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PANEL 1

Foundations of future
energy policy

We have the facts, but ... what is the story?

1-003-17

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Keywords

behavioural change, business strategy, governance

Energy efficiency is a bargain for most actors. They can reduce their energy use and at the same time increase the quality of their service. This is a fact. 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 as fast as the advantages would merit.

This fact has been well documented 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/OECD. The latter has, however, also verified that the lion's share of the profitable potential will still remain unharvested for decades to come.

It seems as if mere facts about profitability, environmental advantages, energy security, productivity etc. 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, who argue the need for energy efficiency, may have to reconsider our approach. We may have to "qualify the facts". The facts have to be put into a more relevant context to fit how people think and react. The factual story must appeal to people and result in narratives that encourage the necessary mobilisation of the efficiency market actors. If simple facts do not support their vision of reality they will not act. The facts have to be fitted into a suitable/understandable context. We have to tell a better story or tell the story better!

Rwanda energy landscape 1-049-17

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Keywords

energy policy, energy behaviour, energy sources, environmental sustainability, regulatory, legal and institution framework measures

This paper reviews Rwanda's energy landscape. It looked into potentials energy resources, installed capacities and available technologies. Rwanda is well endowed with energy resources, such as solar, biomass, hydro, and methane gas and geothermal, though most of these resources remain untapped. Energy is considered the most powerful keys for a country to measure its economy development. Therefore, the inter-paly between energy production and consumption, and is preccursor of the level of development. The access to clean energy is very paramount and brings along with it a lot of socio-economic benefits to the citizens in terms of poverty reduction, cost effectiveness and safeguarding the environment. As a result of improving the service sector with emphasis on energy, regulatory, legal and institution framework measures, Rwanda has been, in 21st century, one of the ten fastest growing economies in the world. Among others, has fast growing energy accessibility rate of 8 % in 2008 that is currently standing at 23 %. Rwanda has an ambitious target to be achieved 70 % access rate by 2017/2018. Hydro remains the major source of electricity; followed by solar which has high potential; biomass, at 85 %, is Rwanda's primary energy source; and lake Kivu methane gas is the new source of energy.

Energy efficiency potentials in Iran: a precise look to one of the biggest energy producers ¹⁻⁰⁵³⁻¹⁷

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Keywords

policies and measures, investment, industry, energy balance, energy efficiency action plans, carbon emissions

The “Energy Efficiency Market report 2016” of the International Energy Agency (IEA) [4] estimates that global investment in energy efficiency, i.e. the additional investment required for efficient products, grew 6 % in 2015 to 208 billion Euros. Investment in buildings was over half of the total investment in efficiency and experienced the strongest growth at 9 % in OECD countries, compared to 2014. Investment in industry grew by 6 % and transport grew by 3 %. In another report called “Capturing the Multiple Benefits of Energy Efficiency” [2], IEA focused on its benefits beyond just reducing energy use and emissions, including overall sustainability, economic and social development, and increasing prosperity.

Iran has one of the greatest resources of fossil energy in the world. Statistics show that Iran with having 21.4 billion metric Ton oil equivalent (Btoe) is in 4th place and 1st place in Natural gas and totally by having 82.5 Btoe, is the 3rd country in terms of possessing fossil fuels (oil, gas and coal) (BP, 2016) [1]. On the other hand, this country is the 3rd consumer of natural gas and 12th consumer of crude oil in the world. Based on IEA energy indicators, by comparing energy intensity of Iran between years 1998 to 2009 for supply of primary energy to GDP, it would be seen that energy intensity (without considering production losses) from 0.43 TPES/GDP (toe/thousand 2010USD) has reached to 0.47 TPES/GDP in year 2009 with a slight slope, which shows economic growth and development from one hand and failure in energy efficiency on the other hand.

Based on Iran's policies for “General Policies of Consumption Reform” (2011), energy intensity should be halved till 2021 compared to amount of the base year 2011. In this way, the cumulative energy saving in the country is estimated to reach around 1,230 million metric Ton (Mtoe) which is approximately 5 times of the primary energy supplied to the country in 2009. As a result, Iran could avoid the threats of the energy shortage in buildings, industries, transportation, and agriculture sections. [...]

Mind your business: entrepreneurs, their dynamic capabilities, context and new business models for energy efficiency services

1-067-17

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Keywords

adoption, business models, user perspective, energy services, innovation policy

It is expected that as many as two thirds of the total potential for energy savings in 2035 will not be exploited. Energy services are considered to be a good delivery mechanism for Energy Efficiency. To bring these energy services to the market, the first step is a good business model. User-centred approaches to business model design are key as they are characterized by user involvement and interaction in different stages of the supply chain. A second element of importance to delivering effective energy efficiency services are the dynamic capabilities of business model developers and providers of services to focus on this customer perspective and tailor their services. A third element of relevance to understanding how to deliver more effective energy efficiency is the context influencing the model. Based on a comprehensive analysis of 42 businesses and their business model in 5 countries and an accompanying context analysis, our conclusion is that the tech-push perspective is centre stage in many framework conditions such as policies, regulations, incentives, financing institutions. As a result, the energy efficiency market is dominated by limited types of business models mainly focused on delivering goods and given the established framework conditions only incremental innovation of business models occurs in the energy field. We indeed need these products and the business models delivering them are successful enough to some extent, but the uptake of energy efficiency products demonstrates that to be effective at mass-marketing energy efficiency we also need services that facilitate this uptake. Such as services alleviating decision stress, or providing non-energy benefits as well. Because of their constitution however, these more user centered and service oriented business models challenge or stretch the existing framework, i.e. servitisation business models have a difficult time emerging. In this paper, we discuss findings from our empirical analysis, which led to the identification of four business models for delivering energy efficiency services, the dynamic [...].

Are international product energy-efficiency policies becoming endangered species? ¹⁻⁰⁷⁰⁻¹⁷

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Keywords

agreements, long-term scenarios, minimum energy performance standards (MEPS), overcoming barriers, TTIP, Brexit

The total primary energy supply curve in OECD-countries has been nearly flat since 2000, thanks to energy-efficiency improvements on several sectors, where international cooperation has resulted in binding legislation among members of the organisation. Earlier, we studied the impacts of free-trade agreements in force among OECD-members to speculate how the prospective EU–U.S. agreement (TTIP) could affect the minimum energy-efficiency performance standards (MEPS) policy. The TTIP wasn't agreed in 2015 as estimated, and it is still being negotiated, but chances are that the political tide is changing due to recent events in Europe and the presidential elections in the USA. Instead of free trade, we could experience countries withdrawing from international cooperation, and perhaps from widely accepted technical legislation (like MEPS) as well. The Brexit has left Britain to decide how they will continue with their product efficiency policy, with several options discussed in this paper. For the case of TTIP failing its target, we will discuss alternatives to harmonized technical legislation, for example, the possible role of IEC-standards defining several levels of efficiency for products on the global marketplace. Moreover, if TTIP results in increased industry self-regulation instead of mandatory requirements, as the latest textual proposals state, certain principles presented here should be followed when deciding the product groups for such treatment. Finally, we consider how to keep MEPS in pace with technological development and even pursue improvements if there is less ambition for international cooperation in 2020s.

Do smart homes know what people want and allow them to realize it? 1-085-17

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Keywords

household consumption, built environment, smart buildings

American architect and author, Malcolm McCullough, recently posed the question ‘Are smart buildings smart enough to allow me to open the window’ (McCullough 2016). This question succinctly captures one of the central dilemmas of the trend in energy policy towards reducing the fullness of energy consumption in buildings to technology-driven performance, and in so doing, discounting occupant know-how and limiting flexibility in the ways people create comfortable home environments, including light, ventilation, views, access to surroundings (such as gardens and balconies) and interaction with other people, both in their own household and with others. Smart is dumb if it means locking buildings and people into pre-determined patterns and disabling creative low-energy and user-adapted comfort solutions. In this paper, we situate ‘smart’ technologies in a historical context within energy policy, flesh out conflicts between goals of smart comfort and smart energy and argue for a new focus that engages with people’s know how and accommodates differences in among households of differing socio-economic and age groups, giving attention to building designs, building structures (materialities and technologies), embodied comfort, and smart interfaces. We sketch out the policy implications of this new focus for houses in the rich, high energy-using countries as well as in parts of the world that still rely on producing comfort through flexible, culturally grounded and climate-adapted building designs.

Stimulating energy sufficiency: barriers and opportunities ¹⁻¹¹⁴⁻¹⁷

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Keywords

sufficiency, behavioural change, barriers, potential savings, policy recommendations

Energy efficiency policies and measures have so far mostly focused on technical optimisation, that is reducing the energy needed to provide a certain service, without so much questioning the service itself and its relevance in comparison to other ways of delivering societal progress and well-being. As it has been reported, there are limits to this approach, especially if in parallel to efficiency progress the amount of delivered or expected energy services continues to grow wildly and offsets the benefits of the former. There are undoubtedly potentials and benefits in broadening the scope and exploring ways of encouraging not only efficiency but also energy sufficiency. However, this broadening of the scope suggests having a more holistic approach looking at behaviours and societal organisation. It raises specific challenges and barriers, whose nature can be political (challenging the dominant consumerism paradigm), sociological/organisational (adjusting values and the framework in which personal decisions and habits take place), and even technical (designing tools and practical nudges that could facilitate a more sober energy behaviour).

This paper provides an overview of this topic, building on recent projects and research on sufficiency in the French context in various fields (energy modelling, social sciences, etc.). It also looks at a number of new developments that could directly or indirectly stimulate energy sufficiency, such as the rise of the sharing economy, the diffusion of societal innovation practices, as well as new trends in lifestyles (e.g. vegetarianism). The paper calls for increasing exchanges and networking between sufficiency researchers and experts in the EU, to reach a critical mass able to put sufficiency at the level it deserves on the EU political agenda.

China's trajectories beyond efficiency: CO₂ implications of maximizing electrification and renewable resources through 2050 ¹⁻¹⁴²⁻¹⁷

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Keywords

bottom-up analysis, CO₂ reduction, renewable energy, modelling, emissions scenarios, China

In support of the Paris Agreement, China committed to peak its CO₂ emissions by 2030 or earlier and to reduce its CO₂ intensity by 60–65 % from 2005 levels by 2030. While energy efficiency will continue to play a major role, other significant actions in China beyond efficiency are needed to help limit the average global temperature increase to 1.5 °C. This study uses a bottom-up national end-use model to evaluate even lower CO₂ emissions pathways for China beyond cost-effective efficiency by maximizing end-use electrification and adoption of new renewable resources. Unlike most recent modelling studies that only focus on renewable electricity generation with simplified projections for future electricity demand growth, this study evaluates maximum electrification for specific end-use sectors and non-conventional renewable resources on the demand-side.

We use scenario analysis to evaluate the potential CO₂ reductions if China is able to rapidly decarbonize its power sector while maximizing electrification across all sectors and the additional opportunity from maximizing biomass and low temperature renewable heat use in industry and solar heating, cooling and water heating technologies use in buildings. While already widely used in some European countries, large-scale adoption of these non-conventional technologies have not yet been considered in China. We find that maximizing non-conventional electric and renewable technologies can help China peak its national CO₂ emissions as early as 2023, with significant additional CO₂ emission reductions through 2050. The greatest additional CO₂ reduction potential beyond efficiency lies in fossil fuel displaced by renewable heat in industry. These results suggest accelerating the utilization of non-conventional electric and renewable technologies present additional CO₂ reduction opportunities for China, but new policies and strategies are needed to change technology choice in the demand sectors.

The future of EU energy efficiency policies – a comprehensive analysis of gaps, shortcomings, and potential remedies ¹⁻¹⁸⁶⁻¹⁷

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Keywords

EU policy, evaluation, policy packages, policy-mix

Energy efficiency activities are high on the current EU energy policy agenda. Key policy instruments like the Energy Efficiency Directive (EED), the Energy Performance of Buildings Directive (EPBD) and the Energy Labelling Directive are under revision. In a project for the German government, we therefore analysed the effectiveness and consistency of existing sectoral policy packages anew, to open the discussion on which policy changes to the EU's energy efficiency policy packages are crucial to reach the targets. This comprehensive review addressed the industrial, buildings, and transport sectors plus the overarching governance framework (targets and roadmaps, EED, energy taxation and EU ETS). For each of these, the first step was a gap analysis of the main deficits in the sectoral policy packages, against effective model packages.

At first glance, the combination of energy efficiency policies at EU level seems already quite comprehensive. However, their design and implementation often lack a consistent and ambitious approach to leverage their full potential. To give some examples of the many shortcomings identified, the governance framework suffers from exceptions and the transport sector being only marginally considered in the EED; an outdated Energy Tax Directive has very low minimum rates and several exception clauses; there is a lack of commitment to implement energy management systems and investment projects in large companies; a clear EU-wide definition of nearly zero energy buildings (nZEB) is missing; and the labelling of energy-using products is still confusing for consumers.

Subsequently, we elaborated comprehensive policy recommendations to increase the effectiveness of all these policies, and to bridge some gaps with new policies. A list of priorities was established to sort them by their relevance.

The use of evidence reviews to inform demand-side policy ¹⁻²⁰⁸⁻¹⁷

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Keywords

policy, demand side management (DSM), evidence reviews, evidence quality

The UK's Department for Business, Energy and Industrial Strategy (BEIS) undertakes and commissions programmes of research on the demand-side, managed by government scientists and analysts to inform and advise policy officials on the development of demand-side policies, such as energy efficiency, demand-side response and smart technologies. Evidence reviews, commonly confused with literature reviews, are a crucial method not only for collating and synthesising the evidence base, but also for determining what the quality of previous evidence is and extracting the most amount of value from previous studies using systematic techniques.

The paper focuses on the use of evidence reviews to inform the development of current and future demand-side management policies in the UK. An innovative framework and methodological approach for conducting evidence reviews for policy analysis and development is discussed and four recent government-commissioned research reports that have applied the approach are summarised as case studies: two focus on the international and UK evidence base for heating controls, one investigates the evidence base for occupancy patterns, and the fourth examines the evidence base for demand-side response. The evidence reviews have been used to inform the development of policies for domestic heat and smart energy. The paper concludes with recommendations on the use of evidence reviews to inform energy policy, and the application of UK experiences to other countries.

Energy sufficiency policy: how to limit energy consumption and per capita dwelling size in a decent way ¹⁻²³⁰⁻¹⁷

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Keywords

energy sufficiency, policy packages, electricity use, survey, governance, dwelling size policy, absolute energy savings

Energy sufficiency has recently gained increasing attention as a way to limit and reduce total energy consumption of households and overall. This paper presents selected results of a research project funded by the German Federal Ministry of Education and Research that examined the potentials and barriers for energy sufficiency with a focus on electricity in households, how household members perceive sufficiency practices, and how policymakers could support and encourage these. Bottom-up calculations for an average 2-person household in Germany yielded a total electricity savings potential from energy efficiency and sufficiency combined of theoretically up to 75 %.

The continuous growth of per capita living space was identified as one important driver for additional energy consumption both for heat and electricity. The paper will present findings of a representative survey of 600 persons responsible for the housework. It revealed that a part of the households is already practicing sufficiency options or are open towards these. Up to 30 % of these households can imagine, given the right conditions and policy support, to move to a smaller dwelling or to share an apartment with others when they are older.

Results of a first comprehensive analysis of an energy sufficiency policy to encourage and support households to sufficiency practices form the second part of the paper, with a focus on the feasibility and potential effectiveness of instruments for limiting the growth in average living space per person. This includes a case study on fostering communal housing projects as a measure to reduce living space. Further, the feasibility of a cap scheme for the total electricity sales of a supplier to its customers was examined. Instruments supporting energy-efficient and sufficient purchase and use of equipment complete the integrated energy sufficiency and [...].

Reinventing fire: China – the role of energy efficiency in China’s roadmap to 2050

1-242-17

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Keywords

energy efficiency action plans, roadmaps, China

As part of its Paris Agreement commitment, China pledged to peak carbon dioxide (CO₂) emissions around 2030, striving to peak earlier, and to increase the non-fossil share of primary energy to 20 % by 2030. Yet by the end of 2014, China emitted 28 % of the world’s energy-related CO₂ emissions, 79 % of which were from coal use. How China can reinvent its energy economy cost-effectively while still achieving its commitments was the focus of a three-year joint “Reinventing Fire: China” research project completed in September 2016.

A team of Chinese and U.S. researchers developed a comprehensive bottom-up model of China’s energy demand and supply sectors and analyzed two scenarios to contrast a reference pathway of current development and a “Reinventing Fire” alternative path of meeting national needs by deploying the maximum feasible share of cost-effective energy efficiency and renewable supply through 2050. The results show that China’s CO₂ emissions could peak 11 years earlier than the reference pathway if the more aggressive Reinventing Fire pathway is pursued.

