides recommendations to the European Commission and Member States based on an assessment of the implementation status and effectiveness of Article 17 of the Energy Efficiency Directive (EED) across the European Union Member States.

Article 17 provides a framework on broad dissemination of information and availability of training initiatives related to energy efficiency. Besides Article 17, Member States have to introduce national measures to provide information on the energy performance of buildings and to create a framework for developing skills, such as energy audits. Given their cross-cutting nature, the measures addressing these obligations in other articles of the EED (i.e. Articles 8, 12, 16 and 19), as well as the EPBD (Articles 17 and 20) were also considered.

Based on the Member States' National Energy Efficiency Action Plans, an overview was made of the implementation status and the measures implemented by all Member States to ensure wide dissemination of information to market actors and citizens. Moreover, an assessment of the measures' effectiveness was carried out for a selection of ten representative Member States, following the intervention logic of inputs-outputs-effects of effective policy design, implementation and monitoring. The study also provides insights in the types of information measures targeted at financial institutions to stimulate the uptake of energy efficiency investments.

Efficiency first in Europe's new electricity market design – how are we doing?

Pató Zsuzsanna, RAP, Hungary

Richard Cowart, Regulatory Assistance Project (RAP), Belgium

Jan Rosenow, The Regulatory Assistance Project (RAP), Belgium

Panel

3. Policy and governance

Keywords

efficiency first, electricity market design

Efficiency First is now a principle of EU energy policy. It has been embedded in the EU's electricity market design following intense negotiations in 2018. There are many instances where power market rules can and should reflect the Efficiency First principle.

Key questions by which to assess its applicability include:

- Are capacity markets being designed to reward the value of energy efficiency and demand response?
- Are demand response resources enabled to participate fully in the new markets, or are restrictions such as supplier compensation requirements standing in the way?
- Are transmission and distribution investment plans open to alternative (and more cost-effective) “nonwires” solutions? Do reliability rules reflect the high value of demand response options? – Are the national regulatory agencies (NRAs) and Agency for the Cooperation of Energy Regulators (ACER) empowered to require equal treatment for demand-side resources?

With these and like questions in mind, we provide guidance and recommendations for Member States, relevant ministries, and NRAs on what actions they can take in their jurisdiction to implement the brand-new European legislative framework so that it creates opportunities for energy efficiency and demand response.

Why do energy efficiency receive less government support than other energy policies?

Benoit Lebot, International Partnership for Energy Efficiency Cooperation (IPEEC), France

Jurei Yada, International Partnership on Energy Efficiency Cooperation (IPEEC), France

Panel

3. Policy and governance

Keywords

governance, energy efficiency policy, energy saving assessment, mitigation potential, mitigation options

Over the past decade, energy efficiency has received growing recognition as a central pillar for achieving sustainable and low-carbon growth across economies. However, despite its emergence on international agendas such as the United Nations Sustainable Development Goals adopted in 2015, energy efficiency remains by and large under-resourced compared to other areas of energy policy, in particular when taking into account its significant potential to help deliver climate goals and achieve economic growth. An example of this can be seen in the Kyoto Protocol, under which energy efficiency was the least supported option for climate change mitigation. End-use energy efficiency projects account for less than 1% of the Clean Development Mechanism Certified Emission Reductions(i). This was in contrast to the findings of numerous studies at the time, which demonstrated that energy efficiency could significantly reduce GHG emissions in cost-effective ways. More recently, the 2018 IPCC report has shown that the most reasonable scenario for the international community that meets the Paris agreement is the Low Energy Demand (LED) scenario (known as P1).

Energy efficiency is central to reach this scenario as it lowers energy demand, which can then be met more readily by renewable sources. What can then be done to ensure that energy efficiency fulfils its vast potential and contributes to countries' energy transitions? To become a fuel and the first fuel, energy efficiency needs the following: sound human and institutional capacities, a coherent policy framework that triggers investments in energy efficiency solutions and measures, a long time horizon. All economies are concerned as the potentials for energy efficiency is large in every sector and energy efficiency is by essence a dynamic process.

To deliver, energy efficiency needs to be adequately resourced over the long time horizon. A dedicated financial flow for technical assistance is instrumental to the deployment of energy efficiency in order to build transformative policy frameworks. Strengthened international action on energy efficiency can make a real difference for economies and climate change, individuals and

businesses. To become reality, energy efficiency requires a set of ingredients: political willingness, special human, technical and institutional capacities, massive data gathering and analysis, and dedicated tools and instruments such as metrics, ratings, and monitoring. International cooperation can provide the crucial first step for all of this by creating the right environment for exchange and collaboration, and by giving the political signal that energy efficiency is important and must be taken further - as was the case with the Paris Agreement and the G20 energy efficiency plans.

Energy efficiency is by essence domestic and local, if not very local. Energy efficiency solutions are the results of very granular decisions and investments. Here, international cooperation can contribute by accelerating the exchange of information, technical opportunities for regional harmonization, and mobilization of key partners by national governments - typically financial institutions. International collaboration can therefore greatly accelerate the adoption and implementation of domestic energy efficiency policies.

i. CDM Pipeline. United National Environment Programme :
<http://www.cdmpipeline.org/cdm-projects-type.htm>. Table for January 2019

Energy consumption in Europe: why is it increasing and what are the policy implications?

Samuel Thomas, RAP, France

Jan Rosenow, The Regulatory Assistance Project (RAP), Belgium

Panel

3. Policy and governance

Keywords

energy consumption, EU 2020 target, energy efficiency policy, decomposition, economic analysis, policy implementation

Two years ago, the EU appeared to be well on the way to meeting its 2020 energy efficiency targets. 2014 final energy consumption was lower than in any year since the 1980s, and lower than the level required in 2020. Since then, energy consumption has risen in two consecutive years and looks set to have kept on increasing in 2017. If these short-term trends continue, the 2020 targets will be missed.

The drivers of increasing energy consumption are diverse. Since 2014, economic growth has been consistently stronger than at any point since before the Great Financial Crisis, putting upward pressure on industry, service and transport sector consumption; end-user energy prices have fallen, particularly in the transport sector, contributing to the increase in passenger travel; progressively colder winter temperatures have pushed up residential and service sector consumption; and decomposition analysis suggests that energy efficiency progress has slowed.

Various policy questions emerge from this analysis. Has energy efficiency policy been less ambitious in terms of energy savings? Are energy efficiency policies not achieving energy savings objectives? Are policies adequately monitored and evaluated to enable judgements on effectiveness to be reached? Are there immediate “no regrets” policy actions that can reduce energy consumption by 2020? When planning to meet absolute consumption targets, should allowances be made, to counter the potential impact of factors such as economic growth and the weather? This paper presents an analysis of the drivers of recent increases in EU energy consumption. It suggests that short-term trends are likely to lead to the EU’s 2020 energy efficiency targets being missed and outlines a number of implications for policy makers.

Building energy efficiency policy in Chinese cities and comparison with international cities

Wei Feng, Lawrence Berkeley National Laboratory, USA

Virginie Letschert, Lawrence Berkeley National Laboratory -Environmental Energy Technologies Division, USA

Panel

3. Policy and governance

Keywords

cities, renewable energy, buildings, energy efficiency policy, net zero energy

Buildings consume approximate 30% of the world total primary energy annually. With the fast global urbanization, urban building sector has become the major energy consumer and greenhouse gases emitter around the world. In China, residential, commercial and public buildings in cities consume 80% of China's building sector total energy. To control the fast increase of buildings energy use, cities in China have issued policies to improve energy efficiency and reduce CO₂ emission.

This paper reviews four Chinese cities (Beijing, Fuzhou, Qingdao, and Shanghai Changning) policies and experience on energy efficiency and renewable energy utilization in buildings. Different aspects of policies in Chinese cities are discussed, including: existing building retrofit, ultra-low energy buildings, and renewable energy application. To contrast with the Chinese cities' policies, several international cities building energy efficiency policies are reviewed and compared. International cities' policy best practices in the similar areas with Chinese are illustrated. Finally, recommendations for Chinese cities to further develop building energy efficiency policies are discussed.

Alleviating energy poverty: An interplay of energy and social policy?

Viktoria Noka, Öko-Institut (Institute for Applied Ecology), Germany

Katja Schumacher, Öko-Institut (Institute for Applied Ecology), Germany

Johanna Claudius, Öko-Institut (Institute for Applied Ecology), Germany

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Panel

3. Policy and governance

Keywords

energy poverty, policy interaction

The issue of energy poverty is prominently debated in the context of energy efficiency policies. The households which are most affected are those already vulnerable to income poverty. Energy poverty can only be tackled by a combination of policies and measures, encompassing different policy domains (e.g. social policy and energy policy) and actors on the national, regional or local levels.

The aim of this study is to elaborate and examine instruments and measures in place to combat energy poverty in a selection of EU Member States (Denmark, France, Ireland, Sweden and the United Kingdom), test their applicability and transferability to the German context and draw tentative conclusions about a transferability approach in other countries. A special focus lies on policies which alleviate energy poverty and at the same time contribute to reducing energy consumption.

Our assessment identifies six essential aspects which should be met (at least in part) in order to address both energy poverty issues and energy efficiency in Germany. Measures and instruments should i) have a long-term focus ii) address the target group of low-income households, iii) offer a combination of information and financial investment incentives, iv) be implemented preferably at the local or regional level or even peer-to-peer, v) address the landlord/tenant dilemma, vi) not replace social policy but focus on energy efficiency and behaviour in a way not to distort distributional effects.

We find that the socially responsible design of energy and climate policies is a particular challenge, but that it is essential in order to generate broad social support for the far-reaching changes needed to achieve ambitious efficiency targets. An exchange of experience and mutual learning across political and geographical borders can prove beneficial in this context.

Measuring the legitimacy of energy transition policy in the Netherlands

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Christine L. Carabain, Sociaal en cultureel Planbureau, The Netherlands

Panel

3. Policy and governance

Keywords

legitimacy, energy policy, public support, transition

In line with the Paris Agreement, the Dutch Government aims to achieve a 49% reduction in CO₂ emissions by 2030. Achieving this goal requires an energy transition. This transition will have a large impact on Dutch society and the business community. It is important that Dutch citizens and companies support and agree on the policies that aim to accelerate and achieve the Dutch energy transition.

This paper explores the legitimacy of these policies and how to measure the degree of such legitimacy. Policy legitimacy consists of public support for policy goals (input legitimacy) and support for the specific interventions needed to achieve these goals (output legitimacy). Policy legitimacy is based not only on effectiveness and efficiency, but also on other underlying aspects that are related to good governance. We conducted a survey among Dutch citizens and company representatives which shows there to be support (input legitimacy) for the Dutch climate policies. In other words, Dutch citizens and companies support their government's pursuit of an energy transition.

We also explored two concrete interventions:

- 1) an 'in-home display', collectively paid for by all energy consumers, and
- 2) an in-home display that is paid for by the energy companies.

Both types of interventions are supported by around 50% of citizens and companies. Companies and citizens broadly agree with each other, although they are slightly more likely to support the type of intervention with the least negative impact on them.

We found strong correlations between eight underlying aspects of legitimacy and the overall support for the interventions. The eight aspects had differing levels of appreciation, depending on the type of intervention. However, in general, we found fairness to carry more weight than cost-effectiveness. We also found that public support for a particular policy goal would not automatically result in support for the associated intervention. This last finding emphasises the importance of ex-ante testing of specific interventions, to determine the related level of public support, so that policy will be more effective and efficient.

Trade wars of 2020s – a new hope for energy efficiency

Teemu Hartikainen, Finnish Safety and Chemicals Agency, Finland

Alan Meier, Lawrence Berkeley National Laboratory, USA

Panel

3. Policy and governance

Keywords

compliance, trade policy

It is a period of trade war. Extreme protectionism, resulting from an economic conflict of states, is about to make them set new tariffs and trade barriers against each other. Such measures have earlier implied increase in domestic production of goods, instead of importing them from overseas, and thus lowered availability of certain products and lower overall consumption. Today, this would mean less container-kilometers for a ton of freight moved (tkm) to end-users, making transportation of goods for customers more energy efficient in general, but what other effects a trade war might have?

We argue, that with today's regulatory structures in OECD-countries the domestic production is far more energy efficient and environmentally sound compared to 1980s when manufacturing first started to move to East Asia. In addition, the domestically manufactured products itself are more often compliant with energy-efficiency regulations, because enforcement, or market surveillance, can target local manufacturers more effectively. And since the market surveillance is based on random, though risk-based, sampling in mostly reactive manner, some free-riders can exploit the system and import inefficient non-compliant products with little risk of being caught.

A trade war could lessen this activity by making the marketplace more compliant. On the other hand, as shown in our earlier eceee articles, international regulatory cooperation could be halted under these circumstances, and further efficiency improvements become unreachable. However, there is very much uncertainty connected with the political development of the starting trade war, so we are not going to work on analyzing the impacts just yet, but rather identify the issues and areas where energy efficiency implications could occur. For these reasons, this paper is only an extended abstract, but it can form the basis for a full article later.

The effect of energy labelling on consumers' decision: a field experiment in Spanish appliances' retailers

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Ibon Galarraga, Basque Centre for Climate Change (BC3), Spain

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Panel

3. Policy and governance

Keywords

domestic energy efficiency, energy label, household appliances

The primary driver of global Greenhouse Gas (GHG) emissions is the production and consumption of energy. Under this context, is one of the main goals of EU energy policy (European Commission, 2008) is to increase the energy efficiency (EE) of energy-related products.

The most widely used policy in EU are the energy labels. These are designed to highlight the EE of a energy using products. They provide information on the energy consumption, on the possible use of other resources (e.g. water) and on the comfort levels of the product (e.g. noise level). For an energy labelling scheme to be effective individuals must recognize them, must understand the information provided, must trust the label and must find the information useful.

The effectiveness of energy labels in promoting EE purchases has been called into question (Heinzle and Wüstenhagen, 2012; Noblet et al., 2006; Waechter et al., 2015a). There is a currently growing literature that studies the capacity of the energy labels to influence consumers' choices. In the case of household appliances, several studies point out that providing running-cost information potentially improves the effectiveness of the labels.

Under this context, a field experiment has been carried out between February and July 2018 to test the effectiveness of a monetary labelling system on retailers in Spain. The experiment involves three product categories: washing-machines, fridges and dishwashers.

So as to promote the purchase of energy efficient household appliances, two hypotheses have been tested:

- (i) providing energy savings information through a complementary energy label; and
- (ii) training of the sales staff on energy efficiency.

Results will be helpful to design future EE policies as regards to the effectiveness of providing energy savings info.

Property taxation as a policy instrument to steer energy efficiency and sustainable land use: a review

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Panel

3. Policy and governance

Keywords

taxes, land use, energy performance, energy sufficiency

Many countries apply a form of property taxation, as a tax on housing services, on capital, on land or other, mainly to finance local governments, but also to affect land use, to improve energy efficiency. In Belgium, the tax base for property taxation is the (fictitious) yearly net rental income value, but the reference year for the rental income value is 1975 and this was never updated since. This has resulted in large inequalities between property taxes for houses with similar size or quality. Furthermore, aspects like energy performance or sustainable land use were not at the core of political and societal discussions in 1975 and thus not taken into account in the setup of the tax base.

In an attempt to structurally reform the outdated property taxation system in Belgium, the RETAX research project has been set up in 2018, in close consultation with stakeholders from administrations and society. One of the aims is to investigate the opportunities to include energy efficiency and sustainable land use in this policy instrument as a way to reduce energy consumption of buildings and urban sprawl.

In this context a review is made on how different countries have integrated energy efficiency and/or sustainable land use in property taxation. E.g. although not included in the tax base itself as a criterion, an energy performance beyond legal requirement leads in Flanders, Belgium, since 2013 to a reduction of the property tax from 20% up to 100% for a period of 5 to 10 years, depending on the energy performance level. This has resulted in a growing share of nZEB houses, from 10% of the new houses in 2013 up to 52% in 2016, although nZEB only will become mandatory from 2021 on. The extended abstract will present the results of the review and aims to induce a discussion on if and how property taxation with a combined focus on energy efficiency and sustainable land use could contribute to a shift from efficiency to sufficiency.

A cross-national comparative study of the political and regulatory impact on the adoption of demand response in Denmark and Austria

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zheng Ma, University of Southern Denmark, Denmark

Henrik Tønder Aabjerg Friis, University of Southern Denmark, Denmark

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Panel

3. Policy and governance

Keywords

Demand Response, Policy and regulation

The energy sector is undergoing a green transition which entails the challenge of balancing electricity demand and supply. A way to deal with this problem is to make the electricity demand flexible by introducing demand response, which leads to new business opportunities and stakeholders in the market. Furthermore, the business opportunities for demand response and new stakeholders, like the so called aggregators (a service company that pools flexibility from customers and converts it into electricity market services), are strongly influenced by national and international policies and regulation. Therefore, this paper aims to investigate the business opportunities of aggregators and how aggregators, in the smart energy business ecosystem, are influenced by the changes in policy and regulation.

This research examines two case studies, Denmark and Austria. With qualitative research on several stakeholders in the smart energy ecosystem, a cross-national comparative study investigates the similarities and differences of policy and regulation related to the business opportunities for the aggregators in the demand response.

This research finds that the climate goals, regulation of energy prices and market structure are factors that are influenced by policy and regulation and will influence the adoption success rate of demand response most. The two ecosystems have many similarities, but also disparities. Currently, it is legally possible to enter the electricity market with the aggregated demand response in both countries, however, it only happens in Austria and not in Denmark.

The main differences between the two energy systems are the ambitious Danish climate plan to make Denmark carbon neutral by 2050 and the flexible tariffs in Austria to make the grid congestion visible to the consumers. Also, electrification and sector coupling should be considered to optimize the business opportunities for the demand response. The results of this

research contribute to understanding the political and regulatory factors which influence the adoption of demand response under different national frames and help smart energy market players to predict market opportunities and challenges in the future European energy sector.

Matchmaking tools and resources with needs on implementing the Energy Efficiency Directive policies

Vlasis Oikonomou, Institute for European Energy and Climate Policy, The Netherlands

Erwin Hofman, JIN Climate and Sustainability, The Netherlands

Mia Dragović Matosović, IEECP, Croatia

Pietro Falconi, ENEA, Italy

Ana Mostecak, Institute for European Energy and Climate Policy Stichting, The Netherlands

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Panel

3. Policy and governance

Keywords

local or regional energy efficiency measures, Energy Efficiency Directive (EED), assessments, overcoming barriers, operational tools

As a result of the Energy Efficiency Directive (EED) requirements, Member States implement policies on national, regional and local levels. In the implementation process of energy efficiency policies, several barriers hinder the adoption of the measures foreseen.

This article demonstrates the needs from policymakers in various governance levels (related to EED Articles) from a needs assessment survey carried out in the EC H2020 PUBLENEF project.

The main needs on a regional/local level are the insufficient budget, the lack of stakeholder's available time, the difficulty in mobilisation of local stakeholders, legislative issues that do not allow the launching of multigovernance energy efficiency policies, and finally the needs of simplification of administrative procedures and training of the senior staff on energy efficiency. At the same level, evaluations demonstrate a lack of energy modelling on the regional/local levels for energy efficiency policy planning, absence of monitoring policy outcomes on the local level, low enforcement process for not reaching local targets and finally the innovative financing means for energy efficiency are few for local levels.

To overcome these issues, several tools and best practices are developed in EU projects addressing the EED Articles. PUBLENEF shows that most best practices addressed Energy Audits and Management Systems, Technology issues and financing technical support (with an absence on practices on target setting and quality of savings).

Tools mainly address information and training, energy services, financing support, public procurement, while there are few or none on the role of public buildings, metering, billing, cost of

access to metering and billing, penalties, energy transformation, distribution, qualification – accreditation and certification schemes. This paper departs from evaluations and describes thus the reasons for the lack of such resources and suggests a focus for the EED Articles that require support.

STEP up! The competitive efficiency tender in Germany – step by step towards an effective new instrument for energy efficiency

Nora Langreder, Prognos AG, Germany

Lars-Arvid Brischke, Institut fuer Energie- und Umweltforschung Heidelberg, Germany

Friedrich Seefeldt, Prognos AG, Germany

Tim Chmella, Federal Office for Economic Affairs and Export Control, Germany

Panel

3. Policy and governance

Keywords

Energy Efficiency Directive (EED), tender, competitions, alternative measures

With respect to implementing Article 7 (Art.7) of the Energy Efficiency Directive (EED), the idea of an 'Energy Efficiency Tender' (EET) was introduced into the political discussion in Germany (cp. eceee 2015 paper 2-345). By the end of 2014, Germany presented the National Action Plan on Energy Efficiency with the new developed competitive efficiency tender (STEP up!), an innovative approach, which drew inspiration from the ProKilowatt tender scheme in Switzerland and adapted it to European regulations on state aid. However, the birth and early childhood of STEP up! was not that easy. The scheme had to be adapted to European state aid (and other) regulation, which led to constant loss of strength. The first tenders, starting in 2016, attracted few applications. After 3 years of constant support, STEP up! is strengthening its muscles and ready to leave the pilot stadium. However, sustained and joined efforts were needed to make the program more attractive, starting with the focus on the program marketing, a proactive program support and not yet ending with a continuous improvement of the leading parameters for the efficiency tender.

The paper reports about the practical experiences of the program owner and the evaluation team. The results of the first five call for tenders, the relevant tender parameters such as the cost / efficiency ratio will be presented. The initial setup and stepwise improvement of the tender design and the program architecture will be discussed. The paper addresses the challenges of bringing a new instrument into life with specific respect to the competitive efficiency tender.

Note. The progress of STEP up! is under constant evaluation (BfEE program evaluation) and the content of the paper has to be confirmed by the respective authorities. Before publication program owner BMWi and evaluation authority BAFA are to give their official final approval.

Energy poverty in the EU – indicators as a base for policy action

Florin Vondung, Wuppertal Institut for Climate Environment and Energy, Germany
Johannes Thema, Wuppertal Institut for Climate Environment and Energy, Germany

Panel

3. Policy and governance

Keywords

energy poverty, indicators, policy-making

In 2016, the European Commission presented the Clean Energy for all Europeans Package, comprising legislative proposals to facilitate the clean energy transition within the EU, such as the revised EPBD 2010/31/EU and EED 2012/27/EU. Besides putting energy efficiency first and achieving global leadership in renewable energy, a third goal of the package was to provide a “fair deal to consumers” with “no one left behind”. While in some Member States the issue of energy poverty already was on the political agenda, enabling affordable access to basic energy services for all households and thus reducing energy poverty is now an explicit policy target of the revised EU Directives.

In order to assess and monitor the extent of the issue across the EU and address it by suitable measures, the concept of energy poverty needs to be defined, operationalised and measured. The paper aims to investigate the role of energy poverty indicators for policy making. To do so, it provides an overview on existing measurement approaches. Furthermore, the paper presents the development and current state of energy poverty across the EU using a set of four complementary indicators used by the EU Energy Poverty Observatory. These consensual and expenditure-based indicators are calculated using data from the EU Survey on Income and Living Conditions and the Household Budget Survey.

In addition, the paper highlights peculiarities of results on the different indicators, describes persisting issues with regard to their calculation and interpretation against the background of the underlying data base.

Based on the results of this analysis, further necessities of data collection and research are pointed out.

Energy efficiency directive in figures: 5-year assessment of the annual reports submitted by member states

Marina Economidou, European Commission, Joint Research Centre (JRC) Ispra, Italy
Nicola Labanca, Institute for Energy and Transport - Joint Research Centre, Italy
Paolo Zangheri, Joint Research Centre, European Commission, Italy
Sofia Tsemekidi-Tzeiranaki, Network Research Belgium S.A., Belgium

Panel

3. Policy and governance

Keywords

efficiency trends, policy implementation, EU 2020 target, Energy Efficiency Directive (EED), energy efficiency obligation, public buildings

Following the adoption of the Energy Efficiency Directive (EED) in 2012, the EU Member States implemented various policies and measures to meet the Directive's requirements, including national energy efficiency targets for 2020. The progress made at national level is tracked through the annual reports notified by Member States to the European Commission in accordance with the EED Article 24.

To provide valuable insights of the actions taken by Member States towards increasing energy efficiency in various sectors of their economies, this paper presents a 5-year assessment of the Annual Reports since their first submission in 2013. Notably, the implementation status of key EED provisions such as Article 5 on the exemplary role of public bodies' buildings and Article 7 on Energy Efficiency Obligation schemes is discussed, providing a historical review on the progress made from the inception of various actions until now. The need of more efforts, in particular with the Article 5 implementation, is highlighted. The national contributions towards the EU 2020 target are also discussed, including an analysis of the latest energy consumption trends and reasons why energy consumption remained stable or increased in some Member States.

Alongside this analysis, the main energy consumption trends in 2005-2016 are examined and the impact of various underlying factors beyond efficiency such as activity effects, structural changes in national economies, weather are analysed. While the aforementioned factors are generally expected to drive up energy demand, continued commitment by Member States can ensure that the EU remains on track towards its 2020 targets and beyond. Lessons learned from the EED experience so far are drawn that provide valuable input for the successful implementation of the future requirements under the new Energy Union Governance.

A methodological framework to assess the gaps from national energy efficiency policies to local actions within a multilevel governance system

Valeria Zambianchi, UNEP DTU, Copenhagen Centre on Energy Efficiency, Denmark
Ksenia Petrichenko, UNEP DTU, Copenhagen Centre on Energy Efficiency, Denmark

Panel

3. Policy and governance

Keywords

energy efficiency policy, local and regional energy planning, cities, policy implementation, national energy efficiency plans

The role of cities has recently gained attention in the global energy arena, for instance during COP23, a delegation of 25 cities pledged to become carbon neutral by 2050. Scientific evidence shows that cities are essential partners to work with to achieve a sustainable energy transition, while organisations such as Covenant of Mayors, ICLEI and C40 are supporting the movement towards a larger inclusion of local institutions. Historically, local governments were considered policy-takers, as they tended to implement actions following the national energy agenda. Yet, despite the progress in the energy governance system, the local energy efficiency potential is far from being fully captured.

This paper aims at presenting a methodological framework to identify the gaps preventing municipalities from reaching their energy efficiency goals. Building upon theories of multilevel governance for energy policy, the paper presents an innovative methodology, assessing if and how energy efficiency policies and projects are translated from the national to the local level. The methodology includes the typology of gaps, defining commitment, action, coordination and replication gaps. Using the data collected during interviews with national and local policy makers and experts, the methodology is applied to a case study of five municipalities in Argentina.

The case study demonstrates that municipalities with the presence of a coordination gap tend to be embedded within the vertical typology of multilevel governance, while those with an action gap fall under the hierarchical type. Therefore, despite the progressive role of cities and local authorities, the dynamics between national and local levels tend to be top-down. With the presence of diverse gaps within the same nation-state, diverse typologies of energy efficiency governance are present. Conclusively, regardless of the typology of the detected gaps, the dynamics between local and national level are determinant for the success of energy efficient city actions, demonstrating that the increased role of cities and the change of the system of governance has not yet fully occurred.

What is the energy saving potential for financial subsidies under Article 7 of the EED? The case of the Greek household sector

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Alexandros Flamos, School of Industrial Management and Technology, University of Piraeus, Greece

Panel

3. Policy and governance

Keywords

subsidies, energy saving potential, SIR ratio, programme potential, evaluation

Greece ranks very low in energy efficiency across EU countries with the household sector suffering the most from the on-going recession and resulting energy poverty levels. Governmental efforts have thus far focused on financial support programs incentivising households with lower income levels to invest in EE and the arising question is set on what are the realistic potential for these subsidies in the Greek household sector. Most efficiency potential studies for the Greek building sector have thus far provided only some rough estimates on technical savings potential.

Our assessment develops these insights further by offering a more realistic analysis of the savings potential in the Greek household sector for financial subsidies. To do so we adopt a simple bottom-up economic-engineering method to determine the impact of financial subsidies on measure-specific product sales that builds on consumer behaviour as well as evidence from past programme participation rates. This approach allowed us to include a behavioural realism aspect to our estimates of potential savings for policy induced energy efficiency measures (EEMs) which is usually not included in energy efficiency potential assessments.

We combine the results of this assessment model with engineering estimates and cost-effectiveness (CE) calculations to determine measure-specific & aggregate savings potential for alternative financial subsidy scenarios. We extend our CE calculations to include ancillary energy security related benefits and compare these benefits to inferred costs at a measure and programme level by using the Savings-to-Investment-Ratio (SIR) index.

Finally we propose a rationale for determining the final portfolio of EEMs and estimate the total programme costs and benefits for financial subsidies when implemented in the Greek residential sector and until 2030. Through a careful consideration of the wider energy-security related benefits of EEMs and by applying the SIR CE screening at a programme level, we estimate that the energy savings potential, that can be achieved by a financial subsidy may range from 3% to almost

11% of existing household energy consumption, depending on the subsidy level. When compared to programme-level targets these are more ambitious suggesting that larger-scale investments than currently foreseen are required to capture these.

From a methodological perspective, our approach is resource-intensive and underlines numerous challenges notably relevant to additionality and uncertainty in model inputs and assumptions. Despite its limitations, we consider the proposed approach to be directionally reasonable and straightforward enough to allow estimating the effect of financial incentives on the market share for the multitude of measures that are usually assessed in EE potential assessments.

The proposed assessment framework, improves our understanding on how to estimate the energy efficiency potential that can be attributed to financial subsidies and highlights the importance of including evidence from ex-post analysis into ex-ante EE potential evaluations to more accurately reflect how these will perform in the future.

Criteria based approach for assessment of policy instruments for deep renovation of residential building in the Netherlands

Brijesh Mainali, Linnaeus University, Sweden

Krushna Mahapatra, Linnaeus University, Dept. of Built Environment and Energy Technology, Sweden

Georgios Pardalis, Linnaeus University, Sweden

Panel

3. Policy and governance

Keywords

policy instruments, deep renovations, residential buildings, assessments, Impact, Output

The building sector is responsible for more than 40% of the energy use and 32% of carbon dioxide emissions in the European Union (EU). Previous research has shown that the present rate of energy retrofit and refurbishment in Europe is far below (< 50%) than that is required to meet the EU's building related energy efficiency goals for 2020.

Appropriate policy interventions for deep renovation is perceived as a catalytic agent in promoting energy efficiency and leveraging more investments in the building sector. EU directives regarding Energy Efficiency reflects in various member states' national targets and policy measures to improve the energy performance of the existing building stocks.

Economic policy instruments seem to be influential in steering the deep renovation market, but this alone may not be sufficient for the sustainable growth of the market. There is a need for market-based approach to enhance the private sector involvement, both in terms of technical and financial capabilities.

This paper evaluates the policy instrument used for promoting deep renovation of residential buildings in the Netherlands. A "Theory-based evaluation" technique has been used in analyzing the content of the policy instrument, and the underlying theories and policies, at output and impact level. A set of the evaluation criteria have been applied for assessing such policy instruments in leveraging energy efficiency investments and their effectiveness in terms of energy savings.

The assessments are done based on the meta-analysis of relevant literature and data sources, and finalized in consultation with the Dutch partners from INNOVATE (Integrated solutioNs for ambitiOus energy refurbishment of priVATE housing) project under Horizon 2020. Further, the challenges for scaling up such existing effort for the sustainable growth of the deep renovation market has been explored.

Building energy efficiency progress in world-leading cities: what do the data show?

Adam Hinge, Sustainable Energy Partnerships, USA

David Ribeiro, ACEEE, Utilities, State, and Local Policy Program, USA

Panel

3. Policy and governance

Keywords

cities, building energy policies, world leading cities, energy data, CO2 emissions

Cities are often described as the policy laboratories where new policies can be tested, and cities are often cited as leading the world in new climate policies, including building energy efficiency policy activity. Many of the policies are adopted based on expected effectiveness in driving energy use reduction, though there has not been a lot of formal evaluation on the progress that cities have in reducing building energy use across a large economy. Some world-leading cities have in the past decade launched policy initiatives linked to close tracking of both energy and GHG performance from an established baseline, which provides an opportunity to review the real progress from the policies

This paper will review the progress on building energy reduction, normalized to economic activity and population where possible, in a small number of the globally recognized largest cities, including Tokyo and New York City. The paper will focus on those cities that have committed to ambitious building energy and GHG reduction policies (e.g. building energy benchmarking and cap-and-trade) and have done comprehensive annual progress reporting of both energy and GHG emissions down to building sector (e.g. residential, services, etc.) level. It will discuss data challenges with comparability of progress, and recommend additional data that might make future comparisons of relative progress more robust.

Near-term actions for transforming energy-service efficiency to limit global warming to 1.5 °C

Charlie Wilson, Tyndall Centre, United Kingdom

Nuno Bento, University of Lisbon, Portugal

Benigna Boza-Kiss, International Institute for Applied Systems Analysis, Austria

Arnulf Grubler, International Institute for Applied Systems Analysis, Austria

Panel

3. Policy and governance

Keywords

energy services, climate change mitigation, action, efficiency, transformation pathways, mobility, heating, consumer behaviour

A global 'Low Energy Demand' (LED) scenario published in 2018 shows how global warming can be limited to 1.5°C by transforming the way energy services are provided and consumed (Grubler et al. 2018). We follow up this long-range scenario study by setting out a wide range of near-term actions for improving energy-service efficiency through a combination of technological, organisational and behavioural innovation.

We focus on three energy services: heating and cooling in buildings, ownership and use of consumer goods, and passenger mobility. We identify a set of 28 actions across these three energy services ranging from multi-functional end-use devices and area-based procurement of whole-home retrofits to shared urban mobility services and open digital platforms. For each action we identify the lead implementation actor, scale of action, and the extent of policy and financing requirements. For selected actions, we also provide examples of best practice from around the world, drawing on both peer-reviewed and grey literature.

Finally we identify six basic strategies which are the means by which our diverse set of actions achieve their goal of transforming energy services: electrification, functional convergence, usership, utilisation rates, efficiency frontier, and user-oriented innovation.

Identifying what matters – the way forward in energy efficiency from a demand side perspective

Stefan M. Büttner, Institute for Energy Efficiency in Production (EEP) - University of Stuttgart, Germany

Diana Wang, Institute for Energy Efficiency in Production EEP, University of Stuttgart, Germany

Christian Schneider, Institute for Energy Efficiency in Production (EEP), Germany

Christoph Bihl, EEP Institute for Energy Efficiency in Production, University of Stuttgart, Germany

Panel

3. Policy and governance

Keywords

energy efficiency index, quantitative survey, industry, energy intensity, decision-making process

For more than five years now, the Energy Efficiency Index of the German Industry (EEI) describes a path for evidence-based decision-making on energy efficiency for companies, policy makers and financiers on the one hand, but also provides important evidence to decision- and policy makers that often have limited means to get an untainted view from the demand side's perspective - much needed after the German and European energy transition have focussed on supply side measures for a long time.

The industrial "demand side" can contribute significantly to limit global warming, increase energy efficiency and provide flexibility to the future energy system. To make this possible, it is essential to switch from a 'watering can' approach to an 'understanding the demand side' one. The EEI builds the foundation for shaping policies, and business models that take account of the needs, values and realities of key industrial sectors by reflecting businesses' perception of energy efficiency opportunities and (potentially lacking) policies. It allows specific comparisons across 27 economic sectors and the 4 company sizes (as defined by EC 2003). With the Barometer, this systematic is currently being extended and prepares the ground to objectively assess, inform and boost to accelerate energy efficiency as a whole.

This paper takes stock of the past years findings and gives an overview of the state of energy efficiency in industry in Germany and beyond and explores the gap between perception and action across sectors and company size, sectors and energy productivity which indeed matters in many aspects.

Electricity consumption in the service sector in Taiwan: cross-dataset calibration

Yu-Wen Su, Industrial Technology Research Institute (ITRI), Taiwan

Panel

4. Monitoring and evaluation for greater impact

Keywords

calibration, data connection

Energy statistics are the foundation of energy study, and correct data support reliable policy. Within the service sector in Taiwan, the “other service” consumes approximately 40% of electricity, higher than the wholesale and retail trade, based on the Bureau of Energy (BOE). Moreover, the electrical intensity of “other service” was 47.8 kWh/1000TWD, larger than that of industrial sector. These numbers seem to be unreasonable, due to the bias of industrial classification of electricity consumption. This bias, especially for the small and medium-sized enterprises (SMEs), was discussed in this study.

To obtain the correct data, an approach of cross-dataset calibration was proposed. Two datasets were connected:

One is users’ data of low-tension commercial electricity consumption from Taiwan Power Company (Taipower), which was directly classified to the “other service”. Another is firms’ tax information statements, which is one of the open data from the Ministry of Finance in Taiwan and updated every month. The common variables, which are address, company name and Government Uniform Invoice (GUI) number, are used as key variables to merge these two datasets and connect electricity consumption to a specific industrial classification. As the result, the correct and immediate industrial classification of electricity consumption was obtained.

More specifically, the calibration process consists of five steps:

- First, date rolling back of tax information ensures two datasets are time-consistent.
- Second, address data are cleaned and format is unified to increase the match rate.
- Third, datasets are integrated based on addresses, GUI numbers, or company names.
- Fourth, the belonging industry of electricity consumption is identified by rules.
- Finally, the electricity consumption of 19 industries is analyzed.

Out of 1,243,004 electricity users who consuming low-tension commercial electricity of 16,932 GWh in 2017, 61.5% of companies and 73.9% electricity consumption were classified to a specific industry. The integrated data were separated into three groups based on the match conditions:

- First, observations with two match conditions and one of which is address are those with high reliability (nearly 30.0 of electricity consumption).
- Second, matching through address but not company name or GUI number represents the

address has been transferred to other producer (18.5%).

– Third, matching through other conditions but not address, comparatively, represents the company still exists but has moved to other places (25.4%).

These transferring addresses and moving companies, which were not revised in the dataset of electricity consumption, are the main sources of the incorrect industrial classification.

All of the electricity consumption was originally classified to the “other service” but now is separated into different industries. Most of electricity was consumed by the wholesale and retail trade (5,383 GWh, 31.8%). Following was the accommodation and food service (2,063 GWh, 12.2%). These two industries were mainly consisted of SMEs. Not only the service sector, but manufacturing also consumed low-tension commercial electricity (2,055 GWh, 12.1%). Actually, the other service only consumed 329 GWh (1.9%) of electricity. These results indicate that classifying low-tension commercial electricity to “other service”, based on Taipower, leads to incorrect industrial electricity consumption, which may cause incorrect industry-related policy.

The cross-dataset calibration is an efficient approach to ensure the correctness of energy statistics, and can be referred by other countries or economies. The dataset of electricity consumption and tax information have already existed for years. All we have to do is connect them regularly to obtain the accurate distribution of industrial electricity consumption.

Monitoring campaign 2.0, an innovative way to produce energy statistics based on long-term electricity consumption measurement in 100 French households

Muriel Dupret, Independent Consultant, France

Therese Kreitz, ADEME, France

Nicolas Andreau, Enertech, France

Panel

4. Monitoring and evaluation for greater impact

Keywords

end-use metering, household consumption, user behaviour, end-use efficiency, energy monitoring, statistics

The residential sector with 36% of the total French electricity consumption in 2017 is the sector with the highest consumption. Despite a decrease in unitary consumption of numerous appliances, mainly due to European EuP directives, energy savings are negated by new additional consumption, possibly because of increased ownership level, appliance size, as well as emergence of new devices. Even though this is a major issue, there appears to be a basic lack of information on long term evaluation of the subject, which affects the capacity to implement appropriate actions.