This paper focuses on the role of energy efficiency in realizing the CO₂ emissions reductions under the more aggressive pathway. We define energy efficiency broadly and include any actions that reduce energy demand through improved use of materials (e.g., longer product lifetimes), through energy intensity improvements, through structural shifts in industry from energy-intensive activities to more service-oriented activities as well as process and mode shifts in urbanization, industrialization, transport, societal consumption and awareness. In addition to energy efficiency, we identify opportunities for moving away from carbon-intensive fuels through [...].

Creating an interdisciplinary energy lexicon: Working with terminology differences in support of better energy policy

1-267-17

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Keywords

accessibility, collaboration, communication, dialogue, disciplinary approaches, EU policy, EU project, methods, interdisciplinary approaches, language, social sciences

Language shapes the practices and processes of energy research and policy. It is thus challenging that each disciplinary community has its own taken-for-granted terminology, which can be difficult for ‘outsiders’ to understand. Much of the interdisciplinary literature has focused on the challenges experienced in relation to this, with very little done on solutions. Moreover, most attempts to provide an overview of such (energy-related) definitions have still been undertaken within disciplinary silos and have tended to be narrow in scope (e.g. glossaries for one particular research/policy community), and have thereby failed to provide an adequate platform for cross-cutting policy debate and interdisciplinary exchange. This paper therefore aims to investigate how an interdisciplinary lexicon might be practically produced for energy researchers across the Social Sciences and Humanities (SSH), as part of providing a basis for interdisciplinary collaboration and a transparent platform for subsequent policy discussions. Specifically, the core of this paper (1) identifies a set of guiding principles that may assist in the creation of a lexicon and (2) proposes a method for creating an energy-SSH lexicon. All this is discussed in the context of a new EU Platform (SHAPE-ENERGY: Social sciences & Humanities for Advancing Policy in European ENERGY), which is following this proposed method in creating its own interdisciplinary energy lexicon. We will conclude by reflecting on how a lexicon such as the one that we propose – e.g. one that is reflexive, participatory, solutions-focussed, noted as being the start (not the end) of dialogue, and accounts for difference, etc. – could be used more broadly in other interdisciplinary and multi-stakeholder contexts.

Challenges to achieving low carbon domestic retrofit and its effect on UK employment

1-294-17

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Keywords

zero-emission houses, domestic energy efficiency, building retrofitting, retrofit, policies and measures

In order for the United Kingdom (UK) to meet its overall climate change targets a reduction in domestic carbon emissions of at least 80 % by 2050 is required. The achievement of this goal necessitates a significant retrofit of the oldest housing stock in Europe. Completing this task will, therefore, present significant technical and economic challenges as well as economic opportunities. These opportunities include but are not limited to job creation needed for the performance of the retrofit.

This paper explores the major employment issues around retrofitting the UK housing stock, the likely broader economic impacts, and the policy requirements of performing large scale retrofit. In particular, it contrasts the rate of retrofit required to the capacity of the existing industry to both do the work and to train new workers. The paper also explores the implied decline in fossil fuel consumption and the increasing role of microgeneration within the wider UK energy sector.

Current research in other European countries has suggested that the net result of these conflicting trends will be a small net increase in jobs, as the labour-intensive sectors of construction and renewable energy grow at the expense of a decline in employment in the less labour intensive fossil fuel industries. However, UK has a number of unique characteristics, which may cause divergence from other European countries, such as the age of the housing stock and hence the complexity of retrofitting; an energy system highly dependent on fossil fuels; and a cold and damp climate. Using emerging findings from modelling of the UKs housing stock, the key employment challenges for successful achieving of retrofit targets are highlighted, and possible solutions are discussed.

Mobilizing climate finance to support energy efficiency ¹⁻²⁹⁷⁻¹⁷

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Keywords

climate change mitigation, policy-making, international negotiations, strategic decision-making, public policy, International cooperation

Energy efficiency investments need to be significantly scaled up in all economies. Energy efficiency can contribute up to a third of emission reductions necessary to limit global temperature increases to less than 2 degrees Celsius by 2050. Yet, energy efficiency is not happening as quickly and broadly as it should. The estimated investment gap is in the order of USD 430 billion (Kyte 2016). Under the Kyoto Protocol for example, international mechanisms failed to tap into the energy efficiency potential in a significant manner. Part of this is due to the fact that energy efficiency does not come easily. For energy efficiency to work, the right conditions need to be in place. This 'enabling environment' – that is, the range of upstream policy, regulatory, financial, knowledge and human measures – is important to stimulate efficiency investments to the level where energy efficiency will truly take off. In Emerging economies and developing countries such a conducive framework has a cost that can or should be supported by what we can call 'transformative funding' typically offered by the Green Climate Fund or other sources of climate finance.

This paper discusses the significant gap between the strong potential of energy efficiency to contribute to international climate goals and the level of finance allocated to it, especially through climate finance. Financial mechanisms under the Kyoto Protocol focused more on project finance rather than transformative finance. The paper develops arguments to increase the financial flows into transformative long lasting institutional change necessary to create the enabling environment and conducive framework for energy efficiency projects and strongly contribute to lowering GHG emissions in the future. In particular the GCF and other climate funds are faced with the crucial opportunity to address the financing gap and play a critical role in allocating transformative finance for energy efficiency, filling the void left by other institutions (typically a national governments but also the private sector). The paper concludes with a series of concrete recommendations aimed at delivering energy efficiency in all economies at the levels necessary to realise the climate goal of the Paris Agreement.

The influence of near zero energy buildings on the future Danish energy system ¹⁻³¹⁵⁻¹⁷

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Keywords

renewable energy, carbon emissions, cities, supply, efficiency, socio-economic, building codes, system analysis

Buildings consume a large proportion of primary energy in Europe in the form of electricity, heating, cooling and gas. In response to this, the concept of near Zero Energy Buildings (nZEB) has been developed. These buildings have very low energy demands, integrate renewable energy, and to increase energy efficiency they utilise smart technologies. nZEBs aim to increase energy efficiency from a demand-side user perspective. For example, the building is more energy efficient by having a well-insulated envelope, and the user reduces energy consumption through better user-behaviour, or with different smart technologies. This leads to a reduced end-use energy demand and carbon emissions. When looking at buildings within the entire energy system, there are also energy efficiency gains to be achieved on the supply-side. For example, within a district heating system, heat pumps can be installed. If an energy system becomes more efficient on the supply-side, then the question is how much energy needs to be saved on the demand-side, for instance by nZEBs. The purpose of this paper is to analyse and understand the implications from building nZEBs within an energy system that is a) transitioning to 100% renewable energy, and b) has substantially improved supply-side energy efficiency. A case study from Denmark is used to understand the outcome for the energy system when nZEBs are built in this context. The analysis looks at the total system energy savings, costs and resource consumption. Based on the results from the study, the paper finishes with some basic policy recommendations around nZEBs in Denmark and Europe.

Benchmarking the EU reference scenario 2016: An alternative bottom-up analysis of long-term energy consumption in Europe

1-316-17

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Keywords

energy consumption, bottom-up, EU member states, long-term scenarios, end-use efficiency, ex-ante analysis

Long-term scenarios of future energy demand are a major prerequisite when planning future energy systems and policy intervention. A prominent example of this is the recently published 'EU Reference Scenario 2016', which supports the European Commission's policy decision-making process via model-based energy system analysis until 2050 using the PRIMES energy system model. In terms of modelling energy demand, the EU Reference Scenario is analysed on sector level based on non-linear optimization routines and econometric functions. Due to the high relevance of the PRIMES results for the political discussion on a European level, we use the data published by the European Commission to compare and benchmark the projection of energy demand with the results of our own bottom-up analysis. The goal of this comparison is to critically reflect upon the results provided by the EU Reference Scenario on the one hand and to better understand the forces driving energy demand on the other hand. The applied modelling platform FORECAST aims to develop long-term energy demand scenarios of individual European countries. FORECAST is designed as a simulation-based bottom-up modelling approach, which considers the dynamics of technologies and socio-economic drivers on a high level of granularity. This includes vintage stock modelling for space heating equipment, household appliances and industrial steam systems, among others. To ensure a high level of comparability, we use similar framework assumptions (GDP, population, energy prices, etc.) as those provided in the EU Reference Scenario. The model results for final energy demand in the EU27 are compared by sector and country up to 2035, focusing on the residential, tertiary and industry sectors. [...]

Energy efficiency quo vadis? – the role of energy efficiency in a 100 % renewable future

1-318-17

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Keywords

decarbonisation, energy efficiency policy, scenarios, low carbon targets

Following the decisions of the Paris climate conference at the end of 2015 as well as similar announcements e.g. from the G7 in Elmau (Germany) in the summer of 2015, long-term strategies aiming at (almost) full decarbonisation of the energy systems increasingly move into the focus of climate and energy policy. Deep decarbonisation obviously requires a complete switch of energy supply towards zero GHG emission sources, such as renewable energy. A large number of both global as well as national climate change mitigation scenarios emphasize that energy efficiency will likewise play a key role in achieving deep decarbonization. However, the interdependencies between a transformation of energy supply on the one hand and the role of and prospects for energy efficiency on the other hand are rarely explored in detail.

This article explores these interdependencies based on a scenario for Germany that describes a future energy system relying entirely on renewable energy sources. Our analysis emphasizes that generally, considerable energy efficiency improvements on the demand side are required in order to have a realistic chance of transforming the German energy system towards 100 % renewables. Efficiency improvements are especially important if energy demand sectors will continue to require large amounts of liquid and gaseous fuels, as the production of these fuels are associated with considerable energy losses in a 100 % renewables future. Energy efficiency on the supply side will therefore differ considerably depending on how strongly the use of liquid and gaseous fuels in the various demand sectors can be substituted through the direct use of electricity. Apart from a general discussion of the role of energy efficiency in a 100 % renewable future, we also look at the role of and prospects for energy efficiency in each individual demand sector.

Decarbonizing residential space and water heating: The case for electrification ¹⁻³²⁹⁻¹⁷

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Keywords

residential buildings, electrical heating, fuel transition, zero-carbon houses, load management, space heating

In order to meet ambitious carbon reduction goals, direct combustion of fossil fuels in homes will need to largely cease. The largest portion of this reduction will likely come from energy efficiency, but efficiency alone will not be sufficient. This paper looks specifically at California and builds the case for why energy efficiency with electrification of heating is the most likely path to achieve the large carbon emission reduction needed from this sector. We examine alternative decarbonization strategies, such as solar thermal, biogas, synthetic natural gas, and electrification and show why electrification is likely to be the most promising path. While electrification may be the most promising path in California, it is not necessarily the most promising path in all regions. We discuss the benefits of electrification and its limitations.

Challenges of designing and delivering effective SME energy policy ¹⁻³⁵³⁻¹⁷

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Keywords

SME, policies and measures, energy demand

SMEs (small and medium enterprises) are widely acknowledged as a difficult target for energy policy. This is in part due to their diversity: they operate in every sector, in all property types and vary from one person operations with no business premises, to manufacturers with up to 250 employees. Their energy use is poorly understood: evidence on where, why and how much energy they use is incomplete. This paper uses theory, literature review and examples from the UK and France to investigate where the major difficulties arise in designing effective, economic and equitable policy for SMEs, and suggests how this might be improved. Firstly, the policy context is described with reference to the scale and characteristics of SMEs. Available data on their energy use and potential for savings are presented from literature, followed by a discussion of different models of understanding SME decision-making. Three categories of options available to policy makers are described: (1) designing 'universal' policy (2) developing organisational policy designed with minimum obligation thresholds, and (3) deploying measures specifically targeted at SMEs. We argue that the focal unit of policy design is the crucial factor influencing whether SMEs are likely to be included in scope. Where the organisation is the primary focus, SMEs are more likely to be exempted, whereas universal policy such as those focused on products, buildings or technologies may hold potential for extending the benefits of energy efficiency to SMEs. Targeted SME policies largely consist of incentives and information provision, and are typically delivered by business support organisations with primary aims to support economic growth. We argue that while there are benefits from utilising existing support networks for delivering energy efficiency programmes, SMEs with stable business plans are deprioritised, and contradictory effects may arise.

Are current policies promoting a change in behaviour, conservation and sufficiency? An analysis of existing policies and recommendations for new and effective policies

1-362-17

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Keywords

sufficiency, consumer behaviour, energy conservation, policies and measures

There is a strong consent that reducing or capping global energy demand is a key component to reach ambitious climate targets together with the de-carbonisation of energy production. The EU 2020 and the 2030 energy efficiency targets are expressed as a maximum consumption level. Given the nature and magnitude of these targets, a change of energy consumer behaviour is required in order to deliver the requested energy reduction. Traditionally many energy efficiency policies have targeted and promoted efficient technologies (e.g. appliances standards or prescriptive insulation levels or building energy performance standards), which do not always guarantee energy savings (e.g. larger appliances, larger new buildings) and/or are not enough to reach the ambitious energy and climate targets. To the contrary some policies may have even incentivised larger energy consumption than necessary (e.g. some appliances standards which are easily met by larger appliances).

Policies are needed to influence consumer behaviour and lifestyle and the concept of sufficiency has to be introduced in future energy efficiency policy design. Policies targeting sufficiency should discourage increased energy use due to a variety of factors such as increased floor space, increased comfort levels beyond what reasonable, increased number and larger appliances/equipment/cars and increased usage of energy consuming equipment. Policy instruments that may target sufficiency includes: personal carbon trading (i.e. carbon markets with equitable personal allocations); property/car taxation (e.g. related to a building's CO₂ emissions); energy taxation; progressive appliance and cars standards, and building codes, including absolute consumption limits (kWh/person/year) rather than efficiency requirements (kWh/m²/year).

The present paper reviews the concept of energy saving compared to energy efficiency. It identifies existing energy efficiency policies that may induce higher [...].

Policy making by participation – the German Climate Action Plan 2050 1-385-17

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Keywords

CO₂ reduction, climate action plan, climate policy, CO₂ reduction, long-term strategies, long-term policy, policy measures, participation, dialogue process

With regard to commitments under the Kyoto Protocol and the climate agreement reached at the climate conference in Paris, Germany has set a national goal for the reduction of greenhouse gas emissions of 80 to 95 percent by 2050 compared with 1990. In order to enforce the achievement of this long-term target, Germany adopted a first Climate Action Plan 2050 in December 2016. In order to increase acceptance for this long-term energy and climate strategy in society and business, the Federal Government launched – for the first time – a broad-based participatory process. In several rounds of dialogue between June 2015 and March 2016, Federal states, municipalities, associations and citizens could actively participate in the development of the Climate Action Plan 2050. In the course of the dialogue process, the participants worked out a large number of policy measures covering five action areas: 1) Energy Sector 2) Industry and Services 3) Buildings 4) Transport 5) Agriculture and Land use. The final outcome of the dialogue process was the so-called “Measure set 3.1”, which contains a proposal of around 90 policy measures in the five action areas, which are described in detail. This measure set was the basis for the formulation of the Climate Action Plan 2050 by the Federal Ministry for the Environment (BMUB), which was mandated by the Federal Government to develop this plan and to coordinate and consult on it with other government departments. In our paper, we first of all analyse and evaluate the importance of the dialogue process as a new approach of long-term policy making. Secondly, we analyse the actual contribution of the preceding dialogue process to the following political process which was finally deciding on the Climate Action Plan 2050. One main conclusion is that the dialogue process itself was a success and the starting point for a new type of policy making, which takes more into account the views both of the relevant stakeholders and the citizens. This may also help to increase the public confidence in future climate policy, even if the actual contribution of the dialogue process on the contents of the final Climate Action Plan 2050 was smaller than intended in the beginning.

Energy management: a key driver of energy-efficiency investment? ¹⁻⁴¹⁰⁻¹⁷

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Keywords

energy efficiency investments, energy management, energy performance, non-energy benefits (NEBs), multiple benefits, organisation behaviour, strategic value

Improving energy efficiency is the primary pillar of the Swiss “Energy Strategy 2050”. Investments in energy efficiency often remain undecided, however, and there is a large potential for enhancing energy efficiency in the industrial and commercial sectors in Switzerland.

Within this context, the aim of the research project “Management as a key driver of energy performance” (M_Key) is to assess the influence of the level of energy management on companies’ energy-efficiency investment decision-making. M_Key is supported by the Swiss National Science Foundation (SNSF) and is part of the National Research Programme “Managing Energy Consumption” (NRP 71; 2015–2017; www.nrp71.ch). The overarching objective of the project is to gain a better understanding of energy-efficiency investment decision-making by large-scale energy consumer companies. With about 35 % of the total Swiss electricity consumption, these companies are an important target group for energy efficiency measures in Switzerland. It is expected that research results will enable to characterize and categorize Swiss large-scale energy companies based on their energy uses and financial behaviours, which will help frame customized policies.

M_Key empirical research applies three research methods chronologically: 1. Survey. 2. Interviews. 3. Case studies. The goal of this paper is to describe the findings of M_Key survey; it will then conclude on the implications of these findings for future energy policy.

Regulatory update: A twenty-state (US) review of regulatory regimes and effective energy efficiency programs ¹⁻⁴¹⁵⁻¹⁷

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Keywords
regulation, legislation, mandatory requirements

The US regulatory environments in which program administrators operate energy efficiency (EE) programs are constantly changing. EE policies define program implementation, program evaluation and spending so as to capture savings and determine cost recovery. A continuing experiment is in progress with each state's regulatory regime taking a different approach to governing EE. This paper seeks to answer a number of key questions regarding the EE policy framework in 20 states and their ability to facilitate the achievement of regulatory goals, updating similar assessments conducted in 2012 and 2014. Key questions include: What can be learned by comparing EE programs? What are the unintended consequences? What does this show about how to encourage EE?

In addition to a comparison of EE program performance, our analysis includes a summary of state-by-state legislative and regulatory EE goals, cost recovery provisions and incentives. Based on research and interviews, we review and categorize regulatory approaches to EE programs across specific states, and analyze the range of positive and negative outcomes that follow from the various types of regulatory approaches. We conclude that states in which EE targets are set by a legislature and enabled by a state commission typically achieve greater EE savings than do states in which legislatures and commissions have done little to implement formal EE initiatives.

PANEL 2

Policy: governance, design,
implementation and
evaluation challenges

Costs and benefits of energy efficiency obligations: a review of European programmes

2-011-17

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Keywords

white certificates, energy efficiency obligation, cost effectiveness, economic analysis, Energy Efficiency Directive (EED)

The economics of energy efficiency programmes, including their costs and benefits, have been subject to considerable academic debate lasting well over three decades now. However, robust data on the cost-effectiveness of different types of energy efficiency policy instruments is still scarce. A recent investigation into economic instruments supporting energy efficiency by the International Energy Agency concluded that 'very few thorough evaluations of economic instruments in energy efficiency policy are available that would facilitate benefit-cost ratio comparisons'.

In this paper, we contribute to filling this gap by reviewing the costs and benefits of a specific type of policy instrument that recently gained significant traction in Europe – Energy Efficiency Obligations (also known as White Certificates). Following the introduction of the EU Energy Efficiency Directive in 2012 the number of EEOs in Europe has grown from five schemes to now 16 EEOs in operation or planned across the EU. There is now an emerging body of evidence on the costs and benefits of Energy Efficiency Obligations covering a wider range of EU countries, which offers an opportunity to improve our understanding of the economics of Energy Efficiency Obligations. In this paper we draw on this new data and provide a) a comparative analysis of the costs and benefits of Energy Efficiency Obligations in a number of European countries, b) discuss the uncertainties and challenges around calculating the costs of Energy Efficiency Obligations, and c) provide a categorisation of the multiple benefits often overlooked in cost-benefit-analyses with selected quantified examples.

Energy efficiency inside out ²⁻⁰³⁶⁻¹⁷

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Keywords

energy demand, energy supply and demand, indoor environment, CHP, refurbishment

This research study applies a multi-disciplinary approach for analysing the relationships between energy supply, energy efficiency measures and indoor environment. Stakeholder interviews and a review of existing literature reveal that residents only occasionally are involved, and energy companies are rarely consulted when property owners are implementing energy efficiency strategies and measures in residential buildings. Neither the added value to indoor environment nor the impact on district heating production is properly understood when planning and implementing energy efficiency improvements.

The intuitive conclusion for district heating production is that energy savings captured during the winter season are more attractive, as winter savings lead to a lower demand during peak. This is often but not always true, as the impact from energy savings will differ based on the heat production profile of the system. District heating systems based on biomass are likely to be affected differently by energy-efficiency measures than district heating systems with waste heat as base load. Electricity generation in combined heat and power production (CHP) plants also affects the environmental and financial outcome.

Stakeholder participation can create synergies. With greater commitment to implementing energy-efficiency strategies in the residential building sector, energy utilities can support their customers to choose and implement measures that benefit residents, property owners and the company at the same time. The incentives for property owners include lower energy bills and environmentally adapted heating, and the incentives for the utilities are lower costs, reduced emissions and more satisfied customers.

Seeing is believing – visualizing helps realize the hidden benefits of energy efficiency

2-042-17

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Keywords

benefits, visualisation, model

Most people agree that energy-efficiency measures contribute to several benefits in addition to saving energy and costs. There are several benefits that come with the bargain! However, it is often difficult to calculate the value of these benefits; hence we often neglect their true value. By visualizing the different added values that comes with an energy-efficiency project it is possible to raise awareness, interest and knowledge among all kinds of stakeholders.

Based on the IEA report “Capturing the Value of the Multiple Benefits of Energy Efficiency” a model for visualizing the hidden benefits of energy-efficiency projects, implemented at local and regional level in Sweden, has been developed and tested. Based on interviews with the project managers of eight different projects, estimates of the impact on the 15 benefit categories identified by IEA have been made. The impacts have been estimated at four different levels to indicate whether the effects occur at an individual, local, national or global level. Finally the results have been presented in a pie chart diagram showing the multiple benefits for each project. The goal was to visualize the added benefits, or values, of energy efficiency measures. No attempt to calculate the actual values of these benefits has been made.

The results from the model are presented as a visual picture of the normally hidden benefits of energy efficiency. The model can be used for different purposes for instance:

- In early project planning to assess what added values the project may contribute to, and thus be used as part of a decision-making document.
- Follow-up and evaluate implemented projects.
- Increase knowledge and awareness of the effects of energy-efficiency projects.

The model was developed in 2015 and has since been further developed and tested. Today it is a free of charge, easy to use-tool readily available for local and regional actors to use. The aim is that the tool should support local actors to accelerate [...].

India's experience in implementing strategic schemes to enhance appliance energy efficiency & futuristic integrated policy approaches to adopt most efficient technologies 2-055-17

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Keywords

appliances, efficiency standards, minimum energy performance standards (MEPS), model, challenges, policy approaches, future technologies

Energy Efficiency (EE) in India has come to acquire a great deal of importance in the wake of the thrust that is being laid by the government to save its primary energy sources, combat climate change and provide 24×7 power to all. This paper reviews and analyses the strategic approaches of the government that led to ready access of efficient appliances to consumers and unlocked the potential for energy management at operational level.

On the one hand, existing national policies and energy saving models such as Appliance Standards & Labelling program (S&L) and Domestic Efficient Lighting Programme (DELP) help to trigger and transform an energy efficient – cost friendly market as well as achieve energy savings. On the other hand, some intergovernmental programmes & efforts like Space Cooling Efficiency Enhancement and Demand Response, India AC Challenge etc., aimed at meeting the increasing energy demand, help in the identification of future technologies and the potential barriers and challenges in adopting such most efficient technologies.

This paper will discuss and analyse the success and learning from these energy saving models and policy approaches, and lay out the possible options to overcome the barriers, propose integrated policy approaches to adopt and implement the most efficient technologies and the potential impact on energy savings and global climate change.

The future of energy efficiency obligation schemes in the EU 2-059-17

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Keywords

energy efficiency obligation, Energy Efficiency Directive (EED), policy, future outlook

EU Member States have been encouraged to introduce Energy Efficiency Obligation Schemes (EEOS) to help meet energy saving objectives. As a result, there are now sixteen EU EEOS in existence or planned, compared with just six prior to the introduction of the 2012 Energy Efficiency Directive. At the same time, the long-standing EEOS in Denmark and UK have faced challenges because of concerns over increasing costs. This paper considers the role of EEOS in current and future EU and national policy: can established EEOS continue to deliver significant savings; will new schemes meet their targets; and will EEOS have an important future role?

This analysis builds on research for the EU Commission, IEA and European Parliament and an EU project (ENSPOL). Firstly, this paper sets out in more detail the place of EEOS in EU energy policy. Then the future of longer-established EEOS is explored, with case studies presented for the UK and Denmark. Recent and planned re-designs in these two countries are detailed, with analysis of the factors which led to changes in policy ambition. For new EEOS, key risks to delivery of savings are an over-ambitious delivery target and time line in the absence of policy learning opportunities. These risks can be mitigated by either having a preliminary or voluntary phase, or by adopting policy design from another country. The policy risk for nine EEOS is assessed, and the conclusion is that savings are at most risk in Croatia, Latvia and Spain.

The paper concludes with an analysis of EEOS within the future policy mix. The discussion considers the place of EEOS in EU policy, future savings from EEOS, their relationship with energy companies and the possible influence of different framings of energy efficiency. Then thoughts about what it would take to not need EEOS as an option in the policy mix are presented, with concluding ideas about how to secure a strong and effective future for EEOS.

Energy saving obligations across three continents: contrasting approaches and results

2-066-17

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Keywords

white certificates, energy efficiency obligation, Energy Efficiency Directive (EED), energy efficiency resource standard

One of the major energy efficiency strategies in the EU is a requirement that Member States establish energy efficiency obligation (EEO) schemes or alternative measures that would deliver a growing level of energy savings from measures delivered to end use energy customers. Sixteen Member States have adopted or plan to adopt such schemes, including six whose schemes predated the Energy Efficiency Directive and have longer-term results. At least two additional Member States are now considering EEO schemes, and the Commission is in the process of developing a revised Directive to take the schemes forward to at least 2030. In the US, similar obligations are called energy efficiency resource standards (EERS's) and have been adopted in 26 states, even in the absence of a federal mandate. Some of these have been in place for many years and on average have reduced electricity use by more than 10 %. In Australia, similar EEO policies have been adopted in three states plus the Australian Capital Territory. The New South Wales EEO scheme in Australia commenced in 2003 as part of a larger emissions trading scheme and was actually the first operational white certificate scheme in the world.

This paper summarizes and contrasts the different EEO schemes implemented across the EU, the US and Australia, looking at structure, motivations, results and lessons learned. We find that EEO schemes have been a generally successful policy in all three regions, saving a substantial amount of energy (more than 20 % in a few cases), cost-effectively (e.g., at costs generally less than half those of supply-side resources). In addition, we examine a number of leading questions that decision-makers face when considering whether and how to create an efficiency obligation on energy suppliers or their substitutes and offer recommendations that states, nations and the European Union should take into account when designing or improving energy saving obligations.

Carbon budgets, buildings and Brexit: are Britain's non-EU climate change targets at risk?

2-099-17

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Keywords

greenhouse gas emission reduction, residential sector, commercial buildings, public buildings, multiple benefits, impact assessment

The last 18 months have been a major set-back in the British policy landscape affecting carbon emissions from buildings with several policies being abolished or downgraded. Following the vote to leave the EU, there is now considerable uncertainty around the future of UK energy efficiency policy. This is despite the fact that an increase in policy action is required: In June, the 5th Carbon Budget was adopted by Government setting firm carbon targets for the period from 2028 to 2032. Parliament approved them in July 2016. Reaching those targets will require bold and ambitious policy action across all sectors including buildings.

In this paper, we analyse whether or not the UK is on track to meeting its carbon targets. Through modelling of a range of scenarios for the period 2016–2030, we show that the Government's own projections for abatement indicate that the UK will not meet the 5th Carbon Budget in buildings. Worryingly, a large part of the projected abatement from buildings (85 %) is considered by the Committee on Climate Change to be 'at-risk', and after the vote to leave the EU there is uncertainty around which previously EU driven policies driven will remain. In other words, the majority of projected emissions abatement from buildings is seen as uncertain and may not be achieved.

We also illustrate what would be required in order to meet the carbon targets including the technology mix and potential policy options. Our research shows that the benefits of meeting the 5th Carbon Budget in buildings justify considerable public and private investment to capture them. We quantified the main costs and benefits generally considered for formal policy impact assessments, calculated in accordance with official guidance. We show that there is a strong economic case for investing in upgrading the UK's building stock.

Help or hindrance? Does energy efficiency in general, and product policy specifically, even up income disparity or make it worse?

2-100-17

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Keywords

data, product policy, policy evaluation, income distribution

Recently, there has been an increasing focus on the wider impacts of energy efficiency policy - beyond reducing costs and carbon emissions. Amongst these impacts is the effect of energy efficiency (EE) policies on income distribution – do they help to reduce or widen the difference in incomes across the region's population; that is, are they progressive or regressive within the region they are implemented?

It is generally recognised that household income has an effect on how consumers use energy and how citizens respond to energy policy. For example, it is hypothesised that lower income groups are generally less able to access the benefits of EE, partly as a result of their lower ability to fund up-front costs of measures. This hypothesis has been tested by researchers for some climate change and EE policies using a variety of theoretical and empirical approaches, producing mixed results. Whilst some studies provide evidence to support the hypothesis, others have found evidence that EE policies focussed on lower income residents have reduced income inequality for targeted households, and some studies suggest that in some countries EE appliances do not in practice incur higher up-front costs and so may not incur distributional impacts. However, for product policy specifically (including minimum energy performance standards (MEPS), labels, grants), there appears to be a paucity of research using data to evaluate the impacts on income distribution. The few investigations of such impact that have been found tend to be theoretical and focus on implied consumer discount rates and MEPS.

This paper synthesises the literature on the distributional impact of climate and EE policies. It examines the context for product policy, before examining the literature for product policy specifically. Based on this review, some initial product policy implications will be drawn. Finally, it assesses potential data sources that would enable additional research to better understanding distributional impacts of [...].

Invisible energy policy: A new agenda for research and intervention 2-105-17

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Keywords

policy-making, governance, policy, social practices, demand

Energy demand is not only shaped by energy policy – it is profoundly influenced by a host of other policies, laws, regulations, standards and cross-cutting ambitions like those of liberalisation, growth or austerity. Since the impacts of non-energy policies on energy demand are often unintended, unseen and ignored, we describe them as ‘invisible energy policies’. Although invisible, such policies are nonetheless critical, often underpinning increasing consumption, but with the potential to engender radical demand reduction.

Having introduced the concept of invisible energy policy and explained why it warrants attention from researchers and policy-makers alike, we outline a series of propositions regarding the relation between energy demand and non-energy policy. We distinguish between forms of policy process, on the one hand, and policy objectives on the other, both of which have implications for energy demand. We consider the boundaries that exist within policy-making: dividing ‘energy’ from ‘non-energy’; demarcating the roles, remits and responsibilities of different actors; and situating certain forms of energy demand as ‘non-negotiable,’ and we discuss the relation between energy demand reduction and what counts as ‘core business’ for national policy makers and for organisations like those in the health sector or higher education.

Building on these observations, we make some suggestions as to how non-energy policy might be deployed in pursuit of radical energy demand reduction. In taking this question seriously, we outline a new agenda for research and policy intervention designed to achieve radical energy demand reduction through many and varied forms of non-energy policy.

How much could domestic demand response technologies reduce CO₂ emissions?

2-107-17

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Keywords

assessments, carbon emissions, demand response, load management, storage, demand analysis, demand aggregator

It is standard government procedure to subject all policies, programmes and projects to comprehensive and proportionate assessments to promote the public interest and ensure best use of resources to secure national objectives. A key assessment criterion for energy efficiency policies is their expected impact on CO₂ emissions and, accordingly, governments require environmental impact assessments to inform decisions about which policies should be supported. As electricity systems decarbonise and progress towards higher penetrations of renewable energy, however, system balancing becomes increasingly challenging and, as a result, there is increasing value in demand response. The efficiency of low-carbon systems depends not only on policies that promote demand reduction, but also those that promote demand response.

Smart appliances are, from the grid's perspective, a means to achieve demand response and this paper is interested in the question: how much CO₂ do smart appliances save, in their capacity as 'demand response technologies'? This paper aims to clarify this topic by reviewing the literature on carbon savings from demand response technologies, describing a simple conceptual model that illustrates the importance of accounting for the long-run structural impact of demand response, and estimating the CO₂ impact for a case-study of domestic battery systems in the Irish power system. The results indicate that the carbon impact of demand response technologies may be negligible, or even negative, unless structural change in the power system occurs, such as changes to the dispatch and decommissioning of generation. This highlights the added value of the role of demand aggregators, who act as the necessary intermediary between the small-scale and distributed smart appliances and the electricity markets where their beneficial structural impacts can be most effectively enabled.