In this context, the goal of the PANEL ELECDOM project, funded jointly by the French Energy Agency (ADEME) and the French Transmission System Operator (RTE), is to provide accurate household consumption data. Based on field measurement, it will allow to evaluate dynamically the evolution of the electricity consumption breakdown, as well as the impact of societal changes and the consumption patterns (products, behaviour). The intention of this research project is to continue over time in order to become a reference observatory of household equipment. The initiative aims at designing a neutral and unique platform which will provide baseline data sets. Simultaneously some analyses will be published annually.

Three thousand connected sensors will be installed in the electrical panel and directly to appliances in a representative sample of one hundred French dwellings in 2018. Data will be sent, checked then stored daily on an ftp server. Participants will also fill in a questionnaire in order to indicate the technical features of their equipment and their lifestyle. The paper will present the first results and describe this original approach targeting the most valuable use of electricity consumption monitoring at a reasonable cost. It will detail how it introduces a new way of producing statistics from real time field measurements and contributes to the assessment of demand side management policies.

The need of harmonization in energy efficiency policies: building a taxonomy for European industry

Anna Realini, RSE S.p.A., Italy

Simone Maggiore, R.S.E. (Ricerca sul Sistema Energetico) S.p.A., Italy

Erwin Hofman, JIN Climate and Sustainability, The Netherlands

Claudio Zagano, Ricerca sul Sistema Energetico SpA, Italy

Vlasis Oikonomou, JIN Climate and Sustainability, The Netherlands

Panel

4. Monitoring and evaluation for greater impact

Keywords

energy efficiency policy, harmonisation, industrial energy saving

The Energy Efficiency Directive 2012/27/EU (EED) has been the starting point for both the development and the update of energy efficiency (EE) laws and regulations in all the European Union (EU) Member States (MS). Moreover, CO₂ emission reduction goals at 2020 and 2030 have oriented MS towards stricter regulations on energy production and consumption. However, the application of the EED is not uniform across the different MS, and large differences persist in how national policy makers are responding to the achievement of emission reduction goals. Harmonization among different countries represents therefore a huge challenge.

The EU-MERCI project (acronym for “EU coordinated MEthods and procedures based on Real Cases for the effective implementation of policies and measures supporting energy efficiency in the Industry”), funded by the European Commission under the Horizon 2020 programme (Grant Agreement nr. 693845), tries to address such issue by developing a methodology to harmonize data from EE projects from different sources in different MS. Such methodology can be used as a basis for all EE policies and regulations across the EU and represents a fundamental tool of the project, as it allowed the building of the core products of the project, which are the EU-MERCI Database and Platform.

After highlighting the initial difficulty in aligning data on implemented projects incentivised through different policies in different MS, this paper describes the proposed harmonization methodology, which comprises a detailed “taxonomy” (defined on purpose), developed in order to allocate EE projects in pre-defined categories and to easily perform both the statistical analysis of almost 3,000 collected records and the extraction “Good Practices” of Energy Efficiency in the EU industry. A discussion about the integration of the methodology in local policies will be concluding the paper.

Reflections on representativeness of voluntarily recruited intervention participants compared to a unique nation-wide data set

Devon Wemyss, ZHAW Zurich University of Applied Sciences, Switzerland
Yann Blumer, Zurich University of Applied Sciences

Panel

4. Monitoring and evaluation for greater impact

Keywords

recruitment, intervention

Many energy-related intervention studies use voluntary recruitment of participants. Often findings from these studies are compared to a control group or the general population. However, typically only socio-demographic data is available for these comparisons, thus it is not possible to know whether the intervention participants are representative in terms of their living context, attitudes, or social influences. This raises questions related to the generalizability and scalability of the findings.

In 2016, as part of a Swiss energy research programme, a nation-wide panel was established to collect data on energy use behaviours in Swiss households. Importantly, contextual and psychological variables were collected, along with socio-demographic information. This data is compared to items measured in baseline studies of three energy behaviour studies in Switzerland (details in slides). The three Swiss studies aimed at: 1) household electricity savings through a neighbourhood challenge, 2) replacing the car with an e-bike, and 3) using alternate modes of transport for sports teams. The results of the studies suggested that all three interventions were effective in reducing energy consumption.

As it was not possible to compare all four data sets across items beyond socio-demographic variables only individual studies were compared to the national dataset where possible. There were clear differences of socio-demographics between the interventions and the overall population, which can be explained by the study design (i.e. target group addressed). For example, in study two, which was aimed at car owners, participants had significantly more cars than the Swiss average. Similarly, study three focused on recreational sports teams and this resulted in a lower average age than the population.

Less intuitively, differences in environmental attitudes and social norms are not always in line with what could be expected considering the study contexts. For example, in study one, a neighbourhood challenge, the participants indicated that they feel less pressure from their family

and friends to save energy (injunctive norm) as compared to the general population. But they did think that more people around them actively save energy (descriptive norm). Indeed, the study one participants felt significantly more obligated to save energy. The range of responses show that while the participants may be more environmentally conscious of their consumption in some areas, they nevertheless also exhibit typical 'unsustainable' behavioural patterns, similar to the general population.

This exploratory analysis highlights the challenges in comparing study impacts, and questions assumptions around the expected representativeness of voluntarily recruited participants. Comparing results is challenging and thus efforts to implement standardized questions, such as suggested by IEA-DSM Task 24, can make this exercise easier and help identify (more) effective schemes. However, specific behaviour is strongly embedded in the individual's context, and thus reported behaviour may be better used as a proxy for awareness.

For interventions that target a very specific behaviour, choosing specific channels and programme framing can elicit a self-selection bias which can be beneficial for the effectiveness of the study (i.e. a mobility intervention that addresses heavy car use), albeit more challenging for researchers to compare results. On a more general level, this analysis highlights the need in energy social science research to reflect very carefully whether transferability or effectiveness is more important for scalability of the approach and generalizability of the results.

What can connected thermostats tell us about American heating and cooling habits?

Alan Meier, Lawrence Berkeley National Laboratory, USA

Tsuyoshi Ueno, Central Research Institute of Electric Power Industry, Japan

Marco Pritoni, Lawrence Berkeley National Laboratory, USA

Leo Rainer, Lawrence Berkeley National Laboratory, USA

Abigail Daken, U.S. Environmental Protection Agency, USA

Dan Baldewicz, ICF International, USA

Panel

4. Monitoring and evaluation for greater impact

Keywords

connected thermostat, cloud control, HVAC, behaviour, big data, survey

At least five million American homes have Internet-connected thermostats. These devices improve comfort and reduce energy consumption using cloud-based algorithms. Every five minutes, they collect and transmit detailed operating information, including thermostat setpoints, actual indoor temperatures, occupancy, and HVAC operation.

One thermostat provider established a program that enables customers to anonymously “donate” their data to researchers and more than 50,000 customers have opted in. This dataset represents the most comprehensive public data on home temperature preferences for North America and provides far more detail than any previous method based on surveys or monitoring programs. The data show in detail preferred temperatures while occupants are home, sleeping, and away.

On average, these households lower their thermostats about 1°C when they are asleep compared to when awake, though this average conceals both widespread constant operation and deeper setbacks. The peak usage of air conditioners in Texas was shown to precisely match the grid’s systemwide peak.

The connected thermostats also raise a survey research question: when should policymakers rely on a small sample of rigorously selected buildings instead of a huge, unrepresentative sample with detailed data? Many fruitful applications of this dataset will be constrained by privacy protections and reluctance of firms to share information.

The German national climate initiative – evaluation of its impact and success factors on the occasion of its 10-year anniversary

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Angelika Paar, IFEU - Institut für Energie- und Umweltforschung Heidelberg, Germany
Julia Repenning, Öko-Institut (Institute for Applied Ecology), Germany
Hans-Joachim Ziesing, INCOMPLETE ADDRESS, Germany
Kerstin Tews, Environmental Policy Research Centre, Germany
Maria Rosaria di Nucci, Freie Universität Berlin, Germany
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Carina Zell-Ziegler, Environmental Policy Research Centre, Germany
Christian Nissen, Freie Universität Berlin, Germany
Lothar Eisenmann, Öko-Institut (Institute for Applied Ecology), Germany
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Panel

4. Monitoring and evaluation for greater impact

Keywords

evaluation, monitoring, climate policy, mitigation potential, National Climate Initiative, Germany

The German National Climate Initiative (NCI) presents one cornerstone of the German Government's ambitious plans to reduce GHG emissions. It was initiated in 2008 to contribute to the German climate targets and addresses businesses, consumers and local authorities in areas with significant efficiency and mitigation potentials that cannot be tapped by other instruments. The NCI stimulates behavioral change and investment towards energy efficiency and lower GHG emissions by bringing together different actors, initiating local initiatives, reducing barriers and setting examples for multiplication and imitation.

The NCI supports diverse projects and programs including campaigns, broad and specific information programs, local energy/climate concepts as well as stimulus programs for efficient street lighting, commercial cooling systems or household-scale cogeneration facilities. Each program/project addresses at least one target group: consumers, municipalities, business and/or

education. In the last decade, the NCI has funded more than 25,000 projects for around 800 million Euros.

The NCI is the first German climate program which has been subject to policy evaluation from the very outset. A systematic theory-based methodology was developed to master the challenges connected with the broad range of intervention types. Clustering interventions according to the program logic and mapping their causal chains proved very useful to discern the different levels of impact related to different types of intervention.

This paper describes the activities carried out under the NCI, presents the evaluation approach and illustrates the findings of the evaluation (on investments, GHG reduction, employment effects etc.). We find substantial differences between information-based and investment-based activities, and between the various information-based project approaches. Moreover, the paper describes success factors and lessons learned that could also be helpful in other contexts.

Everything you always wanted to know about evaluation but were afraid to ask: a new toolbox to answer your needs

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Boonekamp, TNO, The Netherlands

Jean-Sébastien Broc, IEECP, France

Panel

4. Monitoring and evaluation for greater impact

Keywords

evaluation, online tool, energy efficiency policy

Evaluating the impacts of energy efficiency policies can be complex and tricky. There is a lot of experience available, which can make it difficult when one looks for answers to specific questions. The EPATEE project developed a toolbox to support stakeholders to find the right resources that fit their needs.

The toolbox helps defining their evaluation approach with an interactive user interface that provides users with practical guidance tailored to 30 combinations of sector, policy instrument and method for evaluating energy savings. The toolbox is primarily focused on ex-post impact evaluation.

The specific guidance for energy savings calculations takes into account the diversity of situations (e.g. evaluation objectives, level of expertise, data availability) and covers methodological (e.g. defining the baseline, factors to take into account) as well as practical (e.g. data collection, quality, resources needed) aspects. Other guidance was developed or gathered about cross-cutting issues, such as evaluating net energy savings or comparing estimated and measured energy savings.

In addition, links to or storage of existing resources have been arranged to provide an easy access to guidance about general principles and approaches of evaluation other than impact evaluation (e.g. process evaluation, cost-benefit analysis, market transformation). Likewise, this deals with evaluation of impacts other than energy savings. Feedback from stakeholders also showed the importance to include guidance about how to integrate evaluation into the policy cycle.

This short paper describes briefly the background and how the toolbox was developed. It is illustrated with examples of evaluations that can be done with the toolbox. The display will make it possible for participants to test and comment on the toolbox. This is meant for all types of users, from beginners to evaluation experts.

What role do transaction costs play in energy efficiency improvements and how can they be reduced?

Katja Hünecke, Öeko-Institut (Institute for Applied Ecology), Germany
Katja Schumacher, Öeko-Institut (Institute for Applied Ecology), Germany
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Hauke Lütkehaus, Universität Oldenburg, Germany

Panel

4. Monitoring and evaluation for greater impact

Keywords

cost benefit, cost effectiveness, barriers, overcoming barriers, transaction costs, energy services

Ex-ante policy evaluation requires a detailed understanding of how the subjects addressed by the policy react to its implementation. In the context of energy efficiency, policy measures typically aim at influencing investment decisions towards more efficient options.

As has been discussed widely in the context of the “energy efficiency gap”, investments in energy efficiency improvements are frequently not conducted even though they seem cost-effective from a simple cost-benefit perspective, where transaction costs have been identified as one important barrier.

While transaction costs have been discussed widely from a conceptual perspective, empirical studies quantifying transaction costs and measures to reduce them are rare. This paper presents approaches, results and insights from a recently completed research project funded by the German Federal Energy Efficiency Center (BfEE), addressing transaction costs in various energy efficiency measures and the role of energy efficiency services to overcome the barrier.

We analyse a set of 11 energy efficiency investments covering private households, public institutions and the industry sector. We gather data on direct investment costs and energy cost savings and provide a detailed analysis of the various barriers and transaction costs associated with the implementation. We then analyse the costs of existing energy efficiency services using data provided by the BfEE. We compare the different cost elements and analyze the potential of energy efficiency services to reduce transaction costs.

We find that the role of transaction costs differs substantially between households, public institutions and companies and that the impact of energy efficiency services on transaction costs needs to be evaluated using different methodological approaches. We conclude that while data

availability on disaggregated transaction costs is a major challenge, energy services can reduce transaction costs considerably.

Monitoring efficiency and impact of the energy efficiency and renewable energy measures in the residential sector

Tadeja Janša, Josef Stefan Institute, Energy Efficiency Centre, Slovenia

Andreja Urbancic, Josef Stefan Institute, Energy Efficiency Centre, Slovenia

Barbara Petelin Visočnik, IJS, Slovenia

Gašper Stegnar, IJS, Slovenia

Panel

4. Monitoring and evaluation for greater impact

Keywords

monitoring, cost efficiency, monitoring efficiency

As more and more data are available every day we can now develop more detailed analyses than ever before. However, we must pay attention to the comprehensive understanding of the subject specifics and be careful when evaluating and interpreting the results. For the purpose of the research the subsidies for energy efficiency and renewable energy measures in the residential sector (buildings) on a national and municipal level were observed. The subsidies are granted by the Eco Fund, a public fund specialised in promoting environmental actions.

The main goal of this research was to:

- Analyse the cost efficiency of the implemented measures and
- Develop climate indicators on the municipal level.

The cost efficiency of the paid subsidies targeted at the CO₂ emission reduction and energy savings in households was evaluated. Ex-ante and Ex-post analysis were carried out with the focus on measures for increasing renewable energy use (installation of solar thermal collectors, heat pumps, biomass boilers etc.). The effects of these measures were assessed using the methods for determining energy savings, which were applied in line with the Article 7 of the Energy Efficiency Directive (2012/27/EU). Cost efficiency of the measures in Ex-post varied from 853 €/tCO₂ for the solar thermal collectors to - 614 €/tCO₂ for the air to water heat pumps. Cost efficiency of the measures in Ex-ante varied from 418 €/tCO₂, again for the solar thermal collectors, to - 282 €/tCO₂ for the water to water heat pumps.

Results presented are focusing on wood biomass boilers only. The Ex-post analysis was carried out for the “old” and the implemented new technologies, and the Ex-ante analysis was carried out for the “reference” and the implemented new technologies. The boilers were divided into the groups according to the type of the biomass used (pellets, chips, logs) and the nominal heat output. Results show that most commonly the boilers from the groups with the lowest heat output (≤ 25 kW for chips, ≤ 20 kW for logs) were installed, except for the pellet fired boilers, where upper

medium group (> 27 and ≤ 30 kW) was the most common. From the CO₂ emission reduction point installing high heat output boiler was more efficient than low heat output boiler where cost efficiency varied from - 2 to - 257 €/tCO₂ in Ex-post and - 53 to -172 €/tCO₂ in Ex-ante analysis.

The climate indicators developed on the municipal level were designed in order to get the information on how active the residents are in the implementation of the energy efficiency and renewable energy measures and to observe the differences across the country. To get an overview about the actions taken an application “Local climate action scoreboard” was designed. Two of the indicators from the scoreboard refer also to the energy efficiency and renewable energy measures in households triggered by the Eco Fund subsidies. In 2016 those subsidies stimulated an average annual investment of around 59 € per capita.

Energy poverty in households is an important issue as almost 40 % of households can't afford to implement renewable energy and energy efficiency measures. Due to the lack of data, it is a challenge how to design an appropriate energy poverty indicator and how to track it properly. Additional steps will be needed to further develop this indicator and to get useful data for research in this area.

The research gave not only an insight into the climate actions in the residential sector but also a more detailed, holistic look into the matter. In addition, differences in the use of subsidies among the households from different income groups have been analysed as well. The analyses performed includes the elements of the future monitoring system for the Integrated National Energy and Climate Plan (NECP) for the years 2021 to 2030, where energy efficiency and climate actions play an import role.

The pitfall of a single indicator to rule them all? Evaluation of the performance of the French housing stock in the light of various indicators

Marie-Hélène Laurent, EDF - R&D Département ENERBAT, France

Stanislas Nösperger, EDF - RD, Département TREE, France

Dominique Osso, EDF-R&D, France

Fabienne Boutiere, R&D EDF – Department Technologies & Research for Energy Efficiency – Group Residential Housin, France

Panel

4. Monitoring and evaluation for greater impact

Keywords

energy efficiency indicator, building energy certification, energy efficiency policy, energy saving potential

The energy performance of a building can be evaluated with various indicators that will not give the same rating. This study evaluates the performance of the French housing stock in terms of several indicators based either on the energy stage (primary, final or energy needs), carbon emissions, or the energy bill.

An indicator calculated at the 3 stages of the energy chain allows a sequential approach to the building's performance: the "useful energy" stage measures the performance of the envelope's, the "final energy" stage adds the performance of the equipment providing the energy services, and the "primary energy" stage associates the performance of the energy sources.

It is proposed to focus on comparing the indicators of French and British Energy Performance Certificates (EPCs). The European Union has widely disseminated the EPC for housing through the 2003 EPBD (Energy Performance in Building Directive). Originally, with the exception of the number of seven energy classes, Member States were free to choose the details of "national" EPC's calculations. Most of European countries – including France - have chosen a scale in absolute values to define performance bands and an indicator at the primary energy stage for energy performance. UK chose on a relative scale and an indicator in energy bill.

The impact of the different proposed approaches on the evaluation of the performance of the French housing stock is analysed. The relevance of the indicators is discussed according to two criteria: the nature of the actors to whom the evaluation is addressed (households, planners, policies), and the objectives of the actions that the evaluation should guide (improvement of the housing performance, lower energy consumption and carbon emissions, reducing energy bills). As

the recent revision of the EPBD requires that the energy performance of a building is expressed by means of a numerical indicator of primary energy use, this study shows here all its interest.

Monitoring the German market for energy efficiency services – 5 years of hunting an unknown animal

Dominik Rau, Prognos AG, Germany

Friedrich Seefeldt, Prognos AG, Germany

Dominik Jessing, ifeu - Institut für Energie- und Umweltforschung Heidelberg GmbH, Germany

Ann-Cathrin Horward, BAFA, Germany

Panel

4. Monitoring and evaluation for greater impact

Keywords

energy services, monitoring, evaluation, evaluation methods, ESCO market development, ESCO market query

The energy service market in Germany has experienced continuous growth over the last decade. The German Federal Energy Efficiency Center (BfEE) is responsible for monitoring the energy efficiency service market (EESM) and for its further improvement according to the German Act on Energy Services and other Energy Efficiency Measures (EDL-G). The BfEE furthermore supports the Ministry for Economic Affairs and Energy in matters regarding energy efficiency by inter alia supervising evaluations of funding schemes.

Together with a scientific team, a robust methodology to observe and evaluate the development of the EESM has been developed and further optimized. For about five years, BfEE and the scientists have been chasing the timid animal called EESM, albeit it has tried well to hide in the forest of standard economic statistics.

Built upon continuous efforts regarding the standardization of services and definitions thereof, mapping the field so to speak, a tight net is cast through a large survey: each year more than 6000 telephone interviews in households, public institutions and in private (large & SME) companies were carried out on the demand side and more than 10.000 listed suppliers are invited to an online query.

The fourth market query was carried out between July and October 2018. It aimed to update and specify the findings of the previous study. A new challenge was the adaptation of the concept to the public sector (with an equivalent of 500 telephone interviews and an online questionnaire). The present study examines, if the fur of the animal is big enough to give a proper coat for the German 'Energiewende'.

Both the official federal and the scientific perspective of the monitoring team are covered by the

authors of this paper. They will discuss the challenges of tracking a not always very visible animal, but are also giving also in-depth insight in different market segments of the energy consulting, energy management and energy contracting market in Germany.

Analysis of international residential solar PV self-consumption

Eoghan McKenna, UCL Energy Institute, United Kingdom

Simon Elam, UCL Energy Institute

Ellen Webborn, University College London

Philip Leicester, Loughborough University

Panel

4. Monitoring and evaluation for greater impact

Keywords

self-consumption, photovoltaics, economic viability

How much do solar PV panels reduce electricity bills? Despite over 800,000 households with solar panels in the UK today, we do not have a firm answer to this simple question. This is because the empirical data necessary to calculate solar self-consumption is not widely available; an issue common to many countries.

Without electricity metering that records solar generation, imports and exports, it is impossible to know exactly how much solar power is being used directly in the home, and as a result, how much solar panels actually reduce electricity bills. As many countries reduce state subsidies, the revenue stream from avoided grid imports (i.e. self-consumption) becomes increasingly critical for the economic viability of PV. Quantifying this potential revenue is also vital for the solar industry to evaluate the potential benefits of battery storage and flexibility services.

This paper will help to address this knowledge gap by analysing a previously unused dataset of electricity readings from over 1,300 households with solar panels located across the UK, USA, Australia, Germany, the Netherlands, and Belgium. The results quantify how much solar power is self-consumed and how this varies between different countries and households, highlighting the importance of improving data availability for 'behind-the-meter' micro-generation. The findings will be relevant to regulators for making evidence-based decisions about solar energy policy and provide better information about potential self-consumption to people interested in adopting solar panels.

Gained in translation: evaluation approaches for behavioural energy efficiency programmes in the US and Canada

Sea Rotmann, SEA - Sustainable Energy Advice, New Zealand
Kira Ashby, Consortium for Energy Efficiency, USA

Panel

4. Monitoring and evaluation for greater impact

Keywords

behavioural change, behavioural savings programmes, data monitoring, evaluation methods, impact evaluation, persistence

One of the greatest challenges of behavioral energy efficiency programmes in North America is verifying savings and getting credit for them. The US Department of Energy, together with the Consortium for Energy Efficiency (CEE) and its 76 US and Canadian utility members, joined a global behaviour change collaboration through the International Energy Agency (IEA DSM Task 24) to tackle this difficult problem, together, in 2018.

This paper will be co-authored by the Operating Agent for IEA DSM Task 24, together with the National Expert for the US. The paper and presentation will share what has been learned from project researchers and practitioners, and analysed international best practice on evaluating behavioural programmes. The focus of the US work on this collaboration has been on better understanding which evaluation methodologies and approaches have strengthened the credibility of behavioural programmes in North America. This includes insights on regulatory frameworks and barriers North American utilities are facing. We also analysed studies on the persistence of energy savings after a behavioural programme has ended, and have helped assess the effectiveness of behavioural programmes on hard-to-reach customers.

The work on this project took place in the United States and Canada but has included insights from international Task 24 case studies. It is a comprehensive synthesis and analysis of proving what works, how long and for whom when implementing behavioural savings programmes and interventions.

Integrated resource analysis in energy-intensive industries

Jonathan Cullen, University of Cambridge, United Kingdom

Ana Gonzalez Hernandez, Emerson

Panel

4. Monitoring and evaluation for greater impact

Keywords

resource efficiency, exergy analysis, Sankey diagrams, control and monitoring devices

A clear rationale exists for using resources more efficiently in industry. However, despite the energy and material interactions that exist in industrial processes, most efficiency studies still analyse energy and materials separately, providing only partial insight into potential savings. At the same time, companies collect large quantities of energy and material process control data for historical records, but rarely utilise this data to provide system-level efficiency metrics and decision support. In response, a new methodology—called Integrated Resource Analysis—has been developed to evaluate the combined energy and material efficiency of energy-intensive industrial processes.

The research is a collaboration between the Resource Efficiency Collective at Cambridge University and the global automation solutions company, Emerson. The methodology is built on four key components:

- i) the extraction and reconciliation of bottom-up process control data or statistical data to quantify energy and material flows;
- ii) the conversion of energy and material flows into a single metric, exergy;
- iii) the visualisation of system-level resource flows with Sankey diagrams;
- iv) the exploration of potential efficiency savings using integrated metrics for both energy and material resources and benchmarking results against other plants, historical performance and physical efficiency limits.

The new methodology is demonstrated using three industrial cases studies, at different scales and with data from varying sources: ammonia production (using simulated data), global steel production (using statistical data), and basic oxygen steelmaking (using process control data). The results reveal that savings from material efficiency can be as high as from energy efficiency and are linked to upstream energy consumption and emissions. In each case study, the challenges of balancing data availability, confidentiality, quality and uncertainty make for interesting discussion.

The impact of the 'Waste Checker'; an application that generates automated household specific insights and advices

Margriet van Lidth de Jeude, ECN part of TNO, The Netherlands

Casper Tigchelaar, ECN part of TNO - Energy Transtion Studies, The Netherlands

Lieke Dreijerink, ECN part of TNO

Panel

4. Monitoring and evaluation for greater impact

Keywords

automated household specific insights and advice, real energy data linked with survey data

The 'Verspillingschecker' (Energy Waste Checker) is an application launched by a Dutch energy supplier. The application is offered to clients that use their smart thermostat. Clients can download the app at their devices of choice (smartphone, lap/desktop, tablet). The application generates automated household specific insights and advices about where energy is wasted in a user's home. During the measurement period of this research (December 2017 until May 2018) in total 7 appliance-specific insights (about dryer, washing machine, fridge, dishwasher, stand-by usage, thermostat, showerhead) and 3 overall insights (about total gas for heating the home, gas for heating water, and overall electricity use) were made available.

TNO was asked to measure the impact of the application. We set up a field experiment with an experimental group with smart thermostat and Verspillingschecker app (N= 53.931), and a control group without smart thermostat and Verspillingschecker app (N=38.868). For both groups weekly gas and electricity consumption were measured. A post-experimental online survey about the topics of this study was filled out by 5000 participants. 3.858 Users (almost 2000 per group) gave permission to link their household energy data to their survey answers.

With these data we are generating answers to the hypotheses below:

1. The experimental group shows a 5-10% stronger change in energy usage than the control group.
2. The experimental group will on average show a stronger change in attention, interest and desire to take measures, attitude towards the measures addressed and the amount of measures taken, than the control group.
3. The data collected by the Verspillingschecker application is adequate for detecting inefficient energy usage.
4. The Verspillingschecker app does increase awareness of:
 - a. energy conservation potential
 - b. which energy conservation measures are of interest

At the ECEEE conference TNO presents the results.

Approach, learnings and way forward for the State Energy Efficiency Index in India

Sangeeta Mathew, Alliance for an Energy Efficient Economy, India

Steven M. Nadel, American Council for an Energy Efficient Economy (ACEEE), USA

Satish Kumar, Alliance for an Energy Efficient Economy, India

Sandeep Kachhawa, AEEE, India

Panel

4. Monitoring and evaluation for greater impact

Keywords

energy efficiency index, energy efficiency indicator, State EE Index for India

The Alliance for an Energy Efficient Economy (AEEE) under the leadership and guidance of NITI Aayog and the Bureau of Energy Efficiency (BEE) has developed the first State Energy Efficiency Index (SEEI) for India to help drive EE policies and program implementation at the state and municipal level.

The first edition of the SEEI assessed states' policies and regulations, financing mechanisms, institutional capacity, adoption of energy efficiency policies and the resultant energy savings achieved in buildings, industries, municipalities, transportation, agriculture and electricity distribution (DISCOMs).

The SEEI has 63 EE indicators in all, 59 across buildings, industry, municipalities, transport, agriculture and DISCOMs; and 4 cross-cutting indicators. The indicators are both qualitative and quantitative, which include outcome-based indicators as well to signify realisation of the intended performance outcomes for various EE policies.

The SEEI categorises states based upon their efforts and achievements towards energy efficiency implementation as 'Front runner', 'Achiever', 'Contender' and 'Aspirant'. The Index puts a spotlight on best practices and encourages healthy competition among states, and aids in identifying areas for energy efficiency intervention by state as well as local actors per the provisions of the Energy Conservation Act, 2001.

This paper shall delineate the data collection approach followed for the first SEEI and how it can help track progress in managing states' and India's energy footprint. The paper shall also suggest a framework to streamline EE indicator data collection involving all state stakeholders with the State Designated Agencies at the epicentre to better monitor and evaluate energy efficiency interventions in all demand sectors, thus contributing towards state and national energy data management in India.

Impacts of India's large scale LED bulb programme

Aditya Chunekar, Prayas (Energy Group), India

Panel

4. Monitoring and evaluation for greater impact

Keywords

evaluation, LED, incandescent light bulbs, market transformation

India's Unnat Jyoti by Affordable LEDs for All (UJALA) is arguably the world's largest zero-subsidy LED bulb program for households. More than 300 million LED bulbs have been sold under the program since its launch in 2014.

Overall demand for LED bulbs in India has gone up by 50 times since 2014 and the retail price has dropped to a third. Energy Efficiency Services Ltd. (EESL), its public sector implementing agency, is now using the program model to sell energy efficient ceiling fans, air-conditioners, agricultural water pumps, and other equipment in India as well as other countries. In this paper, we present the impacts of the UJALA program in India. The primary objective of this study is to draw lessons to increase effectiveness of the existing UJALA program, and to aid the design of similar future programs in India and abroad.

We consider three key aspects to assess the overall program impact. First, we look at the program's impact on India's lighting market and the response of manufacturers, suppliers, retailers, testing laboratories and certifying agencies. We then examine the change in consumer behavior that can be attributed to the program. Finally, we evaluate the effectiveness of the different processes employed under the program.

We employ a combination of desk and field research to evaluate the impact. The desk research includes market research reports, technology reports, tender documents, and policy/regulatory submissions. The field research includes surveys and in-depth interviews. We conducted surveys of 1029 households in three cities and 445 rural households in one district in India. We also conducted survey of 150 retailers to understand the impact of the program on their sales. Our in-depth interviews cover manufacturers, independent technical experts, electricity distribution companies, and public sector agencies.

What makes you peak? Cluster analysis of household activities and electricity demand

Aven Satre-Meloy, University of Oxford, Environmental Change Institute, United Kingdom

Philipp Grünewald, ECI - Energy Group. Environmental Change Institute, University of Oxford, United Kingdom

Marina Diakonova, ECI - Energy Group. Environmental Change Institute, University of Oxford, United Kingdom

Panel

4. Monitoring and evaluation for greater impact

Keywords

peak load, household electricity, cluster analysis, demand response, time use, demand patterns

Researching the dynamics of energy consumption at finely-resolved timescales is increasingly practical with the growing availability of high-resolution data and analytical methods to characterise them. One of the methodological approaches that has recently become popular for exploring energy consumption dynamics is load profile clustering. Despite an abundance of available algorithmic techniques, clustering load profiles is challenging because clustering methods do not capture the temporal aspects of electricity consumption well and because cluster results are difficult to validate without detailed auxiliary data. These challenges make it difficult to use cluster analysis to better understand drivers of different electricity consumption patterns. We address these challenges by applying a novel approach to a unique dataset of high-resolution electricity data, household socio-demographics, and occupant time-use data for a sample of 135 UK households.

Clusters can be identified for typical electricity use patterns and linked to activity patterns underlying these. We use this detailed data to validate load profile clusters, exploring how different socio-demographic data and patterns of household activity explain electricity consumption trends, focusing primarily on late afternoon and evening hours in the UK (4-9 pm), during which peak demand occurs.

We present peak-period clusters and the household characteristics and activities driving their demand. We show how such an approach can aid in segmenting classes of consumers to develop more targeted strategies for demand reduction and response interventions. This knowledge can be used to better understand the constraints and opportunities for a more flexible demand-side in the electricity sector.

Quantification of energy savings from energy conservation measures in buildings using machine learning

Alexander Severinsen, Storekeeper AS, Norway

Rob Hyndman, Department of Econometrics & Business Statistics, Monash University, Australia

Panel

4. Monitoring and evaluation for greater impact

Keywords

energy savings calculation, IPMVP, energy saving methodology, gradient boosting

This paper demonstrates how machine learning is used to measure energy savings from energy conservation measures (ECMs); in particular ECMs with a low expected saving. We develop a model that predict energy consumption in buildings on an hourly level. The model is trained on energy data from the main meter before the ECMs took place. The model is then used to predict energy consumption after the ECMs.

The difference between the prediction (the estimated energy consumption in the building given no ECMs) and the actual usage is the estimated savings. According to the International Performance and Verification Protocol (IPMVP) using data from the main meter is a recommended option when the collective savings of several ECMs are analysed, and the savings are expected to be large.

For ECMs where the expected savings is less than 10 % the IPMVP recommends system simulation or installation of sub-meters to isolate the ECMs. However, when performing smaller ECMs (< 10% expected savings) the added cost of installing sub-meters and/or undertaking system simulation could turn a previous positive cost-benefit analysis into negative taking into consideration the increased cost of measurement and verification.

For this purpose, we show that recent developments within predictive modelling will enable the building owners to quantify energy savings from ECMs where the expected saving is less than 10 %. The model has a feature set of 32 different variables that can explain energy consumption in buildings. For example, calendar-data, minimum, maximum, and average temperatures last 12, 24 and 36 hours. Based on this feature set the model chooses the variables that best explains the energy consumption in each building. Results from analysis in 9 Norwegian grocery stores suggests that our methods are able to detect and quantify savings from small ECMs, thus a cost-efficient and viable alternative to simulation and installing sub-meters.

Gotta catch 'em all – catches to evaluating heterogeneous energy efficiency programmes

Fabian Voswinkel, Fraunhofer Institute for Systems and Innovation Research, Germany

Panel

4. Monitoring and evaluation for greater impact

Keywords

evaluation, evaluation methods, energy efficiency policy, energy policy, impact evaluation, policy mix, comparing evaluation

Think about policies! When do you consider policies successful? Ideally, successful policies strive to take influence in an efficient and effective manner to reach a defined goal. However, when it comes to asking about the efficiency and effectiveness of policies, one challenge is well known: How to verify whether these conditions are met? The answer is good evaluation practice.

The German Energy Efficiency Fund, a special budget of the Federal Ministry of Economic Affairs and Energy (BMWi), finances more than twenty national programmes to support energy efficiency in businesses, households and the public sector. The heterogeneity of the programmes ranging from energy savings check-ups for households to large-scale financial support programmes for energy efficient technologies in industry makes evaluation even more challenging. For evaluating the Fund in its entirety, a way had to be found to catch them all and present them in a harmonised way. Therefore, an evaluation system, which encompasses a definition of indicators, savings metrics, effects and additional assumptions was developed and applied.

This paper provides an introduction to the evaluation methodology. It focuses on practical catches for adequately covering the wide range of programmes. A major catch that lies within a uniform methodology for heterogeneous programmes is the interpretation of results. While using indicators to compare evaluation results between different programmes sounds appealingly simple, direct conclusions are often misleading. The success of a programme is very individual and an equal value of e.g. savings per Euro of funding does not necessarily mean that two programmes are equally successful. Detailed examples for such catches from the up-to-date evaluation of the Fund are presented in this paper and suggestions are made for avoiding premature conclusions from multi-programme evaluations.

Monitoring and evaluation of a policy is essential – what is sufficient?

Ulla Suomi, Motiva Oy, Finland

Panel

4. Monitoring and evaluation for greater impact

Keywords

energy policy, impact, impact evaluation, monitoring, data collection, voluntary agreements, multiple benefits

From the beginning, since 1997, when the policy ‘Voluntary energy efficiency agreement scheme’ was established, it was seen that the monitoring and evaluation of the results have a critical role. Among the main commitments for companies and communities they have an obligation for annual reporting.

A well-functioning monitoring system has had a central role in revealing the results, create trust and credibility among all agreement parties and in achieving long-term top-level commitment. It has clearly been one of the success factors in the scheme. Reliable results and communication of results has led to increasing motivation and further improving results, i.e., a circle of positive development has been created.

Data gathered via a good monitoring system also gives a possibility to more robust evaluations to find out possible issues to be taken into account in the new agreement periods. While monitoring includes, in addition to the energy efficiency measures and their energy savings, also other obligations in the agreements it has also helped to report several other reporting requirements in EU reporting.

In the beginning the monitoring system served purely national purposes. During the continuation of the scheme evaluation system has evolved due to e.g. needs and requirements of EU legislation (ESD/EED). This also means that in addition to the operational costs there always need to be some resources to develop the system.

Even we have a long-lasting experience of monitoring the biggest energy efficiency policy in our country, it is sometimes a challenge how to fulfil all different and changing reporting requirements and needs. In general, should be clearly be kept in mind that it is easy to write several strict requirements for monitoring and evaluation – more grey hairs will appear to implement requirements in practice. Sometimes it seems that the pragmatic and important “keep it simple” principal is contradicting what is sufficient.

CREATE: a toolbox to develop, implement and monitor advanced energy and climate goals and strategies

Martin Jakob, TEP Energy GmbH, Switzerland

Benjamin Sunarjo, TEP Energy GmbH, Switzerland

Claudio Nägeli, Chalmers University of Technology, Sweden

Giacomo Catenazzi, TEP Energy, Sweden

Holger Wallbaum, Chalmers University of Technology, Sweden

York Ostermeyer, Chalmers University of Technology

Panel

4. Monitoring and evaluation for greater impact

Keywords

urban model, local and regional energy planning, climate policy, local energy policies

Various environmental and regulatory changes, such as climate change mitigation strategies and market regulations, have increased the complexity of the challenges to which cities, utilities, and real estate owners are faced. Thus, cities and their utilities are confronted with various problems: How, and at which costs can ambitious climate change mitigation goals be reached? How can urban planning be developed while simultaneously tackling climate change? How can the long-term economic and environmental performance of the building stock be optimized? How to plan electricity, gas, and thermal networks according to future energy demand and the existing urban topology?

These problems are usually addressed individually and independently from each other using instruments that lack an interdisciplinary approach. Data gatherings are often done “ad hoc” and not from a systemic point of view, resulting in datasets that are often incomplete, incoherent, with different structures that make them impossible to merge.

The paper reports on a comprehensive modelling and data toolbox, the Carbon Resource Energy and Adaption Toolbox Europe (CREATE) to overcome these shortcomings. This toolbox includes elements that are specially conceived for different use cases of decision makers (and their service providers): urban planners, energy utilities, grid and network operators, building portfolio owners, building code designers and implementers, energy and climate policy makers. CREATE has two main elements:

- GIS-bound scenario analysis tool for urban and utility energy planners, providing evaluation and management of energy demand, emissions, renewable energy resources, and other parameters.
- Simplified web-based spatial data information, monitoring and visualization tool for smaller

municipalities and utilities.