Advances in green leases and green leasing: Evidence from Sweden, Australia, and the UK ²⁻¹¹³⁻¹⁷

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Keywords

tenants, landlords, non-domestic, minimum energy efficiency standards, Energy Performance of Buildings Directive (EPBD)

Improving the environmental performance of non-domestic buildings is a complex problem due to the participation of multiple stakeholders. This is particularly challenging in tenanted spaces, where landlord and tenant interactions are regulated through leases that traditionally ignore environmental considerations. ‘Green leasing’ has been conceptualized as a form of ‘middle-out’ inter-organisational environmental governance that operates between organisations, alongside other drivers. Green leases form a valuable framework for tenant–landlord cooperation within properties and across portfolios. This paper offers a comparative international investigation of how leases are evolving to become ‘greener’ in Sweden, Australia, and the UK, drawing on experience from an IEA project on behaviour change and a UK project on energy strategy development. It considers how stakeholder retrofit opportunities and interactions in non-domestic buildings are shaped by the (1) policy context in each country (e.g., the EPBD, NABERS, and MEES) and (2) prevailing leasing practices in each country. Based on this analysis, the paper develops a new market segmentation framework to accentuate the different roles that public sector organisations and private property companies play as both tenants and landlords across countries. We suggest that national government policies assist the public sector in leading on better leasing practices, whereas international certification and benchmarking schemes (e.g., BREEAM & GRESB) may provide more fuel to private sector tenants and landlords. The paper concludes with a discussion of the fit between property portfolios and policies, suggesting that international green lease standards might assist multinational tenants and property owners in upgrading both their premises and their operational practices.

Reorienting finance towards energy efficiency in the UK ²⁻¹²⁰⁻¹⁷

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Keywords

financing, green investments, institutions, transition, demand side management (DSM), institutional economics

This paper examines the challenges associated with stimulating large-scale investment in energy efficiency and demand management measures. We focus on institutional changes necessary for mainstream financial institutions, such as pension funds and insurance companies, to seriously address efficiency and demand side issues. This draws on recent literature on green finance to examine the role of financial institutions in transforming energy systems. Recent policy-oriented research has proposed framing energy efficiency as a core part of infrastructure investment. This could enable appraising multiple social and environmental benefits of energy efficiency, and overcoming accounting rules which hinder fair treatment of energy efficiency investments. We explore how this could be applied in the UK context to fill the policy vacuum left by the failure of the Green Deal. We examine the potential for this to deliver comparable benefits to other major infrastructure investments, with the added benefit of reducing supply-side investment needs and thereby the risk of stranded assets.

However, this type of reorientation of energy efficiency policies would require commitment from the mainstream investment community, which faces structural as well as behavioural constraints on investing in low carbon options. We examine the roles of potential funding vehicles including the Green Investment Bank and green bonds, learn from a large scale publicly funded domestic energy efficiency project, and consider new proposed models, such as revolving funds financed by private investment. We draw interim conclusions and outline how future research will draw on interviews with members of the investment community, in order to examine what further measures may be needed to overcome structural and behavioural constraints to large-scale investment in energy efficiency and demand management measures.

Potential for district heating/cooling and cogeneration in Europe: An analysis of EU Member States' assessments under EED art. 14 ²⁻¹⁴¹⁻¹⁷

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Keywords

Energy Efficiency Directive (EED), combined heat and power (CHP), district heating

This paper analyses the comprehensive assessment reports on the national potential of high-efficient cogeneration (CHP) and efficient district heating (DH), submitted by the EU Member States to comply with Art 14 of the Energy Efficiency Directive. In total 26 reports from 24 Member States are analysed. The analysis focuses on following elements: (1) the reported forecasted evolution of the heating and cooling demand; (2) mapping of heating and cooling demand and potential supply points; (3) the results of the technical and economic potential studies for CHP and DH; and (4) the reported policies and measures to realize this potential

While extensive guidelines were given by the European Commission and the JRC, the Member States applied different calculation methods and input parameters and presented the results in different ways. Different interpretations on how to calculate the technical potential could be observed as well. In addition, several Member States failed to report all required data to the European Commission. It is, as a result, very challenging to compare the results of the comprehensive assessment reports. As a recommendation, a reporting template and a set of mandatory indicators could be integrated in a future comprehensive assessment.

Several Member States reported a high additional economic potential for district heating networks. The additional potential of cogeneration was more limited and often correlated with the potential for district heating. The nation-wide estimates of the energy savings by district heating/cooling and cogeneration of the different Member States could not be compared.

A wide range in quality of heat maps indicating demand areas and supply points could be observed as well. Some Member States have developed sophisticated interactive geographical analysis tools. While this might herald an era in which such tools become standard analysis tools, efforts are needed for a better spread of such [...].

Exploring energy saving policy measures by renewable energy supplying cooperatives (REScoops) ²⁻¹⁵⁹⁻¹⁷

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Keywords

household consumption, behaviour, tool, policies and measures, electricity savings

Cooperatives for renewable energy supply (REScoops) provide their members renewably generated energy within a cooperative model that enables members to co-decide on the cooperative's future. REScoops do not only collectively own renewable energy production facilities and supply this to their members, they also use their specific position as energy suppliers to take several actions to persuade their members to save energy. Although the activities that REScoops undertake to some extent resemble those of other organizations, because of their particular organisational and business model as citizens initiatives, the cooperative model, REScoops are supposed to be very well positioned for activities to influence and help their members to save energy. The paper discusses arguments why the REScoop model in energy supply can be an important contributor to reduce energy use by their members. Further this paper discusses measures that have been undertaken by REScoops studied in the REScoop Plus project. We use some illustrative examples to discuss if REScoops are in a relatively good position to take certain measures and succeed in persuading customers to lower their energy consumption level and elaborate on future experiments to explore the proposition that REScoop members save more energy due to actions of these REScoops towards their members.

Impact of financial and informational policies promoting energy efficiency in SMEs ²⁻¹⁹³⁻¹⁷

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Keywords

SME, industry, policy-mix, financial incentives, energy audit, matching estimators

In light of alleged un-tapped potentials for cost effective energy savings in the industrial sector various policies have been implemented to overcome barriers to the adoption of energy efficiency measures by companies. Especially, small and medium-sized companies (SMEs) are supported in their adoption decision by informational and financial instruments. To adequately design these instruments a thorough understanding about their mechanism is crucial. Thus, this paper investigates the impact of two financial instruments (funding for cross-cutting (CC) technologies, low-interest loan) in addition to an informational instrument (energy audit) on the adoption of four generic energy efficiency measures in SMEs in Germany. Based on 766 observations, we apply t-tests and propensity score matching techniques to estimate the effects of these instruments. Findings suggest that the financial instruments in addition to an energy audit accelerate the adoption, but effectiveness varies by technologies. Based on a t-test, the adoption rate for insulation is 15 % and for heating 19 % higher for companies which used a low-interest loan (and an energy audit) compared to companies which only had an energy audit. For lighting, the adoption rate is nearly 12 % higher for companies which used the CC technologies programme (and an energy audit) compared to the control group. The propensity score matching results differ: To adopt measures for insulation the propensity is 12 %, for heating optimization 12% and for heating about 25 % higher for companies which used a low-interest loan (and energy audit) compared to the control group. Regarding lighting we do not find a significant effect of the CC technologies programme on the adoption. Findings indicate that estimates of policy effectiveness by t-tests might be misleading, i.e. overestimating the effectiveness regarding the adoption of measures for lighting, insulation and heating optimization, and underestimating the effectiveness for heating.

Seizing energy efficiency policy opportunities to improve water and sanitation services in Tanzania ²⁻²¹¹⁻¹⁷

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GIZ Sustainable Energy Program, Tanzania

Keywords

action plan, audit, capacity building, energy management, national energy efficiency action plans (NEEAPs), awareness, regulation, water supply and sanitation, guidelines

Tanzania's Ministry of Energy and Minerals (MEM) and GIZ agreed to develop a National Energy Efficiency Action Plan (NEEAP), which will be available by June 2017 and will include four fundamental kinds of action: Quantifiable actions; Legal, Regulatory and Administrative actions; Capacity Building actions; and Awareness actions. One anticipated cornerstone of the NEEAP will be requirements for large energy consumers to prepare, implement and report on Facility Energy Efficiency Action Plans (FEEAP) through an Energy Manager assisted by Certified Energy Auditors. Urban Water Supply and Sanitation Authorities (WSSA) are among the largest energy consumers in Tanzania, and many are challenged with high energy intensity and costs that limit their ability to provide water and sanitation services. To exemplify these NEEAP actions, this paper presents initiatives by GIZ, MEM, the Ministry of Water and Irrigation (MOWI), and the multi-sector Energy and Water Utilities Regulatory Authority to promote energy efficiency in the water sector. Energy audits carried out at two WSSAs in 2016 revealed significant energy-saving investment opportunities and a need to establish both an Energy Management (EM) unit and a FEEAP. To help build capacity necessary to operationalize EE in the utilities, GIZ trained and assisted the two WSSAs in setting up EM Teams and FEEAPs. The experiences from these pilot trainings have been used to raise awareness on the benefits of EM with other WSSAs in Tanzania. The audits also revealed a number of design flaws common among WSSAs, and as a result MoWI requested GIZ assistance to prepare Energy Guidelines. These guidelines will ensure that important EE aspects are considered in initial design and procurement processes. This paper explores the design and impact of these initiatives, and their potential for further implementation in Tanzania and similarly situated sectors.

Funding measured energy savings: first findings on performance-based “Energy Savings Meter” funding scheme ²⁻²¹⁴⁻¹⁷

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Keywords

savings, evaluation, energy efficiency programmes, data monitoring, smart metering, end-use metering, consumers, railways, energy savings meter, pilot scheme

German energy policy aims at halving the country’s primary energy demand by 2050: an objective which should translate into more significant reductions in final energy demand than the reductions observed in the past. Although energy reduction potentials are high, they are fragmented and therefore currently hardly accessible to energy service companies. At the same time, digitisation offers new opportunities to deliver energy services at low costs. However, it appears that current digital services are not yet as linked to energy savings as they could be. Well-designed digitised energy services might visualise energy consumption and save both costs and energy. Moreover, energy savings might further be promoted if customers received direct information about economic potential, offers for implementing energy saving measures or applying for funding.

The German Federal Government has thus launched a pilot scheme for an innovative digitised energy savings programme in 2016 – the “Energy Savings Meter” – which the authors are currently supervising, administrating and evaluating, respectively. Eligible companies propose “smart” energy services to end customers in the residential, commercial and industrial sectors. As the overall energy consumption is measured, the programme addresses absolute energy savings and also taps savings to be made from behavioural patterns. This represents a policy development that favours actual savings over deemed savings and introduces what we believe to be a unique combination of performance-related funding and support for a new kind of digitised energy service.

The paper analyses related price-based and performance-oriented funding schemes in scientific literature. In a second step, it explores potential savings linked to an [...].

When prices don't steer – mimicking ambitious carbon pricing with energy performance standards ²⁻²⁴³⁻¹⁷

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Keywords

minimum energy performance standards (MEPS), climate policy, policy-mix, life cycle cost (LCC), carbon tax, social cost of carbon

Pricing carbon is often considered to be the cornerstone of any climate policy and, at least in economic theory, it is the only policy intervention required to reach an optimal level of mitigation. In practice, various market and behavioural failures, as well as political barriers, necessitate a policy mix that also encompasses policies to induce energy efficiency and stimulate the up-take of renewable energy sources. Minimum energy performance standards (MEPS) are one group of instruments to drive energy efficiency. However, MEPS are viewed very differently by different actors; some see them as complementary to carbon pricing, while others view them as market distortion. Recent studies indicate that MEPS for appliances and vehicles are currently the best performing climate policy instruments. There is a need for more research about how MEPS and carbon pricing policies interact and how they can best be combined for an effective climate policy mix.

In this paper, we examine the advantages and potential of using MEPS to drive more ambitious climate policy. We first model the market price of appliances in a UK market and how life cycle costs (LCC) shift when the social cost of carbon (SCC) is factored in. We then examine how the inclusion of the SCC affects the point at which least life cycle costs (LLCC) for an appliance class are reached. We consider carbon prices ranging from the current carbon market price to high-end estimates of SCC, and then estimate the corresponding MEPS in each scenario. Finally, we discuss the implications for mixed policy design when climate change externalities are addressed primarily through MEPS, as well as the merits of such a policy approach.

Paving the way for an energy-efficient future – energy efficiency policy developments in EU member states and recommendations for policy adjustment based on findings of the Energy Efficiency Watch 3 Project

2-247-17

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Keywords

survey, policy recommendations, case studies, good practice, Energy Efficiency Directive (EED), Energy Performance of Buildings Directive (EPBD), EU member states, policy developments, NEEAPs

The core objective of Energy Efficiency Watch 3 (EEW3) is to establish a constant feedback loop on the implementation of European and national energy efficiency policies and thus enable both compliance monitoring and mutual learning on effective policy making across the EU. The project team applied a mixed-method approach to assess energy efficiency policy developments in EU Member States. It analysed progress of national policies by screening official documents, sought experts' knowledge via an EU-wide survey and has been creating new consultation platforms with a wide spectrum of stakeholders including parliamentarians, regions, cities and business stakeholders. Analysis of the National Energy Efficiency Action Plans (NEEAPs), the expert survey with input from over 1,100 experts on policy ambition and progress in each Member State, as well as 28 Country Reports have been central elements in EEW3. This paper will present the main conclusions and policy recommendations of EEW3. In doing so, it will first summarise the findings of the document analysis based on the 28 Country Reports, showing developments of energy efficiency policies since the second NEEAP in 2011 in a cross-country overview for six sectors. These findings are then contrasted with the experts' perspective on progress in energy efficiency [...].

A spatial perspective on the transition towards low carbon homes: evidence from the green deal ²⁻²⁵⁴⁻¹⁷

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Keywords

energy assessment, diffusion, evaluation, transition, building retrofitting

This paper aims to highlight the importance of environmental contexts in the pursuit of sustainability transitions by demonstrating the role local conditions play in the adoption of low carbon technologies. This aim is pursued by an empirical case study of the uptake of household energy assessments provided under the Green Deal energy policy of the United Kingdom. An analysis of uptake is presented which displays the spatial and temporal variation which has occurred throughout the lifetime of this energy policy. Through this illustration, it becomes apparent that uptake has occurred in a spatially heterogeneous manner, with certain areas of the United Kingdom exhibiting relatively high levels of adoption whilst others display comparatively low levels. A spatial regression model is specified to explain the observed spatial variation in uptake which draws attention to how the socioeconomic characteristics of the population, the attributes of the homes and the allocation of funding to local government condition the level of receptivity a particular area has to this energy policy. The findings of this analysis will likely prove of interest to the research community as evidence concerning the impact of spatial factors in energy transitions and to the policy community by demonstrating how spatial analysis can provide unique insights when evaluating the outcomes of energy policies.

Policy dialogue programmes on energy efficiency in transition countries – how to make it a success

2-257-17

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Keywords

policy-making, energy efficiency policy, legislation, policy evaluation, institutions, transition countries

International Financial Institutions have long understood the need to incorporate energy efficiency policy dialogue into their investment activities. Despite this, little work has been done to evaluate the impact of energy efficiency (EE) policy dialogue in transition countries and to draw generic conclusions.

- Based on an evaluation of policy results and practical experience gathered in the field by the European Bank of Reconstruction and Development (EBRD) this paper addresses the question: How to achieve strong, long-lasting EE policy outcomes in transition countries? Specifically, the paper presents a conceptual framework that emphasises the following critical elements:
- A systematic approach is required where interventions are planned within the broader strategic context, and implemented at the right place and the right time.
- The importance of high-quality secondary legislation and other implementation procedures (such as technical standards, support tools etc.) to implement primary legislation.
- Enforcement procedures need specific attention in transition countries.
- The need to consider the institutional setting related to energy efficiency to ensure policy longevity.
- The mutual learning process needed in policy development. Only if the donor has learned something new during the process can we assume that the peculiarities of the recipient country have been fully captured.

Why is demand response not implemented in the EU? Status of demand response and recommendations to allow demand response to be fully integrated in energy markets

2-278-17

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Keywords

demand response, energy markets, aggregators

The importance and benefits of Demand Response (DR) are well known, especially its contribution to the decarbonisation of the electricity supply.

Despite the barriers remaining today, in 2013 Europe was almost entirely shut to Demand Response while today consumers in some Member States have the opportunity to participate in Demand Response programs. In particular, the Energy Efficiency Directive Article 15.8 establishes consumer access to energy markets by asking Member States to encourage Demand Response.