- **PortfolioBSM:** Building portfolio assessment tool for real estate portfolio owners and managers to guide the decision-making processes of portfolio owners (or external service providers). The tool provides expert users with a framework to analyse the status quo of their portfolio and the possibility to develop short and long-term strategies in terms of economic, energy and carbon performance.

As such CREATE enables to engage with the various decision making levels and bodies of cities, municipalities, and real estate portfolio owners.

Useful energy balances as means to monitor energy efficiency policies impact and progress – example of the innovative approach in Colombia: data challenges and methods comparison

Felipe Toro, IREES, Institute for Resource Efficiency and Energy Strategies, Germany

Fabio Gonzalez, National University in Colombia and Corpoema

Carlos Garcia, Energy and Mining Planning Unit in Colombia - Energy Ministry Colombia

Eliana Lopez, IREES GmbH and Freiburg University

Jan Steinbach, IREES GmbH

Ulrich Reiter, TEP Energy GmbH

Andrea Palacios, TEP Energy GmbH

Humberto Rodriguez, National University in Colombia and Corpoema

Bibiana Trujillo, Corpoema

Panel

4. Monitoring and evaluation for greater impact

Keywords

policy impacts, data availability

Useful Energy Balances as means to monitor the impacts and progress of energy efficiency policies is still in its infancy despite the fact that the European Union and Brazil have been conducting such balances since the late 1970s. The international comparison conducted by the authors indicates that 5 Latin American countries have prepared Useful Energy Balances and have used it as an energy planning and policy tool. In Europe only Finland and Austria have generated Useful Energy Balances while 31 EU countries calculate applications for heat and cold uses or even more detailed as the case of Switzerland and Germany. Useful energy is defined as the energy available to final consumers after the last conversion by energy-consuming equipment, i.e. final energy minus conversion losses (Eurostat, IEA, 2009, Pardo et al., 2012).

This research was developed within the framework of a policy consulting project funded by the Energy Planning Unit in Colombia, adjacent to the Ministry of Energy of Colombia from August 2018 with the objective to create the Methodological Framework to calculate the first Useful Energy Balance for Colombia and develop a tool for quantification of losses as well as estimate an

energy efficiency gap.

This paper discusses: 1. the challenges and difficulties in obtaining relevant sectoral data (industrial heat and cold technologies, transport mode efficiencies, residential technology efficiencies for different altitude levels, etc.) and its related uncertainties for each demand sector in an international comparison context; 2. recommends methods for data collection (surveys, measuring), 3. discusses the quantification of energy losses as well as the energy efficiency gap and necessary investments, and 4. analyzes the possibilities for useful energy balances as a tool for monitoring energy efficiency policy progress and impact.

CO₂ assessment methods for electric heating in France

Florence Khayat, ENGIE, France
Cristian Muresan, ENGIE Lab CRIGEN, France

Panel

4. Monitoring and evaluation for greater impact

Keywords

electrical heating, CO₂ abatement, CO₂ assessment

Calculation of CO₂eq content is a rather straight-forward task for fossil fuels as it derives mainly from combustion equations. It is much more complex for electricity, since it is not a naturally available energy but an energy vector (it does not emit greenhouse gas (GHG) at the time of consumption, but during production). At a given moment, the kilowatt hour (kWh) consumed on the grid comes from a mix of the different energy sources used to produce it.

The CO₂eq content of the electric kWh corresponds to the CO₂eq emissions generated by the production of this kWh of electricity. Thus, to know the emissions related to the consumption of an electrical appliance, one question arises: how the electrical system responds to the corresponding demand and by what means of production? GHG emissions depend on the plants called to meet the demand, and therefore the production mix.

Determining the exact relationship between electricity consumption and the corresponding CO₂eq emissions requires precisely associating a means of electricity production with this consumption. The electrons circulating freely on the electrical network, it is however impossible to know the exact origin of the current supplying electrical use at a given moment. Therefore, how to estimate the GHG emissions generated by an electrical appliance knowing that the means of production mobilized vary at each moment to respond to the variability of demand? The choice of the method depends on the objectives sought.

What calculation method can be used to evaluate the CO₂eq content of electricity in the two following cases: the achievement of an overall measurement of GHG emissions and the establishment of a long term action plan to reduce these emissions? This article is dealing with all these questions using various calculation methods.

Each question involves selecting the most relevant allocation method:

– To define an overall balance, the average calculation methods are the most suitable : The average methods are all based on the simple principle of dividing GHG emissions from a given electricity production by all the electricity produced or consumed associated with that electricity production. Various variants are existing seasonal and per usage ones and with various time steps (yearly, monthly etc). For the French context where an important part of the power production is

done by nuclear power plants the results are the following ones: monthly method by use provides a CO₂eq content about 80g/kWh, seasonalized method by use (focused on the generation sources requested by the peak load) provides a CO₂eq content up to 210g/kWh. These methods have structural limitations but also related to the integration of various renewables sources to the grid. Moreover if these average methods make possible to differentiate the CO₂eq content of a kWh according to its use and period, it does not make possible to asset the effect of a variation in consumption, upwards or downwards, on the electric production plants.

– The marginal methods are consequential methods focused on the generation systems that, at the margin of the mix (current or prospective), can respond to an increase or a decrease in demand. These methods are based on physical, technological and economical behaviors of the electricity ecosystem and dedicated to support energy policies. In order to properly decide investment choices in the framework of an energy policy, it is necessary to use a prospective vision, to take into account future changes in the generation fleet (e.g. construction or not of a new nuclear power plant) and the impacts on the power demand and associated GHG emissions. The use of the marginal method on the historical French mix, the marginal CO₂eq content values are between 450 and 550g/kWh.

A European standard on the topic, under CEN/TC371 is being published for public inquiry. We will expose the variety of methods introduced in this standard, as well as impacts on policy makers.

Mapping the energy community cooperation chains

CS SEBI, GRENoble ECOLE DE MANAGEMENT Univ Grenoble Alpes ComUE, France

Anne-Lorène Vernay, GRENoble ECOLE DE MANAGEMENT Univ Grenoble Alpes ComUE, France

Julien Doutré, GRENoble ECOLE DE MANAGEMENT Univ Grenoble Alpes ComUE, France

Panel

5. Smart and sustainable communities

Keywords

energy communities, sharing economy

In response to growing concerns about climate change and the will to take individual actions, citizens increasingly want to be involved in renewable or sustainable energy development projects. This involvement can take different forms, from, for example, financing only via crowdfunding platforms to co-governing when a local energy cooperative is created. Many argue that involving local communities is crucial to help accelerate the energy transition. It is often key to overcome NIMBY opposition (Not In My BackYard) and can provide additional sources of financing. Besides setting up an energy community can be a way to strengthen the local economy and the local social fabric.

In this paper, we argue that besides looking at individual initiatives, it is important to study the cooperation chain (Becker, 2008) that supports their creation and growth, and more generally, to position these communities in a “world” of citizen led energy production. The paper intends to benchmark the structure of citizen led energy production “world” in two countries, namely France and The Netherlands, to better understand what is key for such cooperation chains to function.

These two countries present different level of maturity. Indeed, The Netherlands has a high density (in relation to its population) of communities engaged in energy management solutions. And France which is maybe less mature compared to The Netherlands but where a momentum is starting. Ultimately, our objective is to map the chains of cooperation in order to understand why certain work better than others and to derive preliminary recommendations to facilitate the development of energy communities.

The Vallastaden model – alternative urban governance and energy system designs

Wiktorija Glad, Linköping University, Sweden

Madelene Gramfält, Sweden

Panel

5. Smart and sustainable communities

Keywords

governance, urban planning, design, local energy system, infrastructure, building design

In 2017, the new city district Vallastaden hosted an urban planning and housing exhibition to show the innovative and sustainable results of “the Vallastaden model”, a cross-sectoral governance concept and energy system designed at local level in Sweden. The concept cut across sectors such as energy, housing, transport and local businesses. One of the core features of the concept was quality criteria-based land sale. These quality criteria included alternative energy systems such as the design of passive and plus-energy housing, design diversity and renewable construction material, e.g. timber frames.

This research analyses energy relevant European Union Directives as implemented at local level: the alternative urban governance concept “the Vallastaden model” and resulting diversity and alternative energy designs. Research questions are: how was alternative urban governance possible and how was the “Vallastaden” concept implemented?

The research is a detailed case study, based on an analysis of public documents from the local council, interviews with stakeholders and field observations. The results show how for several years the concept was part of the political processes at local level, publicly debated and in focus during post-election periods, but survived and was eventually embraced by several political parties along the left-right scale.

The implementation followed one of the core ideas of the concept: Diversity in architectural design and design of energy systems as well as housing tenure. In contrast to the visible diversity “above ground”, the underground energy system has one single designer: the local publicly owned energy company, which implemented an innovative infrastructure culvert for all basic energy services.

The conclusion is that, under the pressure of joint challenges such as housing shortages, local economic constraints and low-emission carbon goals, alternative urban governance concepts can emerge which provide long-term commitments and joint efforts across sectors and political party agendas.

Is heat storage with a possibility of district heating beneficial to Solar Plus micro grids

Marko Kovač, Energy Efficiency centre of Jozef Stefan Institute, Slovenia
Stane Merse, Energy Efficiency Centre, "Jozef Stefan" Institute, Slovenia
Andreja Urbancic, Josef Stefan Institute, Energy Efficiency Centre, Slovenia
Damir Staničić, Energy Efficiency Centre at Jozef Stefan Institute, Slovenia

Panel

5. Smart and sustainable communities

Keywords

photovoltaics, heat storage, solar thermal, Solar Plus, battery storage

The substantial drop in prices of photovoltaic installations and battery storage causes Solar Plus concept, which incorporates photovoltaic panels with battery and smart installation, is becoming more and more viable for self-sufficient households, especially in remote areas, where building essential energy infrastructure (such as power lines) might not be economical.

In addition - scattered populated areas (typical for Slovenia) means that similar approach is also appropriate for villages or smaller parts of towns, where several near-by households could form a micro-grid.

Trying to meet a household energy needs with only photovoltaic production and battery storage is still somewhat pricey. However, adding heat storage devices into the micro Solar Plus energy mix seems like a feasible option, which would also benefit from possible additional local or district energy source (e.g., biomass).

A simplified but proven numerical model is used covering most important features of micro-grids, including solar power production, battery and heat storage and heating. The model accounts for the main influences: the weather pattern, load curves and roof orientation. This enables some additional insights into micro-grid capabilities and dynamics. The obtained data and knowledge serve for additional actions in decarbonization of households.

Sufficiently engaged? How smart metering systems help local authorities become smart cities

Richard Bull, Nottingham Trent University, United Kingdom

Graeme Stuart, De Montfort University, United Kingdom

Leticia Ozawa-Meida, Institute of Energy and Sustainable Development, De Montfort University, United Kingdom

Ken Dooley, Granlund, Finland

Panel

5. Smart and sustainable communities

Keywords

smart cities, smart metering, local authorities

A significant cultural shift occurred recently with the majority of the world's population now living in cities and contributing over two thirds of global carbon emissions (UNEP, 2015). If countries like the UK are to meet their challenging carbon reduction targets, 80% by 2050 for the UK, then how our cities are governed and managed to maximize energy efficiency is of vital importance. Faith is increasingly being placed in what are commonly referred to as 'smart cities' to meet these targets.

Most visions of these smart cities though revolve around increased ICT efficiency through what has become known as the 'digital economy.' Smart meters are an example of this and offer clear potential for automated meter readings and innovative displays to help energy managers as well as facilitate better engagement of building users. Evidence is limited on the impact and challenges of ICT tools that genuinely attempt to engage building users across all levels of the organisation. This paper contributes to that evidence base by presenting findings from the H2020 EU-funded project EDI-Net (Energy Data Innovation Network). The project has designed three energy focused ICT tools with specific functionalities:

- 1) to track energy performance and communicate this performance in a user-friendly way (energy data dashboard and league tables),
- 2) to facilitate communication between stakeholders (online discussion forum), and
- 3) to manage intervention plans for energy efficiency (energy efficiency benchmarking tool). Do these tools come anywhere near fulfilling the potential of smart cities?

The paper presents results of feedback from interviews with selected building users about the individual, social and institutional changes prompted by the EDI-Net ICT services in the three participating public authorities during the operation of EDI-Net: Leicester, Catalonia and Nuremberg.

A smart and sustainable vision when assessing a smart urban renovation project: an application example

Stanislas Nösperger, EDF - RD, Département TREE, France

Nicolas Damesin, EFFICACITY, France

Cédric Chenot, EUROPOLIA, France

Valérie Furio, Toulouse School of Economics, France

Panel

5. Smart and sustainable communities

Keywords

district heating, economic assessment, community energy systems, non-energy benefits (NEBs), employment

Smart and sustainable urban districts are key to address the challenge raised by cities' impact on climate change. First, they foster energy mutualisation and optimal use at a district space; secondly, they enable the integration of thermal and electric renewable energy sources (RES). However, smart district projects lead to increased up-front costs that related energy savings cannot payback alone. However, such projects generate non-energy impacts which are very seldom taken into account in the economic assessment, although they are underlined in academic studies.

This paper proposes an operational assessment of potential co-benefits of a real smart energy project for an urban district currently under renovation and extension. The project considers a partial or total integration of thermal RES in a district heating and the integration of a collective renewable power production capacity.

The hereafter presented assessment process focuses on four main impacts, each of them on a specific relevant territorial scale. Two impacts are macro-economics at a regional scale:

- direct, indirect and induced employment impacts related to the different district energy planning scenarios; and
- employment impacts of the reintroduction in the economy of the saved energy expenses assessed in each scenario compared with the reference scenario.

Health impact is considered at the city or district scale and is related to the implementation of energy-recovery from train braking technologies leading to the substitution of PM-emitting braking solutions by cleaner ones.

Finally, the monetized CO₂ emissions related to energy consumptions are considered at a world wide scale. Such operational economic assessment of non-energy benefits supports political

decision which are very seldom based on the sole consideration of mere financial payback from energy efficiency. However, the valuation of created or maintained jobs remains controversial and needs further discussion.

How much demand-side flexibility can a community deliver? A multi-agent modeling approach

Inês Reis, INESC Coimbra, Portugal

Carlos Henggeler Antunes, INESC Coimbra - Department of Electrical and Computer Engineering, Portugal

Marta Lopes, INESC Coimbra, Portugal

Ivo Gonçalves, INESC Coimbra, Portugal

Panel

5. Smart and sustainable communities

Keywords

Demand-side flexibility, Multi-agent systems

The on-going transformation of energy systems into a decentralized renewable-based model, in which end-users have a more active role, brings new challenges that need considering energy systems at a community scale. Energy communities have gained momentum as promoters of collective actions to generate, store, manage and trade local energy, allowing their members to increase their energy autonomy with potential savings and environmental benefits.

Research on energy communities has mostly focused on households and urban areas that have been modeled as purely residential, although they also include services, industry and cross-sectoral activities, with their own characteristics and energy consumption patterns. The annual demand of services and industry is similar to the residential sector, but their load profiles are noticeably distinct.

This paper proposes a multi-agent modeling approach to exploit the influence of demand-side flexibility of different activities within an energy community. This type of modeling is adequate for the representation of socio-technical systems as is the case of energy communities, in which members may play different changing roles over time in function of interactions with other members and the environment. Special emphasis is given to the behavioral dimension associated with agents' decision processes and preferences such as comfort and cost thresholds.

Agents included in the model and their roles are as follows:

- Grid agent: provides the energy required by community members and buys the excess of energy produced by the community.
- Residential agents: prosumers and consumers are represented by distinct agents with different consumption profiles and flexibility patterns regarding electricity cost and comfort. All prosumer agents have photovoltaic generation and may have storage systems (static or EV batteries). Generally, the prosumer agent prefers to consume from his resources (generation and storage). In

surplus generation scenarios, prosumers may negotiate with the coordinating agent to sell energy to the community. Consumer agents prioritize the purchase of energy from the community instead of the grid and may use EV battery when cost thresholds are exceeded or community availability is compromised.

- Service sector agents: represent a primary school, a restaurant and an office building. Data from ventilation, space cooling and heating, lighting and equipment are included in the model. Since some energy services (as lighting) would be difficult to manage without jeopardizing quality of service, only ventilation, space heating and cooling and some equipment flexibility are exploited.
- Public lighting agent: requires community resources to meet the community lighting service. In case of resource shortages, a dimmable profile is displayed requiring less resources.
- EV charging station agent: also requires community resources. In case of abundance of resources, fast charging is provided. In resource shortage periods, slow charges are provided.
- Coordinating agent: manages the available demand-side flexibility while interfacing with the power grid. It forecasts the prosumers and community generation status and grid purchase prices for the next 24 hours. It optimizes prosumers and consumers load flexibility to offer resources to the remaining community agents.

Self-sufficiency indexes are created to quantify how much energy demand can be locally supplied through different generation scenarios. The revenues obtained through energy transactions within the community and between the community and the grid are quantified. The results show the impact of synergies of demand-side flexibility of the different activities according to economic, technical and environmental indicators.

Acknowledgement:

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Developer-driven sustainable communities: lessons from a case study of The Sustainable City in Dubai

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Panel

5. Smart and sustainable communities

Keywords

sustainable communities, zero-emission houses, developers, intentional community, Middle East

In Dubai, a private developer conceived, built, and now manages, a gated community called “The Sustainable City” (TSC), with more than 2,000 residents, shops, a school, and a hotel. TSC was purpose-built to consume almost no energy and be especially frugal with water, harnessing cutting-edge technologies and green building practices to promise residents both efficiency and luxury.

But can a culture of sustainability be cultivated to ensure the behaviors requisite for achieving sustainability goals in developer-driven planned communities?

A long history of grassroots intentional communities demonstrates how a culture of sustainability emerges from the design of the built environment together with the shared purpose of engaged residents. In developer-driven planned sustainable communities, residents may not cohere around a common vision; they may lack knowledge regarding sustainable practices; and they may not develop relationships amenable to sharing resources and getting social and economic needs met within the community.

This research investigates the community culture of TSC, with attention to similarities and differences relative to grassroots intentional communities with sustainability goals. TSC has managed to attract residents who subscribe to the sustainability ethos, create a sense of community, and foster informal social interaction, yet a minority of residents participates in community affairs in a meaningful and regular way.

The social aspects of community have largely been facilitated by the management, which does not seem to be economically sustainable. Key to TSC’s success is that the developer has remained involved and been able to iteratively improve the physical design and systems, as well as social structure, to adapt to changing conditions and residents’ needs. Lessons for other developer-driven sustainable communities are drawn from this case study.

Unfolding organisational and behavioural demand response in SMEs toward smart(er) energy communities

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Panel

5. Smart and sustainable communities

Keywords

SME, demand response, smart grid, organisation behaviour, behaviour

Demand response (DR) is currently recognised as a key resource to balance supply and demand in a context of significant amount of intermittent renewable generation. Demand-side flexibility in the timing and magnitude of energy consumption is expected to be provided by different sectors. Although DR in the residential sector has been thoroughly studied, other activities have been less exploited, particularly concerning organisational and behavioural factors to reach effective engagement and participation in DR programs. A recent DR pilot in businesses launched by the Portuguese Energy Services Regulatory Authority (ERSE) had limited success due to a reduced level of participation. This work proposes a multidisciplinary approach to assess DR barriers and enablers in Small and Medium Enterprises (SMEs) to support the design of pilot DR programs aimed to a context in which SMEs represent most of businesses. In Portugal, SMEs account for 99,8% of total enterprises, employ 67% of workers in the private sector and represent 58% of labour productivity.

Often, SMEs do not have specific expertise on energy management, thus being a relevant target for DR research, namely to understand how they will cope with DR challenges. In this setting, problem structuring methods are used to identify the main stakeholders, their interests, roles and actions. A set of 20 interviews were performed to SMEs selected based on the technical potential of controllable demand-side resources and the impact of business sectors on national electricity consumption.

Different dimensions are assessed to identify potential barriers and enablers for SMEs enrolment in DR programs. A critical analysis of the regulatory framework and identification of associated barriers is done, also providing policy recommendations for the design of more effective DR programs.

Preliminary results show that, as a main actor, the Portuguese government translates EU energy policies into national policies, regulations and financial incentives, which are implemented by

governmental agencies and the regulator. ERSE is currently launching a public consultation on the smart grids regulation.

Electric utilities, such as distribution system operators, transmission network operators and producers, are also particularly interested in exploiting DR as a flexible energy resource, while retailers and aggregators aim to trade it through commercial offers. Industry, commercial and consumers' associations represent their partners' interests and benefit from a trusted relation with them, being privileged actors during the public consultation and providing support during contracts' negotiations. Manufacturers are responding to DR challenges by developing "smart" appliances able to be remotely controlled thus enabling energy usage flexibility. The scientific community promotes knowledge on DR, with results being disseminated within the community and society. The SMEs interviewed comprise business activities that represent around 57% of total electricity consumption, including industry, agriculture, water supply services, education, offices, commerce, restaurants and transportation.

The interviews allowed to identify potential barriers and enabling factors for SMEs enrolment in DR programs, related to behavioural (awareness, literacy, inertia, attitudes, privacy), organisational (energy management and DR as an institutional activity with defined formal tasks and attributed responsibilities, compatibility with the organisation's activities), technological (smart metering, energy management systems, safety of operation, standardisation, equipment's smartness), economical (savings, financial incentives, financial risk), and commercial factors (complexity of tariffs, commercial offers and contracts).

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ICT for sustainability: reflecting on the role of ICT to enhance communication and empowerment of building users

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Panel

5. Smart and sustainable communities

Keywords

behavioural change, feedback, energy conservation, ICT-based behaviour change, User engagement

ICT solutions within a Smart City environment are often hailed as the low carbon, efficient and low-cost solution – but is this sufficient? These solutions often neglect user behaviour and treat users as passive consumers or even obstacles. Energy related ICT behaviour change is also starting to appear more frequently at the forefront of policy agendas and research funding calls as a prime focus for reducing energy consumption and improving efficiency across all energy intensive sectors.

Research shows that improving and widening user engagement has the potential to foster greater acceptance and impact. Recent research has focused on behaviour change towards more sustainable energy use, often involving users co-designing interventions. As such, ICT is a prominent tool, with its application including feedback tools, apps, interactive dashboards and gamification.

Frequent barriers are user engagement with ICT tools, both initially and over the long term, with research consistently showing that users are hard to engage, face a complex array of competing demands and easily become disengaged with energy programs and interventions. This paper presents a summary of some of the common problems relating to user engagement with energy interventions faced by many research projects, as well as presenting findings from eTEACHER, an EU H2020 project, aimed at empowering energy end-users by enabling behaviour change via a set of ICT solutions.

eTEACHER, aims to employ principles of user-involvement and engagement to enhance the design of an ICT-based tool promoting energy conservation in buildings. eTEACHER has applied the 'Enabling Change' framework as a novel approach to ensure user engagement and stakeholder involvement. Results and reflections are offered from eTEACHER's implementation of

the Enabling Change framework and the engagement of building users within the eTEACHER pilot buildings, surrounding the design and implementation of an ICT-based tool.

Reflections are given throughout on rethinking how we engage with citizens and our success in identifying, engaging and eliciting feedback from building users. The real-world issues and constraints are explored alongside, and opportunities are identified for improving energy efficiency using an evidence-based intervention design in practice and discusses how ICT can aid the empowerment of building users towards their own energy use.

Smart home technology enabling flexible heating demand: implications of everyday life and social practices

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Panel

5. Smart and sustainable communities

Keywords

flexible demand, smart home technology

Integrating households into the energy system is considered a potential strategy for a low-carbon future, where balancing energy production and consumption becomes a challenge due to the intermittent and fluctuating nature of renewable energy sources. Time shifting electricity demand related to appliance use or heat pump production has been a focus in recent research, whereas heating consumption in district heating systems has received less attention.

However, smart home technology (SHT) has been highlighted as a solution in which increased automation of heating could lead to balancing the supply and demand. SHT can enable households to be flexible energy hubs where heating can be stored, time shifting energy consumption to avoid peak-demand problems. Based on a review of the technical components of SHT, combined with a review of user engagements with SHT, we create a classification of SHT in a district heating system. Exploring several cases in real-world settings in the context of Denmark, we highlight the implications of everyday life and social practices when integrating SHT for enabling a flexible heating demand.

While SHT may empower users with control of space heating (increased awareness and engagement with heating consumption), new notions of comfort and convenience may result in new and more energy-demanding practices, resulting in less flexibility within the district heating system. Based on these reviews, this paper underlines how active engagement with SHT is entangled in practices of everyday life and that, when integrating SHT to enable flexible heating demand in households, the role of everyday practices requires careful consideration.

Don't waste the water, use wastewater – excess heat distribution for private households through sewer networks

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Panel

5. Smart and sustainable communities

Keywords

excess heat, wastewater, district heating, households

Private households accounts for a quarter of the EU's final energy demand. Approximately 80% of this is used to provide heat and hot water. 84% of this heat is generated from fossil fuels. The provision of space heating by means of environmentally friendly district heating is regarded as an important lever for the decarbonisation of the building sector. In this respect, one of the EU's targets is to find heat sources for district heating networks that emit no or few GHGs.

In this context, industrial excess heat is often discussed as possible supply option. However, if this heat is far away from district heating networks, then the construction of new infrastructure is capital intensive. This can lead to low economic efficiency.

For this reason, the existing sewer network offers a solution with an existing infrastructure. Here excess heat can be transferred to the wastewater with heat exchangers, which leads to a rising wastewater temperature. The energy quantity of the wastewater is then taken at another point along the flow direction of the sewer and used as heat source for a heat pump. The raised wastewater temperature then leads to the heat pump being operated more efficiently.

However, the potential for transporting excess heat via sewer networks has not yet been assessed and we are therefore carrying out such an assessment.

We use a data set of more than 900 industrial sites and more than 26,000 sewage treatment plants.

- First, for a given set of industrial sites with information about excess heat, we identify the nearest sewage treatment plant.
- Second, we determine the maximum distance and the flow direction of the wastewater.
- Third we calculate the heat loss in the sewer network.

Our results demonstrate that transferring heat via the sewer network offers high theoretical potentials. In conclusion, in the overall dataset the average heat loss in the sewer network is smaller than 15%. Further research is needed to quantify the economic and technical potential.

Moving towards sustainability: insights from district heating, water systems and communal housing projects in local communities

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Panel

5. Smart and sustainable communities

Keywords

sustainable communities, district heating, water management, housing, municipalities

Services such as energy supply, water supply and wastewater management or housing are part of daily life and are usually provided on the municipal level. They all play an important role in a transition towards sustainability. In this contribution we report on findings from a project where sustainability innovations ('niche') from three different areas were analysed.

Cases included:

- (1) innovative low-carbon heat grids using renewable sources or waste heat,
- (2) sustainable water management, and (3) community housing addressing people of different ages.

The case studies are based on a series of semi-structured interviews (n=69 from 16 cases), document analysis and expert workshops. The paper addresses the following research questions:

Q1. What is the stage of development of the niches under study?

Q2. What are the similarities and differences in the case study's drivers and barriers that have arisen between the fields of action and what conclusions can be drawn from these insights in order to maximize success factors or to minimize obstacles in advance?

Q3. What are potential synergies between the three fields of action?

Overall the housing niche seems to be the one that is most established while the level of diffusion is lowest for water projects (Q1). Furthermore, we find that all niche projects rely on municipal support, that strong networks are important to accelerate learning curves and windows of opportunities are a precondition for success (Q2).

However, while some of the relevant factors are similar across the cases it is very difficult to create synergies in real life and is hardly ever achieved (Q3). Starting from these findings we discuss in

how far initiatives in the field of community housing could serve as local nuclei to trigger further sustainable developments in other fields and present recommendations for how this could be achieved. We finally discuss the implications for local sustainability governance.

Energy efficiency in the district heating sector – an analysis of the Renewable Energy Directive regarding alternative feed-in options

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Panel

5. Smart and sustainable communities

Keywords

district heating, heat feed-in, waste heat, Renewable Heating Law, RED II, legislation, Energy Efficiency Directive (EED), Directive on Electricity Production from Renewable Energy Sources (RES)

How much has legislation changed concerning alternative feed in into an existing district heating (DH) network?

In this article, we address the research question whether the current version of the Renewable Energy Directive (RED) provides an effective and efficient regulatory framework for cost-efficient integration of renewables and waste heat into existing DH systems.

As of today, feed-in of waste heat into DH systems through third parties requires in many countries private-law agreements between the feed-in company and the DH network operator. In the course of opening the DH network, the first and third stages of the value chain of DH supply, i.e. production (upstream market), trade, and distribution (downstream market) shall be subject to free competition. The second stage of the value chain, the DH network, would be preserved as a natural monopoly.

While the European Commission's original proposal of the RED had foreseen mandatory uptake of heat from renewable sources and waste heat, the current version of the Directive requires opening of the DH networks for third party feed-in only if it is technically and economically feasible for the DH network operator. This milder version of opening DH networks to third party feed-in was a precondition for achieving political agreement in June 2018. Hereof, questions arise if the RED in its current form goes far enough to unleash the economic and environmental potential of opening the DH networks to renewable and waste heat from third parties, or if this would only happen under a more ambitious regulation? We further add to the debate by presenting an economic mechanism design analysis and by deriving a respectively optimal regulation for a better integration of renewables and waste heat into the DH system and therefore, an open heat market.

A middle-out strategy for shaving summer peak demand: findings from a field study

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Panel

5. Smart and sustainable communities

Keywords

middle out

July and August are the warmest months of the Israeli summer, with temperatures rising daily above 30°C. The air-conditioner penetration rate is higher than 90%, and during summer middays they are responsible for more than 50% of residential electricity consumption. Because Israel's electricity generation is based on fossil fuels, the mid-week summer peak demand hours (10:00-17:00) are the most expensive and polluting. Thus, 'peak shaving' has both economic and environmental benefits.

In a first of its kind, controlled field study, a 'middle out' (MO) strategy was developed and applied for reducing mid-week summer peak demand in two local communities (Kibbutzim). The MO strategy focuses on middle actors as agents that can induce change from the middle out, exerting influence via their networks in three directions: downstream (on end users), upstream (on suppliers and regulators) and sideways (on other communities). All interventions in the study were discussed with and mediated through the local middle actors (community key-figures) and middle platforms (communication channels and procedures).

The study took place in the summer of 2018 in two Israeli Kibbutzim, Yakum and Hazorea (n(Y)=66, n(H)=258 households). In both Y&H: (a) demand was monitored via smart meters, (b) generic and tailored SMS messages were sent twice a week during peak hours, and (c) economic incentive (~\$43) was offered to households that either saved 10% of their electricity during peak hours compared to 2017 or 10% in August 2018 compared to July 2018. The interventions differed in the level and intensity of the middle actors' involvement (in H more intense than Y), and in the type of community engagement activities that took place: four engagement activities in H, none in Y. Additional data was collected in surveys and interviews.

Analysis shows that a third of the participants reduced their peak consumption by 10%, with an average reduction of 4.5% (Y) and 6% (H). We used two benchmarks for evaluation: (1) a comparison to non-participating households in Kibbutz Y, which increased consumption during the same period, (2) a comparison to a previous project (2016), in which a similar economic

incentive (\$45) was offered in Y and H, but no middle actor involvement or engagement activity took place. In 2016 consumption increased by 6% (Y) and 2% (H) compared to 2015. Survey analysis indicates that in H the economic incentive was ranked low in terms of its perceived contribution to motivation, while in Y it was ranked high. The SMS reminders were ranked as less effective in H compared to Y. Results suggest that given a similar economic incentive, community engagement activities and intense involvement of middle actors have a higher impact on demand reduction compared to middle actors' involvement alone.

Interim findings from interviews indicate that middle actors in both Kibbutzim are interested in repeating the project next year. Middle actors in Kibbutz Y believe that had community engagement activities been held, greater reductions would have been achieved. In addition, some middle actors discussed the project with middle actors from other Kibbutzim and with leading figures in the Kibbutzim organization. A few other Kibbutzim expressed interest in conducting a similar project in their Kibbutz. Furthermore, the Kibbutz Economies Group (Mishkei HaKibbutzim) and Dalia Power Company (in which Mishkei is a shareholder) are currently interested in repeating and expanding the project next year.

While the research looked more closely at the downstream impact, overall, a middle out impact of the MO strategy was demonstrated: a downstream impact - end users reduced their peak consumption; a sideways impact - middle actors from other Kibbutzim indicated their interest in conducting such a project next summer; and an upstream impact - the Kibbutzim organization and a large electricity company indicated their interest in supporting similar projects next year.

To PV or not to PV? Prospects for residential solar PV system and self-consumption of excess power in Japan

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Panel

5. Smart and sustainable communities

Keywords

self-consumption, consumer awareness, photovoltaics, residential, energy policy

It is crucial for policymakers and relevant service providers to motivate prosumers to continue adopting solar PV without relying on subsidized Feed-in Tariff (FIT) schemes. This is especially true in Japan, where utilities will no longer be obliged to purchase surplus power from residential PV installations when the ten-year buyback period begins to end from November 2019. One possible solution is self-consumption of excess power, which will help prosumers to reduce energy bills and to shift peak demand besides energy efficiency. Batteries, heat pump water heaters and electric vehicles are some of the technologies expected to promote self-consumption. In this paper, we evaluated feasible solutions in order to understand the future prospects of self-consumption in Japan. We examined the implications of three aspects of future self-consumption: policy trends, business decisions, and prosumer's awareness and intentions.

The policy trends are crucial, so we summarized recent government discussions and decisions about self-consumption after the end of the FIT scheme, and the implementation status of policies that promote self-consumption technologies. As for batteries, Japanese government identified that the high installation cost is one of the main barriers of the dissemination of batteries, and pointed out the importance of financial incentive for the customers. Therefore, regarding the implementation status of policies, a subsidy program has been established and currently in operation. Households which are eligible for this subsidy are the ones which meet the ZEH (net Zero Emission House) requirements, in addition to having installed efficient energy management system for equipment such as batteries. In 2018, a total of 336 subsidy applications have been made by ZEH compliant households which installed energy management systems.

In terms of businesses, we conducted qualitative research on relevant services presently offered by utilities and service providers. For batteries and heat pump water heaters, artificial intelligence

(AI) is applied to effectively utilize surplus power of PV. The AI learns about the operation history of these equipment as well as electricity consumption pattern in the household, and by combining external information such as the weather forecast, it automatically decides the optimal operation plan for the next day. As for services currently provided by utilities, we identified pilot projects by mainly electric power companies which are related to power aggregation or Peer to Peer power trading.

Lastly, to understand views of prosumers, we conducted a questionnaire survey on 1,500 households with PV regarding their awareness of the future decreasing purchase price of surplus power, their plans after the FIT ends, and their perspectives on the adoption of self-consumption technologies. Survey results showed that should the purchase price of surplus power fall below 15 JPY/kWh (12 cents EUR/kWh) following the end of mandatory buyback period, more than 50% of the respondents wish to self-consume the surplus power of PV rather than selling to utilities. Furthermore, 24% of the respondents said that they may consider shifting the usage of specific home appliances from nighttime to daytime in order to effectively utilize surplus electricity. Also, 50% of the respondents are interested in batteries, indicating that there is a promising market for self-consumption related technologies.

However, 70% of the respondents prefer batteries with payback period of less than 10 years. On the other hand, 39% of the respondents think that reducing installation cost is the key to dissemination of self-consumption technologies, while 23% of the respondents wish to first obtain basic/necessary knowledge on self-consumption technologies. Regarding knowledge acquisition, about 25% of the respondents wish to obtain information from manufacturers, contractors, housing manufacturers and electric power companies.

The disruptive potential of blockchain technologies in the energy sector

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Panel

5. Smart and sustainable communities

Keywords

blockchain, demand side management (DSM), prosumers

The rapid transition of energy markets from centralized to distributed models entails several challenges, such as the management of bi-directional energy flows and complex transactions, increased volatility, the exponential growth of the number of players and of data volume, legacy issues for players, cyber security and data privacy. Direct peer-to-peer trading based on the blockchain technology applied to the virtual power plant concept can create a direct connection between suppliers and consumers of energy and represents a viable solution to meet these challenges. Blockchain can be defined as an immutable distributed ledger that verifies and records, in a safe and secure way, peer-to-peer transactions without a central authority. In recent years, blockchain is acquiring an increasing relevance, since it guarantees transparency for every transaction, creates trust through a shared database, and increases the efficiency of the transactions.

Furthermore, blockchain reduces the number of third-party intermediaries, simplifies market processes and architectures, and increases the operational efficiency. Blockchain technology has an extensive range of use that can disrupt the energy sector. For instance, it has the potential to speed-up an open energy market also for small customers, where electricity prices come from the balance of demand and supply like other tradable commodities. Peer-to-peer energy trading platforms also open-up the possibility to distinguish where energy is coming from (i.e., renewables, coal, oil, and gas), which allows environmentally conscious consumers to choose renewable energy.

The aim of this work is to investigate how blockchain can transform the current energy market in order to highlight advantages and disadvantages and to understand the related potentials and risks for prosumers and grid operators. Moreover, managerial insights will be provided for supporting stakeholders and regulators in the management of the future energy market enabled by the blockchain.

Selection of key performance indicators (KPIs) in the transition towards low-carbon urban communities

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Panel

5. Smart and sustainable communities

Keywords

key performance indicators (KPI), sustainable communities, energy efficiency measures

In EU, the topic of "sustainable and smart cities/neighbourhoods" is gaining increased attention as the overall sustainability goals on the EU level are being incorporated down to regional/local level. This is seen in the 'Clean energy for all Europeans' package with the promotion of Local Energy Communities (LEC) in the Electricity Market Directive, and Renewable Energy Communities (REC) in the Renewable Energy Sources Directive.

Key performance indicators (KPIs) are crucial instruments to support decisions in connection with transforming urban communities and achieving set targets for sustainable neighbourhoods. They enable the creation of specific transformation plans and make it possible to follow up on the progress made. However, it is often challenging to identify the KPIs that are most important and measurable for each project.

In this work we propose a methodology for selecting indicators for specific low-carbon transformation of urban communities projects. The methodology consists of the following main steps: 1. Identification of the project goals based on how they are described by the planners in the municipality, 2. identification of possible indicators through literature surveys, 3. selection of the most relevant indicators through multiple attribute decision making (MADM). 4. Feedback from the users. The process is performed iteratively until all project goals are associated with suitable indicators.

The methodology is applied in a Norwegian setting, and the selected indicators are tested in an indicator planning tool that has been developed to aid an efficient planning process towards sustainable communities. The work also highlights the challenges related to such selection processes, especially regarding stakeholder engagement and involvement.

Why do customers switch the contract to a local or renewable electricity supplier?

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Panel

5. Smart and sustainable communities

Keywords

Liberalized electricity market, Consumer's contract switching behavior

Do customers who switched their contracts to renewable energy companies have higher environmental consciousness and stronger intentions to invest than customers remaining with their legacy power companies? In Japan, as in many other countries, electricity retailing has been completely liberalized, and since the start of the system in April 2016, new types of electric power companies have been emerging. As of the end of March 2018, the number of electric power companies registered by the government had exceeded above 400, though customers who switched contracts to new electric power companies were still only about 10% nationwide. With the growth of the power retail market, competition among companies will benefit customers such as improving services and lowering electricity rates and will grow the company and stimulate the economy. To foster the household energy market, it is necessary to accelerate customers' switching activities, and therefore, "why do customers switch their energy contracts?" becomes a significant research question.

This study aims to investigate and clarify what factors effect the customer's contract switching behaviour in the liberalized electricity market. This study indicated that customers that chose the community-based energy company tend to have an intention to contribute to their community. Customers that chose a renewable energy company were found to be willing to purchase renewable electricity. The common factor among customers who chose a community-based and renewable energy company is that they have higher environmental consciousness than others.

This research indicated that consumer's attention to energy system has the same level of effect on contract switching intention as customer satisfaction level and switching costs found in previous studies on consumer behaviour. This study also indicated that there are the individual factors and intentions affecting the relationship among contract switching behaviour, electricity consumption behaviour, and equipment investment behaviour. This study is expected to be useful in accelerating the electric retail market and in developing marketing strategies for established and emerging electric power companies. In the Japanese government project called CREST, Energy Demand Science is identified as an emerging research field, and customer's switching behaviour is addressed as one of new research topics.

Large-scale implementation of peak heating power optimization and demand-response in residential buildings connected to district heating systems

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Stephan Kolb, Danfoss, Belgium

Susanne Tull, Danfoss, Belgium

Mark Draper, Danfoss, Denmark

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Panel

5. Smart and sustainable communities

Keywords

demand response, digital, load management, end-use efficiency

Digitalisation has been an important trend within the district energy sector in recent years. A key area of interest is the use of intelligent demand side management technology for heat peak load reduction and reduction of bottlenecks. Demand side management offers an attractive alternative to investments in peak plant capacity or centralized storage. Peak power optimisation (PPO) using demand side management through predictive control has been a research area for several years, but its full scale implementation on large district heating networks is not trivial.

This paper documents the experience of implementing PPO on a cluster of 45k apartments.

– Firstly it defines the challenges of optimizing the overall energy performance of an entire district-heating system with multiple energy carriers.

– Secondly, a description of the model predictive control approach is given outlining the challenges presented by the tradeoffs between:

i) the end-use energy performance of both building space and water heating systems,

ii) the comfort of occupants, and,

iii) the economic optimization at network level through the profiling of heat generation. It is shown that, on average 15 kWh/m²/a end-use energy savings were achieved, corresponding to a reduction of 5200 kt CO₂/a.

This approach also leads to an increase in the utilization of carbon-neutral energy carriers, thus achieving further CO₂ emission reductions. Available feedback from building occupants and owners is presented as well as comments from the district heating operator. In addition, potential market barriers for a larger-scale rollout of PPO technology are outlined. The paper concludes with suggestions on how energy and climate policies could improve the overall building/district-heating system performance, for a successful energy transition in the district energy sector.

Smart and sustainable, fast and slow

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Panel

5. Smart and sustainable communities

Keywords

smart grid, actors, energy transition, infrastructure, technology adoption

The ‘smart energy solution’ concept is a powerful one, implying rapid, smooth processes and results, with technology in the driving seat. Sustainable communities, by contrast, are works in progress: they require people to develop, maintain and adapt infrastructures, processes and governance over long periods.

As the need to stabilise Earth’s climate becomes more and more urgent, the appeal of ‘quick fixes’ grows. But smart solutions are rarely as quick and straightforward as they appear in blueprints. Even in completely new settlements, fast-changing devices are installed alongside slow-to-change infrastructure elements such as buildings, transport networks, pipes and wires. Actors and organisations who are responsible for building, operating and adapting energy systems will learn and change at varying speeds. Regulations take time to develop and often lag behind operational requirements, hence the need to pay close attention to logistics and flexibility when planning and implementing energy systems. If the systems are designed to be ‘smart’, new types of connectivity add complexity and risk alongside potential control benefits.

The paper outlines two examples of smart energy innovation at different scales: a large-scale demonstration of smart residential storage heating in three contrasting European countries and a project to enable a rural community to gain more value from local solar generation. The first focused on technology and customer experience; the second, on place and community. In each case, the smart technologies took longer than expected to establish, devices and people did surprising things, longstanding rules stood in the way of implementing socio-technical possibilities, and ‘middle actors’ were able to play an important role in negotiating challenges and making it possible for environmental and social benefits to emerge. Fast- and slow-moving processes were taking place at the same time and on at least three levels: regulatory, system-operational and user-operational.

Lighting systems in the tertiary sector: local actions and results in the Premiumlight Pro initiative

Andrea Roscetti, Politecnico di Milano, Dipartimento di Energia, Italy

Casper Kofod, Energy Piano, Denmark

Joao Fong, ISR - University of Coimbra Dep. Electrical Engineering, Portugal

Panel

5. Smart and sustainable communities

Keywords

LED, public lighting, local authorities, tertiary sector, lighting systems, building design, Directive on Energy Performance in Buildings (EPBD), white certificates, training, guidelines, procurement, public procurement

Despite the broad availability of LED (Light Emitting Diode) technology, there are still relatively few policy measures implemented at international and national level that encourage or facilitate the use of high quality and high efficiency LED lighting systems in the tertiary sector. This action is considered very important in this timeframe: buildings and street lighting systems are being refurbished and the impact of such new systems will have a long-time impact due to its very long lifetime. The international initiative Premiumlight Pro, funded by Horizon 2020 and delivered by an experienced consortium of experts in 9 European Countries, covered information and policy elements to achieve an impact on a multi-level approach.

The communication and information campaign, carried out at national level, includes three main tools: trainings, the action on policy-instruments, and the development of an improved information service. For the training, the nine partners from the participating countries developed different strategies for addressing different actors, based on the local situation. Traditional courses from basic to the advanced level were carried out directly by the consortium members or by local training partners. The action was successful and with positive feedback, mainly within the public sector stakeholders (municipalities, local governments, ...).

The improvement of policy strategies was proposed from the EU to the local level. The main fields in which Premiumlight Pro focused were the EU Ecodesign and Labelling, the EPBD national implementation and the national GPP minimum requirements. The initiative covered the active contribution to legal frameworks for LED lighting systems at EU-level, expert discussions with municipalities, manufacturers, associations and policy makers, the improvement and standardization of schemes (e.g. white certificates) as well as development and recommendation of new incentive schemes.

In parallel, for informative purposes, informative tools were developed such as a database for high

quality LED products, the collection of best practice examples, the distribution of calculation tools (covering quality and life cycle, the development of procurement criteria and planning-guidelines for LED-lighting solutions both for indoor and for street lighting, in the public and private sectors.

During the action some of the weaknesses of the professional lighting sector were identified and discussed within the consortium and with stakeholders,: the lack of a wider and reliable standardized set of technical information regarding some of the products, the infrequent use of qualified designers in some countries for ensuring light quality especially in smaller projects, and the absence of limits in consumption for lighting systems (also when considered as indicator and included in the building performance certificate).

The concrete implementation in more than 160 public authorities and 450 private companies, the training of more than 1200 experts, the involvement of 6000 public and private entities supported the implementation of efficient and high quality LED lighting systems in the service sector. The savings triggered by the project activities are expected, in the mid term, to reach for indoor lighting 165 GWh/y and 118 GWh/y for outdoor lighting, considering only the 9 countries involved.

What hinders local authorities in EU member states from financing and implementing sustainable energy investment projects? Preliminary results from the PROSPECT benchmark survey

Mia Dragović Matosović, IEECP, Croatia

Vlasis Oikonomou, Institute for European Energy and Climate Policy, The Netherlands

Niki-Artemis Spyridaki, TEESLab - University of Piraeus Research Centre, Greece

Alexandros Flamos, School of Industrial Management and Technology, University of Piraeus, Greece

Katerina Papapostolou, School of Industrial Management and Technology, University of Piraeus, Greece

Panel

5. Smart and sustainable communities

Keywords

local authorities, energy efficiency financing, local and regional energy planning, sustainable development, benchmarking

The role of local authorities in national planning, as well as their effect on the achievement of European sustainable goals, is being neglected. The entire planning process stemming from the Energy Efficiency Directive (EED) is formed through a top-down approach, with countries setting goals for national policies without a sufficient understanding of which actions would be more appropriate for local authorities such as municipalities or regions to implement.

Within the framework of the Horizon 2020 PROSPECT project, a City Capacity Assessment Framework was developed focusing on city planning, financing and implementation capacity for Sustainable Energy Climate Action Plans (SECAP) related projects. The framework is intended to form a standard or point of reference (i.e. Benchmark) against which cities' ability to attract investments, identify and utilize diverse funding sources and implement investment projects, could be measured and compared. The developed Benchmark is operationalised through an online survey including properly defined questions, assessment scales and practical city-examples reflecting a city's overall capacity to finance and implement SECAP related projects.

The main capacity-related aspects covered in the benchmark and assessed through the survey concern a city's local strategy and commitments, as well the legislative and economic setting

framing local actions and investments as well as public acceptance issues. In terms of more project specific aspects, the benchmark assesses a city's capacity related to phases of origination and underwriting in an investment project life-cycle as well as more general capacities in servicing investment and administration capacity. The results of over 40 cities across Europe have been collected and analysed comparatively across the different levels of cities' progress and experience with SECAP related projects.

The analysis is supported through descriptive statistics and qualitative evidence provided by the city participants aiming to provide insights on the state of, as well as barriers and opportunities to SECAP financing and implementation at the local level.

Preliminary results suggest that a city's progress and experience with SECAP implementation does not seem to correlate with GDP per capita, whereas a trend is obvious between the level of SECAP experience and bank lending rates. This may indicate that the nominal bank lending rate can be an appropriate means of representing general economic attractiveness at the local level.

At the same time a city's level of SECAP experience may relate more closely with variables relevant to city capabilities and personnel availability. With regards to the latter, it appears that cities with different general institutional capacities can be successful in financing and implementing SECAP related investment projects, with the importance of educated staffing, as well as good overall cooperation with other cities highlighted through our survey findings. This points to the need for initiatives similar to PROSPECT, which cater to the need for city employees to be informed about the types of innovative financing and to make contacts with those cities which have already been successful in overcoming hurdles relevant to implementing sustainable finance solutions.

We consider the developed Benchmark to consist the first step towards an active learning process, as it enables participating cities to gain a better understanding of their state of play in relation to their peers highlighting areas for further improvement. The results of the Benchmark survey are also of value for prospect investors and finance institutions providing novel insights on general city economic attractiveness and implementation capacity in relation to sustainable energy investments at the local level.

Forecasting and technoeconomic optimization of PV-battery systems for commercial buildings

Jonathan Fagerström, IFE, Norway

Kari Aamodt Espegren, Institute for Energy Technology, Norway

Alexander Severinsen, Storekeeper AS, Norway

Josefine Helene Selj, Institute for Energy Technology, Norway

Josefine Krogh Selj, Institute of Energy Technology, Norway

Panel

5. Smart and sustainable communities

Keywords

photovoltaics, batteries, energy model, system simulation, peak load, load management

The cost structure of electricity tariffs is being modified from a two-part tariff, where the cost is divided between a fixed installation cost (EUR/installation) and a cost for consumed electricity (EUR/kWh), to a three-part electricity tariff where customers additionally pay demand charges for capacity usage (EUR/kW). To combat demand charges, commercial customers are looking into supplementing PV installations with batteries to more efficiently reduce peak electricity demand, i.e. peak shaving.

A crucial part of the complete energy system is also the energy management, where forecasting improves the efficiency and economics. The objective with this work was to investigate the profitability with peak shaving in Norway for a commercial building. A forecasting algorithm for load prediction was developed, and the economic value of forecasting was determined for a PV-battery system.

The load forecasting was developed using component-wise gradient boosting and the results from the model was verified against a renowned benchmarking load forecasting model. The economic value of forecasting was determined through simulations with Homer Energy Software that optimizes the net present cost of the systems. The results showed that battery storage was only economically beneficial when forecasting was deployed. Moreover, the cost savings came mainly from reduced demand charges, not from increased self-consumption of PV electricity. It was also discussed that the application of forecasting in an energy management system could be divided into three phases. One phase where forecasting is deployed to dimension energy system components in an early stage, one monthly forecast overview that identifies height and frequency of maximum peaks, and finally one high-resolution forecast that operates the battery on an hourly basis. Altogether, such an energy management system could additionally also be used by utility grid owners to schedule demand response actions for power quality control.

Smart community energy schemes: a case study-based model

J Richard Snape, Institute of Energy and Sustainable Development, United Kingdom

Panel

5. Smart and sustainable communities

Keywords

smart grid, community energy systems, energy localization, demand response

Smart energy usage forms a key component of sustainable, smart future infrastructure. The urgency of incentivising energy transitions to low and zero carbon system grows ever greater and European policymakers and academics alike are recognising the need to accelerate transitions to clean energy systems, within which community energy schemes have a potentially large role to play.

With an approach grounded in case studies in the UK, potential for both energy saving and demand flexibility through local schemes allowing within-community usage of local renewable energy sources is explored. The analysis makes use of empirical results from a pioneering 50 household study of a community using realtime data on local generation availability in combination with a time of use tariff to influence use of PV resources installed on rooves of scheme participants within that community. PV assets were owned by individuals rather than collectively, however both owners and non-owners benefitted from a scheme incentivising smart usage of locally generated renewable electricity within that community.

An issue for community energy schemes is understanding how they might be scaled up, either by mass replication of very small schemes, likely to be highly diverse and administratively burdensome, or via a smaller number of larger schemes, which may lose the essence of community that works at smaller scale. In addition, schemes exist in the context of differing and evolving technology ownership, for example with increasing EV ownership and changing modes of heating and cooling via use of heat pumps and building fabric changes. An approach to understanding the interactions between technology, economics, community members and policy via agent-based modelling is presented in this paper and illustrated using the case study. The paper demonstrates the utility of the agent-based approach when investigating replicability and scale-up in a necessarily complex environment and presents early findings on potential for community energy schemes to proliferate.

Municipal energy companies in California, Great Britain, and Germany: comparing institutional context, business models, and opportunities

Laura Brinker, ECI-CREDS, University of Oxford - Environmental Change Institute, United Kingdom

Andrew Satchwell, Electricity Markets & Policy Group, Lawrence Berkeley National Laboratory, USA

Panel

5. Smart and sustainable communities

Keywords

municipal utilities, local authorities, business models, energy services

In recent years, cities have actively engaged in supporting climate change mitigation and many local governments have established or are considering new municipal energy companies (MECs). Cities have also been motivated to increase clean energy access and help low-income and other vulnerable customer groups manage energy expenses.

In this paper we show that MECs operate in very different legislative and regulatory contexts across jurisdictions, and that this has implications for their business model opportunities and the impact they can realize. We present data from three jurisdictions: California, Germany, and Great Britain.

We first discuss key institutional differences that influence the possible range of MEC business activities. We then compare MEC business models across multiple dimensions, including value propositions, customer segments and channels, value configuration, partnerships, and revenue model. Key differences affecting opportunities to establish clean energy business models across our example jurisdictions include the opportunity for California MECs to access and spend energy efficiency subsidies, regular opportunities to purchase energy distribution infrastructure in Germany, and the use of different customer acquisition models (opt-in versus opt-out).

We then discuss the relative opportunities and potential impacts of the different MECs in terms of decarbonization, economic sustainability, and social objectives. We argue that opportunities and risks differ widely across states, and that municipalities considering establishing an MEC must, therefore, carefully assess the institutional context within their own jurisdiction.

Towards inclusive urban building energy models: incorporating slum-dwellers and informal settlements (IN-UBEMs)

Kathryn Janda, Energy Institute, University College London, United Kingdom

Charlotte Johnson, Newcastle University, United Kingdom

Pamela Fennell, Energy Institute, University College London, United Kingdom

Julia Tomei, Energy Institute, University College London, United Kingdom

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Panel

5. Smart and sustainable communities

Keywords

equity, inclusion, energy model, cities, urban planning

Urban building energy models (UBEMs) are emerging as a data-driven method for predicting energy consumption and assessing the impacts of policies aimed at reducing carbon emissions in cities. To date, the majority of these models have been developed for cities in the global north where urbanisation rates are relatively slow, the building stock turnover is low and data are relatively easy to obtain. As their use expands, they are being applied in faster-growing urban areas in the global south, where considerable investment is planned in capital infrastructure.

This paper focuses on slums, which include populations that are hard to reach, underserved by current energy systems, and largely absent from UBEMs. It asks: what are the social, economic, and environmental implications of excluding slum dwellers and informal settlements from UBEMs used for policy development?

If existing UBEMs do not adequately capture the needs of low-income urban residents, then planning decisions based on these models risk both carbon lock-in and deepening poverty for already marginalised groups. To redress these problems, this paper considers three key questions:

- how informal settlements and low-income groups have been represented in UBEMs to date and the potential implications of their exclusion
- the politics, norms and behaviours of energy supply and demand within informal settlements
- what issues should be explored to integrate these marginalized housing groups within UBEMs.

In conclusion, it calls for additional social science research to reduce the impacts of exclusion and to co-produce new methodologies with energy modellers. Future steps include fostering ongoing engagement with both expert and non-expert populations to facilitate citizen participation in evidence-based planning decisions.

5-410-19:

Self-sufficient microgrid – Feasibility study on Atlantech low carbon district

Valentin Gavin, France

Cristian Muresan, ENGIE Lab CRIGEN, France

Panel

5. Smart and sustainable communities

Keywords

A microgrid is an energy supply network built around local power and heat generation facilities. It is designed to operate autonomously or in synchronization with a national grid within a clearly defined area based on a local control strategy. A microgrid is typically a set of components such as : renewable energy sources (solar, wind or biomass) and energy storage solutions (batteries, hydrogen storage, mechanical storage, etc.) coupled with fossil fuel energy sources to ensure grid stability.

Microgrids offer an alternative for safeguarding power dependability by integrating and automating decentralized energy resources. They have become properly competitive as a result of technological progress and competitive prices of certain key components, such as photovoltaic modules, batteries and power control systems. Moreover, local communities are progressively involved in investing in green solutions at the district level and the idea of self-sufficiency is more and more driven by economical aspects but also by sustainability reasons.

The object of the present article is to investigate the self-sufficiency conditions within different technological scenarios on a low carbon district. Atlantech is a district near to the city of La Rochelle (France) that is designed and operated as a low carbon district around a refurbished building stock. It is a forerunner district in the areas of sustainable development, soft mobility and eco-design. The district possesses a particular energy and sustainability policy which set-ups the ambitions of Atlantech focussed on the design and operation of a self-sufficiency microgrid based on massive PV production (ground PV and building integrated). Atlantech district is composed by high efficient buildings (dwellings and offices) refurbished in order to fulfil the requirements of the Energy+Carbon- label in France (from Net Zero Energy Buildings to Positive Energy Buildings). More than 4 MW of PV capacity will be progressively installed (above 40 % ground mounted and 60 % as building integrated PV).

The investigation of the different technological scenarios was conducted by using dynamic energy simulation. A structured approach was developed beginning with the energy demand assessment (heating, cooling and refrigeration, electrical appliances, etc.). The approach was completed by the local compensation of uses (e.g. share the energy between office residential buildings) while balancing the massive energy production from renewable sources and the storage.

Soft mobility based on electrical and hydrogen vehicles coupled with additional stationary

batteries and hydrogen storage was inspected and considered as a promising way to balance the microgrid. Functional and financial KPIs, such as the capital expenditure, were investigated for all the proposed scenarios. A self-consumption rate above 45% could be reached only by using an appropriate compensation of thermal usages (heating and cooling via electric heat pumps) and electrical appliances as a base load.

According to the analysis, hydrogen solutions (electrolyser + hydrogen storage + fuel cell) are mandatory in order to tackle the lowest investment for 100 % rate of self-consumption. A storage solution based only on electrical batterie becomes prohibitive because of exponential increase of batteries price beyond 72% of self-consumption.

Success on a global scale of microgrids will depend on many country-specific factors, like energy policy and regulations. If optimized effectively, the microgrids could serve as a focal point in the local drive to adopt renewable energies and could play a vital part in supporting efforts to energy transition and meet climate targets. The technical solution explored in this article is particularly interesting in France were the rate of renewable is one of the lowest in Europe (above 10 % compared with the European champions that are tackling 55 %).

The governance of sustainable city business models

Colin Nolden, University of Bristol Law School, United Kingdom

Panel

6. Transport and mobility

Keywords

governance, cities, sustainability, mobility, buildings, alternative energy systems (AES)

This paper analyses how sustainability and climate action relating to mobility, buildings and energy networks are governed in European cities. To this end, different modes of governance for sharing burdens, costs and risks of innovative low-carbon experiments, projects and demonstrations in ten European cities in seven countries are compared.

Some cities succeed by co-producing planning and policy-making with a wide range of public, private, academic and community stakeholders through new forms of intermediation. Other cities rely on a hierarchical approach reliant on in-house expertise and policy-agendas for the delivery of experiments, projects and demonstrations. Others again rely heavily on entrepreneurial governance through outsourcing.

Instead of descriptive best-practices and prescriptive one-size-fits-all solutions for replication and up-scaling, this paper concludes that place-specific governance approaches, taking into account historical, cultural, social, political and administrative complexities on the one hand, and citizens alongside different institutional actors at local, regional and national level on the other, are necessary for the delivery of sustainable city business models.

Excess? Exploring social, structural and behavioural drivers of energy demand in areas of high combined energy consumption or “how much energy is more than enough?”

Tim Chatterton, United Kingdom

Jillian Anable, University of Leeds, United Kingdom

Malcolm Morgan, School of Earth and Environment, The University of Leeds, United Kingdom

Milena Buchs, University of Leeds, United Kingdom

Robin Lovelace, University of Leeds, United Kingdom

Karen Lucas, University of Leeds, United Kingdom

Caroline Mullen, University of Leeds, United Kingdom

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Panel

6. Transport and mobility

Keywords

spatial distribution, energy justice, mobility, domestic energy, energy sufficiency, electrification

Previous work within the MOT (Motoring and vehicle Ownership and Trends) project identified correlations at a spatial level between energy consumption through the use of private vehicles and through domestic gas and electricity. High vehicle energy areas also tend to be high domestic consumption areas, with the top 5% highest consumption areas using around 2.5 times as much direct energy per capita as the lowest.

Due to growing electrification, energy demand from private vehicles is becoming increasingly linked to domestic consumption. There are approximately 200,000 electric vehicles in the UK fleet (including plug-in hybrids) – this is around 0.5% of the light duty fleet. Around 75% of these are in private ownership. Both for assessing energy footprints and to deal with strategic issues such as local grid capacity, there is a need to look at energy consumption in a holistic manner, investigating relations between energy use in the home and from transport. With the rapid rise of options for virtual mobility, personal transport has become less necessary for participating in a range of activities, yet this does not necessarily reduce overall energy use. Linked analyses are essential to assess where and how consumption in one domain may become displaced to another e.g. technologies that permit home working may reduce transport use but increase energy

consumption in homes.

The 'Excess?' project, is being undertaken within the Centre for Research into Energy Demand Solutions (CREDS). It is using a mixed-methods approach to better understand the causes of disproportionately high consumption, i.e. can it be explained by structural and systemic factors (e.g. poor public transport, inefficient or precarious housing), social factors (e.g. demographic characteristics) or behavioural factors (e.g. social expectations and norms, or lifestyle choices). The aim is both to highlight risks to distribution networks from clustering of new electric technologies, and to examine justice issues around unequal patterns of energy demand. Whilst much work on energy demand has focussed on meeting basic needs (e.g. fuel poverty and transport vulnerability), Excess? has its sights on examining high consumption in order help identify where energy consumption can be reduced 'furthest and fastest'.

The presentation will cover the initial identification and characterisation of high consumption areas, and a review of high consumption households from national surveys.

Spatial Data Analysis

Aggregated data based on readings from over 70m domestic energy meters and vehicle odometers will be used to map patterns of energy consumption across England. These will be analysed in terms of socio-demographic and geographic data at the LSOA level (av. size 672 households), exploring relationships with housing type, household composition, levels of accessibility and public transport provision. The data will also be used to model down to an Output Area (OA size = 129 households) level using Geographically Weighted Regression.

National Survey Data Analysis

Data from a range of national surveys (incl. National Transport Survey, Living Costs and Food Survey, Understanding Society) will be used to explore the relationships at a household level between transport and domestic consumption that lie behind aggregated spatial data, and the structural, socio-demographic and behavioural factors driving high consumption.

Local Area Household Analysis

Then, using a framework derived from the above analyses, alongside an exploration of theoretical framings of excess, a number of areas will be identified for face-to-face methods to provide a qualitative exploration of reasons for high energy consumption.

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Electrification as an energy efficiency and decarbonization strategy

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Panel

6. Transport and mobility

Keywords

electrification, decarbonisation

Energy efficiency and no/low carbon energy can substantially reduce greenhouse gas emissions, but in order to reach the 2050 Paris targets, additional reductions will be needed. A variety of studies in Europe and the U.S. have found that electrifying substantial portions of energy demand can help to achieve substantial emissions reductions. This paper will summarize recent studies in the U.S. to explore electrification as well as emerging programs and policies to begin promoting “beneficial electrification”, meaning electrification that reduces emissions, reduces primary energy use, and saves consumers money. These efforts will be compared and contrasted with parallel efforts in Europe.

In the U.S., electrification efforts so far have focused on transportation and homes. In transportation, recent projections are that electrification can reduce energy use and greenhouse gas emissions in 2050 by as much as 50% relative to a 2050 reference case. The focus of promotion efforts so far is on passenger vehicles and buses but delivery vehicles are also a major opportunity.

For homes, 2050 energy use and emissions reductions can be approximately 20%. The best conversion economics are for water heating, space heating in new construction, space heating for existing homes in the south and space heating in homes that now use fuel oil or propane. For existing homes in the far north as well as homes that use natural gas outside of the south, conversion economics are often challenging. Electrification in the commercial and industrial sectors is more nascent but efforts to date will be described.

The regional impact of heavy-duty fuel cell trucks on electricity demand – a case study for Germany

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Till Gnann, Fraunhofer Institute for Systems and Innovation Research ISI, Germany

Patrick Plötz, Fraunhofer Institute for Systems and Innovation Research ISI, Germany

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Panel

6. Transport and mobility

Keywords

heavy-duty vehicles, fuel cell, greenhouse gas emission reduction

Long-distance road-freight transport causes a large share of Germany's greenhouse gas emissions with about 20% of traffic emissions. A potential solution for an emission reduction in this sector is the use of hydrogen in fuel cell heavy-duty vehicles (FC-HDV). However, the large-scale use of green hydrogen production for FC-HDV usage comes with implications on the energy system as this would increase the local electricity demand.

In this study, we use German driving data for heavy-duty trucks in a market diffusion model and a refueling station design model. Together with an electricity demand model, we determine the FC-HDV electricity demand per region up to the year 2050.

In 2050, the FC-HDV stock will sum up to 176,000 FC-HDVs cumulating an annual demand of hydrogen of about 830,000 tons, which will be distributed to the FC-HDV fleet via 525 hydrogen-refueling stations (HRS). With assumptions about electrolyzer efficiency, the regional electricity demand can be determined. The hydrogen demand for FC-HDVs can have different impacts in regions, depending on the existent structure and future developments for population density, industrial sites and urban areas.

As a result, we find a noteworthy impact of the additional electricity surplus caused by FC-HDVs with over 50 TWh (almost 10%) of the total electricity demand per year. Furthermore, FC-HDVs amount for the highest share of total electricity demand in some eastern German regions.

Our results indicate a regional diverse surplus of energy demand through FC-HDVs. Simultaneously, regions with high surplus may avoid grid expansion by either shifting hydrogen production towards periods with low electricity load (e.g. night times), make better use of local

potentials for renewables (e.g. wind) or distribute hydrogen from other regions (e.g. through pipelines). For this reason, the reduction of greenhouse gas emissions through FC-HDVs seems feasible with limited challenges from a transport and energy sector perspective.

CODEC – modelling consumer decisions towards energy technology adoption

Suzanne Brunsting, ECN part of TNO, The Netherlands

Casper Tigchelaar, ECN part of TNO - Energy Transition Studies, The Netherlands

Jacob Janssen, ECN, The Netherlands

Geerte Paradies, ECN part of TNO, The Netherlands

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Panel

6. Transport and mobility

Keywords

consumer behaviour, cognitive agent models, innovation adoption, decision-making process, energy policy

The transition towards sustainable energy requires the adoption of numerous new technologies. Policies aimed at the stimulation of adoption are not always as successful as planned. In this paper we present CODEC (COConsumer DEcision Comprehended), a psychology based, quantified consumer decision model that supports policy makers and companies to predict and enhance the adoption of new green technologies by consumers.

Adding psychological knowledge to models is challenging, but pivotal for predicting and stimulating adoption since it is people who will have to adopt. CODEC models the decision-making process for various consumer groups for a specific innovation and its alternatives, comparing policy measures designed to expedite the rate of adoption. The model shows a product's market share development over time, and the barriers for full scale adoption, providing input for concrete policy recommendations.

In order to reach these results, the model balances psychological modelling aspects and theories, including the effects of habits, factual barriers, social processes, and economic irrationalities in the consumer decision processes. In the model these aspects are represented by fourteen questions in three phases: Attention (e.g., for how many consumers is there a decision moment?), enablers (e.g., how many consumers could pay for this innovation?), and intention (e.g., does the innovation provide status?). The model thus provides a more holistic evaluation compared to many economic optimization models and provides quantitative insights into how policies affect various non-economic elements in the consumer decision process. To illustrate the model, the paper shows results from the application of a case study: The adoption of solar panels.

Grid to vehicle and vehicle to grid systems for large-scale penetration of renewable generation

Pedro Manuel Soares Moura, Institute of Systems and Robotics - University of Coimbra, Portugal

Anibal T. de Almeida, Institute of Systems and Robotics - University of Coimbra, Portugal

Joaquim Delgado, Institute of Systems and Robotics, Portugal

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Panel

6. Transport and mobility

Keywords

vehicle charging, electric vehicles, electric storage, renewable energy

The electric power system is quickly changing due to the growing penetration of intermittent and non-dispatchable renewable energy sources. Simultaneously, the demand should ideally be able to be adapted to the renewable generation availability, directly with demand response or indirectly using energy storage technologies. The transport sector with electric vehicles (EVs) is increasingly an important consumer of electricity, and as fleets increase, EVs can be used as controllable loads, charging in periods of high renewable generation or low prices, using the Grid to Vehicle (G2V) system. With adequate technology, in addition to absorbing power from the grid, EVs can also use some of their storage capacity to inject energy into the grid, in order to ensure the balance between the generation and demand, using the Vehicle to Grid (V2G) system. However, the additional charging cycles due to V2G will accelerate the degradation of batteries and therefore its associated cost must be taken into account.

This paper discusses the technologies and methodologies for the implementation of Grid to Vehicle and Vehicle to Grid systems, as well as their potential benefits for the grid in a scenario with large-scale penetration of renewable generation. To assess such impact a case study for the Portuguese grid is presented, considering three scenarios of penetration of EVs in the Portuguese vehicle fleet (in which EVs constitute 10%, 25% or 50% of the fleet). The obtained data allowed to assess the potential of V2G to transfer the generation surplus between hours of low and high demand. Additionally, the economic benefits from the grid and user point-of-views were assessed considering the degradation of the batteries (evaluated through a model developed in Simulink environment), associated with the use of V2G, and their replacement cost. The results show a high impact on the compensation of renewable generation surplus, as well as economic benefits from the grid point-of-view. Even considering the battery degradation, in some scenarios, there is also a potential economic benefit for the user.

Who is willing to buy an electric vehicle in France? Electric vehicle penetration split by household segments

Franck Pernollet, EDF R&D, France
Jean-Michel Cayla, EDF, France
Christophe CROCOMBETTE, EDF, France

Panel

6. Transport and mobility

Keywords

electric vehicles, willingness to pay, market barriers, households, plug-in hybrid electric vehicle

Although electric vehicles (that is to say battery electric vehicles (BEV) and plug-in hybrid vehicles (PHEV) economic interest seems already acquired for some mobility needs, EV adoption by households still raises questions. This paper examines EV diffusion in France taking into account monetary and non-monetary drivers. Barriers to this diffusion are examined based on a discrete choice experiment among 12,000 future vehicle buyers in France.

Willingness to pay (WTP) for autonomy, charging time, charging point density and EV specific criteria were calculated for different household types distinguished by standard of living, annual mileage and charging point installation facility at home. Then these non-monetary attributes were included to a traditional investment behaviour model based on a total cost of ownership (TCO) calculation to estimate EV market share.

This paper examines which type of household segments are likely to buy EV at different time horizons. It shows that it is essential to take into account non-monetary attributes to correctly simulate EV diffusion. Indeed, even though, in the near future, BEV TCO will be lower than internal combustion vehicle (ICV) TCO, the probability that a purchaser will not buy a BEV could also be influenced by non-monetary constraints such as autonomy or time to refuel.

By taking into account non-monetary attributes, we can assume that BEV diffusion should not be as fast as expected by analyses that only rely on monetary attributes. In an EV-friendly scenario, we found that BEV buyers from 2020 to 2025 are likely to be households with either low income or with limited annual mileage. Around 2025, these people are likely to buy 30 or 40 kWh BEV since BEV TCO shall be cheaper and they are ready to have autonomy constraints. Then, in 2030, high income and long distance drivers are likely to buy PHEV in order to avoid autonomy constraints whereas medium income and long distance drivers should prefer 80 kWh BEV which is a good compromise between cost and autonomy.

This article also shows that BEV should spread faster for large and medium vehicles than for small

vehicles. In particular, without ban, a significant proportion of people having a small car, with medium or high revenue and small or average rider in 2040 is still expected to buy small ICV. Finally, this paper highlights that people who have no easy access to charge at their homes are more reluctant to buy BEV.

The value of energy efficiency as a public health and climate mitigation strategy

Cassandra Kubes, ACEEE, USA

Sara Hayes

, American Council for an Energy-Efficient Economy, USA

Panel

6. Transport and mobility

Keywords

US policy, health, climate change mitigation, regulation

Saving energy in buildings and making vehicles more fuel-efficient reduces the harmful pollution emitted by fossil fuel consumption. Pollution avoided by energy efficiency results in substantial improvements to public health through reduced morbidity and mortality. However, the public health benefits of energy efficiency are oftentimes underestimated or omitted when communicating the value of energy efficiency as a climate change mitigation strategy. Communicating the health benefits of energy efficiency creates an opportunity to motivate leaders to take action on climate change.

As described in a recent IPCC special report, any increase in global warming is projected to negatively affect human health. In order to achieve the levels of emission reductions required to prevent further warming, countries participating in the Paris Agreement will need reaffirm and ramp-up commitments. However, the United States continues to lag behind. The US and countries worldwide have an opportunity to mitigate climate change and realize significant health benefits by advancing energy efficiency.

Building on previous research, this paper identifies existing and proposed policies to regulate carbon in the US and compares these with examples from countries in the European Union, emphasizing strategies that incentivize energy efficiency and maximize public health gains. This paper presents findings from two analyses that model the emission reductions and associated public health gains from a combination of energy efficiency policies in the power sector and through electric vehicle adoption. These estimates underscore the magnitude of public health benefits that can be achieved by using energy efficiency and make the case for an increased commitment from the US to mitigate climate change.

EU fleet consumption regulation undermines climate protection

Dieter Seifried, Büro Ö-quadrat GmbH, Germany

Sebastian Albert-Seifried, Büro Ö-quadrat GmbH, Germany

Panel

6. Transport and mobility

Keywords

fleet consumption regulation, hybrid and electric cars

The EU fleet consumption control mechanism is misconceived to help to reduce the overall CO₂ emissions in Germany. Due to the generous credit and super-credit system for electric and hybrid-vehicles and the measuring method, the consumption control mechanism has far-reaching negative consequences for the climate and German taxpayers.

The EU's CO₂ reduction targets for fleet consumption of 95gCO₂/km for 2021 and a further 30% or 35% reduction for 2030 compared to 2021 can only be met through a strong increase in pure battery (BEVs) and plug-in hybrid (PHEVs) vehicles. PHEVs are designed to pass the NEDC test cycle (since 1.9.2018 the WLTP test cycle) using the electric charge when the battery is initially fully charged. If the emission from fossil fuel supply for a further 25 km is calculated to be below 50 g/km, they - like BEVs - are accounted as zero emission vehicles (!). In reality the large and heavy PHEVs predominantly run on combustion engine in normal daily use.

Credits and super-credits for PHEVs and BEVs can halve CO₂ emissions by 2030 on paper, but they will not actually reduce CO₂ emissions on the medium term. We will demonstrate this discrepancy through various case studies. Contrary to its original intention, the existing EU fleet consumption regulation is the basis for the German automobile manufacturers to further expand their product range of heavy vehicles with high CO₂ emissions.

The consequence is costly to the taxpayers: as the non-ETS reduction set by the EU Climate Change Guidelines and the Climate Action Regulation of 2018 will fall far short, compensation payments from the German Government will be unavoidable. According to calculations by Büro Ö-quadrat the compensation will amount to more than €10 billion by 2030 - for private transport alone. The paper will close with suggestion to close the gap in the EU-regulation and will discuss instruments which make it possible to achieve the climate protection goals in the transport sector.

Vehicle tax design and car purchase choices: a case study of Ireland

Ivan Petrov, University College Dublin, Ireland

Lisa Ryan, University College Dublin, Ireland

Sarah La Monaca, University College Dublin, Ireland

Panel

6. Transport and mobility

Keywords

passenger vehicles, taxes, CO2 emissions, emission reduction policy analysis, econometric evaluation

On the 1st of July 2008, the motor taxation regime in the Republic of Ireland underwent a complete overhaul. Both Vehicle Registration Tax (VRT) and Annual Motor Tax (AMT) switched from being engine capacity based, to one based on carbon dioxide (CO₂) emissions ratings per kilometre. The goal behind this action was to reduce CO₂ emissions from passenger car use by aligning the emissions externality with the vehicle taxation system, thereby making it more expensive to purchase and operate a high-emitting vehicle. The aim of this study is to quantify the effectiveness of this (and subsequent) vehicle policy changes at achieving this goal.

Quantifying the effectiveness of such a policy change presents a number of challenges. Although the average emissions ratings of newly registered vehicles in Ireland have declined in recent years, this may also be due to vehicle suppliers offering lower-emitting vehicles, rather than a change in consumer purchasing behaviour due to the policy shift. Using a difference in differences quasi-experimental design, we attempt to recreate the missing counterfactual (in the absence of the policy change(s)) of vehicle purchasing patterns in Ireland using the trend in UK new passenger car emissions over the period.

The findings suggest that the initial policy change in 2008 is responsible for reducing the fleet average CO₂ emissions rating of newly registered passenger cars in Ireland by roughly between 8 to 11 gCO₂/km. Some subsequent policy changes (such as the introduction of a scrappage scheme) have also had an effect at stimulating the purchase of low-emitting vehicles. However, we find that this decrease in rated emissions is driven by a significant shift towards diesel-powered vehicles with resulting increases in other types of pollutants such as NO_x emissions. This highlights the potential for trade-offs in policy outcomes unless full impact analysis is carefully undertaken ex-ante.