The paper summarises the status of Member States legislations, market rules and technical regulations to enable Demand Response. In reviewing Member States progress in enabling Demand Response and consumer load aggregation, it emerges that a significant portion of them have yet to begin their regulatory review with any seriousness. However those Member States who have looked to enable Demand Response are succeeding despite continued challenges. In successful cases, TSOs and regulators are using the deregulated and competitive market structures to empower providers and encourage market entry for consumers. Europe's energy market is unique, and there is the opportunity to create unique solutions, combining competitive market structures with the decarbonisation agenda.

Finally the paper identifies and proposes regulatory initiatives that would significantly further facilitate this development. An important consumer enabler is to define and allow full Aggregation of Consumer Load. European market design should enable the participation of Demand Response and other distributed resources [...].

Will the Winter Package deliver on efficiency first? 2-281-17

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Keywords

end-use efficiency, policy instruments, wholesale markets, national energy efficiency plans, winter package, efficiency first

The European Commission's so-called 'Winter Package of energy legislation will provide the framework for energy policy in the European Union for many years to come. It contains proposals for a whole range of energy-related reforms including energy markets, energy infrastructure, renewable energy, climate policy and also energy demand. In this paper, we carry out a preliminary review of the proposals and what they mean for energy efficiency. The European Union has adopted the principle of 'Efficiency First' through the launch of the Energy Union Communication in February 2015. We assess the extent to which the Winter Package keeps the promise of putting energy efficiency first. More specifically, we analyse the revised Energy Efficiency Directive (EED), the Energy Performance in Buildings Directive (EPBD) the Directive on common rules for the Internal Energy Market for electricity (IEM), the Regulation on the electricity market, and the Regulation on Governance of the Energy Union. We conclude that, while many improvements are proposed across the different pieces of legislation, the Winter Package falls short of comprehensively reflecting the Efficiency First principle. The paper provides a number of concrete policy recommendations in order to incorporate the Efficiency First principle more fully into the proposed set of European energy legislation.

When European collaboration makes energy efficiency policies more effective

2-290-17

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Keywords

energy efficiency programmes, EU policy, capacity building, policy implementation, energy efficiency investments, EU project

This paper shows how EU-funded projects are facilitating the definition, implementation and monitoring of energy efficiency policies. It focuses on actions supported by the Horizon 2020 programme for research and innovation (2014–2020) and the Intelligent Energy Europe programme (2003–2013). These two EU programmes have co-funded hundreds of collaborative projects supporting legislation by: generating, testing and converting into actions new policies; checking compliance on the ground; building capacity amongst market actors; and mobilising large scale investments. Of all EU programmes, they have had the closest link to EU energy efficiency policy developments. This paper explains and illustrates the different means of intervention that have been used. It provides examples and lessons learned in various end-use sectors. It builds as much as possible on the results from recent evaluations which have measured the extent to which EU-funded projects have supported energy efficiency policy goals.

Implementation of the energy efficiency directive: progress, challenges and lessons learned ²⁻²⁹²⁻¹⁷

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Keywords

Energy Efficiency Directive (EED), saving targets, policy measures, implementation

The Energy Efficiency Directive (EED), adopted in 2012, forms a key part of the EU's overall climate and energy legislative package, laying down the foundation for actions to be taken by Member States in order to help them realise their energy efficiency potential. The European Commission tracks the progress made by Member States through the annual reports (ARs) submitted by national authorities to the European Commission. This paper reviews the information in the latest available ARs to draw a picture of the implementation status of key EED provisions and progress achieved towards the various national energy efficiency targets set by the Directive. It specifically reviews the progress made in relation to Article 3 targets for 2020, the obligations on central government building renovations (Article 5) and implementation of energy efficiency obligation schemes (Article 7). The paper examines the type of policy measures (regulations, financial/fiscal measures, information and advice etc.) used in practice to generate the energy savings in order to meet the Directive's various provisions as well as the relative contribution of the various sectors (residential, services, transport and industry). Policy recommendations are drawn based on the experience gained so far, which constitute important implementation lessons as we move forward to the revised EED and new timeline to 2030.

Harmonization of product energy efficiency standards and free trade agreements: the role of international cooperation ²⁻³⁰⁰⁻¹⁷

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Keywords

policy measures, efficiency standards, harmonisation, cooperation, climate, free trade agreements

Free trade agreements (FTAs) can bring major economic gains, but can equally affect energy efficiency policies. Since FTAs most often include consideration of issues like standards, definitions, test procedures, and legal regulations dealing with energy efficiency, their impact on energy efficiency policies can be great.

A main objective of FTAs is harmonization. By aligning policies, regulations and other trade barriers, harmonization can facilitate trade, conformity assessment and policy setting comparisons. Linked to energy efficiency it can also have major effects on energy and emissions reductions, which are necessary for the 2 °C climate goal. The global CO₂ savings potential from best practice policy harmonization for product energy efficiency standards, for example, is estimated at around 7 % of all energy-related emissions from all sectors in 2030, and can thus confer energy saving, environmental and other social benefits.

The challenge is to ensure that convergence occurs around the highest level of efficiency and not the lowest, and that standards are not ‘frozen’ over the long-term. Yet as FTA negotiations take place outside common national and international forums that establish and implement energy efficiency policies, energy efficiency policymakers must find a way to work outside these channels to influence harmonization at the level of international best practice. International collaboration can play a big role in this by bridging the gap between the trade and energy efficiency policy spheres.

This paper explores the under-recognized link between product energy efficiency standards, harmonization and FTAs, arguing that energy efficiency policymakers should actively consider FTAs as potential tools to further harmonization. It considers how increased cooperation between energy efficiency and trade officials can positively influence this process, and how dedicated international collaboration platforms can contribute to this end.

What's going on in energy efficiency research? A platform to enhance the transparency of energy research funding in Germany

2-319-17

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Keywords

public information, research, database, policy implementation, public funding

Public funding of energy research projects is a major pillar for developing new energy-efficient technologies and concepts. With European energy and climate targets driving such projects, it is becoming challenging to keep up with their ever-increasing number. Our contribution demonstrates how combining the expertise on energy efficiency and renewable energies, linguistic text processing and modern information technology can help to respond to this challenge and thereby render research funding more transparent and accessible to the public. We provide an overview of the German energy research funding information system 'EnArgus'. This web-based system makes it possible to intelligently review and cluster the vast number of publicly-funded energy research projects in Germany carried out since 1970. The core element of the system is an ontology-assisted search engine derived from more than 2,200 short articles, which were specifically prepared for this purpose. These texts cover energy technologies as well as the related basic terminology and concepts. To illustrate the system, we provide an overview of its structure, its main components and a summary of its evaluation as well as important lessons learned from the project. The results of the evaluation indicate that the system is well suited to help structure and access the growing number of publicly-funded energy research projects.

25 years of experiences with the voluntary agreement scheme for large industries in Denmark

2-339-17

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Keywords

voluntary agreements, energy efficiency agreements, industrial energy saving, industry, practical experiences

Danish energy efficiency policy directed at the industrial sector took its beginning in the early 1990s. In 1990, the government launched an overall energy plan on how to reach its ambitious climate and energy policy goals. Analysis showed that cost-effective CO₂-reductions could be achieved in the industrial sector, but governmental action was necessary to overcome several barriers.

The Voluntary Agreement Scheme for Large Industries (VA scheme) was launched in 1992 as a central measure targeting the industrial sector. It has continued to be a central measure targeting industrial energy efficiency in Denmark until today. The basic principles of the VA-scheme laid down in the 1990s are still the same: Energy intensive industries can get a tax refund in return for signing a binding three-year agreement to implement energy management systems and energy saving projects with the Danish Energy Agency (DEA).

The VA-scheme has resulted in documented energy savings in the large energy intensive industries in Denmark. Typically, energy savings in the companies in the average of 1½ per cent a year can be attributed to the VA-scheme.

The success of the Danish VA-scheme is caused by a variety of reasons. First, the VA-scheme has been administered in a dynamic manner. The scheme has changed and has been significantly developed over the last 25 years while the basic mechanisms have remained the same. The drivers have been political decisions and also to a large extent experiences gained through evaluations of the VA-scheme, analysis of developments in energy consumption and potentials for energy savings in industry. The development of energy efficient technologies and solutions has also played an important role. Secondly, the VA-scheme has had a strong technical approach and set strict requirements to the participating companies on which focus areas to address etc. DEA is responsible for administering the VA-scheme. Throughout the past 25 years, DEA has maintained close dialogue with all stakeholders resulting in [...].

Size matters – and so does comparable performance data ²⁻³⁴⁴⁻¹⁷

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Keywords

data, indicators, evaluation, barriers, behaviour, industrial energy saving, realistic baselines, energy efficiency index, barometer, values

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. This is highly relevant: more than half the GHG reductions that need to be tackled through energy efficiency to fulfil the Paris Agreement will need to come from industry and would also considerably strengthen energy productivity and hence competitiveness (IEA 2016).

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 gives an overview of the state of energy efficiency in industry and explores the gap between perception and action across sectors and company size, which indeed matters in many aspects. However, it is not always the biggest companies that are the driving force and some topics are just emerging. Do companies see an energy-related benefit for themselves in the flexibilisation of their energy consumption, a higher variability in supply through the integration of power sectors or through new services and business models coming with digitalisation? How can transaction costs and risks be reduced? How do implemented measures actually perform? These are all questions that the EEI is designed to find answers for, based on data from hundreds of manufacturing companies to develop tailored policies and business models that accelerate energy productivity and mitigate climate change.

Designing cookstove labels to influence consumer behavior in Ghana ²⁻³⁷⁰⁻¹⁷

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Keywords

willingness to pay, social norms, air pollutants, behavioural change, cooking, developing countries, efficiency standards, labelling

Three billion people in low- and middle-income countries use cooking fuels and technologies that pose health risks associated with household air pollution, and environmental impacts associated with GHG emissions and deforestation. In response, efforts are underway across the globe to transition households to cleaner, safer, and more fuel-efficient cookstoves. The government of Ghana is planning to launch a new national performance standards and labeling (S&L) program for improved cookstoves, in an effort to increase the uptake of ICS across their urban and rural populations. This paper discusses the development of the Ghana improved cookstove label, specifically two components: informed visual label design, and setting performance thresholds for label tiers (tier-setting). The paper includes the approach and methodology for both components, as well as preliminary results from consumer research on preferences and behavior change in response to cookstove labels, and analysis and recommendations for label tiers.

Words matter – even when speaking about energy efficiency ²⁻³⁸¹⁻¹⁷

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Keywords

barriers, cooperation, energy efficiency policy, standards, air conditioning, white certificates, Europe, USA

The choice of words matters in energy policy, even when speaking about more technical aspects of energy efficiency. Experts from North America and Europe can be in complete disagreement – or agreement – because their definitions of key words and terms differ. The likelihood of cross-cultural misunderstandings can only increase during periods of rapid political change. Our aim is to focus on the language barriers, but since language is directly linked to phenomena “IRL” (in real life) and institutional set ups, the paper will touch briefly on the link between organising energy efficiency and the language being used to describe how it is organised.

This leads to a second kind of miscommunication that may be encouraged in some situations. As climate change – and the role efficiency could play in mitigating it – has become politicized, efficiency advocates have sought to continue policies by linking their policies to outcomes that are not as politically charged. There are often multiple benefits of energy efficiency, ranging from energy security to high student performance, but also issues such as climate, health and air-quality that can be used for this purpose. Climate related or climate relevant work may also be based on other legal or policy foundations, such as trade policy and consumer protection. These strategies may lead to conflicts of interests and awkward bedfellows that go beyond language. In this unusual political environment, we need to be nimble but not lose our ethical compass.

How carbon tax could contribute to greater CO₂ and electricity savings in Switzerland

2-437-17

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Keywords

carbon tax, energy efficiency programmes, subsidies, CO₂ savings, electricity savings

In Switzerland, climate policy includes ambitious CO₂ emissions reduction targets, and a carbon tax is one of the major instruments to achieve them. Currently, about 30 % of carbon tax revenue is used to finance energy efficiency and renewable energy programs (EEREP), while 70 % is redistributed to the energy consumers. The future Swiss climate policy is still under discussion, but taken into account current legal and political basis it is likely that most or even full amount of carbon tax revenue will be redistributed back to energy consumers rather than used to finance EEREP. As another energy policy objective, Switzerland announced the phase-out of nuclear power by the 2030s. With a current share of nuclear power generation of about 40 %, Switzerland is now searching for solutions to replace nuclear energy by energy savings and renewable energy sources. Against this background, we discuss the potential impacts of using the carbon tax revenue for financing EEREP. According to our insights, such a policy choice would not only allow to achieve a considerable reduction of CO₂ emissions or electricity demand (approximately doubling the effect of the CO₂ tax), but it would also lead to other positive socio-economic impacts. CO₂-saving programs could trigger approximately 40 % higher GDP and 60 % higher employment compared with the situation where carbon tax revenue is reimbursed and used for general household needs. In the case of electricity-saving programs the respective values are approximately 10 % of GDP increase and around 25 % higher employment.

PANEL 3

Local action

Bridging the information gap on energy efficiency? Experiences from energy advice experiments in three German cities ³⁻⁰³⁴⁻¹⁷

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Keywords

building refurbishment, communication, effectiveness, energy efficiency gap, information, urban, process evaluation

One of the most pressing issues of climate policy is how to get building owners to invest in the energy efficiency of their homes. The German federal government has set the goal of decreasing the energy demand of buildings by 80 to 95 percent until 2050. One pillar of the strategy to support building owners in this task is the provision of targeted energy advice, to both motivate owners to implement an energy efficiency refurbishment and help them to choose the most efficient measures. In this paper we analysed the demand for energy advice in three German cities of the Ruhr area finding the number of energy consulting provided to be extremely low compared to the stated goals. Based on the approach of joint knowledge production we invited stakeholders from the three cities to participate in a series of workshops in order to develop ideas how to more effectively bring homeowners and energy advisors together. As a result, different energy advice experiments were co-operatively developed for each city targeting different groups by using tailored channels for outreach. The evaluation of both the process as well as the outcome of the experiments indicates that while joint knowledge production is a suitable approach to enable knowledge transfer and formation of new networks between different stakeholders in science and practice, it does not necessarily lead to superior approaches with regard to effectively addressing a policy issue at hand. Apart from the experiment in which the window of opportunity change of building ownership was taken advantage of, participation of target groups in the experiments has been soberingly low, underlining the value of so-called trigger points when designing effective outreach strategies to building owners.

Towards a territory-based economic model for regional energy efficiency programmes: learning from past initiatives ³⁻⁰⁵⁷⁻¹⁷

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Keywords

local economy, energy-saving programme, economic model, local or regional energy efficiency measures, functional economy

Many Energy Efficiency programmes have been undertaken in the name of Energy savings and with a view to efficiency-cost assessment. Energy savings targets had to be met. In this case, the relevant question was to find the least expensive way of achieving this when considering a merit order on which EE actions are ordered given a ratio expressed in €/saved MWh. Many energy suppliers have been involved in this programme in order to meet their EE obligations (e.g. in a white certificate scheme) or in the frame of territorial industrial challenge (undersized energy transport or distribution network for instance). Yet such EE local programmes could be carried out in the frame of self-financed and economically viable activity. However, relevant economic models based on a territorial and multi-partnership approach must be identified. This paper is based on the review of several EE regional programmes with the insight of the functional economic model in order to identify key success factors to the development of such economic models.

Findings underlined the crucial importance of the consideration of specific local challenge – beyond energy aspects – when designing an EE scheme, for instance, the problems raised by an aging local population or by increasing fuel poverty. The ability to manage deep partnership with an approach focused on “functional sphere” instead of driven by a traditional sector-based vision is a key point. For instance a comprehensive intermediation activity (technical, financial and professional) is a key added value source to monetize and to convert into financial flow. It is also important to develop a long-term relevant assessment procedure beyond traditional measurable effects (energy savings) and which encompasses intangible effects. These findings should complete popular business-model tools so that this “functional sphere” based vision can be embodied in a more comprehensive, sustainability and territorial-based economic model canvas!

Intermediation in a low energy building project: A case of One Brighton housing development

3-060-17

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Keywords

buildings, zero-carbon houses, qualitative study, intermediaries, transition, local activities

Many experimental local projects have been carried out in low energy buildings that integrate a range of energy efficiency and renewable energy technologies and solutions. These have been important in showing how low energy building can be carried out and stimulating future expectations on energy demand reduction through buildings. However, a key question remains as to how we can spread these experiments to other localities and, importantly, into commercial applications, and who are important actors in these processes.