Review of the effects of developments with low parking requirements

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Cecilia Hult, Sweden

Åsa Hult, IVL

Anders Roth

Panel

6. Transport and mobility

Keywords

car transportation, mobility, individual mobility, parking, car sharing

Parking management and planning can be used to address several issues related to sustainable urban development. E.g. parking availability affects both car ownership and usage, and parking planning can affect both land use and building costs. A tool, used in several countries is minimum parking requirements (MPR) and lowering these could be a pathway to more sustainable mobility. However, the actual effects of lower MPR have not systematically been studied.

In this paper we present the results of a review of twelve developments with low MPR in Sweden, Austria, Germany and Switzerland. Existing research and reports have been analyzed to compare these and draw conclusions on the effect of MPR on mobility patterns and mobility services. In addition, interviews were made with representatives from municipalities and developers. Some of the key findings are:

- All of the studied projects have good prerequisites for sustainable mobility such as access to public transport, a central location, mobility services, bike paths and services.
- Results indicate that the mobility patterns of individuals in the studied projects are more sustainable than in nearby projects. However, the causality of MPR and mobility is hard to establish.
- Many projects combine MPR with mobility services such as car-sharing. For this to be successful, requirements for MPR and mobility services should be included in the planning permission.
- Legally binding contracts are needed to clarify responsibilities between developer, municipalities and mobility service suppliers.
- Swedish and European developments differ in posed requirements. Swedish projects only put requirements on parking and mobility services, whereas European ones put requirements on traffic or car ownership..
- It is important to look at a wider geographical area and not only the specific project. Parking availability and pricing in the surroundings might affect the outcome of a low MPR project.

The quality rebound effect in transportation

Matteo Craglia, University of Cambridge, United Kingdom

Jonathan Cullen, University of Cambridge, United Kingdom

Panel

6. Transport and mobility

Keywords

rebound effects, car transportation, fuel economy, fuel consumption, energy efficiency policy

The use of energy in society is needed to provide energy services. Reducing the energy to deliver these services is at the core of energy efficiency. Energy services have both a quantitative and qualitative value. In the case of transportation, the quantity of service can be expressed simply in passenger kilometers, whereas quality aspects are affected by several vehicle attributes such as size and performance as well as travel times and comfort. Improving energy efficiency can stimulate consumers to travel more and consume a greater quantity of transportation. This phenomenon is known as the 'rebound' effect and has been well studied.

Less studied are rebound effects in quality of service; how reductions in travel costs, due to fuel price changes and technical efficiency improvements, can stimulate people to increase the quality of transport, for example by purchasing a larger vehicle. Consumers continue to buy larger and more powerful vehicles in all countries. These purchasing trends mean that technical improvements in vehicle fuel consumption are undermined by shifts to larger vehicle segments.

New hybrid and electric powertrains entering the market promise large improvements in fuel consumption. However, if these efficiency improvements stimulate shifts to even larger vehicles through quality rebound effects, the full potential energy savings may not materialize. Understanding and quantifying these quality rebound effects is therefore of paramount importance for energy modelers and policy makers.

This paper uses a unique dataset of vehicle sales in the UK between 2001 and 2017, to investigate the effects of fuel price, income and technical improvements on stimulating a shift to larger and more powerful vehicles. Econometric regression techniques are used to show increasing income and the growing share of diesel powertrains partially explain the shift to large vehicles. This suggests vehicle taxes in larger segments have not been sufficiently high and need to be rectified.

A small area estimation of the capability of individuals to replace car travel with walking, cycling and e-bikes and its implications for energy use

Ian Philips, University of Leeds, United Kingdom

Tim Chatterton, United Kingdom

Jillian Anable, United Kingdom

Panel

6. Transport and mobility

Keywords

spatial data, walking cycling and e-bikes

The negative impacts of excessive car use are well documented and this illustrates the need to reduce car use. Mode shift from car use to walking, cycling and e-bike use is one of many possible solutions, addressing for some locations the multiple negative impacts of car use including reduction in transport energy demand. Walking is the most sustainable and equitable travel mode. Cycle use is also sustainable and may be provided equitably. E-Bikes are a smart technology often overlooked due to the hype around e-cars, and are potentially a sustainable and more equitable means of reducing transport energy demand.

Some useful work has investigated the potential for emissions reduction by mode shift though a number research opportunities remain. Until recently information at fine spatial scales was not available on either total car use nor the distance individuals in these same small areas were capable of travelling by walking, cycling and e-bike use.

This paper brings these two data sets together. This allows production of novel spatial indicators.

- Firstly, an estimate of the potential car travel distance which may be transferred to walking, cycling and e-bike use.
- Secondly, indicators of the energy reduction potential of transfer of distance travelled from car to walking, cycling and e-bike use are produced and described.

The utility of these indicators is to provide fine scale information on the potential for transport energy demand reduction. Quantifying the benefits of reducing car based travel demand at the local scale is useful to policy makers to identify specific locations where large reductions in emissions per person may be achieved by shift to active modes, and it can be used to target resources and policy interventions. The method is applied to a case study in the UK. Maps and other visualisations are shown which illustrate the ease of interpretation of results for policy makers.

Projections of mobility demand and vehicle efficiency improvements for Europe under deep decarbonization

Marianna Rottoli, PIK-Potsdam Institute for Climate Impact Research, Germany
Robert Pietzcker, Potsdam Institute for Climate Impact Research (PIK), Germany
Gunnar Luderer, Potsdam Institute for Climate Impact Research (PIK), Germany

Panel

6. Transport and mobility

Keywords

mobility, energy model, demand patterns

Deep transport sector decarbonization is extremely relevant in achieving ambitious climate targets, due to its significant carbon emissions. Transportation is expected to play an even more significant role in the future, as decarbonization is likely more challenging than in other sectors. At the same time, sketching possible futures for a low-carbon transport is a challenging task, as its particular dynamics pose significant barriers to a full-sector decarbonization.

We contribute to this research area by developing the mobility model EDGE-Transport that provides projections of future demand trends. The model assesses alternative evolutions of mobility demand, vehicle choice and efficiency as a reaction to changing assumptions about input parameters like fuel and vehicle prices, efficiency standards and user preferences with respect to alternative vehicle types and modal switching. It covers the whole world in aggregate regions, achieving country level detail for Europe. This allows us to compare the development of mobility demand and transport efficiency across different mitigation targets, giving a measure of the extent to which price signals from the market could result in different transport behaviors.

The input prices are based on results from the integrated assessment model REMIND, which covers all energy sectors and therefore accounts for the competition for scarce fuel resources and CO₂ emissions in deep decarbonization scenarios. While the current analysis provides crucial insights into transport mitigation scenarios for EU countries in a global context, we work on extending it by using the obtained demand projections as input for the integrated assessment model REMIND. Coupling the two models will allow us to tackle a wider range of viable abatement options in a fully consistent way: technology-related strategies (improvements in energy efficiency, reduction in carbon intensity) and behavioral strategies (shift in transport modes, reduction in demand).

A week in the life of a car: a nuanced view of possible EV charging regimes

Giulio Mattioli, TU Dortmund, Germany

Jillian Anable, University of Leeds, United Kingdom

Phil Goodwin, University West of England

Panel

6. Transport and mobility

Keywords

electric vehicles, flexibility, behaviour, clusters, time use

In thinking about the charging and associated energy requirements of plug-in vehicles, spatial and temporal forecasts of electricity demand tend to rely on analysis of individual car usage. These are derived from travel diary studies or, increasingly, GPS traces to provide diurnal, weekly and seasonal patterns by different people in different places.

More accurate forecasts of electricity demand require knowledge of the patterns of the individual cars themselves – where they will be, when, for how long, and with what likely level of battery charge. We present a two-stage optimal matching analysis of the 2016 UK National Travel Survey (NTS) to classify cars based on their patterns of use over a week. This required a novel reconfiguration of NTS data into a ‘vehicle travel diary’ dataset, to which sequence and cluster analysis of individual vehicle use sequences were applied.

Firstly, each of the seven days of the travel diary was subdivided into 48 half hour time slots with cars recorded either in use or not in use at any point in each slot. From this, six types of ‘car day’ were identified, with less than half of cars found to exhibit day-types with the stereotypical pattern of ‘morning-out and evening-home’. These six rhythms are exhibited by different groups of cars, and in different proportions on different days of the week.

Secondly, each car was attached with their own set of 7 x daily rhythms using the car-day types and then grouped with cars with similar ‘lifestyle’ across the week. Here we found 8 clusters of car-weeks, each with different rhythms within and across weekdays and weekends. We examine how these car ‘lifestyles’ are associated with household and vehicle characteristics using a broad range of variables available within the NTS. Finally we assess likely typical charging regimes and the flexibility of these patterns and contrast these findings to assumptions commonly being made in assessments of the impacts of electric vehicle grid integration.

Shore power supply and electrification of transport – how C40 cities could contribute to the Paris Agreement

Helge Schramm, Danfoss A/S, Denmark

Karen Roijy, Danfoss Drives A/S, Denmark

Panel

6. Transport and mobility

Keywords

electrification, commercial transport, shore power supply, sector coupling

C40 connects 92 cities in the world and represent one quarter of the global economy. This paper presents an analysis of the role of shore power supply and electrification of transport to deliver the ambitions of the Paris Agreement limiting global temperature rise to 1.5 degrees C.

The scope of the analysis is how much C40 cities could contribute to the Paris Agreement through electrification of transport and electrification and coupling of energy systems. It considers technologies that “get the basics right”, and achieve “high performance” from an electrification and sector coupling perspective.

- First, the paper summarizes the results of new, independent research on C40 contribution to the Paris agreement, aggregated GHG emission and primary energy saving potentials.
- Then, the paper explains key functionalities, benefits and added-value of existing technologies, like electrifying (hybrid and full electrification solution of vessels) and supplying vessels with shore power supply, as well as flexible storage and district energy networks.
- The third part illustrates barriers that impede the uptake of shore power supply and electrification of transport. – Finally, as an input to C40’s on-going identification of clear emission reduction targets and the projects and policies within this area, the paper recommends policy measures that would overcome typical barriers for investments into shore power supply and electrification of transport, and assesses the interaction between power and transportation networks towards an energy efficient and carbon neutral future.

‘Disruption’ and ‘continuity’ in transport energy systems: the case of the ban on new conventional fossil fuel vehicles

Christian Brand, ECI - Energy Group. Environmental Change Institute, University of Oxford, United Kingdom

Jillian Anable, University of Leeds, United Kingdom

Panel

6. Transport and mobility

Keywords

disruption, car transportation, CO2 emissions, transport electrification

The phasing out of the sale of new conventional petrol and diesel vehicles by a given date is one of a number of potentially disruptive policies that have been announced over the past five years. While the UK has opted for a target year of 2040 other jurisdictions have announced more challenging target dates (2025: Norway, Paris; 2030: Germany; 2032: Scotland) and scope (petrol and diesel, diesel only, non-electric).

There is lack of robust analysis that examines the various targets and phase outs in terms of the key trade-offs in improving carbon emissions, air quality, and public health at various scales. There are also important issues around public acceptability, including how people buy cars and vans, how cars and vans need to be sold, accessed and utilised in order to accelerate turnover in the fleet. These need further investigation through the lens of ‘disruption’.

This paper investigates a number of alternative futures around the proposed ban on conventional fossil fuelled vehicles in the UK. By doing so it explores how such a strategy/ban can be achieved while maximising ‘co benefits’; what the impacts might be if the Government were more ambitious; how much ‘disruption’ is needed; and what the implications of different consumer acceptability scenarios are.

We used established modelling techniques and prospective scenario analysis to explore existing and alternative disruptive strategies with the view to achieve near ‘zero emissions’ and much improved air quality from light duty vehicles by 2050. The results suggest that the existing, relatively unambitious 2040 ban on internal combustion engine cars and vans can be achieved by essentially doing what we are doing anyway (continuous change) whereas more ambitious bans (e.g. 2030, and including hybrids) would require some ‘disruptive’ change within the existing socio-technical system. We conclude by discussing and mapping the policy options in terms of disruption for government, industry and consumers.

Municipalities as promoters of electric mobility? A survey study in Germany

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Elisabeth Dütschke, Fraunhofer Institute for Systems and Innovation Research, Germany

Panel

6. Transport and mobility

Keywords

municipalities, electric mobility, quantitative survey

The use of electric vehicles (EVs) has the potential to make the transport system more sustainable and to improve the quality of life in local communities. Municipalities are an important player in the market diffusion of EVs as they can promote and implement electric mobility in various ways, e.g. in their own fleets or municipally-owned companies. They are also in a position to create the conditions that make electric mobility more attractive, not only to local companies, but also residents. This includes supporting the development and expansion of infrastructure, e.g. charging stations. Furthermore, they can act as information brokers and thereby enhance levels of awareness and knowledge.

We conducted a survey of 540 German municipalities with 5,000 inhabitants or more, including all major cities in Germany. The survey aimed to examine which fields of action are the most promising from the point of view of municipalities, and which structural factors influence their decision to engage in this topic.

We found that electric mobility is an important topic for German municipalities: More than 80% are already active in this field, another 10% are planning activities. To analyse the degree of activity in more detail, we developed an activity index comprising different fields. This indicates that the majority of municipalities are classified as having only an intermediate or low level of activity. Electric mobility is primarily an environmental and transport issue as well as an image issue. The expansion of charging infrastructure and the electrification of municipal fleets are the dominant fields of activity. We identified several structural factors that can help to predict the activity of municipalities in the field of electric mobility. These include variables concerning population, population growth as well as urbanisation and density indicators.

Estimating the sufficiency potential in buildings: the space between under-dimensioned and oversized

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Stefan Thomas, Wuppertal Institute for Climate Environment and Energy, Germany

Panel

7. Make buildings policies great again

Keywords

energy sufficiency, residential buildings

The emission reduction potential of energy efficiency and energy supply in buildings is estimated in various energy and climate action plans, scenarios, and potential analyses. But the third pillar of sustainability – sufficiency – is neglected in most studies. The increasing demand of space per person in the residential sector is a trend in most European countries. Its implication on energy use, demand for resources like land, building material, equipment, and waste production is enormous. Next to the ecological impact, the distribution of space has social and societal effects. Thus, sufficiency policies in the building sector complementing efficiency and energy policy are needed for a sustainable development of the European building stock.

But how can a sufficiency potential in the building sector be estimated? How much space and equipment is needed for a decent living and how much is too much? The paper proposes four areas of sufficiency in buildings: space, design and construction, equipment, and use. It presents a set of indicators, a quantitative estimate of energy savings from reduced per capita floor area, and visualises the sufficiency potential in European countries in an experimental approach. The final discussion focuses on the question: What does this mean for policy making?

Built environment as mediator of good (or bad) household practices: moving towards sufficiency in middle-class houses in Pakistan

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Minna Sunikka-Blank, Department of Architecture
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, University of Cambridge

Panel

7. Make buildings policies great again

Keywords

material arrangements, practice-based interventions, households, practices, socio-technical, electricity consumption

Recent work in socio-technical theories has focused on conceptualising agency of the built environment in shaping social change. For energy policy, connections between building energy consumption and household practices have been well established by practice theorists. However, the role of the built environment in prefiguring household practices remains under-examined. This paper explores how the built environment mediates energy consumption in household practices and how this can inform practice-based interventions for sufficiency in space use.

The study is based on a comparative analysis of three critical case-study houses in Lahore, Pakistan; a typical modernist contemporary house popular among the middle-class today, a technologically advanced low-energy eco house and a passively designed traditional vernacular haveli.

Data collection included in-depth interviews with homeowners, observation and walk-through tours and indoor environmental monitoring as well as spatiotemporal mapping of practices using time-use diaries. Analysis reveals that the spatiotemporal arrangement of practices and resulting electricity consumption is greatly dependent on the house layout and urban design.

The built environment acts as a mediator through which variations in spatial arrangements have direct and indirect implications on sufficiency in space use and daily practices; for example, 'recrafting' the meaning of comfort, 'substituting' sedentary indoor space-use with more outdoor activities promoted through flexibility and prefiguring more collective instead of individualised practices by 'changing how they interlock' through shared spaces.

In addition, household practices are part of a wider system of building regulations and urban

planning that need to be considered in housing policies and integrated with energy policies. The study suggests that understanding the links between the spatial configurations of the built environment and household practices can have policy implications for housing to move towards sufficiency.

How earthquakes shook up Dutch energy policy: an overview on who should do what, when and how to renovate 99% of all Dutch houses in the next 30 years

Casper Tigchelaar, ECN part of TNO - Energy Transition Studies, The Netherlands

Geerte Paradies, ECN part of TNO, The Netherlands

Margriet van Lidth de Jeude, ECN part of TNO, The Netherlands

Renee Kooger, ECN part of TNO, The Netherlands

Nicole de Koning, ECN part of TNO, The Netherlands

Robin Niessink, ECN part of TNO, The Netherlands

Panel

7. Make buildings policies great again

Keywords

built environment, climate policy, natural gas, deep renovations

The energy policy of the Netherlands has made a dramatic shift in the last years. The province of Groningen suffers from earthquakes, caused by decades of gas extraction. As a response, the National government reduced onshore gas extraction with over fifty percent already and decided it should be terminated completely before 2030. The biggest industrial gas consumers are forced to change to alternatives. But the most ambitious target of all is to completely replace the use of natural gas for renewable energy in residential and non-residential buildings in the next three decades, leading to zero emissions in 2050 in the built environment.

In 2015, in the Netherlands 87 percent of all houses are heated with individual gas fired central heating systems. Also 12 percent was heated with gas fired collective heating systems. That means that all but one percent of all houses in the Netherlands will be affected by this shift in policy. On average a thousand houses should be transformed and renovated every day, many of them on a large scale, for the next thirty years.

Although almost 30% of the Dutch housing stock is owned by housing associations, most houses have to be renovated by individual homeowners. Dutch houses have been made more energy efficient gradually in the last decades. Now policy must switch from supporting minor renovation to facilitate major renovations in order to replace natural gas for alternative renewable energy sources.

In this paper we will discuss the scale of the task ahead. The authors of the paper are involved in the ex-ante evaluation of the Dutch Climate agreement, to be signed in December 2018. This

agreement will contain specific measures to facilitate the transition of the Dutch built environment. In this paper we will discuss the natural gas free concepts that are being discussed, the supporting policies as well as the costs and benefits both for society as a whole and for individual households.

Since it will be their houses that must be changed, individual homeowners and landlords are the key stakeholders in this process. All effort should be aimed at supporting them. In this paper we present the outcomes of a one year study that answers the wide-ranging question: Who should do what, when and how to renovate 99% of all Dutch buildings in the next 30 years?

The influence of intermediaries' advice on energy-efficient retrofit decisions in private households

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Barbara Sophie Zaunbrecher, Germany

First name Last name, Germany

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Panel

7. Make buildings policies great again

Keywords

building retrofitting, intermediaries, decision-making process, existing residential buildings, quantitative survey, conjoint analysis, craftsmen

Even though energy retrofits in the building sector are an important lever to reach the goal of a climate-neutral building stock, the investment rate in energy efficiency (EE) retrofits stagnates at a very low level (ca. 1% in Germany). Since most house owners are laypeople in the highly complex field of energy retrofitting, they are dependent on the advice and technical knowledge of experts. Therefore, we assume that the retrofit decision is influenced to a large extent by so called intermediaries (craftsmen, architects, energy advisors) who can, in this way, act as change agents for the diffusion of retrofit measures.

To test this hypothesis, an empirical two step procedure was pursued: a) Qualitative interviews were conducted to explore the decision space of private house owners in the context of energy retrofit decisions (n = 6 intermediaries and n = 6 private house owners); 2) A choice-based conjoint study was run with n = 96 participants (n = 63 with retrofit experience), where the impact of the attributes "cost of the retrofit measure", "type of financing", "energy cost savings", "qualification of the intermediary" and "recommendation of the intermediary" on the retrofit decision was assessed.

The recommendation of the intermediary had the highest impact, followed by the total cost of the retrofit measure and the type of financing. Energy cost savings and the qualification of the intermediary had the lowest impact on the retrofit decision. The influence of the intermediary on the retrofit decision, the relevance of energy cost savings and the qualification (certification) of the intermediary was higher for house owners with retrofit experience.

Findings indicate that not only monetary aspects but particularly the intermediaries' advice and EE-specific qualifications affect retrofit decisions of private house owners. Policy interventions should therefore target this stakeholder group for increasing retrofit rates in the private house sector.

Approach to an unknown: representative sample survey to explore the non-residential building stock in Germany – methods and first results

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Dr. Holger Cischinsky, Institute for Housing and Environment (IWU), Germany

Prof. Dr. Guido Spars, Bergische Universität Wuppertal, Fachbereich Architektur, Fachgebiet Ökonomie des Planens und Bauens, Germany

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Panel

7. Make buildings policies great again

Keywords

sample survey, refurbishment rate, energy consumption, non-residential buildings, building envelope

While residential building stocks are well monitored in order to satisfy the housing needs, in Germany as well as in many other countries the stock of non-residential buildings is a virtually unknown. However, this part of the building stock is of non-negligible relevance in climate protection strategies, hence quantification is needed.

In the project Research Database Non-Residential Buildings (www.datanwg.de) the objective is to shed light on the dark: For the first time, the non-residential building sector is subject to a representative sample survey concerning status and dynamics of its properties. The project is funded by the German Federal Ministry of Economic Affairs and Energy (BMWi) and conducted by the research consortium of IWU (lead), IÖR and BUW.

A new approach became feasible due to the recent development in geospatial data processing. A profound analysis of the Building Polygons (HU-DE) and 3D Building Models (LoD1-DE) provided the sampling frame for the so far unknown population of non-residential buildings. In a multi-stage sampling procedure, a representative sample of 100.000 building polygons was drawn. Screening on-site followed to determine the relevance of each sampling unit for the survey, to establish the relation between sampling units and population units and to gather information on the presumable owner, using a smartphone app. A professional market research institute is commissioned to conduct up to 10.000 interviews by phone or online questionnaire out of these data. These

half-hour interviews cover structural parameters, data on building envelopes and technical installations and refurbishment rates. In case the owner agrees, specialized energy consultants collect data on the actual building use and measured energy consumption in a follow-up on-site, budgeted for up to 1.000 buildings. The pilot project has been conducted successfully, the methods work, first results are encouraging. The main phase of the project is underway until end of 2019.

Evaluating the renewable heating and efficiency obligation for existing buildings – insights into the mechanisms of mandatory building requirements

Martin Pehnt, Ifeu – Institute for Energy and Environmental Research Heidelberg, Germany

Veit Bürger, Öko-Institut (Institute for Applied Ecology), Germany

Jan Steinbach, IREES, Institute for Resource Efficiency and Energy Strategies, Germany

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Sara Fritz, ifeu, Germany

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Panel

7. Make buildings policies great again

Keywords

energy efficiency policy, policies and measures, mandatory requirements, renewable heating law, evaluation

Germany's third largest state, Baden Württemberg, was the first to mandate the installation of renewable heating technologies in 2008. Owners of a heating system need to employ a minimum share of renewable energy of 15% of the heat demand when the heating system is replaced. Instead of employing a renewable heating system, the building owner can also opt for efficiency measures, including insulation of the building. A part of the obligation can be fulfilled by carrying out an energy audit based on an individual building roadmap.

For the first time, the effects of the Renewable Heating Act Baden-Württemberg have been evaluated in detail, based on statistical analyses of the available verifications, on market observations, interviews with 1000 clients, 150 heating installers, 250 chimney sweepers, 50 building companies, clients of energy audits and various stakeholder workshops and interviews, leading to a model calculation of estimated savings of the law. The paper will present the empirical findings and investigate the various mechanisms of the renewable and efficiency requirement, including direct and indirect effects, trigger effects, windfall effects and wait-and-see attitudes.

Overall, the law provides positive impetus for additional installations of renewable energies, more

energy efficiency and advice. This effect results from the sum of different effects: through the explicit requirements, it provides an additional direct incentive to expand renewable energies and substitute measures. Indirectly, the law strengthens the involvement with renewable energies both in the consultation process with heating engineers and planners/architects and in the purchase decision of customers. Additional energy consulting is also encouraged. However, the positive market figures compared to the federal trend are not completely causally attributable to the EWärmeG. The paper will conclude with a set of improvements of the Act itself and the surrounding policy landscape.

Mapping energy poverty in the EU: policies, metrics and data

Faidra Filippidou, European Commission, Joint Research Centre (JRC) Petten, The Netherlands

Maria Kottari, European Commission, Joint Research Centre (JRC), The Netherlands

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Panel

7. Make buildings policies great again

Keywords

energy poverty, domestic energy efficiency, energy efficiency policy, energy union

Energy poverty is a complex socio-economic problem and has recently gained wider attention as a priority policy issue for the EU (European Union). Designing a concept definition which represents adequately all its symptoms within the EU territory and accommodates all existing national understandings and interventions has proven particularly challenging. What is more, the lack of the common definition is hampering coherent EU actions and results in downgrading the importance of the issue from policy makers and citizens. Energy poverty primarily has its root in both low household income and energy inefficient dwellings.

This study provides an overview to the commonly understood, yet not universally defined, issue of energy poverty as it evolves in the EU today. We start by depicting the contemporary understanding on the issue, while attempting to untangle its complexity and highlight its causes and symptoms. The work continues with a synopsis of the legislative initiatives of the European Commission related to the topic, as initiated by the Third Energy Package and has been currently addressed in the package of measures included in the "Clean Energy Package".

Most important, we explore options for measuring the prevalence of the issue in connection to the reporting obligation, derived from the new Energy Union Governance Regulation, on the number of households in energy poverty and the energy performance of the housing stocks by MSs (Member States). The role of energy efficiency interventions at household level as an energy poverty mitigation instrument is discussed.

The influence of uncertainties related to the inputs of the French EPC's calculation method – an analysis for individual houses

Maxime RAYNAUD, ex-EDF R&D, France

Dominique Osso, EDF-R&D, France

Arthur Rolland, Edf R&D, France

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Panel

7. Make buildings policies great again

Keywords

energy performance certificates, uncertainty propagation, individual houses

The French EPC (Energy Performance Certificate) was implemented in 2006 to be mandatory for selling or renting a dwelling. From the beginning, the EPC's robustness was questioned. Field tests shown that, for the same building, 2 different energy labels could be obtained from auditors. Thus in 2012 the EPC was revised to make it more reliable by, among others, doubling the number of inputs in the calculation method.

Unfortunately, recent investigations show that the problems persist whereas a law plans to make EPC enforceable against third persons in 2021. In this way, the French government has announced a new rework of the EPC for 2019. In this context we study the part in the dispersion of EPC's results due to the calculation method.

In 2011, a first study consisted of an uncertainty propagation (Monte-Carlo method) and a sensitivity analysis in the initial version of the calculation method (2006 method) on the case of a single-family house. Using the same case and the same methodology (and also Sobol method), we are able to compare the differences between the initial and revised calculation methods.

The revised version is not more accurate and some main sources of dispersion results are identified:

- in almost all modes, estimated energy consumption has increased while the EPC is known to overestimate actual consumption,
- we observed a doubling of consumption's dispersion,
- significant differences in results exist between the input modes ("known input" vs. "default value" with threshold effects in the value tables),
- a large part of discrepancy depends on the uncertainties on transmission coefficients of the thermal insulation and on the surface area.

In conclusion, in association with the question of the qualification of diagnosticians, the calculation method must be deeply reworked so that the EPC becomes the main tool of the building stock refurbishment.

Is an assessment framework for energy efficient buildings hiding in plain sight?

Sally Semple, Heriot Watt University, United Kingdom

David Jenkins, Heriot Watt University, United Kingdom

Panel

7. Make buildings policies great again

Keywords

building energy certification, energy performance certificates, U-value, Energy Performance of Buildings Directive (EPBD), existing residential buildings, energy consumption

The focus of the Energy Performance of Buildings Directive (EPBD) was on standardising the assessment and energy efficiency rating of Europe's building stock. Energy assessments and energy performance certification (EPC) concentrated on the material properties of buildings, and used simple physical models to estimate energy consumption from these inputs. However, the EPBD has always allowed the use of empirical energy consumption to assess buildings.

This paper comprises an analysis of energy assessments in the six largest European countries, looking at the methods used to generate EPCs and how they vary across countries, regions and buildings. Differences are noticeable and can have considerable impact on what constitutes an energy efficient building within a standardised assessment framework. For example, Germany, Poland and France currently use absolute energy consumption as the basis for EPCs for some of their building stock. Each country applies different philosophies, categories and values to the assessment of the material and physical properties of its building stock.

The simultaneous use of empirical and modelled energy assessments for existing buildings can generate varying results with implications for energy policies that expect standardised assessments. This research quantifies the current extent and use of empirical and modelled assessments and further examines the use of estimated values within modelled assessments. Our research reveals the extent to which empirical data is currently being used across Europe and the variation in input data used for the physical modelling of energy consumption in buildings.

The use of empirical energy assessments can be consistent with the EPBD and formalising their use may be a way ahead for a more coherent low-energy building policy. Variations in the input values available for modelled energy assessments can diminish the authority of assessments for both building residents and policymakers. Identifying good and bad practice in energy assessment may help to develop better compliance structures for the future. This research makes clear the value of carrying out a pan-European analysis of energy assessment methods.

Put the pedal to the metal – how policies can accelerate the diffusion of energy-efficient building technologies

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Christof Knoeri, ETH Zurich, Switzerland

Panel

7. Make buildings policies great again

Keywords

building technology, energy efficiency policy, decision-making process, technology diffusion, construction industry

The diffusion of energy-efficient building technologies (EEBTs) – technologies that either use renewables as an energy source or are more efficient than standard solutions – is crucial for decarbonising the building sector. In many countries, governments thus introduced policies, including building energy regulation, voluntary energy labels, mandatory certificates, and financial support to leverage EEBTs.

However, many EEBTs still do not, or only slowly diffuse despite being economically superior compared to carbon-intensive technologies. Further, even successfully diffused EEBTs show very different adoption patterns and wide time-to-market ranges.

Improving policymaking to close this energy-efficiency gap requires an in-depth understanding of how policies influence the decision-making process of the actors in building planning for different technologies. In contrast, most previous studies qualitatively evaluate the impact of policies on the diffusion of EEBTs and consider the building planning process as a black box. In this study, we open this black box and quantify how policies can effectively target decision makers and thus accelerate the diffusion of EEBTs. To do so, we develop an agent-based model that represents Switzerland's building sector, and ex-ante simulate the diffusion of three successfully diffused EEBTs in Switzerland (i.e., low-e glazing, comfort ventilation, and heat pumps) from 1995 to 2015. This approach allows us to test the impact of different combinations of policy instruments on the diffusion of the three focal technologies quantitatively.

Our results show that, in general, policies had a significant impact on the diffusion of all three technologies – however to a varying degree, triggered by different instruments. While, for example, a label triggered early adoption of comfort ventilation, building regulation accelerated the widespread adoption of low-e glazing; heat pumps were mostly pushed by information campaigns. We further discuss how technological complexity and the construction organisation type moderates the influence of policies on diffusion. By opening the black box of the building planning process and quantifying the impact of policies on the diffusion of EEBTs, this study has clear implications for policymakers and the building industry.

Indian luxury homes: revising the energy conservation building code to address energy sufficiency and re-bound effect

Vivek Gilani, cBalance Solutions Hub, India

Philippe de Rougemont, Noé21, Switzerland

Dhruvit Parikh, cBalance Solutions, India

Prachi Bhujbal, cBalance Solutions, India

Hasan Banna Khan, cBalance Solutions, India

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Panel

7. Make buildings policies great again

Keywords

rebound effects, building codes, energy performance, air conditioning, energy sufficiency

In India, the Energy Conservation Building Code (ECBC), and other similar Green Building Ratings currently legitimize higher energy consumption in large sized (semi-luxury and luxury) 'green-homes'. Heuristic surveys amongst this category of Indian homeowners indicates a pronounced absence of knowledge of, and commensurate responses to, their 'total energy consumption', indoor cooling included. This efficiency-gap, caused by very high per-capita built space is inversely proportional to their acute awareness of embedded, show-prone efficiency features in the building envelope design, renewable energy harvesting on site, and highly energy efficient appliances installed.

1. This study first explores responses to the following question asked to high-emitting homeowners in India: whether the absence of this awareness stems from indifference or deep apathy towards the energy use issue, aversion towards the idea of limits (energy, carbon etc.) despite caring for energy issues, or from the general absence of per-capita (or sufficiency) criteria in the normative environment that they subscribe to.

2. The responses are then interpreted and absorbed into a proposed civil society initiative, a 'sufficient homes' discourse for India amongst government bodies, think-tanks, energy and climate policy advocacy groups, and green-building ratings organizations.

3. The study encompasses a scenario analysis for National Energy Conservation and GHG Mitigation by mathematical modelling of the relative efficacy of two policy alternatives: a) telescopic (i.e. more stringent with increased per-bed-room size) ECBC requirements, and b) replacing the conventional EPI metric (kWh/m²/year) with a per-capita metric (kWh/person/year).

Finally, with the Geneva-based NGO Noé21, the study will explore hypotheses to further a similar

sufficiency program centered on the implications of per-bedroom household size on total building energy consumption of residents in the Canton of Geneva.

Indoor environmental quality as a mean to catalyse the acceptance and implementation of the major new EPBD provisions

Vivian Dorizas, BPIE, Belgium

Maarten De Groote, Buildings Performance Institute (BPIE), Belgium

Jonathan Volt, BPIE, Belgium

Panel

7. Make buildings policies great again

Keywords

indoor air quality, indoor climate, Directive on Energy Performance in Buildings (EPBD), compliance, energy performance certificates, long-term renovation strategies, smart readiness indicator

Indoor Environmental Quality (IEQ) has a direct effect on health, comfort, wellbeing and productivity. Considering that people spend 90% of their time indoors, it is crucial that building legislation ensures sufficient levels of IEQ which can lead to healthy and comfortable indoor environments. Not addressing these inadequacies will be a missed opportunity and come with huge societal costs.

This study summarises the major opportunities to reflect the importance of IEQ in national and EU legal framework. The paper discusses how the aspects of IEQ, and indicators for the evaluation of the indoor environment can be integrated in relevant legislations.

The current EU legislations disclose several weaknesses as they do not sufficiently provide concrete details on how to address and achieve acceptable IEQ. The real opportunity now lies at national level, and it is therefore critical to develop approaches for the integration of IEQ in national policy frameworks.

To achieve this, four areas of opportunities are identified:

- (i) Long-term Renovation Strategies,
- (ii) Energy Performance Certificate (EPC),
- (iii) Smart readiness Indicator and
- (iv) Compliance and Quality control measures.

Reduction of living space consumption as necessity for reaching energy targets – potentials, barriers, policies

Tanja Kenkmann, Öko-Institut (Institute for Applied Ecology), Germany
Katja Schumacher, Öko-Institut (Institute for Applied Ecology), Germany
Johanna Claudius, Öko-Institut (Institute for Applied Ecology), Germany

Panel

7. Make buildings policies great again

Keywords

living space, consumption, energy policy, distributional effects, change of behaviour

Despite a more or less stagnating population, the living space in Germany significantly increases every year and leads to growing living space consumption per capita. A further increase is expected in long-term scenarios and will let sustainability, energy, and climate targets in the building sector much more difficult to reach. It also causes a growing use of space and resources, as well as enormous infrastructure costs.

In Germany there is a growing awareness of this problem, especially on a regional level. In an in-depth research project for the Federal Environment Agency of Germany we estimate the vast potential of a reduced living space per capita in general. We identify most promising target groups that use a living-space far above average and might be interested to reduce it. Retirees and households that face a break in their routine of lives such as reaching retirement age or families whose children are moving out are among those target groups.

For these target groups we analyze specific barriers against the reduction of living space. We have a closer look at actors such as policy makers, associations, and the housing sector, and their specific obstacles and motivations to address the problem. To support households to reduce their living space a mix of policy instruments is necessary, consisting of both informational and financial instruments.

In the project we describe existing approaches and create a set of novel instruments to support households of the target groups to reduce their living space. The impact of these instruments for energy consumption and emissions of the target groups is calculated. Furthermore we analyze whether or not these measures are attractive from the point of view of a household taking into account costs and benefits and show likely distributional effects.

The time dimension in deep renovation: evidence and analysis from across the EU

Tina Fawcett, ECI-CREDS, University of Oxford - Environmental Change Institute, United Kingdom

Marina Topouzi, ECI-CREDS, University of Oxford - Environmental Change Institute, United Kingdom

Panel

7. Make buildings policies great again

Keywords

building retrofitting, deep renovations, EU policy, time

Deep renovation of buildings is acknowledged both as a national and EU priority, and as being very difficult to achieve at sufficient scale and speed. A novel way to understand this complexity is to look at how renovation relates to time and timing in the physical, commercial and social systems in which it is embedded.

Deep renovation fits into a complex set of timings: time taken to renovate, the lifetime of individual measures, the payback time of investments, the amount of time a building is owned or rented, the life / business stage of occupiers, moments of opportunity. The aim of this research is to better analyse, characterise and contextualise the time dimensions of deep retrofit, from policy, market, building and user perspectives, and thus to suggest how deep retrofit can be accelerated.

The research begins with case studies which take different approaches to time. First are those which aim to speed up retrofit. This can be by technical innovations which focus on fast production and fitting of energy saving technologies, or through subsidised funding mechanisms, or both. Examples include KfW loans and Energiesprong. The alternative approach is to encourage deep staged retrofit over a longer time scale, e.g. via individual building renovation roadmaps. Involvement in the retrofit process is elongated rather than compressed in time.

In parallel we gather empirical evidence from EU-funded H2020 projects, recent UK renovation research, member states' building renovation policies, and communication materials from EU-level think tanks and NGOs. Analysing this data, together with the case studies, we look at how deep renovation as a whole is envisaged playing out over time, and the time characteristics of proposed solutions and the extent to which they respond to faster and further policy targets. The paper concludes with suggestions on how EU and national policy could be re-framed to better support deep renovation.

Minimum energy efficiency standards for rental buildings in Germany – untapping health benefits

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Jan Rosenow, The Regulatory Assistance Project (RAP), Belgium

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Panel

7. Make buildings policies great again

Keywords

minimum energy efficiency standards, multiple benefits, health, deep renovations, low income households

German building politics is in crisis. Despite ambitious sectoral climate protection targets in the building sector designed to reach the Paris Agreement, there is no political will to establish the required new and radical policy approaches that would untap the win-win potential of energy renovation. On the contrary, the connection of energy efficiency improvements in the building sector with multiple benefits are widely set aside – if not ignored by the German government.

The paper examines beneficial health effects of energy renovation for low-income households and proposes the introduction of minimum energy efficiency standards for rental buildings to untap this potential. It draws upon a previous literature review carried out in early 2018 on the connection between energy poverty and building types as well as on health benefits of building renovation with a focus on Germany. The literature review has been followed by a stakeholder dialogue and respective feedback loop. This is used to refine and update the desktop research. Ideas for designing minimum energy standards for rental buildings are further developed based on lessons-learned from country case studies (esp. France, UK, NL, Flanders).

Despite a considerable lack in data availability, the results show that:

- Energy poverty affects health. This is also a relevant problem in Germany.
- Tenants who live in buildings constructed before 1980 that have poor energy performance are particularly affected.
- Energy poverty has structural causes that cannot be adequately addressed by social policy measures alone.
- Minimum energy performance standards for rental buildings can help increase the rate of deep renovations, reduce energy poverty and mitigate health problems associated with poor housing conditions.
- The introduction of minimum standards for rental buildings should be accompanied by a financing model and complementary measures to achieve the desired effects and prevent the displacement of tenants.

Green leasing in Sweden – the case of the Swedish Energy Agency

Mehmet Börühan Bulut, Swedish Energy Agency, Sweden

Kathryn Janda, Energy Institute, University College London, United Kingdom

Sea Rotmann, SEA - Sustainable Energy Advice, New Zealand

Veronica Eade, Swedish Energy Agency, Sweden

Panel

7. Make buildings policies great again

Keywords

green lease, split incentive, building retrofitting, deep renovations, commercial buildings

Sweden aims to become carbon neutral by 2045 and improving the energy performance of buildings plays a crucial role in achieving this target. The split incentive problem is among the primary barriers that prevent cost-effective energy efficiency retrofits in the commercial sector, which promises a significant energy saving potential. Green leases, allowing for mutually-beneficial agreements between the landlord and the tenant for the energy efficient operation of a building, may solve the split incentive issue and encourage energy efficiency in the commercial sector. The uptake of green leases on the Swedish market, however, has been slow due to several factors despite the existence of an industry-standard green leasing agreement.

The Swedish Energy Agency, with the help of national and international experts, identified the barriers to the wide-scale uptake of green leases for commercial buildings in Sweden. Some of the prominent barriers that were identified were as following: there is lack of awareness and willingness by building owners and tenants to use green leases more frequently; some green leases are considered “green washing” and therefore not effective; and, there is a perceived imbalance in benefits between tenants and landlords.

The Swedish Energy Agency, which moved to a new building in October 2017 and signed a rental agreement that would entail the inclusion of a green lease clause, has developed, with the help of the experts, a green lease agreement that would minimise the identified barriers and contribute to the further adoption of green leasing practices in the country. This work provides an overview on the use of green leases for commercial buildings in Sweden and presents the pilot project undertaken by the Swedish Energy Agency.

Energy decisions in heating consumption. Results from fuzzy cognitive maps

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Panel

7. Make buildings policies great again

Keywords

consumer behaviour, energy saving assessment, local energy policies, Fuzzy Cognitive Mapping, energy consumption

Background. The residential building sector in Spain, as in Europe, is a major driver of current and future energy consumption and associated CO₂ emissions. The main use of energy by households is for heating their homes. Policy makers need to better understand consumers' behaviour to design effective energy savings strategies.

Methods. We organized three focus groups in Spain to study which are the main factors that determine households' heating expenditure. The objective was twofold: (i) to learn more about the determinants of the energy consumption (and thus expenditure) for heating and (ii) to find out what policies can achieve more sustainable and eco-friendly heating behaviour. The three focus groups targeted a different population – citizens, academics and energy experts – in order to test potential differences. By aggregating the ideas mentioned by different participants, we used fuzzy cognitive mapping to represent key drivers of the system and connections between concepts.

Results. All the focus groups considered that economic variables such as energy price and income of households fully determined the heating bill. Variables related to physical attribute of houses such as number of rooms, insulation or orientation were also important. Other factors mentioned were lifestyle factors, such as turn on the heating system at night or other types of temperature control. Education in energy saving behaviour was also considered as important factor to reduce the heating bill.

Conclusion. The most significant differences between the groups were that, academics and expert groups considered that taxes could improve energy savings. However, citizens group expressed a strong preference for policies that could improve understanding of the energy bill. This study can be helpful for the design of effective policies on heating consumption.

Bridging the gap

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Panel

7. Make buildings policies great again

Keywords

existing housing stock, building trade, decarbonisation, domestic policies and measures, building refurbishment, building retrofitting

One of the many complex challenges in tackling climate change is the pressing need to achieve a major reduction in carbon emissions from existing buildings. Making the necessary improvements to the domestic sector presents particular problems around consumer awareness and priorities, disruption and inconvenience, cost and availability of finance, duration of tenure, and availability of appropriate (and trusted) contractors.

While work has been done to try to understand better the views and needs of the households and homeowners, a perspective that tends to be missing in policy debate is that of the contractors themselves. As the first point of contact for many homeowners who want building work done, these key market actors have a great deal of potential to influence such customers, and a wealth of knowledge to bring to retrofit. They could be the frontline in communicating, selling and implementing energy improvements.

Research carried out in the UK sought to complement existing knowledge with views from different standpoints, across a range of building trades, merchants and suppliers. The aim was to develop a better understanding of standard practice within the local supply chain in relation to home energy improvements, as a basis for seeking solutions to some of the barriers that exist.

The results are presented as a series of gaps: gaps in communications at many levels; gaps in construction education, training and qualifications; gaps between trades and between building professions; gaps in advice and information for homeowners and the building trades; gaps in quality assurance, transparency and accountability; gaps in business offering, and ultimately gaps in policy.

Planned staged deep renovations as the main driver for a decarbonised European building stock

Sara Fritz, ifeu, Germany

Peter Mellwig, ifeu – Institut für Energie- und Umweltforschung GmbH, Germany

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Jonathan Volt, BPIE, Belgium

Panel

7. Make buildings policies great again

Keywords

trigger points, Directive on Energy Performance in Buildings (EPBD)

The 2018 revision of the EU Energy Performance of Buildings Directive (EPBD) sets a clear direction for the full decarbonisation of the European building stock by 2050, and calls for policies and actions to stimulate cost-effective deep renovation of buildings. While one-step renovations have the advantage of integral planning and construction work without component connections and lock-in problems, staged renovations allow for less disruptive and more cost-efficient renovation measures by aligning them with given 'trigger points'. These are occasions either prompted by practical opportunities (e.g. need for repairs or building an extension), personal circumstances (e.g. a new-born in the family, retiring or children moving out), or change of ownership.

Staged renovations are by far the most common across Europe (e.g. 85% of renovations in Germany). This paper analyses how well-planned staged renovations can lead to a highly efficient building based on model calculations for typical German residential building. The model calculation shows that while the one-step renovation leads to 20 % higher energy savings over time for a 1990s multi-family building, the total cost is around 6 % lower in the stepwise renovation due to coupling the renovation measures to the maintenance and repair work required.

The paper concludes that one-step and staged renovations are not in competition with each other, but are both suitable solutions depending on the specific situation. It is crucial, however, that appropriate (national) renovation strategies ensure that staged renovations are deep. For this purpose, the paper draws on material compiled in the European Horizon2020 funded iBRoad project, which focuses on the development, testing and implementation of the building renovation passport (BRP). The BRP has been presented on the 2011 eceee summer study and since then been developed, implemented in several countries and referenced by the revised EPBD. The paper will describe the implementation options and experience gained so far.

Industrialised renovation: learnings from European frontrunners

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Sibyl Steuer, BPIE, Germany

Panel

7. Make buildings policies great again

Keywords

deep renovations, Industrialised renovation, Prefabrication

The European Union wants to decarbonise its building stock by 2050, a vision which entails a rapid scale-up of deep energy renovations and solutions. The vision requires new innovative solutions to effectively improve the building performance on a massive scale. Policymakers in the Netherlands have for several years viewed industrialised renovation as one solution to alleviate gas dependency and remove gas as source of heating and cooking for all residential buildings. Industrialisation, in this context, implies the aggregation and streamlining of replicable processes, instruments (e.g., financial models) or products (e.g., pre-fabricated materials or modular buildings). The Dutch Energiesprong project has demonstrated that the costs for a holistic net-zero renovation of a terraced house can decline from 130.000 euro at the first pilot-project in 2010 to 70.000 euro today. Energiesprong-inspired projects now exist in the United Kingdom, France, Germany and Italy. It is clear that the potential for Europe is huge but, so far, the impact remains limited.

A project funded by the German Environment Agency (Umweltbundesamt) and carried out by BPIE and co2online, aims to contribute to the understanding of industrialised renovation and identify key success factors for how the solution can be replicated. In a first step, elementary information was gathered on the existing European business models and research projects (n=20). The second step comprised a deep dive of the existing business models in France, The Netherlands and The United Kingdom, including analysis of the regulatory and financial frameworks. In a forthcoming third step, the specific situation in Germany will be assessed and transfer opportunities will be analysed.

Preliminary results indicate that to unleash the potential of industrialised renovation, a combination of engaged private actors and a supportive government (regional or national) is essential. To facilitate the uptake of industrialised renovation, policymakers should (i) have an ongoing dialogue with the market actors, (ii) alleviate regulatory and financial barriers, (iii) contribute to a simplification of the process (e.g. sample contracts), (iv) support standardisation in various kinds, and (v) provide financial support for the first phase of the market roll-out.

Decoding India's residential building stock characteristics to enable effective energy efficiency policies and programs

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Satish Kumar, Alliance for an Energy Efficient Economy, India

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Panel

7. Make buildings policies great again

Keywords

building stock, residential buildings, energy data, big data, India

Data is precursor to data-driven and evidence-based policies and promote strategic interventions for overall transformation. For building sector, energy related policy making hinge on the availability of data on the building characteristics like building type, floor area, electricity usage etc.

Residential sector in India, consumes approximately 24% of the national electricity (IESS) with 45% of the demand generated from the space cooling (BEE,2018). While the overall electricity consumption is accounted at national and sub-national level, there is lack of information of demand generated from each sub-sector i.e. High, Medium and Low Income Group due to fragmented character and absence of data disclosure laws. Several sub-sectoral level efforts have manifested into formulating strategies addressing thermal comfort, embodied and operational energy; however, a holistic approach is required to unleash full potential of energy efficiency and to support India's national and international commitments on climate change.

The study proffers a top down approach to decode residential stock with two fold objectives: (a) to inform meaningful insights about the current and near to medium term residential stock growth pattern like floor area, space cooling appliances and electricity consumption for various income groups, thus identifying key areas for interventions and enabling evidence-based national policies, and (b) to promote thermal comfort for all by exploring cost effective and energy-efficient space cooling strategies for various income groups to address India's escalating cooling electricity needs.

The data accounting is a first-of-its-kind exercise to bridge the building sector electricity consumption related data gap, by devising methodologies and illuminating key sources of data for long term assistance to researchers, policy makers and business community in conducting market sizing exercises in future that remain central to promoting data driven policy measures.

The contribution of energy efficient glazing to Paris objective in different EU building renovation scenarios

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Panel

7. Make buildings policies great again

Keywords

Paris agreement, long-term EU GHG emissions reduction, windows, renovation, building envelope

The commitment made in Paris calls on the EU to release a new strategy setting new levels of ambition for its GHG emissions reduction and define the contribution of its different sectors. The building sector is one of the sectors with the highest savings potential, and the distinct benefits of energy efficient buildings (e.g. economic, social and environmental) are often highlighted. To tap into this potential, a number of regulations, financial and fiscal incentives and other soft tools have been developed at all levels of governance, with mitigated outcome. While the building sector accounts for 40% of the European Union's (EU) energy consumption and 36% of its CO₂ emissions, the EU building stock continues ageing with a reduced number of new buildings, and low demolition and renovation rates.

This paper proposes to consider the impact of the renovation rates on the energy savings and CO₂ emissions reduction of one element of the building's envelope; i.e. the windows and in particular their glazing. Based on an assessment of the EU current building and window renovation rates and quantifications in a recent report commissioned by Glass for Europe to TNO (TNO 2019), this paper presents the quantities of energy and CO₂ which can be saved by 2030 and 2050 using adequate glazing depending on the building type and location. Four different scenarios are developed analysed for the entire EU-28: two scenarios assessing the maximum/theoretical savings potential of glazing (in 2030 and 2050) and the impact of doubling the EU building renovation rate between 2020 and 2030. Based on these findings, this paper will reflect on the current renovation trajectories and policies, and how can the reform of the EU climate policy help energy efficient glazing contribute to the Paris objective.

Building renovation passports: an instrument to bridge the gap between building stock decarbonisation targets and real renovation processes

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Lukas Kranzl, TU Wien - Energy Economics Group

Panel

7. Make buildings policies great again

Keywords

building energy certification, building stock, step-by-step retrofit, EPBD

The recast of the Energy Performance of Buildings Directive (EPBD) 2018/844/EU introduced in Article 19a the building renovation passports serving as a complementary document providing a long-term and step-by-step renovation roadmap for a specific building. The step-by-step renovation roadmap should guide and help building owners through the renovation process, therefore addressing barriers such as lack of acceptance and high initial investments, which hinder applying single stage retrofitting measures.

This paper aims to study the potential role of the step-by-step renovation measure sequences, as an instrument to achieve ambitious decarbonisation targets in the residential single family house building stock. For this, based on a literature review, first the concept of the step-by-step renovation roadmap has been explored.

Then, different exemplary, common step-by-step renovation sequences were developed and determined for different reference buildings, in terms of achieved energy needs for space heating. There are different approaches to define the step-by-step renovation roadmaps, first using multi-objective optimization models, and second, making plausible assumptions based on the common practice of retrofitting projects. In the present study, both methodological approaches are discussed.

Finally, by upscaling the exemplary step-by-step renovation sequences for the German single family houses into building stock level, we analysed and discussed the possible impact of these step-by-step renovation sequences, also compared to single stage major renovation measures and a decarbonisation scenario calculated with the Invert/EE-Lab model.

The results showed that the concepts applied (step-by-step and single stage) deliver different results, both in line with the total results provided by the Invert-EE/Lab Model. The analysis of the step-by-step approach resulted in lower energy demand in 2050 than the single stage approach.

However, to realize a more robust analysis, further sensitivity analysis should be done in order to cover other influencing parameters.

Finally, we believe that the step-by-step retrofitting concept is a renovation process taking into account restrictions which are relevant in real-life. Also, we suggest that this concept should be considered, when designing policies and incentives to achieve building stock decarbonisation targets.

How to finance the renovation of residential buildings: innovative financing instruments

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Marina Economidou, European Commission, Joint Research Centre (JRC) Ispra, Italy
Benigna Boza-Kiss, Central European University, Hungary
Valentina Palermo, EC JRC, Italy

Panel

7. Make buildings policies great again

Keywords

deep renovations, energy efficiency financing, ESCOs, subsidies

It is clear that to reach carbon neutrality in the EU by mid-century as recommended by the IPCC Special Report on 1.5 C there is the need to renovate existing buildings. The challenge is to increase both the pace and depth on building renovation, with at least 3 % of existing buildings been renovated each year and with the renovations aiming at Net Zero Energy.

A number of barriers prevent the implementation of deep building renovations. Policies and measures are implemented at EU, national and local level to remove these barriers however current policies and measures are not enough to achieve the mid-century target. The paper focus on the financial barriers in the residential sector, i.e. home owners not able to upfront finance the energy refurbishment. The paper reviews the current financing options as described in the MSs Long Term Renovation Plans. Then the paper investigates some innovative financing options and it assesses the application of these financing options to the residential sectors.

Beside more "traditional" financing schemes such as subsidies (including suppliers' obligations) and "soft" loans, the paper in particular assesses the Property Assessed Clean Energy (PACE), which is an innovative financing scheme successful in the United States but not yet tested in the EU. Other financing mechanisms analysed in details in the paper are: On-bill financing, Energy Efficiency Mortgage, the Feed-in Tariffs.

The papers also investigate the One-Stop Shop concept and the use of Energy Performance Contracting for deep retrofits in the residential sector. The applicability of the different financing instruments is analysed in relation to single vs multifamily buildings and also in relation to owned properties versus rented properties. The paper offers an assessment of the characteristics, benefits and challenges in the EU context of each of the analysed innovative financing mechanisms and it concludes with policy recommendations for the implementation.

Energy efficiency as a catapult to zero carbon buildings: raising city ambition through the Building Efficiency Accelerator

Debbie Weyl, World Resources Institute, USA

Victoria Burrows, World Green Building Council, United Kingdom

Panel

7. Make buildings policies great again

Keywords

zero-carbon houses, global platform, commercial buildings, accelerator, zero-carbon technologies, partnering project, collaboration

The Building Efficiency Accelerator (BEA) partnership works with cities around the world to transform markets for building efficiency. In its first two years the platform learned how to better accelerate local action. Even so, cities will need to make bigger improvements more quickly to meet local, national and global goals for reductions in carbon emissions and energy consumption.

The BEA seeks to enable city building efficiency action at the intersection of policy and private markets. The BEA platform engages 37 cities or subnational governments and over 40 organizational partners. Each city commits to implement at least one building efficiency policy, one demonstration project, and to track their progress.

To increase city ambition and long-term thinking towards a zero emissions future, the BEA partnership is now framing city commitments to include an overall vision of zero carbon buildings (ZCBs) by 2050. This provides a timely rallying message for cities to consider the applicability of ZCBs in their local context, compare notes with those leading the charge, and engage stakeholders to take coordinated action. Through it all, the BEA's support architecture for building efficiency helps cities take the first and most crucial step towards deep decarbonization: reducing demand. This also comes as the World Green Building Council (WorldGBC) launched the Net Zero Carbon Buildings Commitment in 2018 to drive ambition of local governments and businesses toward ZCBs at scale.

ZCBs are not often presented as a near-term possibility in smaller developing country cities where rapid urbanization will lead to immense growth in the next 30 years. Without significant changes, new construction in these cities has the potential to lock in inefficient design strategies that will require new buildings built today to undergo major renovations in the future to reduce emissions and improve adaptability. The BEA plans to help primarily these high-growth medium-sized cities in developing countries understand their near-term feasible pathways to ZCBs.

Some considerations for increasing city action on zero carbon buildings include:

1. Energy efficiency is a critical first step: Addressing energy efficiency increases the feasibility of achieving zero carbon by reducing the amount of renewable energy needed to meet remaining energy demand.
2. Boundary definitions can impact feasibility: Expanding boundaries beyond an individual building can include considering off-site measures, embodied carbon, district or portfolio approaches, or interactions with additional urban infrastructure.
3. Education about the feasibility of ZCBs is needed: increased awareness of ZCBs and how to achieve them results in broader understanding that they are possible in most contexts, or even already exist today.

Getting to the top floor: towards policy options to address the energy saving potentials of lifts

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Antoine Durand, Fraunhofer Institute for Systems and Innovation Research, Germany

João Fong, ISR - University of Coimbra, Portugal

Clemens Rohde, Fraunhofer Institute for Systems and Innovation Research, Germany

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Panel

7. Make buildings policies great again

Keywords

stock model, lifts, elevators, energy demand, energy saving potential, energy efficiency policy

Lifts are nowadays considered an essential part of nearly all larger new buildings. They increase comfort and make buildings accessible to handicapped and elderly people. Due to their longevity, lifts determine the energy demand of buildings in the long run. While a considerable amount of lifts has been installed in the last decades, the bulk of them is considerably older. Some installations, though partially upgraded, still even date back to before the mid of last century.

The aim of this paper is to further investigate how energy efficiency of lifts is currently addressed by European policy-making and to discuss how policy options on lifts might contribute to achieving energy savings for these installations. To underpin the analysis, a quantitative stock model for lifts is elaborated for this paper. Based on this model, different policy scenarios are discussed to analyse their potential impact on the energy consumption of lifts.

The stock model indicates that there are currently approximately 4.6 million lifts in operation in the EU-28 consuming in total about 18.9 TWh of electricity each year. Due to gradual replacements of inefficient older lifts and technological progress, this consumption is expected to decline to 10.4 TWh until 2050. Policy options for new lifts could help to lead to a further reduction in electricity demand of about 2.3 TWh. These options could be based on the inclusion of lifts in the list of technical equipment in the next revision of the EPBD, by further investigating on implementing measures within the Ecodesign process and by considering a European energy label for lifts.

Deep retrofit approaches: managing risks to minimise the energy performance gap

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Tina Fawcett, ECI-CREDS, University of Oxford - Environmental Change Institute, United Kingdom

Gavin Killip, ECI-CREDS, University of Oxford - Environmental Change Institute, United Kingdom

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Panel

7. Make buildings policies great again

Keywords

building refurbishment, deep renovations, retrofit approaches, renovation policies

Energy use in buildings remains a significant part of overall energy demand. Deep renovation projects, delivered at scale, remain a challenging task to achieve a lower carbon building stock. The complexity of building renovation beyond standards and building specifications is related to inherent characteristics of buildings which require distinct project management techniques. While there are now more projects focusing on achieving operational performance, there is still very little research on the management of the renovation and retrofit process itself.

Recognising that each project working on an existing building is unique in type, timing, energy goals and the roles/characteristics of people involved, the aim of this paper is to add to the current debate of how intervention approaches (one-off or over-time, whole-house, fabric-first room-by-room, measure-by-measure) are promoted by different policies, and with what impact.

The paper discusses the complexity of a deep renovation project in terms of planning and management and the ways current policies can lead to unintended consequences in the short and long term, as well in lock-in effects that contribute to energy performance, and to the gap between designed and actual energy performance.

Using a typology of risks, the issues associated with renovation processes and technologies were explored in a sample of cases studies from deep retrofits across the EU. The evidence from these shows that despite holistic planning for renovation, interventions tend to be carried out in phases. These contrasting time dimensions and the different retrofit approaches are discussed with risk profiles for each retrofit project, suggesting how risks emerge throughout a project. A series of risk mitigation strategies are suggested which, taken in combination to suit a specific project's risk profile, may serve to reduce and potentially eliminate the building renovation energy performance gap.

Living spaces: saving energy by encouraging alternative housing options for senior homeowners

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Immanuel Stiess, ISOE - Institute for Social-Ecological Research, Germany

Panel

7. Make buildings policies great again

Keywords

floor space, homeowners, counselling, building design, housing, heating

An important share of Middle European countries' energy consumption is used for space heating. The latter is determined by building energy efficiency, user practices, and floor space. Research and policy tend to focus on the first two factors and neglect the latter. In the German residential sector, per capita floor space has been increasing for decades, causing important rebound effects. Reducing per capita floor space by only 2 m² could bring 6% savings in heat energy.

Senior homeowners are a relevant target group. When grown-up children move out, they typically remain in the homes constructed for a family. 13% of all households in Germany belong to this group. Their average floor space is 70.6 m² per capita, compared to the national average of 43.8 m². These homes are often in need of modernization, and not very energy efficient or barrier-free.

The paper presents first results of the transdisciplinary research project "LivingSpaces", carried out in the district of Steinfurt in Western Germany. Its objective is to develop and assess policy instruments which support senior citizens in choosing housing alternatives that are both space-saving and suitable for their future needs – for example in terms of accessibility, energy efficiency, convenience, or community. Examples are moving to a smaller place, letting out parts of the home, or rebuilding the home so it can be shared with others.

The paper will present results of a representative survey that systematically explores senior citizens' attitudes towards various housing options. Furthermore, it will explain the communication approach that is at the heart of LivingSpaces and consists of several modules such as an awareness campaign, an innovative personal advice service "new housing in old age", workshops, and setting up a support structure that helps with practical issues such as legal, financial or organizational questions.

Social-environmental-economic trade-offs associated with carbon-tax revenue recycling

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Panel

7. Make buildings policies great again

Keywords

fuel poverty, carbon tax, renovation

As carbon taxes gain traction and grow tighter in OECD countries, the question of their recycling becomes crucial for political acceptance. Considering the impact of the French carbon tax in the residential sector, we examine the trade-offs between fuel poverty alleviation, energy savings and economic leverage for two revenue-recycling options – as a lump-sum payment or as a subsidy for energy efficiency improvement, each restricted to low-income households – defined as those belonging to the first two quantiles of the income distribution. We do so using Res-IRF, a highly detailed energy-economy model that interacts housing features (single vs. multi-family, energy efficiency, heating fuel) with key household characteristics (tenancy status, income of both owners and occupants).

We find that the energy efficiency subsidy recycling is superior to the lump-sum payment in all respects; it even annihilates the regressive effect of the carbon tax from 2025 onwards. No recycling, however, effectively addresses fuel poverty in private, rented housing.

EPC+: linking households to archetypes in retrofit decision-making support

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Panel

7. Make buildings policies great again

Keywords

building retrofitting, energy performance certificates, household archetypes, energy efficiency assessment, domestic energy

The under-realisation of domestic retrofit has often been attributed to occupant behaviour such as comfort take-back or rebound effect. Currently the retrofit rate is still low in meeting the UK government's target to reducing carbon emission by 80% by 2050. Energy Performance Certificates (EPCs), introduced by the first Energy Performance of Buildings Directive in 2002, serves an important platform for building owners and potential investors to access retrofit recommendations. However, the implementation of EPCs to date has limited impact on the users due to low reliability and lack of user-friendliness. Alternatively, other services for retrofit recommendations such as energy auditing or consultancy can be too costly and inconvenient for users to begin with. If EPCs can be made more reliable, containing useful, tailor-made and understandable information, it can be an appropriate tool to stimulate retrofits.

Retrofit recommendations accessible through Energy Performance Certificates (EPCs) or other channels use calculations based on standardised occupant behaviour. However, studies have shown that occupant behaviour can have a significant impact on energy consumption and subsequent retrofit savings. Therefore, it is crucial to include behavioural variations in generating retrofit recommendations. Employing dynamic energy modelling or collecting exhaustive behavioural dataset can be too expensive to implement for every household. Alternatively, the provision of household archetypes can bridge the gap between the standardisation and complexity of occupant behaviour. An archetype is a typical example of households sharing similar behavioural patterns and dwelling physical characteristics. It can help improve energy consumption predictions and enable policy interventions to respond to different household types while maintaining a comfortable indoor environment for occupants.

Previous research has demonstrated that using a differentiated retrofit approach can significantly improve energy saving potential compared with the conventional methods that standardise occupant behaviour such as EPCs. The modelling prediction showed that the performance of energy efficiency measures varied significantly and these variations were distinguished by the use of household archetypes. By distinguishing between household groups, each household can work out the most favourable and affordable retrofit strategy.

This research proposes an evolution of EPCs, namely EPC+, to further incorporate household

archetypes that can support building owners with tailored retrofit options using an assessment tool. The aim is that households will be able to access EPC+ through a web application, which requires a set of input data from householders to generate more personalised recommendations. The assessment tool takes into account not only household and dwelling physical characteristics but also occupant behavioural patterns as well as preferences and finances. It is envisioned that EPC+ will perform as an easy-to-access medium to better support the decision-making process of building owners and investors with improved reliability and relevancy to individual households, while triggering wider-spread home retrofits.

Load shifting with smart home heating controls: satisfying thermal comfort preferences

Clare Hanmer, University College London, United Kingdom

Charlotte Johnson, Newcastle University, United Kingdom

David Shipworth, UCL Energy Institute, United Kingdom

Michelle Shipworth, UCL Energy Institute, United Kingdom

Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

algorithmic control, heat pump, heating, heat controls

This paper investigates how UK households react to changes in daily heating patterns from a hybrid heat pump and the altered diurnal temperature profiles, which result from these new heating patterns. In the UK over 80% of homes are heated by a gas boiler heating water circulating through radiators. Most emissions reduction scenarios include a major shift to electric heat pumps. This would change home heating dynamics significantly because UK households are habituated to significant temperature fluctuations over the day as gas boilers are typically only operated in the morning and evening.

Electric heat pumps run for longer at lower outputs than gas boilers and are likely to require demand management to shift times of heating operation away from electricity network peaks. Consequently the patterns of both heat delivery and the resultant room temperatures are likely to change, flattening the diurnal temperature profiles currently found in UK homes.

Results are presented from a UK trial in which conventional gas boilers were replaced by a "hybrid" combination of electric heat pump and gas boiler, operated by smart heating controllers. Setpoint and actual temperature data from heating controllers in 71 homes were analysed and compared with data from conventional heating controllers in 3,579 homes. Interviews with 11 households explored residents' reactions to the changed heat delivery patterns from the heat pump.

Interview responses indicated that residents' temperature requirements are not simply linked to patterns of occupancy but also to the timing of practices taking place in the home, such as childcare. Analysis of setpoint data showed temperature settings were adjusted manually upwards in the evening in a significant proportion of trial homes, indicating a change in temperature requirements at this point in the day. The implications for home heating control and demand management are discussed, in particular the need to satisfy varying temperature requirements at different times of day.

Smart integration of energy efficiency and renewable generation for sustainability in university campus

Paula Fonseca, ISR-University of Coimbra, Portugal

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Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

zero energy buildings, energy storage

Given the challenges of climate change and recognizing their important role to lead the energy transition, Universities have been quite active in implementing energy-related projects in their campus. In the University of Coimbra, there is an increasing consciousness towards energy optimization and a strong commitment regarding good public budget management.

The Electrical Engineering Department (DEEC) building was constructed in 1996 and is composed of 9 floors, with a total area of about 10.000 m² and electricity consumption of about 500 MWh/year. In an electrical engineering department, there is an additional motivation towards raising awareness and students' engagement with sustainability issues. Therefore, the building has been the testbed for the installation of new energy technologies. The lighting was gradually replaced by LEDs. Additionally, the control of the lighting and Heating, Ventilation and Air Conditioning (HVAC) was also improved in the Building Management System (BMS). Another important aspect was the massive replacement of office equipment (computers, monitors, servers, printers, etc.) by options with higher efficiency.

A survey assessment was carried out in 2016 to characterize the use profile and collect all useful energy data. Data collection for lighting was based on building plants and classes schedules for each room. A walkthrough audit was also implemented to collect remaining information on existing systems and the smart meter infrastructure provided raw data for the evaluation of the total electricity consumption. After such assessment several energy conservation measures were implemented and therefore, this work assessed the progress achieved so far and discusses future options for improvement.

Furthermore, there is the objective to transform the building into a nearly Zero Energy Building, by installing photovoltaic (PV) panels with enough capacity to ensure a large share of the yearly electricity consumption. In the first step, a PV system with 80 kWp was installed in 2017, which ensures about 16% of the existing electricity demand and has contributed to a substantial decrease of the net demand. There is a good matching between the generation and consumption,

but there is a generation surplus in periods with a lower occupancy of the building, leading to a small injection of the PV generation into the grid. From the economic point-of-view, this is not attractive since the price paid for consumed energy is much higher than the price received for energy injected into the grid. In the context of achieving a nearly zero energy goal, the increase of the PV system capacity, would lead to a larger generation surplus. Therefore, the next step will be the use of energy storage and demand response to increase the matching between generation and consumption.

In this work, the sizing of a possible expansion of the current PV system was done, as well as the sizing of a storage system with the aim to ensure a reduction of costs with the purchased electricity. Thus, an intelligent control algorithm was defined and simulated with the objective of managing and controlling the storage system to ensure the maximization of the self-consumption and the minimization of costs with energy imported from the grid.

A storage system with low capacity (30 kWh of lithium-ion batteries) was already installed in order to evaluate the positive impacts of the available capacity, and later a larger system will be installed. Another future improvement measure is to implement control strategies in HVAC devices to introduce demand response actions. With the objective of developing a smart grid in a smart campus, the analysis presented in this work will show the impact of existing buildings towards the achievement of climate targets.

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Utilising smart meter data for research and innovation in the UK

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Tadj Oreszczyn, Bartlett School of Environment Energy & Resources, RCUK Centre for Energy Epidemiology, United Kingdom

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Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

smart meters, energy demand, domestic energy, big data, research, web portal

Great Britain aims to install 53 million smart electricity and gas meters in around 27 million domestic properties by 2020. Smart meters provide the potential for high-resolution electricity and gas consumption data that has never previously existed on a national scale. To leverage this national investment, UK Research and Innovation has funded a sizeable project to develop a Smart Energy Research Lab (SERL) to provide access to smart meter energy data for UK researchers. A primary objective of SERL is to develop a secure research portal for researchers to access energy data, linked to relevant contextual data (e.g. socio-demographics, building characteristics and weather data), thereby facilitating high-quality scientific research.

This paper focuses on data availability and will discuss the benefits, challenges and methods for developing a national data resource that will support a wide range of research across the energy sector. The paper provides practical guidance to researchers who want to utilise SERL data directly, as well as insights for researchers, policy-makers or other organizations who wish to utilise smart energy data more broadly.

Issues discussed include the complexities of data governance and quality associated with smart energy data, innovative approaches to research design (enabling both Observatory and Laboratory functions) and practical solutions to sector-wide issues such as smart meter consumer authentication.

Social energy management for energy efficient building operation

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Elias Dörre, Fraunhofer IEE, Germany
Jan von Appen, Fraunhofer IEE, Germany

Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

heat controls, energy management, user behaviour, competitions, social

The reduction of heating demand in existing buildings represents an essential goal of the German energy transition as a step towards carbon-free building heat supply solutions. To raise awareness of end customers for this challenge, a gamification based energy management approach called sema (Social Energy Management) is presented in this paper. The concept aims at motivating consumers to adjust their heating target temperature when rooms or buildings are not used via heating time programming combined with manual adjustment.

The sema concept integrates game design elements into building energy management. The sema concept was put into practice in a field test from 2016 to 2018. During the field test the sema concept was tested regarding electricity and heat demand of the households. This publication focuses on the evaluation of this field test regarding lowering the heat consumption. The test system is based on the open-source modular software framework for energy management and building automation OGEMA (Open Gateway Energy Management Alliance, <https://www.ogema.org>), also developed by Fraunhofer IEE. The central feature in each household is the semaBox that visualizes the participants' individual energy consumption. In addition, the semaBox informs the participants about their score, their ranking and the time-variant bonus for efficient heating within the energy gamification contest.

The reduction in heat demand due to the presence-oriented sema-based heat control could be estimated in the order of 5 to 15 % depending on household and building types. An economical assessment of the technology shows that a payback time of less than 5 years is realistic for the majority of the households in the field test.

Primary energy implications for low-energy buildings with different construction systems under varying climate scenarios

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Leif Gustavsson, Linnaeus University, Sweden

Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

life cycle, primary energy, space heating, cooling, climate change, overheating, construction systems

The building sector contributes largely to climate change through greenhouse gas emissions from building related energy use. In 2015 about 43% of the primary energy production in the European Union (EU) came from fossil fuels and the building sector accounted for 39% of the total final energy. Average EU temperature rise was 1.3 °C from 2002–2011 compared to 1850-1899, while projections for Sweden show average temperature rise of 2-6 °C by year 2100, compared to 1961-1990.

Climate change may thus affect thermal performance and energy use profiles of buildings in the long term. In this study, a 6 storey prefab concrete building in Sweden is used as reference to explore life cycle primary energy implications of different construction systems under various climate scenarios. The building was redesigned as low-energy building to the Swedish passive house criteria with construction systems in cross laminated timber, prefab timber modules or concrete.

With a system perspective approach, we account for relevant energy and material flows linked to production, construction, operation and end-of-life phases of the building alternatives, including thermal mass dynamics under current (1996-2005) and future (2090-2099) climates based on representative concentration pathways (RCP) 2.6, 4.5 and 8.5 scenarios. Results show that the buildings' heating and cooling demands as well as overheating risks vary significantly under the climate scenarios. The timber systems give lower production primary energy and higher biomass residues than the concrete alternative.

The concrete system gives slightly lower operation energy due to thermal mass benefits but still, the timber systems give overall lower life cycle primary energy balance. This study shows that low-energy wood buildings with efficient energy supply can play an important role in mitigating

climate change for a resource-efficient and sustainable built environment under current and future climate with small overheating risk.

How to implement energy management in a university organization

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Andreas Riis Christiansen, Viegand Maagoe, Denmark

Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

universities, Energy Management

As all public buildings in Denmark the University of Copenhagen is obliged to follow the Danish Government decision to reduce energy consumption in public buildings by at least 14% in the year 2020 compared to the year 2006. This decision is a part of Denmark's obligations to achieve compliance with the EU Energy Efficiency Directive.

In order to achieve this goal, the University has carried out a large number of energy saving measures and has already achieved substantial energy savings. To get even further energy savings the University is now implementing energy management on all levels. This article describes some of the challenges in this process and shows some examples on how to achieve actual savings with special focus on ventilation systems.

The beauty contest that nobody won – or how joint efforts brings high performance equipment to the market

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Lovisa Larsson, WSP Sveriga AB, Sweden

Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

energy efficient technologies, innovative technologies, building stock, networks

A unique co-innovation process between housing manufacturers and manufacturers of heating and ventilation systems has led to the market introduction of new high-performance combined compact heating and ventilation systems for energy-efficient single family-houses in a Nordic climate. The background of the project was lack of adequate equipment on the market, a generally increased energy-efficiency awareness and stricter national energy-performance requirements.

The project started 3 years ago with a technology procurement initiated by the Swedish Energy Agency's purchaser group for energy-efficient single-family houses, BeSmå. The purchaser group had identified a need for cost-efficient combined heating and ventilation systems for single-family houses with a low energy demand in a Nordic climate. Heat pumps and ventilation systems were readily available on the market, but they were over-sized with regards to installed power, needed too much space and were too costly. So BeSmå decided to stimulate manufacturers to deliver high-performance combined H&V systems.

Six tenders were achieved. Four of the tenders were very promising, but none of them achieved all of the technology procurement's mandatory requirements. Hence, no winner could be awarded. It appeared to be a beauty contest without a winner. However, the BeSmå purchaser group saw the large value of the received proposals. The Swedish Energy Agency agreed to turn the project into a joint development project between housing manufacturers and equipment manufacturers, and this has led to the imminent market introduction of at least three new combined compact heating and ventilation systems.

This paper presents a market transformation project aiming at more energy-efficient single-family houses. It presents the process from identification of the need to the market introduction, including the potential for energy efficiency in the Swedish building stock and detailed information on the purchaser group's requirements.

When energy efficiency refurbishment projects foster sustainability: a higher education institution case study

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Rui Amaro, IPC-ESAC, Portugal

Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

building refurbishment, higher education, sustainability, Energy Performance of Buildings Directive (EPBD), challenges

The new revised Energy Performance of Buildings Directive, which entered into force as of July 2018, brought new goals, which are mostly associated with national energy performance requirements, long-term renovation strategies, health and well-being of building users, incorporation of smart technologies and e-mobility. Although buildings' energy efficiency (EE) has improved over the years, further developments are still possible. Currently, in the EU, buildings still account for 40% of energy consumption and 36% of CO₂ emissions.

Higher education institutions play a key role in the promotion of sustainability and the dissemination of EE practice due to their educational responsibility. Yet, they face specific challenges due to their characteristics (e.g., organisational complexity of the public sector, resistance to change, old and historical buildings). In this work a case study in a public higher education institution is presented. The challenges emerging during the planning, implementation, monitoring, verification and evaluation stages are discussed. Effective energy savings and environmental impacts are quantified.

The Portuguese Government has recently put in place refurbishment policies in buildings to promote EE, such as the Operational Plan for the Sustainability and Efficient Use of Resources (poseur.portugal2020.pt/en/). This policy finances EE interventions in existing public buildings through a 95% refundable financing scheme supported by energy savings. In this context, the Agriculture College of the Polytechnic Institute of Coimbra has designed and implemented an integrated EE project comprising the deployment of thermal insulation in the roofs, double glazed windows, automated LED lighting, solar panels for water heating and a biomass boiler for central heating.