This paper presents an in-depth case study of One Brighton, a new build housing development in England offering 172 apartments and a community space, constructed during 2007–2010. One Brighton was developed with an objective of creating a residential building complex that enables sustainable, healthy and happy lifestyles. It in many ways stems from Bioregional – an environmental charity, social enterprise and an intermediary organisation championing more sustainable ways of living – and its pioneering BedZed housing development in London. However, also other intermediary actors were needed to initiate and pull through this innovative low energy building project. Triangulation of data sources including interviews, attendance in an on-site learning tour, and written material were used to construct the in-depth case.

Through a detailed analysis of this case, the paper shows (1) the role of a key intermediary actor in advancing systemic innovation in low energy housing beyond its initial experimental stage, and (2) how an ecology of intermediaries and champions advanced energy efficiency and sustainability during different phases of a building project. Intermediation in this case was crucial, taking different forms by different actors and at different periods. For policymakers this highlights the need to support the existence and activities of such intermediaries.

Experiences of consortia for scaling up nearly zero-energy renovations of single-family homes ³⁻⁰⁶²⁻¹⁷

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Keywords

innovation, renovation, collaboration, overcoming barriers, low-energy buildings, housing refurbishment, business models, one-stop-shop

On average 64 % of the dwellings in Europe are owner-occupied. Although there is an enormous potential to reduce their energy use and hence CO₂ emissions, the current average renovation rate is just around 1,2 %. The development of one-stop-shops is expected to increase the market uptake of home renovation. Developing emerging frontrunner consortia of SMEs, this research looks into opportunities and barriers for stimulating business development to develop the supply of integrated nearly zero-energy building (nZEB) renovations of single-family homes.

Experiences were collected from frontrunner consortia that want to offer nZEB renovations to owners of single-family homes. Using a business model canvas approach, the main barriers and opportunities were compiled from business development meetings with 24 consortia from five countries. Furthermore, a year after finalizing this exercise, the researchers evaluated the outcomes of the business development.

Based on the findings from the emerging consortia, the research identified key issues that are important for business model development. For reaching early adoption of nZEB single-family home renovation, effort is still needed for developing collaboration of SMEs, for improving customer interfaces and for dealing with barriers that emerge after business model development. Consortia are advised to pay specific attention to the use of the business model canvas for structuring their ideas, to discuss the opportunities to jointly develop one-stop-shops, and to seek collaboration with "independent" actors to reach out to larger groups of homeowners. Policy could support emerging consortia as the chances for successful market introduction are high.

Shaping consumer energy advice to achieve energy and climate targets 3-083-17

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Energy Advice Exchange

Keywords

building retrofitting, overcoming barriers, individual action, consumer information, deep renovations, long-term strategies, energy advisory services

The European Union has climate and energy targets for 2020 and 2030 that include an indicative target for energy savings. In November 2016, the European Commission launched its proposals for a new energy package, to include a binding energy efficiency target of 30 % by 2030. The three headline goals of the new package entitled 'Clean Energy for All Europeans' are: putting energy efficiency first, achieving global leadership in renewable energies and providing a fair deal for consumers.

In moving from a model focussed on energy supply solutions to one that gives priority to reducing/managing demand, the consumer is placed firmly at the centre of the market. The reliance in this new decentralised model on large numbers of individual actions by consumers creates a huge need for consumer information, advice and support. The emphasis must be on ensuring consumers have the right tools and information to make appropriate decisions on energy renovations, and are supported to take these decisions through to action. Consumer advisory services can help to: create consumer awareness that leads to increased demand for ambitious energy renovations, overcome market barriers and distortions from a malfunctioning market, secure actual delivered energy and carbon savings, and address social inclusion and fairness.

It is argued that in order to be effective in supporting consumers to achieve deep energy renovations, advisory services must be expert, impartial, accessible and practical. The advice provided needs to cover a range of technical, financial and behavioural issues, and cannot be delivered effectively through a remote and depersonalised approach. Based both on practical delivery experience and recent research studies (both in Europe and throughout the OECD), a model for delivery is suggested, with local or regional hubs for consumer contact, and the inclusion of a practical long term plan for the renovation of each building. The latter takes account of the likelihood for many buildings that a deep renovation will be staged over time, and integrated with other repair, maintenance and improvement works.

Making the energy transition happen. Intermediaries as ‘driving force’ of local energy projects – a case study in South Westphalia, Germany ³⁻⁰⁸⁷⁻¹⁷

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Keywords

transition management, transition, sustainable communities, energy policy, local energy policies, local government initiatives, intermediaries

A case study in the rural area of South Westphalia, Germany, showed the importance of independent intermediaries to support the development and implementation of sustainable energy and efficiency projects. The idea behind the project “Dorf ist Energie(klug)” (Village is Energy(smart)) was to foster, accompany, and support energy and efficiency projects in villages from the first idea to final implementation. Therefore, the South Westphalia Agency as independent intermediary initiated an application process in which villages could apply with their innovative energy and efficiency project ideas. During the following process the chosen “coaching villages” benefitted from the consultation of teams of thematic experts. Villages with less developed projects were supported through idea workshops with experts and study visits.

The accompanying scientific study evaluated the overall process focussing on the transferability, the sustainability and the quality of the process. Furthermore, a self evaluation tool for (energy) projects in villages was developed and tested in two of the participating coaching villages.

The paper gives a short insight into the project “Dorf ist Energie(klug)”. It presents the methodology of the accompanying study and the results with a special focus on the role of the South Westphalia Agency as independent intermediary. Finally, it discusses the transferability and sustainability of the project.

Supply chain dynamics in the UK construction industry and their impact on energy consumption in homes ³⁻¹³⁶⁻¹⁷

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Keywords

retrofit, construction industry, socio-technical, zero-carbon houses, windows of opportunities

Small and medium-sized enterprises (SMEs) are particularly important in the delivery of repair, maintenance and improvement (RMI) activity, especially in privately owned housing. The RMI market provides multiple opportunities for integration of energy efficiency improvements, and SMEs could have the scale and reach to influence energy demand at scale, through influencing the myriad individual decisions that are needed for each building project. This paper offers a contribution towards understanding why that potential is not being achieved and how a different perspective on the supply chains for renovation may offer ideas for changes in policy and practice to unlock that potential.

The paper sets out key aspects of how SMEs operate within their own networks and limitations to prepare the ground for a different analysis of the RMI system that could deliver energy retrofit in housing. The supply chain that supports SME RMI activity includes material design and supply, retail – including wholesale and merchants, training, maintenance and warranties/aftercare. There is also a strong local dimension to how the supply chain for renovation operates, encompassing both local policy or incentives, collaborative networks enfolding the SMEs and technical /design constraints and opportunities. By using the idea of a potential “co-evolving” set of systems, we offer a way of identifying new linkages and influences that might change the energy efficiency outcomes of refurbishment works.

Ideas for how the existing supply chain could be updated and amended include: How might product-service offerings to construction SMEs be changed to increase the likelihood of their adoption? What skills and capacities need to be developed at what points in the supply chain? What appear to be the most effective channels [...].

Global public-private approach to city-level acceleration of energy efficiency in buildings ³⁻¹⁵¹⁻¹⁷

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Keywords

cities, buildings, energy efficiency improvements, public private partnerships, building efficiency accelerator, sustainable energy for all

More than half of the world's population already lives in cities. It is expected that within next 20 years this share will increase to two thirds. Cities consume 75 % of world's natural resources, accounting for more than two thirds of global energy demand and 70 % of global carbon emissions from the energy sector.

To accommodate future population and economic growth, energy use in cities is expected to increase exponentially during the next 25 years, with final energy use for space heating, cooling and hot water estimated to grow by at least 50 % globally. This puts cities on the frontline for cutting carbon emissions, making them key to meeting the targets of the Paris Agreement and Sustainable Development Goal 7: ensure access to affordable, reliable, sustainable and modern energy for all. However, city governments and stakeholders need tools and resources to improve the energy efficiency of buildings such as capacity building, national government guidance, and assistance in accessing funding for energy efficiency projects and policies – just to name a few.

The Building Efficiency Accelerator (BEA) under the Sustainable Energy for All initiative has created a network of cities and global organizations to tackle barriers to energy efficiency in buildings. The BEA provides technical assistance to municipal governments and supports policy and project development to accelerate energy efficiency in the building sector. As of March 2017, the BEA works with 28 cities around the world driving policy change and market transformation towards higher levels of energy efficiency.

This paper presents the BEA's approach for city-level support throughout the policy development cycle: from commitment through to implementation and improvement. This approach distinguishes between different levels of engagement based on the city's needs and resources available. Work with cities is grounded on a [...].

2015 China Green Low-Carbon City scorecard 3-152-17

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Keywords

evaluation methods, indicators, benchmarking, cities, carbon emissions, low carbon development, green development

In China's rapid urbanization and industrialization, cities are playing important roles in helping the country reach its climate change mitigation goal of peaking CO₂ emissions around 2030, and improving environmental quality. During the 12th Five-Year Plan (12th FYP) period (2011–2015), Chinese cities set ambitious goals and implemented diverse policies aimed at transitioning to a greener economy. The Chinese central government also set targets on a number of indicators, such as economic energy intensity and carbon intensity (e.g., CO₂ per unit GDP), and air quality (e.g., PM_{2.5} concentration). These targets are helpful for tracking implementation of individual policies or progress at a sectoral level. However, a more comprehensive and integrated approach is needed to assess progress and capture the multi-dimensional aspects of Chinese cities' transition to a greener economy, an approach that offers comparison with international best practices, as well as working with data availability in China's statistical system.

This paper presents the development of a China Green Low-Carbon City Index (CGLCCI, or City Index) and its application to 115 Chinese cities – the largest assessment of Chinese cities to date. The CGLCCI includes 23 key indicators across seven categories: economy, energy, industry, buildings, transportation, environment and land use, and climate policy and outreach. This paper applied the CGLCCI to benchmark the green and low-carbon development status of 115 Chinese cities in the year 2015. Data for the analysis came from government and publicly available data sources. The CGLCCI methodology provides a standardized method to benchmark each indicator, calculate overall city scores, and rank the cities.

The results showed that the low-carbon transition in Chinese cities is still in its early stages. Compared to the best practices benchmarks, the 2015 City Index [...].

A new local energy mapping approach for targeting urban energy renovations ³⁻¹⁵⁸⁻¹⁷

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Keywords

local and regional energy planning, retrofit, residential sector, publicly available data

Large-scale energy renovations need to be better targeted, more cost-effective and result in a higher uptake to alleviate fuel poverty and reduce energy use. This paper presents a localised Geographical Information System (GIS) based approach using publicly-available national and local datasets on housing and energy to plan mass renovation and provide targeted low carbon measures across UK cities. The study used these datasets to first, spatially identify an area for energy renovation (high energy use and/or fuel poor), and then applied a bottom-up carbon mapping model (called DECoRuM) to estimate energy use and potential for reduction on a house-by-house level, and aggregated to urban scale.

To identify an appropriate neighbourhood case study area (covering over 600 households), publicly available datasets were assessed for the town of Bicester, UK, which included Ordnance Survey Mastermap and Address-point data (to identify dwelling characteristics e.g. built form), Energy Performance Certificate data (EPC) and sub-national energy statistics. When the modelled EPC data were compared with the actual sub-national data, the EPC mean energy use was found to be over 3,000 kWh/yr more than the sub-national figure at lower layer super output area. Following this initial analysis, an area with both high fuel poverty and energy use was selected for deeper investigation.

Following this rapid energy assessment, a community engagement campaign was led by the local authority to gather detailed data from householders on their dwellings, to improve the energy model. House-level energy assessment in the selected area showed that a package based approach comprising fabric improvement, heating system upgrade and solar photovoltaics emerged as the most effective in reducing CO₂ emissions. Costs and payback periods however, hinder this success in specific dwellings. Energy improvements in older dwellings such as 1930–1949 semi-detached (dominant type in the area) demonstrated shorter payback periods due to large baseline energy. The online GIS visualisation of the results is considered [...].

Smart energy management for non-domestic buildings: Case studies of two local authorities in the UK ³⁻¹⁷⁴⁻¹⁷

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Keywords

energy analysis, end-use efficiency, energy data, energy management, energy label, smart metering, smart energy management

The use of smart meters has increased since the beginning of the 21st century. The UK government, for example, has recently initiated a programme of rolling out 53 million smart electricity and gas meters for homes and small businesses by 2020 with the expectation that €20 billion will be saved on energy bills over the coming 15 years.

The UK's mass deployment of smart meters has resulted in Local Authorities experiencing additional costs from their installation in their non-domestic buildings, including the costs of new data collection and reporting systems. As a consequence, energy managers are increasingly being forced to consider the ideal frequency for collecting and reporting energy data, appropriate methods for processing that data and the need to rely on 'real-time' energy data when there are several other ways in which energy data can be accessed (bills, direct readings, etc.). Finally, what are the realistic expectations about the financial savings attributable to the installation of smart meters?

This paper seeks to address these questions through two case studies which examine the effects of the smart meter roll-out programme on two separate UK Local Authorities, Northamptonshire County Council and Leicester City Council.

Interactive knowledge transfer as a tool for stimulating energy efficiency on the regional and local level: lessons-learned from a Swedish case study ³⁻¹⁸¹⁻¹⁷

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Keywords

transport policies and measures, capacity building, case studies, dissemination, local government initiatives, interactive knowledge transfer

The immense and urgent climate crisis calls for radical measures to phase out fossil fuels and to use energy more intelligently, in all sectors and levels of society. Whilst new knowledge certainly needs to be developed, already existing solutions and technologies have great potential for reducing energy consumption.

However, existing knowledge is often not disseminated efficiently or utilised to its full potential. Significant economic and human resources are therefore spent on simply reinventing the wheel. We argue that to have any chance of combating climate change, increased attention needs to be placed on the mechanisms and structures for the transfer and exchange of knowledge between key stakeholders, such as municipalities, which hold the mandate, capability and responsibility to act. In fact, the municipal sector hosts a multitude of examples of good practice and proven solutions that could easily and cost-effectively be applied more widely.

To successfully disseminate knowledge and experience of successful energy efficiency work from one context and customise it to the needs of another, it is critical to recognise three key principles: to focus on the learning journey of the individual and the context and preconditions of the organisation that wants to learn from peers in another; to employ a systematic and highly structured process; and to set clear objectives to solve a problem or to make significant improvements.

This paper will describe and discuss lessons learned from a successful pilot project where the abovementioned principles were applied in practice – a 2015 knowledge transfer project between municipalities in the County of Stockholm on the topic of sustainable and energy efficient transport.

Learning from the field: analysing foreign experience feedbacks to enrich the development of a programme for the renovation of multifamily housing in Geneva

3-218-17

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Keywords

renovation, multi-family dwellings, local or regional energy efficiency measures, refurbishment, collective housing, local initiatives

Local authorities or other local stakeholders are increasingly involved in the implementation of energy efficiency policies, and in particular for the renovation of buildings. They can have more flexibility in their action plans, compared to national institutions. They often take the lead to experiment new approaches and are therefore key sources of policy innovation. However, their means are smaller and they encounter difficulties in transforming pilot projects into large dissemination schemes.

This paper presents a detailed review of 9 local and/or innovative initiatives aimed at boosting the renovation of dwellings, and in particular of multifamily housing, mostly in France, but also in Austria, Germany, the Netherlands and Switzerland. This sample is not meant to be representative. The case studies were selected based on the interest they have raised in other local authorities or countries, and to have a diversity of approaches: from tailored support requiring a strong involvement of the homeowners to turnkey renovation services.

The analysis is structured according to the support offered along the customer journey: 1) general information; 2) targeted technical advice; 3) financial engineering; 4) preparation of the works and selection of the professionals; 5) implementation of the works; 6) validation and follow-up. While in the past the initiatives tended to focus on some of these steps, the recent initiatives increasingly cover the whole journey. The case studies bring interesting experience feedback for each of these steps.

Most of these schemes aimed at a renovation rate between one to ten [...].

How is energy efficiency governed in the EU? Multi-level governance of energy efficiency policies, strategies and targets at EU, national, regional, and local level 3-268-17

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Keywords

governance, national energy efficiency action plans (NEEAPs), targets

Energy efficiency is recognised by policy makers at EU, national, and local level as a key solution for the mitigation of climate change. Targets have been established or are still under discussion for energy and climate, e.g. the EU 2030 targets, the national energy efficiency strategies, which may have 2030 or longer-term targets. Several regions (e.g. Lander in Germany) have their own strategies and targets. Finally under the Covenant of Mayors, over 7,000 local authorities all over Europe have set climate targets for 2020 and/or 2030.