Although technical EE solutions in buildings are nowadays standard, the complexity of implementing them in the public sector mostly relies on organisational challenges: The motivation of the leadership: in this case study, it comprised not only monetary and energy savings and the improvement of thermal comfort and well-being of building users, but also the opportunity for

rehabilitating the building and the positive educational impacts on the students and the community. These positive impacts were widely recognised ex-post; The shared organisational decision process involving the institution's leadership at different hierarchy levels;

The capability to comply with technical requirements of EE technologies and, at the same time, with public tender process technicalities and bureaucracy, which required skilled and energetic human resources to facilitate the process and execute the project in due time; The organisational, technical and financial ability to cope with unforeseen and needed complementary actions; The active involvement of the community and a thorough planning, as the EE actions were implemented with all activities running as usual (including classes); The close interaction with the financing agency management as the project progressed, which enabled to test and refine formal procedures.

With a total investment of 360 k€, energy savings were initially estimated using building modelling as 30% (326 MWh/year), but as the project is being formally concluded, preliminary results show that effective savings only reach 17% of final energy consumption (123 MWh/year), avoiding the emission of 108 tCO₂/year and changing the building energy performance status to the B class. This venture has also encouraged the institution to implement other sustainability projects such as the deployment of energy management systems, new five EE refurbishment projects and e-mobility investments and is currently used as a case study in classes.

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Energy performance and lessons learned from detailed measurement of a passive house preschool in cold climate

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Gireesh Nair, Umeå University, Sweden

Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

passive houses, energy measurement, building energy certification, energy efficiency action plans

Public passive house buildings are rare in high northern latitudes. This study reports on extensive measurements and evaluations of the most northerly (64°N) built passive house preschool in Sweden. The two storied preschool, built in 2014, has a total heated floor area of 1407 m². The building was certified according to the international passive house standard. The building has several smart solutions such as demand controlled ventilation of individual rooms and automatic solar shading system.

Energy measurements conducted during 2017-2018 showed that the preschool annually uses 44.4 kWh/m², which is approximately 25 % lower than the passive house requirement for energy demand. However, the annual specific space heating requirement of 15 kWh/m² and the peak heat power demand of 10 W/m² were not fulfilled. This non-compliance was mainly due to excessive ventilation during the heating season which was found to have 2.7 times higher air changes than the requirement in the Swedish building code. Furthermore, the building was found to be over heated from the sun during several occasions in a year. For example, excessive indoor air temperatures in the range 28 – 31°C were found during summer.

The study revealed that the default winter operation by turning off the ventilation system during nights and weekends is continued in other seasons as well. This practice was not a “smart” approach for the air handling units as it was found to be one of the reasons for high indoor temperatures during non-winter months. Also, a mismatch between the operation of the automatic shading device and the ventilation control units was noted.

The investigation shows that smart technical solutions in buildings may not be able to deliver its' promised results if such systems are not monitored, adjusted and carefully evaluated. The paper identifies areas that need attention to ensure that a public building built to passive house standard actually deliver the energy efficiency it promises.

Making green easy: increasing sustainability investments in homes by decreasing the ‘hassle’

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Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

homes, investment decision-making, green investments

To achieve national and international climate goals on energy savings, home owners need to adopt sustainability measures in and surrounding their homes. Notwithstanding the efforts of public and private institutions, incentives to increase green investments in households have not taken flight.

One of the reasons is the persistent focus on financial and technical incentives, which do not tackle the psychological obstacles. An important example of these psychological objections considers the ‘hassle’ that people experience or associate with sustainable investments around the home. The Groen & Gemak (Green & Easy) project identifies and tackles this ‘hassle-factor’. We developed and tested propositions for green investments combined with a factor of ‘hassle-reduction’ For instance: attic isolation in combination with a service to clean the attic. We did this in close corporation with homeowners, local governments and private organizations. The goal of this project is to persuade more home-owners to install sustainable measures around the home by introducing market ready, hassle free solutions-to sustainable homes.

We started out with an initial questionnaire to identify incentives and obstacles for taking sustainable measures. Based on these results we developed initial propositions for green and easy sustainable investments. After testing these, we fine-tuned these to market-ready offers. In this paper we will discuss results of each step and how we came to the final attractive, green and easy propositions for home-owners.

This research is innovative in its approach, which is a synthesis of the home-owner’s perspective on sustainable renovation and practical knowledge of private parties in the field of sustainable renovations. This research provides new and valuable insights in the impact of the hassle-factor in sustainable home renovations which can help other researchers, policy makers and private organizations by describing ways to overcome this obstacle.

Demand-controlled energy systems in commercial and institutional buildings: a review of methods and potentials

Shoaib Azizi, Umeå University, Sweden

Gireesh Nair, Umeå University, Sweden

Thomas Olofsson, Umeå University, Sweden

Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

Occupancy detection, demand-side management

Heating, ventilation and air-conditioning (HVAC) are by far the most energy intensive systems in commercial and institutional buildings with office spaces. This makes HVAC systems attractive targets for energy efficiency improvement. New technological advancements can play significant role on improving energy efficiency.

Such advancements have been also emerged in form of novel management and control strategies, which might lead to considerable energy savings with relatively minor investments. This paper evaluates demand control HVAC and lighting to assess the energy saving potential of upgrading the conventional building energy systems.

This paper provides a summary of different methods and occupancy detection technologies. A range of technologies and methods are covered that vary in complexity, limitations and energy saving potential. Additional benefits such as demand response are evaluated and other emerging applications are discussed. Based on the review of methods and potentials, the paper assesses the state of the art in demand controlled energy systems and suggests areas for further research.

Correlating room air conditioner energy consumption with thermostat setting to encourage occupant behavioural change towards enhanced energy efficiency and thermal comfort

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Sandeep Kachhawa, AEEE, India

Saikiran Kasamsetty, AEEE, India

Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

adaptive thermal comfort (ATC), optimal thermostat setting, behavioural change, air conditioning, testing, energy saving potential, research

With less than 10% penetration today, the installed base of room air conditioners (RACs) in India is 39 million units which is expected to grow exponentially in the coming decades owing to increasing population, rising temperatures and improvements in quality of life. Surveys conducted by AEEE to understand RAC operating behaviour show that approx. half of the surveyed population prefer to operate RACs at set-points much below 24°C. With research efforts worldwide around thermal adaptation of people living in tropical climates, adaptive thermal comfort (ATC) based RAC operation is gaining traction among policy makers in India.

The Government of India is planning to frame definitive guidelines around optimal thermostat setting for RACs to encourage occupant behavioural change towards enhanced energy efficiency and thermal comfort. However scientific lab-based research to correlate RAC energy consumption with ATC based set-point is largely missing.

To support evidence-based policy formulation, AEEE took upon a study to establish energy savings impact through the adoption of ATC. While reviewing various test standards it was found that none of the accepted protocols support such testing and hence customized tests were designed in collaboration with a state-of-the-art balanced ambient calorimeter testing facility (NABL accredited) in India.

Three RACs of the predominant ~1.5TR cooling capacity of different make, efficiency and refrigerant type were tested at all combinations of three indoor conditions 22°C, 24°C, 27°C and three outdoor conditions 30°C, 35°C, 40°C. The test results reveal that an energy saving potential

of 8 to 10% per degree Celsius set-point increase could be reaped while increasing the indoor set-point from 22 to 27°C in inverter RACs.

The energy saving potential in case of used fixed speed RAC was observed to be only one third as compared to new inverter RACs. Empirical evidence on the energy savings or penalties due to thermostat setting presented in this paper shall help both policy makers to frame informed guidelines for occupants on optimal thermostat setting as well as manufacturers to set optimal default set-point and raise the minimum allowable thermostat setting.

The case of fuel cell micro-cogeneration in an increasingly integrated, flexible and low carbon energy system

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Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

cogeneration, CHP, smart grid, decarbonisation, domestic energy efficiency, primary energy, electrification, sectoral integration, flexibility

Europe's energy sector is undergoing significant transformations in response to climate change, energy security, air pollution and increasing energy costs. While addressing climate change has made the case for higher uptake of RES electricity, the intermittency of power from wind and sun, coupled with an increasing electricity demand, leads to an important system adequacy challenge. The electrification of heating in buildings alone is expected to more than double peak demand, causing winter peaks in particular to be likely supplied with inefficient and non-RES electricity in the short/medium run, putting a strain on electricity grids and countering decarbonisation.

Given these challenges, a new energy systems integration paradigm is emerging, aiming to break silos in energy across the different energy networks and markets. Fuel cell micro-cogeneration (FC mCHP) can enable the move towards sectoral integration, by providing flexibility, efficiency and decarbonisation between electricity, heat and gas systems at local level. Dispatchable FC mCHP mitigates the expected peaks caused by electrification, complementing demand response, energy storage and power-to-X solutions. Its key benefits are already proven: 1) reducing power grid costs by more than €2,000 for every kW of installed capacity up to 2050; 2) reducing CO₂ by at least 30% already today, with the potential to be carbon neutral via green gas and H₂; 3) eliminating NO_x, SO_x and PM in cities.

Following trials in real homes with positive customer reviews, FC mCHPs is now on the path to mass commercialisation. EU co-funded project PACE aims to unlock the market for FC mCHP, while demonstrating its smart grid capabilities as part of a Virtual Power Plant. The PACE contribution will present findings from PACE and its predecessor ene.field, showcasing the role of FC mCHP in supporting sectoral integration and delivering a carbon neutral, reliable, efficient and cost-effective smart energy system, now and in the future.

Positive energy districts based on NZEB

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Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

Energy Master Planning, Positive Energy Districts

Increasingly there are discussions about absolute resource limits in our cities. How much we save and how much can we consume? Will we have enough energy to continue as before, if we only apply (much) more energy efficiency and shift to renewables? A more systemic approaches and solutions are needed.

As a sustainable energy transition will see increased electro-mobility, its impact on the energy system needs to be understood and well integrated in planning. The Positive Energy Districts in this work consists of several buildings (new, retro-fitted or a combination of both) that actively manage their energy consumption and the energy flow between them and the wider energy system. Positive Energy Districts make optimal use of advanced materials, local RES, local storage, smart energy grids, demand-response, cutting edge energy management (electricity, heating and cooling), user interaction/involvement and IT. Positive Energy Districts are designed to be integral part of the district/city energy system and have a positive impact on it. Their design is intrinsically scalable and they are well embedded in the spatial, economic, technical, environmental and social context of the project site.

This paper focuses on discussing what limiting energy consumption entails, how this is related to consumption patterns in general, how much we should or could limit energy consumption. In Positive Energy Districts the objectives of climate mitigation and adaptation goals, local energy, air quality and climate targets and a secure and resilient energy system were met. Integrated requirements for Positive Energy Districts were developed based on NZEB and their environmental, economic and social performance indicators were identified. Related to environmental impact the ISO 14031 Standard presents 3 categories of performance indicators: Management Performance Indicators, Waste Indicators & Environmental Condition Indicators.

With these indicators the interaction and integration between the buildings, the users (consumers and producers) and the larger energy system can be monitored. The results can then be used to address implications of increased electro-mobility, its impact on the energy system and its integration in planning. The systemic use of this Matrix of indicators leads to the development of effective business models for sustainable energy services solutions; storage solutions; big data, data management and digitalisation solutions; and electro-mobility solutions.

Bringing Energy Master Planning on a district level gives the possibility to untangle the academic discussions on the dynamics of energy. Consumers and producers are integral parts of the solution by understanding and influencing energy use/consumption both on individual and societal level. Communication issues between consumers and citizens will be eased and their role

empowers them in limiting energy use/consumption and thus in creating the necessary communication and or engagement. This will lead the way towards wide scale roll out of Positive Energy Districts supported by significantly improved energy efficiency, district level optimized self-consumption where consumers (and producers) become the drivers of such systemic efforts. In particular the increased uptake of e-mobility solutions together with improved air quality has the potential to show the way for follow cities.

Behind closed windows – an actor-centred analysis of barriers for the diffusion of energy efficient ventilation systems in residential buildings

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Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

residential buildings, diffusion, ventilation, barriers, energy efficient technologies

Reaching the climate goals for the building sector requires to improve insulation and to increase air tightness of buildings in order to minimize heat loss. To achieve these goals and to prevent risks to the health of occupants and damages to the building fabric due to insufficient removal of pollutants and humidity, broad implementation of Mechanical Ventilation and Heat Recovery (MVHR) systems is crucial.

Comparable and up to date figures on the market penetration of MVHR systems across the EU are hardly available. However, figures point to only a small share of residential buildings being currently equipped with such systems (cf. Riviere et al. 2009). For the German building stock the figure is estimated to be below 5% (Händel 2011). The paper presents insights into the reasons for the slow diffusion of HRV technologies in the German building stock. It builds on the results of a recently completed research project whose central aim was to identify actor-specific and structural barriers for the diffusion of efficient ventilation systems in apartment buildings and to examine how these barriers can be addressed.

The analysis is based on 40 semi-structured expert interviews with energy consultants, HVAC craftsmen, and housing companies, as well as guided in-depth interviews with private owners of apartment buildings or apartments that were evaluated by means of qualitative content analysis. Based on the collected data, seven barrier categories were identified, each containing a range of single barriers for the diffusion of efficient ventilation systems within the residential building stock.

Results of the analysis were quantitatively validated by means of online surveys and a household survey among 1,008 households. The paper points out interdependencies within the chain of effects leading up to the investment decision of building owners. Furthermore, based on good practice examples identified within the data collection process, it proposes different measures to address these barriers.

Costs and benefits of optimizing hydronic performance of water-based heating and cooling systems

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Matjaz Osojnik, Danfoss d.o.o., Slovenia

Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

dynamic efficiency, building commissioning, energy performance, cost benefit

The paper presents physical, economical and practical aspects of optimizing hydronics in heating and cooling systems using water as energy medium by hydronic balancing. The scope covers residential and non-residential buildings with fan-coil, surface and radiator heat emission systems and addresses impacts on building performance under typical, dynamically varying operating conditions.

The paper starts with a qualitative assessment of different hydronic balancing approaches in heat emission, distribution, generation and the consequences for overall building energy use. Then, key results of new independent research on costs and benefits of upgrading buildings with existing technologies for static and dynamic balancing is presented.

The analysis of energy consumption benefits in actual building operation is based on data from validated field tests and from calculation methods of new EPB standards. It distinguishes cases of different energy need/envelope characteristics of older and newer buildings. A qualitative assessment of impacts on occupant well-being is also provided. The cost side analysis covers practicalities and challenges for installation and commissioning of hydronic balancing technologies in buildings and their building automation and control systems. It is shown that under conservative assumptions end-use energy savings of about 10 kWh/m²/a are achieved.

Consideration of full costs for equipment, installation and commissioning results in amortization periods that are in many typical retrofit scenarios cases below 5 years. The paper closes with recommendations for implementation of related elements of the amended energy performance of buildings directive.

Meta-study of the energy performance gap in UK low energy housing

Rajat Gupta, Oxford Brookes University, United Kingdom
Alastair Howard, Oxford Brookes University, United Kingdom
Alkis Kotopouleas, Oxford Brookes University, United Kingdom

Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

energy performance gap

This paper presents new evidence from a nationwide meta-study investigating the magnitude and extent of the difference between predicted and measured energy performance (energy performance gap) of 92 low energy dwellings in the UK. Statistical testing of predicted and measured energy use is undertaken to assess the impact of occupancy related factors (number of occupants, occupancy type, pattern) on energy performance, and to predict the likelihood of the space heating energy performance gap in UK new build housing. The dataset was drawn from the UK Government's National Building Performance Evaluation programme and comprises 30 Passivhaus (PH) and 62 non-Passivhaus (NPH) dwellings, covering different built forms and construction systems. The majority of the sample comprised social housing dwellings built with masonry and timber frames and equipped with mechanical ventilation heat recovery systems.

Although the average annual energy use (gas and electricity) in the PH and NPH dwellings was found to be 73kWh/m² and 117 kWh/m² respectively, electricity use was not significantly different between the two groups. All dwellings in the sample performed better than UK Building Regulations, however average energy use was higher than predicted by an average of 60%, but as much as 147% in PH and 241% in NPH dwellings. The overwhelming majority - 13 out of 14 PH and 35 out of 43 NPH dwellings - did not meet the predicted energy use, demonstrating a performance gap of 22 kWh/m²/year and 45 kWh/m²/year respectively. Occupancy was found to influence 45% of total energy use, with occupancy pattern being more critical than occupancy type and number of occupants.

Despite the high levels of fabric thermal standards, space heating was found to be the largest energy end use (28% in PH and 42% in NPH dwellings) followed by domestic hot water (28%) and small appliances (21%), while the ratio of regulated to unregulated energy was found to be 70:30. The probability of an energy performance gap in space heating occurring in the population of new build housing was found to be over 80%. The study findings are important for bridging the gap between intent and actual performance of new low energy housing.

Practical experience with energy and climate performance contracts towards future energy efficiency gains and sustainability

Harald Gether, Gether AS, Norway

Jørgen J. Gether, Gether AS, Norway

Rune Venås, Trøndelag County, Norway, Norway

Kaare Gether, Gether AS, Norway

Anders Solem, ENOVA, Norway

Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

energy performance contracting (EPC), climate action plan, thermal storage, dynamic efficiency, Negawatt

The article discusses an Energy-, Climate- and Performance Contract (ECPC) used at the Mære Agricultural College, Norway. It is a 15-year co-operation between the technology supplier, Gether AS, and the governmental property manager, Trøndelag County Council. It handles some 11 000 m² of built area. Thermal energy demand is about 2 million kWh annually. The agreement is developed to finance energy- and climate-efficient technology that would otherwise not be implemented. Enova, the national agency for implementing energy efficiency has partly funded the ECPC-agreement development.

Mære Agricultural College uses a Dynamic Thermal Energy Storage (DTES) system, first presented at the ECEEE Summer Study 2009. The energy system allows buildings as such as energy harvesters. The technology involves boreholes (BTES), heat pumps, 800 m low-temperature district heating, dry-coolers, and the DTES with the ability to store heat or cold quickly in order to utilize the 3000 m² Mære greenhouse as an energy harvester. Altogether, this is an extensive investment of some NOK 25 million, approx. €2.5 million. Energy efficiency at Mære is approx. 80 per cent improved over conventional technology using natural gas or bioenergy.

Development of the ECPC-agreement has taken place in cooperation between the County Council municipality and the firm. Key features are:

1. Multiple value elements are included in the agreement. Productivity, as production of tomatoes, is measured. Other productivity gains are climate benefits, or by example, reduced absenteeism related to indoor climate quality.
2. Gains are shared, divided in part on capital investments in the energy technology and by improvements attained.

3. Penalties are deliberately not imposed in order to encourage further gains without the co-operators making reservations.
4. It is considered to introduce items in the agreement that includes «Negawatt-hours». This is an ongoing work partially funded by Enova.

Grid-interactive, efficient buildings: expanding value streams through optimized control of flexible building technologies

Madeline Salzman, U.S. Department of Energy, USA

Aven Satre-Meloy, University of Oxford, Environmental Change Institute, United Kingdom

Michael Specian, US Department of Energy, USA

Jared Langevin, Lawrence Berkeley National Laboratory, USA

Harry Bergmann, U.S. Department of Energy, USA

Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

automatic control, control, demand response, demand side management (DSM), optimisation, building technology, electric storage, heat storage, dynamic efficiency, dynamic solar shading, smart grid, value

Energy efficient buildings can operate at lower loads, but without optimised systems, they are limited in terms of dynamically responding to grid signals to adjust demand to best meet grid and occupant needs. If enabled with intelligent controls, buildings' efficiency and flexibility features can become resources with value in electricity markets. As a result, grid-interactive efficient buildings could reduce and shift electricity consumption to the mutual economic benefit of building owners and grid operators, relieve system stress, better integrate variable renewable energy generation, and better meet building occupant expectations for optimised comfort, cost, and resilience. This paper describes how a new class of grid-interactive efficient buildings (GEBs) can both reduce net demand and benefit the grid through more flexible loads.

This research provides a new taxonomy for flexible building technologies: flexible timing, flexible efficiency, flexible fuel source, and flexible frequency/voltage regulation. Each of these flexibilities is linked to grid services recognised by electricity markets and analysed in terms of technical potential and optimisation requirements. This paper demonstrates an estimated 1.7 exajoules (XJ) of summer season energy savings from the technical potential of efficiency and flexibility in building cooling equipment. By targeting high-value electricity, these strategies could bring an estimated €28 billion in cost savings and over 60 million metric tons (Mt) in CO₂ emission savings.

Activity-based offices: synergies and trade-offs between energy efficiency and employees' work environment

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Cecilia Katzeff, KTH Royal Institute of Technology, Sweden

Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

work environment, activity-based workplace, sustainability, offices

Energy use in office buildings is significant. At the same time, more than half of the Swedish office buildings were erected before 1970, which means that extensive refurbishments and new establishments are expected. Requirements on efficiency in terms of costs, space and energy use are then usually high. To achieve both energy efficient buildings and stimulating workplaces, there is a trend towards the implementation of activity-based offices.

The activity-based workplace is structured to fit the employees' work tasks and may give an impression of stimulating employees' creativity. However, studies show that the work environment does not suit everyone. Instead, mainly managers and employees who frequently interact with others are supported by activity-based working.

Practical examples indicate that the efficiency of buildings may affect the employees' well-being and work environment negatively – i.e. aspects linked to social sustainability. Nevertheless, knowledge on synergies and trade-offs between environmental and social sustainability goals is limited regarding the workplace in energy efficient buildings. It has for instance been shown previously that studies on green buildings mainly focus on environmental sustainability aspects, while the social dimension is basically lacking. This includes aspects of physical and psychological well-being. Still, understanding the interaction between different sustainability dimensions is crucial for implementing sustainability work in practice.

The study presented in this paper is part of an ongoing Swedish research project exploring the consequences of energy efficient office buildings on the employees' work environment based on case studies and literature. This paper presents a literature review of scientific papers on the topic and describes the outline of the case studies to be executed during spring 2019. It is concluded that scientific literature focusing on both energy efficiency and work environment at the activity-based workplace is scarce. Still, to ensure that environmental benefits are not realized at the expense of the employees' well-being, it is highly important to further explore potential synergies and trade-offs between social and environmental sustainability factors.

Energy sufficiency in (strongly intertwined) building and city design – examples for temperate and Mediterranean climates

Lorenzo Pagliano, Politecnico di Milano, Dipartimento di Energia, Italy

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Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

energy sufficiency, low-energy summer comfort, urban planning, progressive tariff, primary energy, total primary energy

Within the future climate, which will bring longer and longer periods of high temperature in summer, exacerbating the heat island effect in cities, efficiency and sufficiency actions in buildings are strongly connected with enabling/hindering conditions in cities. E.g. the use of night ventilation in summer to achieve comfort without using air-conditioning is possible if:

- noise is reduced by car-limitation and/or speed limitation policies
- night air temperature is kept low via increased presence of vegetation and “cool” finishing of urban surfaces
- the installation and correct use of external solar protections on buildings (and streets) is explicitly and correctly included in local building codes and its effective application actively supported and controlled at city level.

The reduction of the per capita building surface might be encouraged by the availability of attractive shared spaces within buildings and outdoor e.g. children having safe, autonomous access to common indoor/outdoor spaces for playing, the creation of cool open spaces for pedestrians at district level by shading streets and squares with tenso-structures (as traditional in parts of Spain and Portugal) and trees. The use of climate and health friendly bicycle transport requires well designed spaces for bikes not only in the streets but also in each new and existing building.

We discuss how new «smart districts» and city re-design should and might include those and other efficiency and sufficiency-enabling physical features. We present a comprehensive matrix of interactions between building and district design for use by building designers and city planners with a focus on the emerging issue of summer comfort under a warming climate. A preliminary relevant question is if current policies are able to promote opportunities as the ones outlined above or there is a need to adapt those policies and how.

Towards urban building energy modeling: a comparison of available tools

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Magnus Åberg, Uppsala University, Sweden

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Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

Urban building energy modeling, Comparison of simulation tools

Along with sustainable urban development and energy efficiency initiatives, city-scale energy modelling of buildings has been receiving an increasing attention as a tool for planning and evaluating future viable cities. However, due to the lack of software developed specifically for urban building energy modelling, computer-based modelling tools, previously applied for evaluation of the energy use and performance of single buildings, are widely utilized.

The indoor climate and energy simulation tool IDA ICE, the transient system simulation software TRNSYS, and the building energy simulation programs EnergyPlus and VIP-Energy are some of the most commonly used examples of such tools. Although these simulation tools should in principle be possible to use for large-scale applications, there is no comprehensive study that reflects on the modelling procedure, inputs, outputs and validity of these tools compare to each other.

Thus, to investigate the capabilities of these tools for urban building energy simulations and to identify their advantages and disadvantages, in this study, a detailed energy model of a neighborhood including 32 district-heated buildings located in Sweden was developed in each tool. Hourly and annual simulation results were compared to each other and validated against thermal energy measurement data.

The results of the study show that the simulated heat demand is a reasonable approximation of the real one in all of the four tools. The annual deviation from the measured heat demand is +18% for IDA ICE, +15% for TRNSYS and about -13% and -16% for EnergyPlus and VIP-Energy, respectively. However, the simulated results from EnergyPlus, TRNSYS and VIP-Energy indicated higher correlations with the hourly measurements compared to IDA ICE. The findings of this study suggest that EnergyPlus and TRNSYS are the most applicable tools for use in UBEM.

SMELL (Using SMell to choose wELL) – alternative ways of communicating energy and climate solutions

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Agneta Persson, eceee President, Sweden

Margot Bratt, WSP Environmental, Sweden

Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

odor, indoor air quality

Increasing the installation of upgraded ventilation system is an important measure to reach Swedish and EU 2030 energy targets. Although improving and upgrading ventilation systems is an important energy-efficiency measure in existing buildings, many property owners hesitate to implement this measure, and tenants are reluctant to have it installed. Seemingly the reduced energy cost is not a large enough incentive and analysing what added values the upgraded ventilation system could provide might offer a better decision ground for the property owners and a communication ground with tenants.

The project idea is based on the difficulty of demonstrating and communicating added value, such as improved indoor environment quality, that can be achieved when upgrading ventilation systems in residential buildings. The hypothesis is that measurement and communication of odours linked to types of residential ventilation may help open up for a new way of evaluating indoor air quality and to strengthen arguments for energy-efficient ventilation.

Our pilot study investigated whether property owners can benefit from:

- 1) using odour as part of the communication with residents when considering measures for improved/upgraded ventilation systems,
- 2) comparing odours associated with different types of ventilation systems in residential building, such as natural ventilation, mechanical ventilation with exhaust air, and mechanical ventilation systems with exhaust and supply air and heat exchange, and
- 3) participating in a project where an odour based method is developed to stimulate upgrading of ventilation systems.

The pilot study was carried out in Sweden, where nine large property owners were interviewed. All of these receive complaints from residents regarding unwanted odours. The complaints are linked to particular types of ventilation systems. The property owners expressed interest in using odour as a parameter when deciding on renovation.

However, the lack of standardized monitoring methods and an existing terminology for a comprehensive understanding of the subject is perceived as a potential risk in doing so. Consequently, a standardized monitoring method with clear odour definitions was requested by the interviewed property company representatives. This standardization should;

- 1) differentiate between odours from the building (moisture, mould, chemicals) and odours from living (food, hygiene, medicine, pets);
- 2) include a delimitation of parameters that may affect odour (temperature, CO₂, presence, moisture).

The realisation of a zero-energy residential renovation in the Netherlands: from user acceptance to zero-energy performance guarantee

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Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

zero-emission houses, energy performance contracting (EPC), building refurbishment, technology acceptance

Realising an affordable Zero-Energy Renovation within the social housing context is particularly challenging, on one the hand due to the advanced performance and the required on-site energy generation, and on the other hand the increased investment costs. The discussed project demonstrated that such a goal is achievable.

The described project comprises a building of 12 dwellings which were refurbished to a Zero-Energy Building, while in an occupied state. 'Zero Energy Buildings' means that the housing complex generates the amount of renewable energy for both the building and users energy demand on an annual basis.

The 12-apartment complex is located in Vlaardingen, the Netherlands and was built in 1952. It is part of a district built of identical middle-rise complexes, using industrialised construction techniques. The dwellings are social rent apartments, and the buildings are owned by a housing association. The project aimed to balance deep retrofit, indoor comfort and affordability for the tenants. All parties involved want to learn from this project and make interventions become socially and financially achievable. Moreover, they aim to prove that this approach could change the rest of the stock into energy efficient and comfortable housing.

The lessons learned during this project are three-fold: the technical solution, including building envelop and services upgrade; the occupants' acceptance process; and the performance guarantee.

The renovation resulted in excellent insulation and air-tightness, featuring external insulation on the walls, new window frames with triple glazing and new, prefabricated insulated roof panels, which are fully covered with photovoltaic panels. As suggested by the national energy goals, the building is disconnected from the gas which complies with the current energy policy. The space heating and domestic hot water are provided by a ground-source heat pump of COP 6. The heat

pump, water tank and heat-recovery ventilation unit are placed in insulated boxes that are located outside the houses on a new, enlarged balcony.

The energy calculations show a net energy surplus on an annual basis for standardised occupancy. Those calculations allowed for a 25-year zero-energy performance contract to be agreed between the building services provider and the building owner. According to the contract, the building services provider guarantees the maintenance of the systems and the energy demand for a fixed amount per dwelling. Furthermore, to overcome the split-incentives barrier, the housing association signed a contract with each occupant for their energy use. The energy budget for heating and DHW, guaranteed by the building services, is 966 kWh per year, per dwelling, which is half of the on-site electricity production, per dwelling.

Nevertheless, to make the renovation possible, minimum 70% of the tenants need to agree. In this, project, the acceptance was 100%, which was achieved by a meticulous communication with the occupants. The tenants were included in the discussion and informed on the measures to be taken. They agreed to the energy budget and contract, which also specified the monitoring of the internal conditions and energy consumption, in order to test and improve the performance. The monitoring is ongoing.

The combination of measured and the energy performance contract resulted in a viable business case without increasing the rent after the renovation. This is an important achievement, given that the increased costs for the building owner is one of the main barriers to the implementation of zero-energy renovation concepts. The project in Vlaardingen is one of the first deep retrofit projects for multi-story social housing to be carried out in the Netherlands, which offers an important contribution to achieving both climate objectives as well as to affordable and long-term housing solutions.

Cost-curves for heating and cooling demand reduction in residential buildings

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Tobias Fleiter, Fraunhofer Institute for Systems and Innovation Research, Germany

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Pia Manz, Fraunhofer ISI, Germany

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Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

cost curves, refurbishment strategies, heating, building refurbishment

In Europe, there is a long-term objective to decarbonise the energy system, but it is currently unclear how this will be achieved for heating and cooling (H&C) demand of residential buildings. The European project “Heat Roadmap Europe” aims to develop low-carbon heating and cooling strategies, by quantifying changes at the national level for 14 EU member states.

One aspect of such strategies is the refurbishment of the existing building stock and the associated costs and energy savings. Therefore, cost curves of reducing the H&C demand in residential buildings are calculated, based on the FORECAST group of models. To estimate the investment costs for additional savings compared to a baseline development, this model framework includes refurbishment measures per building element (e.g. walls, windows, etc.). By ranking the refurbishment measures according to their specific cost and energy saved, one can derive annualized cost curves. Such curves have been widely used as a decision support tool by showing the additional costs or investment needed for a certain additional amount of energy- or CO₂ savings on a national scale.

The analysis shows that supporting deeper thermal renovation of buildings which undergo renovation under baseline considerations, is the most important missed opportunity to further reduce H&C demand. This can be achieved by e.g. converting overhaul of buildings into energy efficient retrofit or to include additional building elements in a planned partial retrofit. Further savings can be achieved by increasing the refurbishment rate (i.e. doing renovations in buildings which are untouched in the baseline).

Beyond certain thresholds, however, additional policy efforts would be needed to e.g. convince investors to aim for respective measures. Addressing these options needs more long-term oriented changes in the investment behaviour but it may be needed to achieve the full potential of additional energy savings.

The project Heat Roadmap Europe (4) has received funding from the European Union's Horizon 2020 research and innovation programme and the Swiss Federal Office for Research and Innovation under grant agreement No 695989.

8-411-19:

Thermal energy storages for cooling applications optimization using Artificial Intelligence algorithm

Jérémie Fricker, Engie
Sébastien Sailler, ENGIE Lab Cylergie, France

Panel

8. Buildings: technologies and systems beyond energy efficiency

Keywords

thermal energy, storage, space cooling, artificial intelligence

The use of energy for space cooling is steadily and globally growing. Cooling needs tripled since 1990 and at the same time greenhouse gas emission due to cooling systems tripled as well. The need for more efficient cooling systems become crucial, and the role of District cooling networks become more complex. They must provide the cooling capacity to meet each client cooling need, while reducing the operational costs, energy consumptions and CO₂ emissions.

Thermal Energy Storage (TES) like chilled water storage or ice storage is regularly mentioned as a way to improve safety and generate operational savings. These potential savings could be achieved if the TES is well designed and managed. The aim of this work is to explain how modeling, optimization algorithms and Artificial Intelligence (AI) could help further than current automated methods to get the maximum benefits of our TES.

Designing a TES – which means choosing its technology, size and control strategy to get high energy and economy efficiencies – is a complex task. Indeed, in addition of space and budget constraints designing calculations must consider simultaneously: electricity prices, equipment's performances, cooling load and TES production strategy. Thanks to energy balance models, equipment models, and production strategy scenarios, our algorithms test all the combinations over technologies, sizes and control strategies. The results of these high-speed simulations (1-year simulation time ~ 7 minutes of computation time) are displayed in graphs to compare them and finally to assist in decision-making. To go further, an Optimization Algorithm is implemented to determine the best daily charge and discharge curve of the TES with the aim to minimize operational costs, electricity consumption. These computations can be realized with past cooling demand profile to evaluate additional savings or with the future one to do a daily management of the TES.

That is the reason why we implemented a cooling demand profile forecast in our algorithms. In practical terms, a Long Short-Term Memory networks (LSTM), which are a special kind of recurrent neural network capable of learning long-term dependencies, is automatically generated for each dataset provided. Our results show that the cooling demand forecast is closed to real data, thus a daily optimal curve can be forecasted and followed by operators.

These algorithms answer to issues of finding out the best design and production strategy for TES. Even if R&D improvements are possible by getting better accuracy or reducing calculation time, the current real challenge is to integrate these methods into our operational processes. In the future, these features of optimization and demand forecast, could be directly added as an automation tool to do predictive management of our cooling plants as a decision-making tool for operators.

Quick seasonal performance testing for heat pumps

Carsten Palkowski, Bundesanstalt für Materialforschung und -prüfung BAM, Section S.4 Ecodesign and Energy Labelling, Germany

Dr. Anne Simo, BAM Federal Institute for Materials Research and Testing, BAM-S.4 Ecodesign, Germany

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

heat pump, energy label, testing, coefficient of performance, seasonal space heating energy efficiency

The surveillance of heating appliances regarding their conformity is of great importance as the energy consumed by space heaters accounts for a significant share by almost 80% of the total residential energy demand in the European Union. As a high-efficiency and low-emissions solution, several studies have identified heat pumps as the most promising technology for meeting future space heating needs.

The test method defined in EN 14825 for testing heat pumps for the Energy Label is validated by round robin tests and found to be very time- and cost-intensive. Therefore, this study proposes a two-point-method based on experimental data which could conceivably be an alternative to the European standard EN 14825 and similar test standards such as ISO 13256. Heat pumps were tested both in line with the EN 14825 and the proposed method.

The reduction of measurement points, from between five to seven (EN 14825) to only two (two-point-method), leads to 60% savings in cost and time. It is shown that the shortened method can be used to determine the seasonal space heating energy efficiency of heat pumps with the same degree of precision compared to EN 14825.

One step back, two steps forward – resource efficiency requirements within ecodesign

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Floris Akkerman, Bundesanstalt für Materialforschung und -prüfung (BAM),
Germany

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

resources, circular economy, Directive on Eco-design (EuP/ErP), energy policy

Resource efficiency is a much discussed topic in terms of improving the sustainability of energy related and energy non-related products. Resource efficiency aspects such as the availability of spare parts, the ability to dismantle, etc. have been included in draft working documents in the revision of several already existing Ecodesign regulations as a first step. However, often these aspects are not consistent with the current technology and design of these products. A possible reason could be a lack of sufficient consultation or of a methodology which is sufficiently tailored for this topic.

The established strategies and tools, used by policymakers, such as the Methodology for the Ecodesign of Energy-related Products (MEErP), do not seem to deal with these aspects appropriately. Draft requirements need to be very well developed before being discussed with member states and other related stakeholders, because including resource efficiency parameters could lead to additional, very wide-ranging effects on society. This topic cannot be covered well with legislative tools developed primarily for energy aspects. In this paper, a method is presented which can be used to combine products' properties with crucial resource efficiency indicators.

The method can be used to develop a set of draft legislative requirements and to pre-evaluate these requirements by target groups which would be affected by additional legal requirements. These include: market surveillance authorities, standardization organizations, manufacturers and their associations, environmental organizations and research facilities. The method incorporates stakeholders' feedback to identify potential resource efficiency measures for materials and/or products, their impact on the European ecology, economy and society. Based on this it would help to develop legislative requirements which are feasible and desirable. The results can then be fed into the formal legislative process, probably speeding it up.

The manufacturer economics and national benefits of cooling efficiency for air conditioners in Brazil

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Won Young Park, Lawrence Berkeley National Laboratory, USA

Nihar Shah, Lawrence Berkeley National Laboratory, USA

Roberto Lamberts, Lawrence Berkeley National Laboratory, Brazil

Nihan Karali, iei-Brazil, USA

Gilberto Jannuzzi, Instituto Clima e Sociedade, Brazil

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Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

appliances, engineering estimates, air conditioning, cost benefit, multiple benefits, bottom-up analysis

The revision of Brazil's minimum energy performance standards (MEPS) for air conditioners (ACs)—which are currently set to a modest level compared with international standards—represents a major energy-saving opportunity. We analyze the technical requirements, manufacturer economics, and broader benefits of strengthening Brazil's MEPS policies. First, we develop a cost-versus-efficiency curve based on more than 300 configurations of mini-split ACs rated at 1.0 refrigeration ton (3.5 kW).

We use this curve and economic modeling to estimate the manufacturer costs and industry net present value (INPV) of higher MEPS levels. The change in INPV is highly positive and increasing for higher-efficiency variable-speed ACs, indicating that manufacturers will benefit most by switching their production to the variable-speed (inverter) technology.

Achieving more modest efficiency levels require similar investments, which manufacturers do not recover through future revenues. Higher MEPS also provide larger consumer and national benefits. At the highest level analyzed (i.e., at the estimated technical potential), Brazilian consumers save R\$27 billion through 2035, and the power sector avoids 4.5 GW of demand (worth an additional R\$30 billion)—representing R\$400 in consumer/national benefits for every R\$1 invested in manufacturing high-efficiency ACs. In addition, higher MEPS result in substantial national CO₂ reductions, which could be increased further by simultaneously and cost-effectively transitioning to refrigerants with low global warming potential (GWP) in accordance with the goals

of the Kigali Amendment to the Montreal Protocol; our manufacturing analysis is applicable to ACs that use low-GWP refrigerants.

Although we focus on MEPS, our analysis can also inform the design of complementary policies that promote high-efficiency ACs in Brazil. We offer several policy recommendations based on our findings.

Accelerating cooling efficiency in Indonesia

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Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

cooling, market transformation, engineering estimates, energy policy, emerging economies

Rapid adoption of air conditioners (ACs) in Indonesia is driving an unprecedented increase in the country's electricity demand. In a previous study, we showed that new ownership of ACs will add 20 GW of peak demand between 2015 and 2030. However, the new AC purchases present an opportunity for large-scale deployment of high-efficiency inverter-driven (variable-speed) ACs in Indonesia, which could reduce AC electricity use by 30%–50%. Inverter-driven ACs have become widespread around the world, and their prices have dropped significantly over the past 5 years. Yet inverter-driven ACs still constitute only 10% of the Indonesian AC market, compared with 40% in South-East Asia and 65% in China.

In 2016–2017, we collaborated with Indonesia's Ministry of Energy and Mineral Resources (MEMR) to gather online prices and efficiency data for ACs in Indonesia through the International Database of Efficient Appliances (IDEA). We found that, although Indonesia's AC costs are relatively low, its incremental costs for inverter-driven ACs are still high, which is deterring mass adoption of this technology.

Our present research provides the technical foundation to design market-transformation programs tailored to the Indonesian context, with a goal of helping Indonesia create a market for high-efficiency inverter-driven ACs and benefit from global economies of scale. We take an engineering approach to assess economic impacts on manufacturers of transitioning to higher-efficiency ACs, and opportunities to transform the market towards inverter-driven ACs.

We develop a cost-versus-efficiency curve based on more than 300 configurations of mini-split ACs rated at 0.75 refrigeration tons (9,000 Btu/hr or 2.6 kW), calibrated using our IDEA market data. We use this curve and economic modeling to estimate the manufacturer costs and industry

net present value (INPV) that result from meeting higher AC efficiency targets. The change in INPV is highly positive and increasing when achieving stringent efficiency levels via higher-efficiency inverter-driven ACs, indicating that manufacturers will benefit most by switching their production to this technology. Achieving more modest efficiency levels requires similar investments, which manufacturers may not recover through future revenues.

We also find that higher efficiency targets provide larger consumer and national benefits. At the highest level analyzed (i.e., at the estimated technical potential), Indonesian consumers save over US\$10 billion through 2035, and the power sector avoids 7 GW of peak demand (worth an additional US\$15 billion). Achieving the technical potential would also result in 35 TWh of annual electricity savings by 2035 and up to 250 million metric tons of avoided CO₂ emissions during 2021–2035.

We plan to use the study to engage with the Government of Indonesia, local manufacturers, and Indonesia's national utility (PLN) to determine which programs will have the largest impact on transforming the Indonesian AC market. Indonesia is already revising its AC efficiency metric to be consistent with ISO 16358, capturing part-load/seasonal operation that better represents the efficiency advantages of inverter-driven ACs.

As a next step, we recommend that MEMR revise its four-star energy label so its labels cover the full spectrum of available AC efficiencies. Then, bulk procurement or green public procurement programs should be explored to drive down the costs of high-efficiency ACs and encourage consumer adoption. AC efficiency-improvement programs should be coordinated with existing and future refrigerant-transition projects under the Montreal Protocol to reduce program-implementation costs to manufacturers (equipment redesign and retooling costs) and consumers (costs passed through from manufacturers). Finally, we recommend that Indonesia adopt an aggressive long-term Minimum Energy Performance Standards (MEPS) target to prevent low-efficiency ACs from entering its market.

State of product energy efficiency in Europe – market insights from the new EU product registration database for energy labelling

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Karsten Schischke, Fraunhofer IZM, Germany

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

domestic energy efficiency, Energy Labelling Directive, database, compliance

In July 2017, the European Commission published the revised Energy Labelling Regulation (2017/1369/EU), setting deadlines for rescaling the current energy efficiency classes and introducing a product database. As from 1 January 2019, before placing on the market a unit of a new model covered by a delegated act, suppliers have to enter relevant product information in the new EU Product Registration database for Energy Labelling (EPREL). The database consists of a compliance part and a public part, which will be made accessible via an online portal. Its main goals are;

- 1) supporting national market surveillance authorities,
- 2) informing consumers on the energy efficiency of appliances and
- 3) providing the Commission with up-to-date information for reviewing energy labels.

The Regulation requires that the information will be made available as open data.

Since 1st January 2019 manufacturers can manually input the requested data in EPREL and since 1st February 2019 a system-to-system mass-upload approach has been made available. However, the Commission postponed the access to the open data (public part of the database) to the second quarter of 2019, for which reason we could not perform a first data analysis of EPREL at this stage, as initially intended.

The main objectives of the paper are fourfold.

- First, we introduce EPREL by providing a short historical background of the new EU database.
- Second, we show the structure and the main functionalities of the database as well as the main obligations for manufacturers.
- Third, we provide a brief overview over selected programmes in countries that have already implemented an online register system for energy related products in the past.
- Finally, we conduct a reduced market analysis for televisions on the German market, using data from the German comparison site www.idealo.de instead of EPREL.

The role of data centres in reducing energy consumption through policy measures

Larisa Maya Altamira, Viegand Maagøe, Denmark

Baijia Huang, Rockwool, Denmark

Jan Viegand, Viegand Maagøe, Denmark

Sophia Flucker, Operational Intelligence, United Kingdom

Davide Polverini, DG GROW — Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, European Commission, Belgium

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

information and communication technologies, data centres, cloud computing, policy measures, market transformation

With increased digitalization and growing trends like Internet of Things and the Industry 4.0, there is an increased and rapid demand for computing power and storage capacity provided by data centres and enterprise server rooms. Ownership models are also evolving rapidly from in-house to outsourcing and Managed Service Providers centralizing computing and data storage. According to recent studies, EU28 data centres' electricity demand in 2015 was 78 TWh/year and is projected to be 160 TWh/year in 2030. Globally, the increase is even higher: From 203 TWh/year in 2015 to 3390 TWh/year in 2030. These are important contributions to the EU/global electricity demands. Making future consumption projections is challenging due to the fast-paced market evolution.

At EU level it can be foreseen that, on one side, larger, more centralized data centres may provide overall energy savings due to higher IT equipment utilization, reduced need for cooling and better market conditions to supply renewable electricity. On the other side, due to factors such as low latency or simply inertia and very recent trends such as 'Fog computing', medium-small sized data centers would still make an important part of the market. In any case, the market on its own will not unleash the full saving potential and the role of policy measures becomes critically important.

This paper investigates the potential effect of two future measures: The servers and storage Ecodesign Regulation and the Green Public Procurement (GPP) criteria for Data Centres. The Ecodesign Regulation is expected to bring savings of 6.1 TWh/year by 2030, which could be larger if the scope would extend to the mechanical and electrical systems. In this way GPP could support it as it broadens the scope. The paper also presents aspects of resource efficiency and their trade-off with energy efficiency. Finally, it touches upon new trends such as distributed cloud computing and how it relates to centralised cloud computing.

Factors affecting the energy efficiency of cold appliances

Helen Foster, BRE, United Kingdom

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

cold appliances, energy consumption

It is estimated that 9.1 TWh of electricity in England was consumed by domestic cold appliances in 2017. Data from a 2015 study conducted by BRE on behalf of the Government Department for Business, Energy and Industrial Strategy (BEIS) provided further insight into the use of cold appliances, with a focus on over-consuming appliances (those that use significantly more electricity than designed to).

A large-scale field trial was conducted in which 998 appliances were monitored in 766 properties across England. Detailed electricity consumption and temperature data were collected. Also, householders were interviewed to establish how their cold appliances were acquired, used, and maintained.

Results indicated that 9 % of households contain at least one over-consuming cold appliance, where the average electricity consumption (730 kWh/year) was found to be more than double that of those operating normally (322 kWh/year). In addition, the main reasons for over-consumption were identified, which were: occupant usage; the age, type, size and location of appliances; and damage/faults.

Building on the findings of the 2015 project, the data has been revisited to examine the following:

- The key factors that impact cold appliance energy consumption
- The influence on the measured consumption from: the age and type of cold appliance; the environment in which it is kept; and the way it is used and maintained
- Differences between low and high consuming cold appliances
- Manufacturer's reported electricity consumption vs measured 'real world' consumption, for cold appliances.

The results of the study are discussed in relation to the results of the Household Electricity-Use Survey and follow-up reports.

Going beyond energy efficiency – method for calculating benefits of resource efficiency

Baijia Huang, Rockwool, Denmark

Jan Viegand, Viegand Maagøe, Denmark

Larisa Maya Altamira, Viegand Maagøe, Denmark

Peter Martin Skov Hansen, Denmark

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

circular economy, Ecodesign Directive (EuP/ErP), resources, environmental impact, life cycle analysis, energy efficiency policy

In light of EU's Circular Economy Package, there is an increasing focus on the potential contribution of energy related products (ErPs) to circular economy targets, by promoting life extension, reuse and recycling, hence reducing greenhouse gases (GHG) emissions and other environmental impacts.

Ecodesign and Energy Labelling regulations traditionally concentrate on reducing energy consumption of ErPs during use. As the energy efficiency of some products has improved and nearly reaching its threshold for further improvement, resource efficiency becomes pivotal in furthering sustainability. This is already observed for notebook computers; when the energy consumption during use phase reduces, the energy needed to produce computers is becoming important.

A review study showed that nowadays manufacturing represents between 56% and 75% of a typical notebooks' life cycle GHG emissions, this was about 40 to 45% in early 2000s. For printers and multifunctional devices (MFDs), the consumption of consumables during their use is more dominant than their energy consumption in terms of life cycle environmental impacts.

This paper discusses the balance of energy and resource efficiency of products, especially when resources outweighs energy consumption in LCAs, and how EU policies should go beyond energy efficiency by focusing also on reduction of resources. It also proposes a methodology for calculating the benefits of improving resource efficiency of ErP in terms of embedded energy and other environmental impacts. This methodology is developed on the basis of the EcoReport Tool that is widely used by all preparatory studies for Ecodesign and Energy Labelling, but with additional focus on other environmental impacts. A case study is presented to illustrate the calculated benefits of concrete resource efficiency improvements from reusing toner and ink cartridges for printers and MFDs.

Can efficiency be sufficient for African cooking?

Robert Van Buskirk, Kuyere, USA

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

direct solar electricity, solar utilization efficiency

Cooking in Sub-Saharan Africa (SSA) consumed nearly 0.5 Gt of wood per year in 2000 which lead to annual net CO₂ emissions of approximately 300 Mt of CO₂. This quantity of annual GHG emissions is roughly equivalent the entire national CO₂ emissions of a large European country: e.g. France, Spain or Italy.

This study examines whether efficiency for cooking—as defined in Europe—can be effective and useful for addressing the inefficient cooking next door in Africa that leads to these emissions. Cooking is the key household energy use in Africa, where 2 to 3 cubic meters of wood is consumed per household per year for cooking on average. This implies that cooking is 10 to 100 times more consumptive than any other household energy use in Africa.

By comparison, solar electric cooking essentially has no GHG emissions. This means that for the global clean energy transition that is currently underway, the largest opportunity for emissions reduction in Africa consists of switching cooking from wood fuel to solar-electric fuel. This study analyses current definitions of efficiency in this context. The analysis finds that a new definition of “solar efficiency” is needed in order to align the efficiency of African cooking with the least-life-cycle cost economics of African households.

A key element is solar efficiency is the capacity utilization efficiency of the solar panel: i.e. how much of the potentially electrical output of the solar panel is actually used by the load connected to the solar panel. When efficiency policy aligns appliance efficiency maximizes solar capacity utilization efficiency it helps minimize the life-cycle cost of the appliance solar electricity supply.

By using information on efficiency to align market incentives with least-life-cycle cost appliances, history has shown that this accelerates life-cycle cost declines for appliances markets. In the case of solar electric cooking in Africa, accelerated life-cycle-cost declines could facilitate both (1) a wood-to-solar-electricity transition for household cooking and (2) access to electricity in general for African households.

Can the provision of energy and resource efficiency information influence what consumers buy? A review of the evidence

Fiona Brocklehurst, Ballarat Consulting, United Kingdom

Catriona McAlister, Sea Green Tree S.L., Spain

Colin Whittle, Cardiff University, United Kingdom

Lorraine Whitmarsh, United Kingdom

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

rapid evidence assessment, resource efficiency

A wide range of information, including energy labels, eco-labels, and procurement guidance, are provided to encourage individuals and organisations to buy more sustainable goods. An understanding of the most successful approaches can enable more effective labelling approaches to support greater energy efficiency and the circular economy. This paper presents some results from research for Defra (the UK Government's Environment department) and WRAP investigating how the provision of factual information about the environmental impact of a product influences more sustainable purchasing.

The core of the research was a Rapid Evidence Assessment (REA), developing and applying a formal research protocol in order to make the process as objective, robust and transparent as possible. The full REA covers a wide range of environmental aspects (energy use; carbon footprint; sustainability; lifecycle impact; water use; reparability and durability) and products (electrical appliances; vehicles; buildings; textiles and clothing, paper and wood products, cleaning/home chemical and cosmetic products). This paper presents an overview of the REA methodology and an outline of some of the results and conclusions. It then focuses on the findings of four studies on the effect of provision of information on different non-energy sustainability aspects for energy using products.

Information on a range of sustainability impacts were found to be effective, for audiences in Europe and Asia, across an assortment of products, for most products. Further, this focused investigation supports some of the specific conclusions of the broader REA – namely that:

- not all sustainability impacts are equal in the minds of consumers; so a positive response to information on one impact may not guarantee a similar response to information on another.
- information on the same sustainability impact may be perceived differently depending on the product.

The recommendation is that further research will be needed to systematically test information across a range of products and consumer groups to determine which aspect of environmental sustainability will be most effective for which product and for which consumer group. Also testing aspects of environmental sustainability that are clear in their focus will help with comparability of effects between different studies and give an improved understanding of what sustainability aspect participants are responding to.

Tackling energy efficiency in professional appliances

Eva Geilinger, Swiss Federal Office of Energy, Switzerland

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

appliances, commercial, government initiatives, procurement, governmental support, public procurement

In contrast to domestic appliances and ICT equipment, commercial appliances often lack energy consumption information. The only appliance category with mandatory EU labelling is professional refrigerated storage cabinets; within the year refrigerated display cabinets and vending machines may also be covered. For others there are voluntary protocols for testing energy performance (ENAK in Switzerland and HKI CERT in Germany for professional kitchen equipment, EVA EMP for beverage and vending machines). Some categories like signage displays or electric hand dryers have no comparable initiatives. Interviews with large procurers reveal that electricity costs and efficiency are of little or no concern, even though significant costs could be saved over lifetime.

Total electricity consumption of commercial appliances in Switzerland is roughly 2-3 TWh per year. Domestic appliances and ICT equipment (domestic and professional) use 5 and 2 TWh respectively. The Swiss Federal Office of Energy (SFOE) set out to create better basics for improving energy efficiency in commercial appliances. This will be a focus of the next ten-year plan. The first steps include compiling an overview of existing basics and interviewing procurers about their current practices and needs. In a second step, SFOE is launching an open call for tenders. All stakeholders are invited to offer the creation of new tools or campaigns. This can include working towards harmonized standards and establishing procurement criteria or elaborating best practice examples or voluntary agreements with large buyers, manufacturers, suppliers and associations. It could also prepare to expand the financial incentive program ProKilowatt to further appliances (currently covering commercial dishwashers, heat pump cloth dryers, induction cooking plates and refrigerated cabinets).

At eceee summer study, I would like to discuss the most promising approaches for diverse appliance categories, challenges and new initiatives.

Novel method determining the degenerating insulation and age-related efficiency loss of domestic cooling appliances

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Rainer Stamminger, University of Bonn - Section Household and Appliance Technology, Germany
Jasmin Geppert, University of Bonn - Institute of Agricultural Engineering, Germany

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

domestic energy efficiency, household appliances, energy consumption, methods, energy saving technologies

Household cooling appliances form an integral part of our everyday life. Nowadays, refrigerators, freezers or combined cooling appliances are viewed as commonplace household commodities that belong to the standard equipment of most kitchens. In fact, more than 99.7% of all German households owned a refrigeration appliance in early 2019 [German Federal Statistical Office, 2019]. Due to this high degree of market penetration, refrigeration appliance's share in German national electricity consumption amounted to 5% [German Federal Environmental Agency, 2018]. Despite the omnipresence of refrigeration appliances, there is still a lack of knowledge about their age-related efficiency loss over time. In fact, past studies provide basic evidence for the increasing power consumption of cooling appliances with advancing age, but fail to investigate associated technical wear. The degenerating performance accounts for rising power consumption and increasing running costs over time. As a consequence, a profound understanding of reasons for refrigeration appliance's degenerating efficiency throughout their lifetime does not exist and has never been investigated before. Our study intends to close this research gap.

In this work, we intend to examine technical components that impact the power consumption of household cooling appliances over time. The age-related efficiency loss is most probably attributed to the wear of three distinct components, namely the compressor refrigerant circuit, door gasket and the thermal insulation of the cooling compartment. The challenge is to identify which component causes which degree of efficiency loss over time. In order to investigate age-related efficiency losses, non-destructive test procedures are inevitable. Therefore, novel measuring concepts relating the degeneration of each component to the increasing electricity consumption of cooling appliances have been developed and applied to a variety of different household cooling appliances. This approach enables us to investigate the decreasing energy efficiency of refrigeration appliances over a long period of time.

This contribution is an extract of our study and focuses on the technical wear of the cooling compartment's thermal insulation. A novel test procedure was developed to assess the influence of the degenerating insulation on refrigeration appliance's increasing power consumption over time. Previous studies investigated the age-related degeneration of refrigeration appliance's insulation based on detached specimens under laboratory conditions. Results thus exist for the stand-alone aging of the thermal insulation material only, disconnected from the operating cooling appliance and not performed under real life conditions.

In contrast to that we examine the degeneration of varying insulation materials intrinsic to cooling appliances. We apply our test procedure to a variety of test devices containing different types of insulation material to assess apparent changes in thermal conductivity. This novel method gives a test value (k_l) describing the quality of a testing device's insulation at the time the test is executed. Afterwards, we connect our test value to the heat transition coefficient (k -value) and conduct standardised energy consumption measurements.

Repetitions of our test procedure at different points in time allow us to draw a connection between domestic cooling appliance's age-related efficiency loss and their degenerating insulation. The course of efficiency loss of refrigeration appliances related to the degenerating insulation can be examined and anticipated. Our proposed method therefore forms an unprecedented test procedure. Therewith, our approach provides an in-depth investigation of household cooling appliance's efficiency loss for the first time and grounds the very basis for future improvements in energy efficiency.

Evolutions of energy labelling: lessons from German energy labels for air-conditioning and ventilation

Uta Weiß, Ifeu Institute for Energy and Environmental Research, Germany

Corinna Fischer, Öko-Institut (Institute for Applied Ecology), Germany

Mandy Werle, ifeu - Institute for Energy and Environmental Research, Germany

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

air conditioning, ventilation, energy-related products, product policy, energy label, building sector, energy labelling, cooling

EU product efficiency policy plays an important role in buildings through ecodesign and labelling of space and water heaters, ventilation units, air-conditioning and more. However, long-term climate and energy objectives require that product efficiency policies tackle even more energy savings. We can identify three areas that are not fully addressed by the existing EU energy label: first, products and systems already in use; secondly, the performance of products or systems in their operational context (e.g. dimensioning); and thirdly, planning and quality control of systems during their installation. A broader understanding of the possible functions of labels reveals that labels could be a helpful instrument in all three areas, and could be used by national governments to complement the EU Energy label.

This paper illustrates the case by way of examples from new German labelling approaches for air conditioning and ventilation: a “non-label” (a so-called QuickCheck with graphical display of results for systems in use), and a more detailed label for systems in use or new systems under planning and up to installation. The QuickCheck delivers an initial assessment that should motivate users to get a more detailed inspection. The system label largely follows the lines of the EU energy label, with the difference that it evaluates efficiency in the operational context: beyond component efficiency, it includes dimensioning and operation.

We show these are promising developments for energy labels with considerable savings potential. We analyse in which ways these labels expand the traditional understanding of labels by addressing new phases in the product / system life cycle and involving new actors, and discuss implications and challenges, e.g. with respect to broad penetration of the voluntary labels or market surveillance and verification. Due to their voluntary status, actual market penetration of the labels remains to be seen.

However, the labels have the potential to shed light on significant areas of energy consumption, which are today mostly opaque to their owners. We thus consider it worthwhile to explore

adaptations to the European context. Finally, bringing product policy closer to complex systems in buildings may also be a way to support long-term targets in the buildings sector.

Worldwide energy use and savings potential of networked devices

Paul Ryan, EnergyConsult Pty Ltd, Australia
Terence Smith, Mississippi Consulting Pty Ltd, Australia
Anson Wu, China

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

energy model, standby power, internet of things (IoT), Internet, bottom-up analysis, energy policy, networks

The network connected energy use of devices due to becoming connected is projected to be 3.5% of total world electricity consumption in 2030. This paper draws on work done for the IEA 4E Electronic Devices and Networks Annex (EDNA) to provide a unique view of where energy is consumed and key savings opportunities. A Total Energy Model (TEM) developed as part of the project illustrates the main downstream categories of energy use as well as the upstream energy use of the data centres (DCs) and wide area network (WAN). The research utilises over 200 data sources to build a bottom up model of network connected energy use.

The TEM calculates that network standby related energy use of connected edge devices (i.e., devices like sensors, TVs, PCs, smart phones) is projected to grow from 64 TWh in 2014 (0.3% share of electricity demand) to 300 TWh in 2030 or 1% of total electricity demand. In addition, the energy use of local area network (LAN) equipment is projected to use a further 350 TWh in 2030. Data centres are also projected to use 350 TWh by 2030. The key trends contributing to increased energy use are identified, and policy and technological opportunities to improve efficiency of network related energy use. Policy approaches could be useful, such as the European Union's Ecodesign networked standby regulation, Regulation (EU) 801/2013, have been introduced to reduce power consumption of ICT networks. Other voluntary approaches have also been successful with improving energy efficiency.

The advent of cloud computing, and more recently, fog computing; and the Internet of Things is resulting in the Internet's architecture changing dramatically. Over 45 billion devices are projected to be connected to the network by 2030 and potential energy savings are dependent on targeted action addressing key categories of energy use. The paper explores significant worldwide potential savings that may be achieved with appropriate policy action and highlights the technical/market factors that need to be addressed to ensure energy efficiency is a priority.

New energy policies to address ICT and network energy use

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Paul Ryan, EnergyConsult Pty Ltd, Australia

Terence Smith, Mississippi Consulting Pty Ltd, Australia

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

Internet, internet of things (IoT), information and communication technologies, energy policy

New policy approaches are required to address the additional energy use due to network connected devices, which is projected to be 3.5% of total world electricity consumption in 2030. This paper builds on work done for the IEA 4E Electronic Devices and Networks Annex (EDNA) to provide a snapshot of existing policy approaches and how to evolve to a more complete integrated approach. Energy use of the devices in our highly connected world include the downstream connected devices as well as the upstream energy use of the data centres (DCs) and wide area network (WAN). Although there are often energy efficiency benefits of automation and control, these complex systems that need to be considered as a whole to ensure that efficient outcomes are realised.

The assessment of environmental impacts, including the network standby related energy use of connected edge devices, the energy use of LAN equipment, WAN and DCs may be appropriate to address our rising energy use of networks (projected to be 1000 TWh in 2030). When major network platforms are introduced, energy efficiency is not always a consideration. The energy use of network delivered video content is one example, which is contributing to 75% of the traffic on the internet. Home voice assistant speaker platforms, such as Google Home, Amazon Echo are growing at an extraordinary rate, with energy use consequences at the device level and upstream in the cloud.

This paper identifies 'blind spots' in existing policies and explores how new voluntary or possibly mandatory reporting and disclosure of the system wide energy use of connected devices needs to be prioritised at the beginning of platform development. It may be possible to create an Energy Impact Assessment that identifies and discloses the various energy contributions and then pathways to minimise energy use. This would be used to guide the platform development over time and hold companies to account for their system wide impacts.

Energy efficiency in light of global trends in technical consumer goods

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Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

efficiency trends, risk management, domestic appliances, television, energy saving potential, trends, Global Trends, Retail Sell Out data

The aim of this presentation is to shed some light on how global trends for Technical Consumer Goods influence energy Efficiency. To understand this better, both the consumer demand and retail sales dynamics are analyzed using GfK data assets identifying the most relevant and common trends in the Technical Consumer Goods arena: Performance, Simplification, Premium, Borderless Shopping and the rise of Developing Economies. While these trends manifest across Telecom, Information Technology, Consumer Electronics, Small / Major Domestic Appliances, etc., one further specific trend exists for Major Domestic Appliances (MDA): Sustainability.

At large, energy regulations around the world are successfully motivating consumers to opt for better labels. Average energy consumption keeps decreasing within distinct product segments, e.g. Combi No Frost fridges or 8kg washing machines. Differences can be quite significant between segments, e.g. 409kwh per year for Side by Side fridges vs. 274kwh for Combi Fridges NoFrost.

The biggest risk for energy efficiency is the trend towards high-performance products, materializing in higher capacities and/or more appliances that are multifunctional. Good examples are Washdryers or Multi-Door fridges, which are energy intensive and sales are growing steadily. When adding market growth (= higher penetration/shorter replacement cycles) to the equation, the sum of the energy consumed and appliances sold in Europe (= fleet consumption) increases steadily every year, resulting in 11% growth in 4 years.

New regulation standards bear potential, because all market dynamics (demand and supply) are energy hungry. The highest impact can be achieved with Washing Machines and Refrigerators, each accounting for roughly 30% of energy consumption of the Major 5 product groups within Major Domestic Appliances. In terms of highest country saving potentials: Great Britain and France are on top of the list in Europe where the average energy consumption is 21% to 34% higher compared to Germany. Finally, smart home solutions may spark more efficiency.

Catalysing technology innovation in the off-grid market through appropriate product performance testing in the laboratory and field

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Makena Ileri, CLASP, Kenya

Elisa Lai, CLASP

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

off-grid electricity, refrigerators, data collection, testing, cooling

Appliance efficiency presents a low-cost and often overlooked tool to expand energy access and deliver higher levels of modern energy services to un- and under-electrified households and communities around the world. The scale of the opportunity in the African context is significant, as over 108TWh of electricity – nearly 18% of Africa's total consumption in 2014 – could be saved annually by 2030 if governments and markets across Africa transitioned to more efficient lighting, refrigerators, air conditioners, and motors .

Refrigerators, in particular, hold unique potential to unlock economic and social progress for the billions of people living without reliable access to electricity globally. Refrigerators enable increased food security, increased access to markets, and decreased health risks relating to food consumption. However, refrigerators intended for use by off-grid consumers must be considerably cheaper and run on far less energy than current industry standard products. A deeper understanding of the unique performance and design considerations for off-grid refrigerators is therefore essential to catalyse necessary advancements in product design and accelerate market growth.

This paper presents an analysis of the performance of off-grid refrigerators based on data generated via laboratory and field testing processes. The paper includes an introduction of an off-grid refrigerator performance testing methodology developed in support of the Global Lighting and Energy Access Partnership (Global LEAP) program. The test method was used to establish a foundational understanding of the performance of commercially available off-grid refrigerators as well as assess best-in-class products for the first ever Global LEAP Off-Grid Refrigerator competition. The paper then further explores the importance of conducting field-testing as a complement to lab-testing to assess the real-world performance of products tested in the lab using this methodology, and presents the results associated with an Innovation Cash Prize for Appropriate Design and User Experience.

It is observed that the energy consumption delta between lab and field testing is significant. Field testing provides some useful insights on consumer preferences, behaviour, and usage patterns and how these variables affect the technical performance of refrigerators. Analysis of these variables alongside technical performance data provides extremely valuable information that can be used towards innovation of the off-grid refrigerator market as well as contribute to continuous improvements and refinement of the off-grid refrigerator test method.

NORDCRAWL – The Nordic framework for collection, analysis and surveillance of market data based on automated and frequent crawling of retail web shops

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Peter Bennich, Swedish Energy Agency, Sweden
Lovisa Blomqvist, Swedish Energy Agency, Sweden
Linn Stengård, Swedish Energy Agency, Sweden
Kasper Schäfer Mogensen, Big2Great ApS, Denmark
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Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

Market data for EuP's under EU-regulation, Market trends, market surveillance, compliance, life cycle cost (LCC)

NORDCRAWL background

The project, financed by the Nordic Council of ministers, set out in 2014 to establish an internet platform for more automated collection ("crawling") of data from the internet. The focus was retail web shops and the ever-increasing web market for electrical household appliances, across the Nordic (Denmark, Sweden, Norway, Finland and Iceland) countries.

The system collects data from several websites representing the Nordic market, through advanced algorithms, ensuring continuous and accurate time series for how the market looks like for washing machines, dish washers, driers, etc, in terms of prizes, electricity consumptions, capacities, sizes, noise levels and other appliance specific parameters.

It is intended to keep the system running for years to establish a solid database describing the market, enabling the Nordic Energy Agencies to analyze all kinds of market trends and behaviors.

OUTPUTS

Outputs from the system comprises from traditional reports of number of specific models on the market, average electricity consumption and sizes, energy label distributions etc. to more advanced analysis of compliance with Eco-design regulations and establishing aggregated input to Policy Evaluation models.

Since the data is collected frequently (weekly), the change in the market can be tracked and

trends can be identified. Using assumptions about appliance lifespan and frequency of use, a life-cycle-cost can be calculated from purchase price and running costs, enabling an almost on-line illustration of how the LCC (and LLCC) moves in time for a specific product group.

FUTURE

From the data advanced metrics like cost-of-energi-efficiency could be derived and analyzed. Also, it is planned to look at how (and how quickly) the market responds to change, e.g. in the regulation levels for eco-design cut-off-values etc.

Factors for enhancing the market development of energy efficient heat pumps – scaling up through European policy instruments

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Caroline Haglund Stignor, RISE, Research Institute of Sweden

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Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

heat pump, ground source, Energy Labelling Directive, Ecodesign Directive (EuP/ErP)

Heat pumps have largely contributed to the almost phase out of fossil fuels for space and water heating in detached houses in Sweden, and for reducing greenhouse gas emissions by more than 90% since 1990. Ground source heat pumps are now a typical heating solution and equip a quarter of the houses, which is the highest penetration in the world.

The paper focuses on the factors behind this development. Special attention is given to the continuous research, development and dissemination policy programmes since the 70's. Also, taxes and subsidies are studied, as well as public product testing, information and advice, which have been essential to create consumer acceptance and trust for a new technology. Both the collaboration and the competition between manufacturers are analysed, as well as the training of installers they organise. The replicability of these factors in other situations is also discussed.

The paper analyses also the possibilities for enhancing the coordination between policy instruments at EU and at Member State level. The paper discusses implementation at national level, namely the interaction between standardisation and the verification of requirements under ecodesign and energy labelling implementing measures.

Lastly, the paper explores the perspectives for increasing the market penetration of heat pumps. One crucial factor is the capacity for demand-side flexibility, which can be promoted through ecodesign and labelling implementing measures, and through the buildings smart-readiness indicator.

The paper is based on the experience of the Swedish Energy Agency in its different roles: funding research and innovation, carrying out information and promotion activities, coordinating tests, negotiating requirements at EU level, and as market surveillance authority.

Development and evaluation of a novel test method for digital signage displays

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Marie Baton, CLASP, Belgium

Bob Harrison, Intertek, United Kingdom

Steve Fernandes, United Kingdom

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

testing, Energy Labelling Directive, standardisation, television, energy efficient products, public information display, digital signage display

Digital signage displays, commonly known as Public Information Displays (PID), are a rapidly expanding energy-using product across Europe and around the world. They are found in increasing numbers in public spaces like train stations and shopping malls; and are projected to grow by nearly 20% between 2017 and 2021, with a steady trend towards increasingly larger screens.

The European Commission's draft electronic displays regulation published in October 2018 proposes to establish an A to G energy label for these displays, helping procurement officers, retailers and specifiers to differentiate between products on the market. This new energy label needs a test method designed specifically for PID so the scale is indicative of product performance.

A comprehensive test method for measuring and comparing the energy performance of PID was developed, using dynamic video and static test patterns, providing accurate, quantifiable measurements of peak brightness, on-mode energy use and automatic brightness control characteristics. The test method reflects cooperative input from industry design engineers and will be presented to the relevant CENELEC and IEC standardisation working groups. The design and characteristics of the new test method are presented, offering a test methodology that is representative of how PID operate in the field.

This new test method is applied to a representative cross-section of products from the major manufacturers responsible for more than half the world PID market. The anonymised test results are presented in the paper, providing the relative ranking of this representative sample of 2018/2019 PID available in Europe. The paper also provides guidance on future test methodology for new trends in, modular, hybrid reflective/transmissive and transparent PID.

Recognizing and rewarding higher efficiency: case studies in moving to a single test metric for fixed and variable speed air conditioners

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Ana Maria Carreño, CLASP, USA

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

air conditioning, energy labelling, minimum energy efficiency standards, testing

Increasing the market share of inverter air conditioners is a key step towards improving the efficiency of residential cooling. Inverter air conditioners typically use 20% less energy than fixed speed air conditioners by operating at part load instead of turning on and off. However, the efficiency benefits from inverters are often not captured in energy efficiency standards and labeling programs because the metric used reflects only performance at full load.

In addition, economies that have implemented standards based on performance metrics that do capture the gains from inverters have often implemented these standards for inverter air conditioners only while continuing to rate fixed speed units under a different metric. Such policies prevent a fair, technology-neutral comparison between all types of air conditioners.

This paper examines the transition to a single test metric for room air conditioners and the resulting market transformation in India and Southeast Asia. In India, the convergence to a single metric and energy efficiency requirement for room air conditioners has accompanied an increase of inverter technologies from 5% in 2014 to about 30% in 2018.

In Vietnam, the introduction of a performance metric that captures the benefits from part load performance coincided with a near doubling of the penetration of inverter ACs in the market from 34% in 2013 to 65% in 2018. These case studies focus on the technical and institutional hurdles when shifting to a single test metric, and the impact on the room air conditioners market from the convergence of efficiency requirements. The lessons from these cases studies provide valuable insights for policymakers seeking to promote high efficiency cooling products in their markets.

Boosting African regional markets of highly efficient appliances through effective energy efficiency and trade policy

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Colin Taylor, CLASP, USA

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

air conditioning, minimum energy performance standards (MEPS), harmonisation

Policymakers in Africa are evaluating opportunities to improve the availability of affordable high efficiency products on their markets by implementing energy efficiency policy. In the Economic Community of West African States (ECOWAS), 6 of 15 member states are currently enhancing or implementing for the first time standards and labeling programs for major appliances. Under the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE), some regional standards have been developed and agreed on by all member states. The Common Market for Eastern and Southern Africa (COMESA) is working on enhancing sustainable regional energy markets through the implementation of standards for widely traded appliances.

On the other hand, 44 members of the African Union established the framework for the African Continental Free Trade Area (AfCFTA). As part of the agreement, countries have committed to remove tariffs on 90% of goods. Such tariff reductions on intra-regional trade, along with regional standards harmonization, have led other markets to be dominated by products manufactured and traded within their regional borders. The intra-regional trade of room air conditioners in the Association of Southeast Asian Nations (ASEAN) is a good example: a regional harmonization framework for room air conditioner standards and a Common Effective Preferential Tariff among ASEAN members resulted in ASEAN countries importing 68% of all room air conditioners from other ASEAN countries.

What if coupling proven energy efficiency policy tools with effective trade policy could reshape the regional market of highly efficient appliances in Africa? This paper evaluates the opportunity to boost the effects of regionally harmonized standards within the African Continental Free Trade Area (AfCFTA), by improving efficiency of appliances while enhancing intra-regional trade.

Assessing testing capacity in ECOWAS and ASEAN regions to support S&L programs for cooling appliances

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Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

testing, appliances, cooling, standards and labeling program

Reliable test procedures and test facilities that can provide consistent and accurate results are the foundation of successful standards and labeling (S&L) programs for appliance energy efficiency. Testing guarantees the quality and efficacy of products and enables governments and other stakeholders to accurately verify product performance, helping safeguard their S&L programs' estimated energy and emission savings.

Ensuring adequate testing capacity is necessary for the establishment of any S&L program, be it for research and design, conformity assessment or market surveillance purposes. Increasingly, policymakers are prioritizing building national or government-owned testing laboratories in support of new S&L programs. However, this requires significant investment, e.g. the cost to build a laboratory to test room air conditioners can exceed USD 1 million, which does not include the continuous funding required to maintain and operate the facility and support its staff. In fact, the actual need for and sustainability of laboratory operations is often overlooked, which can lead to underutilization and underfunding of newly established facilities. Alternative solutions such as outsourcing testing needs to private or foreign test laboratories are less attractive, even though they may be more cost-effective and enable greater market surveillance efforts.

Under the Kigali Cooling Efficiency Program, CLASP is assessing testing capacity and needs for cooling appliances in the Economic Community of West African States (ECOWAS) and the Association of Southeast Asian Nations (ASEAN) to facilitate implementation of regionally aligned standards. This paper will highlight common testing trends in these regions, current regional capacity to test cooling products for energy efficiency, opportunities to enhance existing regional capacity, and alternative cost-effective solutions to extensive testing for market surveillance.

CLASP policy database – an appliance energy efficiency tool for collaboration and innovation

Amanda McCrum, CLASP, USA
Ana Maria Carreño, CLASP, USA
Nicole Kearney, CLASP, USA
Rebecca Schloemann, CLASP, USA

Panel

9. Improving energy efficiency in ICT, appliances and products

Keywords

energy efficiency policy, database, minimum energy performance standards (MEPS), labelling

CLASP created the Policy Database (clasp.ngo/policies) over 15 years ago to provide a searchable listing of every energy efficiency policy covering appliances and equipment worldwide. This tool allows practitioners to both examine individual policies closely and consider them in aggregate to ascertain trends.

Today, over 100 economies have implemented or are developing S&L programmes for a wide range of equipment, from lighting and air conditioners to off-grid solar products. As standards and labelling (S&L) programmes have evolved and expanded, so has the Policy Database.

Ensuring the Policy Database stays current, relevant, and useful to a wide range of stakeholders – in particular energy efficiency policymakers, researchers, and other practitioners – is crucial. With added features and the inclusion of emerging technologies, such as off-grid appliances and equipment, the CLASP Policy Database has the potential to support tracking, benchmarking, and alignment of comprehensive appliance policy development at various levels – globally, regionally, and nationally.

This paper and the accompanying poster highlight the functionality, use cases, and potential outputs of the Policy Database, demonstrating the wealth of policies worldwide, where there are opportunities to do more, and regional collaboration opportunities to align policies and ultimately reduce energy use through the promotion of energy efficient appliances.