The paper presents, analyses and discusses the role and importance of targets, of energy and climate planning at different levels of governance, and of monitoring energy and carbon emissions against a baseline. In particular the paper reports on successful examples of collaboration between municipalities and provinces/regions in the frame of the Covenant of Mayors and likewise co-ordination between regional and national strategies.

National policies could be better implemented if adapted to local situations and closer to citizens, for example urban transport strategies or local building codes. At the same time local administrations should be aware of national or EU policies (e.g. national incentives, efficiency requirements, etc.) when setting city targets and policies. In particular local, regional and national plans should be coordinated and integrated. The same is also valid for the monitoring and reporting progresses on carbon emission reductions and energy savings.

The paper argues that both approaches, i.e. top down (EU and/or national) and bottom up (regional and/or local) are important and needed to reach ambitious climate change targets. These two approaches should be complemented and well integrated in the policy design, implementation and monitoring. The paper concludes with recommendations on how to improve the collaboration between different [...].

Why persist? Organisational perspectives on delivering an energy efficiency programme for the Leeds city region ³⁻²⁸²⁻¹⁷

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Keywords

collaboration, public private partnerships, energy efficiency programmes, organisation behaviour, cities, motivations

Local governments are expected to act as catalysts to improve energy efficiency standards in buildings within their jurisdiction. In response, several UK local authorities have developed city-scale energy efficiency programmes to make effective use of government energy efficiency funding. Recent research documents the scale of involvement in city-scale energy projects, but reasons for actors' involvement are less well understood. Using empirical evidence, we address this limitation by exploring the motives of organisations involved in the delivery of a large-scale energy efficiency programme in the Leeds (UK) city region.

Local economic, social, and environmental priorities are important factors in the development of city initiatives, and collaborative working between the public and private sector can realise energy efficiency objectives while also contributing to local economic growth. With national energy policy subject to ongoing uncertainty, it is important to determine how local and organisational priorities can align to support successful delivery of city-scale energy efficiency schemes.

The focus of this paper is a case study of a joint programme, administered via a public-private framework arrangement to deliver energy efficiency measures across several cities and their surrounding regions. Evidence for the case study is drawn from semi-structured interviews with programme actors and from corporate and programme documentation. Using a theoretical framework with origins in business literature, we analyse the characteristics of the participating organisations and their reasons for involvement in the programme. We discuss the impact of policy changes to the Green Deal and ECO in shaping the programme and its implementation. In the final section of the paper, we identify the key factors contributing to the continued delivery of the programme and lessons that can be drawn to inform future schemes.

The Swedish regional energy agencies: past, present and future 3-293-17

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Keywords

agency, domestic policies and measures, cooperation

The Swedish Energy Agency is the responsible authority for energy and climate issues in Sweden and has been cooperating with the regional energy agencies in Sweden since 2003. The regional energy agencies, which are owned by county councils and/or municipalities, have played an important role in regional energy management. In this paper, we will highlight some aspects in the past and present collaboration between the Swedish Energy Agency and the regional energy agencies. Furthermore, representatives from relevant organisations will give their view on important aspects on the future collaboration. Since 2003, the regional energy agencies are responsible for coordinating the municipal energy and climate advisory service. The regional energy agencies were also appointed regional energy actors by the Swedish Energy Agency from 2004 to 2014. Since 2016, the mandate of the regional energy agencies at the regional level has been strengthened due to the new government decree on financial support for the advisory service which now gives them a more formal role. In addition, the collaboration within the National Regional Fund Programme has made them a formal partner to the Swedish Energy Agency. A role they have not possessed before. Both parties agree on that they wish for a deepened and developed collaboration in the future.

Development of the Taiwan city index: localizing metrics to evaluate cities in Taiwan

3-320-17

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Keywords

local energy policies, local government initiatives, local activities, end-use efficiency, policy, urban planning, urban transport

Local governments throughout the world can take action to lead on energy efficiency. Those that do make their communities better, stronger, and more resilient. Comparing the efficiency initiatives of different local governments can help identify those who are leading on energy efficiency and those with room to do more. This benchmarking process also uncovers best practices in policy development and implementation, as well as general lessons learned.

This paper describes a collaboration between partners in the United States and Taiwan to create a set of metrics to evaluate the efficiency efforts of Taiwanese cities. Previously, the US partner developed a comprehensive methodology to benchmark the efficiency activities of local governments in the United States. The ACEEE City Energy Efficiency Scorecard is a biennial benchmarking effort that captures trends in local policy development in the US and provides actionable guidance for local governments seeking to prioritize efficiency. Just as this city benchmarking has been valuable for US cities, a similar initiative for Taiwanese cities can yield similar benefits.

This research captures the procedures used to localize the US metrics to the Taiwanese context and develop the Taiwan City Energy Efficiency Index. It discusses the research findings that affected our decisions to adjust the methodology and metrics. We discuss differences in the electric utility landscape, local government capacity to act, and efficiency policies. We explain how energy-efficiency metrics can be localized to fit different local contexts. By outlining the process of localizing metrics, this paper serves as guidance for others considering methods of locally benchmarking energy efficiency efforts across all energy sectors.

Resilient urban energy: making city systems energy efficient, low carbon, and resilient in a changing climate ³⁻³³⁵⁻¹⁷

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Keywords

urban planning, integration, energy policy, infrastructure, resilience, low-carbon cities

How can urban energy systems be energy efficient, low carbon, and resilient in a changing climate? This question is analyzed from a systems perspective, considering how climate change impacts both energy supply and energy demand in cities. Temporally, this analysis considers both climate stresses, e.g. rising temperatures, shifts in precipitation patterns, and climate shocks, e.g., storm events, disruptions from cold snaps or heat waves. Using this dynamic systems perspective, this paper draws upon a range of emerging literature and practice on climate action, resilience and adaptation. This ranges from utility reliability and emergency risk management, to end-use energy efficiency and urban infrastructure planning. Case studies of three cities are included – Washington DC, USA; Copenhagen, Denmark, EU; and Shenzhen, Guangdong, China – to illuminate how cities are making their energy systems efficient, low-carbon, and resilient. The analysis finds wide variation in the methods and areas of focus, as well as varying degrees of connection the cities are making between low-carbon efforts and resilience efforts related to urban energy. While institutional coordination is challenging, cities are finding that it leads to better energy and climate change strategies. Beneficial strategies across the cities include: distributed energy resources (such as microgrids, and district heating and cooling), passive and efficient energy systems in buildings, and partnerships across government agencies, businesses, and communities.

Financing models for energy-efficient street lighting ³⁻³⁵⁵⁻¹⁷

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Keywords

energy efficiency investments, business models, energy efficiency financing, street lights, public lighting, energy performance contracting (EPC), project finance, intracting

Investment in the upgrade of urban street lighting infrastructure may offer energy savings up to 80%. It is also very cost-efficient and has a short payback period. Despite these arguments, a large share of the infrastructure in many European countries requires refurbishment. The budgetary constraint of its owners, who are often municipalities, is a common reason. To overcome it, creative business models are required to attract other investors and overcome the barrier of high up-front investment costs.

The paper summarizes the results of a piece of research, which aims to find suitable models to finance urban street lighting infrastructure. The geographical focus is on the countries of Central Europe, namely Austria, Croatia, the Czech Republic, Germany, Hungary, Italy, Poland, Slovakia, and Slovenia. The research represents one of the tasks of Dynamic Light project, which aims to promote dynamic, intelligent and energy efficient urban lighting. The project is supported by the Interreg Central Europe platform.

The paper provides a review of existing financing models, including self-financing, debt-financing, third party financing, and project finance. The paper further analyses these models using a common framework. In particular, it provides the overview of each model, identifies the projects to which it could be applied, specifies its advantages and disadvantages, and provides a case study. The paper concludes with recommendations for decision-makers on finding a suitable financing model.

Local energy planning in France: a way to reinforce energy transition ³⁻³⁹⁰⁻¹⁷

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Keywords

local and regional energy planning, long-term strategies, savings potential, networks, e-learning, renewable potential

Decentralization is a process initiated in France for several years. Recent laws (MAPTAM, NOTRe) have confirmed this dynamic by strengthening the responsibilities of local authorities, and Energy Transition for Green Growth (TECV) law particularly in the energy field. Liberalization of energy markets forced local authorities to position themselves in the market offers for their own needs and thereby appropriating more specifically energy issues. Lastly, local strategies implemented with shared governance are essential to make the ownership of the energy transition by citizens and stakeholders.

In this context, the Regional Directorate of ADEME launched the Local Energy Planning (LEP), a process to support local authorities, as a means to define local energy strategy. Beyond supporting territories in the Energy Transition and the Third Industrial Revolution in Hauts-de-France, goal of LEP is to enable local authorities, including elected officials, to gain skills with their responsibilities, define their energy strategy of medium/long term as well as actions to implement in the short term. A major issue of ESP is to ensure independence of this energy strategy in the public interest.

First, energy consumption, production and networks are analysed and mapped. Energy demand and potentials of local renewable energy are projected at medium and long term to define targets. Development needs, strengthening coexistence and energy networks are specified in these studies. Finally, a roadmap defines the means (technical, financial, economic) to achieve these goals with all stakeholders of the territory.

The paper present how a local approach of energy issues can be a way to accelerate Energy Transition based on some lessons learned from local energy strategies to reach ambitious goals in 2050 (100 % renewable ...) in the Energy Transition context in France. Finally, coordination challenges of a double movement both upward (local authorities) and down (State) are explored.

PANEL 4

Mobility, transport,
and smart and sustainable
cities

Evaluating mobility and sustainability in the transportation sector at the city level

4-022-17

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Keywords

mobility, cities, transportation, transport policies and measures

Local governments have a particularly important role to play when it comes to maximizing energy efficiency of the transportation system. Cities increasingly serve as incubators for forward thinking policies and practices. Creating smart cities with sustainable transportation systems involves a combination of policies that target vehicle efficiency, expand mobility options, and integrate transportation and land use planning.

Given the wide range of policies that cities can implement, evaluating a city's progress towards improving the efficiency of their transport sector can be a challenge. This paper will discuss the approach taken in ACEEE's City Energy Efficiency Scorecard for evaluating local governments on their actions to improve transportation energy efficiency. It will also identify potential improvements and refinements to these methods. Finally, this paper will include a discussion of additional metrics under consideration for future versions of the Scorecard that evaluate how cities are using big data and information and communications technologies (ICT) to create smart transportation systems.

Intermodality – key to a more efficient urban transport system? 4-071-17

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Keywords

mobility, urban transport, transportation, public transports, infrastructure, intermodality

Cities are growing, ways of life and work are changing, people are increasingly mobile and interconnected – the urban population is constantly moving. Traffic congestion, emissions and increasing demand for parking space are among the consequences of these developments and confront society with new challenges. Especially in larger cities, flexible usage and combination of different transport modes – known as intermodality – plays an increasing role and is being discussed as a key to a more efficient urban transport system. Mainly in city centres, distances are short enough to be covered by foot or by bike and the close-meshed public transport network allows users to combine the variety of mobility options in an individual and situational way. A resulting declining use of private cars could reduce traffic congestion and emissions and challenge the lack of parking space in cities. Thereby, intermodality offers a possibility to optimize mobility and to contribute to healthier and more sustainable living in cities.

This paper presents mono- and intermodal travel modes' performance by means of accessible locations and sets them against the results of a survey on intermodality regarding the frequency of using various mono and intermodal travel modes. In addition, other performance indicators for the different modes are given, including the emitted amount of CO₂, personal energy consumption, and price.

Comparison of free-floating car sharing services in cities 4-109-17

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Keywords

car-sharing, mobility, cities

In recent years, free-floating car sharing services (FFCS) have been offered by many organizations as a more flexible option compared to traditional car sharing. FFCS allows users to pick up and return cars anywhere within a specified area of a city. FFCS can provide a high degree of utilization of vehicles and less usage of infrastructure in the form of parking lots and roads and thus has the potential to increase the efficiency of the transport sector. However, there is also a concern that these compete with other efficient modes of transport such as cycling and public transport. The aim of this paper is to better understand how, when and where the vehicles are utilized through logged data of the vehicles' movements. We have access to data collected on FFCS services in 22 cities in Europe and North America which allows us to compare the usage pattern in different cities and examine whether or not there are similar trends. In this paper, we use the collected data to compare the different cities based on utilization rate, length of trip and time of day that the trip is made. We find that the vehicle utilization rates differ between cities with Madrid and Hamburg having some of the highest utilization levels for the FFCS vehicles. The results form a first step of a better understanding on how these services are being used and can provide valuable input to local policy makers as well as future studies such as simulation models.

Renewbility: options for a decarbonisation of the transport sector up to 2050 ⁴⁻¹¹⁰⁻¹⁷

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Keywords

alternative vehicles, alternative fuels, electric vehicles, climate policy, scenarios, transport policies and measures, urban transport, energy efficiency improvements

The project “Renewbility” presents several climate protection scenarios for the transport sector in Germany, modelling vehicle stocks, transport demand, energy consumption, CO₂-emissions and economic effects. Funded by the German Ministry for the Environment, this project has involved a broad range of stakeholders of the transport sector and thus included different positions and interest in the design of the scenarios. Common objective of all scenarios is the full decarbonisation of the transport sector by 2050.

The results show the need for clear and future-oriented political action: Electric vehicles need to be an essential pillar of an overall strategy against climate change up to 2050. Power-generated fuels should only be used where no other option exists – probably in air and maritime transport. Effective policy measures include the phase-out of the internal combustion engine, which could be realised by more ambitious CO₂-standards combined with increasing fuel prices.

Moreover, the scenario analysis indicates that increasing sustainable urban mobility would be an effective strategy not only for a higher quality of life for citizens, but also against climate change and other negative environmental effects. In order to offer alternative options for car users, the promotion of sustainable transport modes such as public transport and cycling is necessary. Important policy measures for local authorities include parking space management. Implementing measures for enhancing the quality of public transport, rail freight traffic, and life in cities is even expected to increase GDP and to reduce external costs.

In summary, the decarbonisation of the transport sector offers the opportunity to combine climate protection with a positive economic balance. It is the role of policy makers in partnership with industry and other stakeholders to build up the necessary framework to realise these benefits and successfully combat climate change. In order to fully decarbonize the transport sector by 2050, transformation [...].

How ready is Europe for the smart building revolution? 4-161-17

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Keywords

smart metering, buildings, renewable energy, zero-carbon technologies, batteries, policy evaluation, policy, built environment, smart-ready

With an appropriate framework, buildings could play a central role in transforming the EU energy system, increasing the speed with which the three biggest CO₂ polluters – the building, transport and power sectors – are reducing their climate impact. Buildings are entering a transition phase, transforming into highly efficient micro energy-hubs consuming, producing, storing and supplying energy, making the system more flexible and efficient enabling a rapid uptake of renewable energy and electric vehicles.

The increased portion of decentralised renewable energy systems – key to achieve a sustainable and decarbonised energy system – causes variable stress on the grid. The growing number of electric vehicles, together with a bigger share of electrical heating of buildings, will challenge the energy system even further. These tendencies highlight the need for the implementation of strategies integrating smart buildings and electric vehicles to avoid a system overload.

This paper provides an answer to the question, what role can smart buildings play in the future energy system?, by presenting ten interrelated principles. Apart from principle 1, maximising the building's energy efficiency, which should be applied first, the sequence of the nine remaining principles is not laid out in order of importance. They are all important separately, but more effective considered in a holistic approach to fully achieve decarbonised transition pathways. Building further on these principles, the extent to which the Member States of the European Union are ready for the transition to a smart building stock is assessed and evaluated.

The purpose of this paper is to inspire policy-makers of how to foster the potential of buildings as “all-in-one” entities that could benefit the energy system and empower the end-users.

What are the effects of incentives on plug-in electric vehicle sales in Europe? 4-188-17

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Keywords

transport, transport policies and measures, statistics, electric vehicles

Plug-in electric vehicles (PEV), both as battery electric vehicles (BEV) and plug-in hybrid vehicles (PHEV) have noteworthy potential to reduce global and local emissions. Governments around the world have implemented monetary and non-monetary policies to accelerate PEV market diffusion. However, empirical estimates of their effectiveness are scarce. Here, we analyse data on PEV sales from 30 European countries from 2010–2016 with respect to direct subsidies, tax rebates, and other incentives. We apply panel data regression models and control for several other influencing factors such as income and fuel prices. We find income, diesel prices and both direct and indirect subsidies to positively influence PEV adoption. The aim of the present paper is to contribute to the discussion on policy-aided market evolution using empirical evidence about electric vehicles and alternative fuel vehicles in general.

Community engagement as a tool to help deliver smart city innovation: a case study of Nottingham, United Kingdom ⁴⁻¹⁹⁸⁻¹⁷

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Keywords

Community engagement, local authorities, REMOURBAN, smart city

Cities are complex urban conurbations and facing many challenges. The majority of the world's population now live in cities and consume 80 % of the resources. 'Smart City' innovation is emerging as a major response to the challenges cities are facing. Much of the focus remains on technological interventions, but technology alone may not be sufficient to reach smart and sustainable city goals. Cities are made up of people who have influence and are therefore key stakeholders in the development of smart city innovation and cannot be ignored. This paper aims to explore community engagement in Nottingham to help deliver smart city innovation and the way Nottingham City Council is engaging local communities in its smart projects. The paper analyses the community engagement strategy of Nottingham developed as part of the EU funded smart city project, REMOURBAN (REgeneration MOdel for accelerating the smart URBAN transformation). The main drivers and barriers to effective community engagement are identified in the smart city context. This exploratory study adopted a case study strategy and qualitative research methods. The data was collected through thirteen semi-structured interviews with middle and senior managers in Nottingham City Council and other stakeholder organisations in the city and a focus group of five community leaders from three local community groups. The content analysis of the REMOURBAN documents related to citizen engagement and the council's energy strategies and policies was carried out. The key results are discussed with recommendations to nurture effective community engagement as a smart city tool and conclusions are drawn.

Cross-sectoral policymaking, a way to achieve an energy efficient transport system? The case of Stockholm and Gothenburg ⁴⁻²¹⁷⁻¹⁷

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Keywords

case studies, policy-making, transport policies and measures, qualitative study, regional policymaking, public administration

Public policy and more specifically cross-sectoral policymaking are considered necessary tools for the transition to an energy-efficient, non-fossil transport system. Thus, the organizational structure and working practices of involved actors are of relevance to the policy content and how it is implemented. The aim of this paper is to analyze the presence of and work with cross-sectoral regional policymaking to address its implications for the development of a more energy-efficient transport system. In Sweden growing transport volumes have made transport increasingly regional, especially in the regions containing a larger urban area. This paper, therefore, builds upon two qualitative case studies of the largest urban regions in Sweden: Stockholm and Gothenburg. Different administrative borders, organizational structures, traditions and approaches to cross-sectoral collaborations characterize the cases. The results show that cross-sectoral collaboration does not necessarily lead to cross-sectoral policymaking, which will not necessarily result in a more energy-efficient transport system. This is due to the level within which the collaboration takes place (if it is on the goal or action level), the territoriality of the collaboration, sectoral power structures and the participants' spatial embeddedness. To be successful in changing policymaking for transport towards energy efficiency, it is important to consider these aspects and take action to solve the potential problems before a cross-sectoral collaboration process is formed. This leads to transport policy based on a conventional approach to planning and limits its energy objectives.

Householders as co-producers: lessons learned from Trondheim's Living Lab 4-226-17

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Keywords

zero-emission houses, lifestyle, user behaviour, demonstration buildings, comfort, transition, living lab, experiments

As energy systems shift from central to distributed production and a combination of these, the lines between the traditional 'supply side' and 'demand side' become increasingly blurred. Passive consumers are expected to become active, providing flexibility to the system, and eventually morphing into 'prosumers', producing and consuming energy. The use and practices related to new solutions and technologies are often taken for granted, and there is a remarkable lack of studies on how implicated publics make sense of their role in this transition. In this paper, we seek to draw lessons from the way in which users have been engaged with a zero emission building. The paper presents results from experiments conducted in the Trondheim Living Lab, which explores the relation between radical technological change, domestic life and energy use. The Trondheim Living Lab is a newly built, 100m², detached single family home that is planned to reach a zero emission balance. The qualitative experiments, conducted in the laboratory between October 2015 and April 2016 involves six groups of residents, each living in the house for 25 days. The empirical material consists of interviews, direct observation, diary records, photography and self-filming, as well as detailed quantitative records of energy consumption and indoor climate. The Trondheim Living Lab offers a unique opportunity to better understand the way in which stakeholder engagement and co-production has been attempted through two avenues: the living lab, and prosumption. This paper reviews these two concepts, and provides lessons learned about how co-production and engagement successfully can be achieved.

Toward functioning international cooperation for sustainable cities – Swedish experience with international city networks

4-231-17

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Keywords

sustainability, collaboration, networks, energy efficiency agreements, multilateral, experiences

This paper provides a retrospective analysis of the challenges and lessons learned from attempting to utilize international collaborative networks to promote urban innovation with the aim of increasing the environmental and social sustainability of the participating cities and municipalities. The paper is based on the Swedish experience with the Global Sustainable Cities Network (GSCN, 2011–2015) and the Alliance for Urban Sustainability (2015–2016).

The GSCN was an initiative adopted in 2011 under the Clean Energy Ministerial. Sweden, the United Arab Emirates (UAE) and China were founding members. The GSCN was intended to become a multilateral high-level international forum to promote policies and programs that advance clean energy technology, share lessons learned and best practices, and encourage the transition to a global clean energy economy. The aims of the GSCN were to provide an open international platform for groundbreaking sustainable city initiatives, to share knowledge that can be utilized and broadly incorporated in the work of the participating cities, and to promote trade between the countries. The countries that participated in the GSCN were: the UAE, Sweden, China, Finland, Denmark and France. Three to five cities from each country participated in the initiative.

In 2015 Sweden began to explore a more targeted bilateral collaboration with France, which was subsequently formalized as the Alliance for Urban Sustainability. The five Swedish cities that were members of the GSCN and four new cities from France are currently active in this collaboration, which is driven by the needs and interests of the cities and coordinated by the Swedish and French governments. This network is learning focused, with the aim of sharing, exploring, improving and scaling up the application of methods for increasing the sustainability of cities. [...]

Developing a city energy modelling tool and approach ⁴⁻²⁷⁴⁻¹⁷

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Energy Saving Trust/UCL Energy Institute, UK

Keywords

cities, modelling, local and regional energy planning, local energy policies, local energy system, residential buildings, district heating, distributed energy resources (DER), retrofit

The Energy Saving Trust and UCL Energy Institute have developed a new model, tool, and approach to assist cities in making energy planning decisions. As energy systems become more devolved and less centralised, cities will play an increasingly important role in defining energy infrastructure. Decisions relating to energy consumption and generation are also becoming more complex and often involve multiple stakeholders with varying, and sometimes conflicting, objectives. SiCEDs – the ‘Stakeholder interactive City Energy Demand Simulator’ – allows city stakeholders to produce, share and understand the impact of decisions on a variety of outputs. The model includes the energy consumed and generated by domestic and commercial buildings in a city. The initial model has been piloted in Birmingham and Exeter, with funding from InnovateUK.

The SiCEDs tool allows stakeholders to build scenarios by altering a variety of inputs including:

- the future energy efficiency mix of buildings
- the source of heat for buildings
- the volume, modal split and power of transport
- the level and efficiency of local generation

The SiCEDs tool will then produce outputs for the city across a time horizon to 2050. These outputs include the overall level of energy demand, the level of CO₂ and NO_x emissions, the peak demand on the grid and the level of fuel poverty.

The outputs can be viewed in time series charts, maps and exported as tables for further analysis. The process that has been developed alongside the tool is designed to allow stakeholders to efficiently develop and collaborate on different scenarios. Stakeholders could include local authority planning, development and energy officers, private developers, community energy companies, landowners, planning [...].

Circumventing limitations to transport energy efficiency – the electric car in two-car households

4-286-17

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Keywords

transportation, electric vehicles, driving distance, energy savings potential, fuel efficiency, two-car households

The electrification of vehicles may lead to considerably lower energy use in transportation due to the high energy efficiency of electric driveline. The deployment of electric cars is hampered by the limited range of current battery electric drivelines. Larger batteries are costly and require energy in production that counteracts the energy gains from the additional driving that is made possible. In multi-car households, the battery electric vehicle (BEV) may drive more while keeping the battery size down by utilising the options of replacing more than one car's driving and having a back-up for longer distances.

An optimisation model is developed to estimate the potential for a BEV, when replacing one of the conventional cars, to viably contribute to the accomplishment of the driving in two-car households. It uses data from 1 to 3 months of simultaneous GPS logging of the movement patterns for both cars in 64 commuting two-car Swedish households.

The results show that a flexible vehicle use strategy fully utilising the available options can considerably increase BEV driving, almost eliminating the driving not possible to fulfil due to the range and charge limitations. This flexibility combines with a smaller BEV battery and results in significantly better BEV economics compared to a car-for-car-only BEV substitution. We estimate the present value of this flexibility on average to around \$6,000–7,000 in Swedish two-car households. The achieved fuel savings amounts to around 11 GJ/yr per household corresponding to a mitigation of around 770 kg CO₂/yr.

User perceptions of the emerging hydrogen infrastructure for fuel cell electric vehicles

4-289-17

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Keywords

adoption, zero-carbon technologies, willingness to pay, vehicles, survey, hydrogen, user acceptance

Hydrogen used to fuel vehicles can help to reduce the negative impacts of fossil fuels in the transport sector. Furthermore, fuel cell electric vehicles (FCEVs) are more energy efficient than conventional ones. FCEVs need an infrastructure of hydrogen refuelling stations (HRS). The “50 HRS Programme”, which was funded by the German Federal Ministry of Transport and Digital Infrastructure (BMVI) as part of the National Innovation Programme Hydrogen and Fuel Cells Technology (NIP), is intended to expand the HRS network and to create the basis for research and development.

This paper presents the objectives, methodology and findings of an integrated qualitative and quantitative study of user perceptions of the hydrogen infrastructure in Germany. The scientific work was part of comprehensive research activities accompanying the 50 Hydrogen Refuelling Stations Programme (financed by BMVI).

The qualitative part comprises refuelling tests at a HRS and focus groups consisting of 6 experienced and 8 inexperienced customers. In a second step, an online survey was conducted with 100 former and current users of FCEVs in Germany.

In the refuelling test, every test participant was able to successfully refuel the vehicle and the refuelling process was perceived as simple. This is supported by the survey results, which indicated that respondents were particularly appreciative of the short duration of the refuelling process (>90 % satisfaction). However, more than 80 % of the survey respondents were confronted with technical problems at least once while refuelling. Overall, the technology is perceived as not yet fully market-ready and requiring improvement, especially of the refuelling infrastructure in terms of density and reliability. Despite these shortcomings, the respondents regard hydrogen as a promising future technology in the transport sector.

Balancing variable supply with flexible demand

4-291-17

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Keywords

smart grid, demand side management (DSM), renewable energy, electric vehicles

The UK electricity system is undergoing a significant transformation. On the supply side, the increasing penetration of renewable energy resources raises concerns for grid stability due to their intermittency. On the demand side, transportation and heating electrification, as well as small scale electricity generators, are making demand side more unpredictable. This challenges the traditional way of balancing electricity in the grid, whereby supply matches demand.

Demand-side management (DSM) can offer a promising solution to the above problems by coordinating electricity consumption with variable supply from renewable resources. However, considering the number of autonomous stakeholders involved, each with their different objectives, it is uncertain how such coordination will be performed. Traditionally, in the UK the system operator is responsible for balancing the grid in a centralised manner. However, centralised coordination raises privacy and scalability concerns (processing a large amount of information in real-time). Decentralised coordination methods offer a way for consumers to retain information privacy and have been shown to work well in a simulation environment whereby a single aggregator controls a pool of identical consumers. This work explores the value of such decentralised coordination methods in the context of the interacting and evolving electricity system in the UK.

The first part of the paper investigates the impact of integrating storage into the UK electricity system. We use National Grid future energy scenarios (FES) to allocate electrical storage capacity to consumer sectors (domestic, commercial and industrial) and the system (referring to pump storage). We explore the benefits and trade-offs of central versus distributed coordination strategies of consumer and system storage for the period of 2015–2050 in accordance with FES. We find that the long-term benefits are higher in the case of centralised balancing however consumers do not benefit equally.

The second part of the paper investigates how the introduction of DSM into [...].

Urban production: smart rooftop greenhouses on factories

4-313-17

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Keywords

urban, waste heat, smart grid, microgrids, e-learning, feasibility studies, flexibility, biological automatization

One approach to increase energy efficiency and energy flexibility of production systems is to connect independent production systems and local supply systems to energy networks. One technology that can be adopted is smart rooftop greenhouses (SRG). The main subject matter of a SRG is the energy symbioses through waste heat usage and smart grid integration to improve energy efficiency of a production system.

With a SRG on a factory the waste heat and CO₂-emissions can be used for plant production. As a SRG can be heated with low temperature waste heat, a big energy efficiency potential in the German industry can be addressed. Furthermore, this allows for space to be used more efficiently for supporting land-use reduction goals. The connection and integration of a SRG in the industrial smart grid brings in further flexibility for its energy optimal control. With a highly automated and digitalized plant production technology in a controlled environment agricultural system like an SRG, the production of bio-based production materials or food can be automated and optimized.

The aim of this publication is to present a concept for smart rooftop greenhouses. Therefore the paper is supported through a systematic literature review on the subject. The results of this review have been combined and further developed with new approaches.

User perceptions of EVs and the role of EVs in the transition to low-carbon mobility

4-325-17

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Keywords

electric vehicles, user behaviour, policies and measures, practices, EV user perceptions

Transport play a central role to reach global greenhouse gas emission targets. Reducing emissions from privately owned cars is of high priority, and the sustainable transition of road transport by electrification is one strategy launched to meet this end. Norway has been a forerunner when it comes to this and is today the country with the highest proportion of privately owned electric vehicles in Europe. Summarizing and publishing Norwegian experiences with electric mobility will therefore be useful for those working with transport electrification in other countries.

In this paper, we study user perceptions of different models of EVs. The paper focuses on how different models of EVs have been domesticated into Norwegian households. The importance of the incentives and policies related to the adoption of EVs are particularly highlighted and discussed in relation to other perceived properties related to EV driving, such as comfort and environmental concerns. The paper is based on qualitative interviews with different segments of EV drivers from 2013–2015, as well as a quantitative analysis of 3,654 EV drivers in Norway from 2016.

The paper aims to strengthen the understanding of individuals' perceptions of EV policies and the possible consequences for policy makers. Also, it seeks to investigate how changing patterns of acting at the individual level may create normality and reconfigure the architecture of choice for others. The study shows that economic and technical aspects of EVs were important for Norway's successful introduction of the technology, in addition to symbolic aspects related to EVs, such as feeling more environmentally friendly. Hence, we argue that the combination of strong economic incentives, environmental awareness and a comfortable driving experience fostered the successful introduction of the electric car.

How to decarbonise heavy road transport?

4-346-17

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Keywords

transport policies and measures, transportation, policy

Ambitious long-term greenhouse gas (GHG) emission targets require decarbonisation of the transport sector. Where plentiful supplies of low carbon electricity are available for road transport, passenger cars with internal combustion engines need to be replaced by electric vehicles. However, despite its growing share of transport's CO₂ emissions, no clear solution presents itself for CO₂ emission reduction on heavy road transport. Potential low carbon options include direct electrification of trucks via batteries, over-head power lines, hydrogen and other power-to-X fuels from renewable electricity. Here, we compare these options with respect to their degree of technological readiness, economy, infrastructure costs and CO₂ reduction potential. We use cost assumptions and cost reduction potential from available literature sources and combine them with actual heavy truck usage data for an analysis for Germany in 2030. Our results show that the high efficiency in direct usage of electricity from catenaries implies less installation of additional renewable power compared to fuel cell electric vehicles. Both could be good long-term solutions but require a massive initial infrastructure investment.

Climate effects of woody biomass and fossil fuel use in stand-alone and integrated energy systems ⁴⁻³⁵⁸⁻¹⁷

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Keywords

bio fuel, vehicles, climate change, electric vehicles, primary energy, integrated energy system, radiative forcing

Biomass is a key resource in a society based on renewable energy, but is a limited resource and the use of biomass in one sector will influence its availability for other sectors. The global energy system is heavily dependent on fossil fuels, and the climate impacts of CO₂ occur regardless of the source of emissions. As a result, the climatic effects of biomass use in an energy system depend largely on which biomass feedstock and bioenergy pathway is being used, and what type of fossil fuel pathway is being replaced. In this study, we evaluate the CO₂ emissions and climate effects of woody biomass and fossil fuel use. We analyse the potential production of electricity, heat or transport distance when using one kWh of woody biomass and fossil energy system designed to provide the same service to society as the most energy efficient bioenergy systems. The fuel cycle inputs are included in the analyses and are based on different state-of-the art as well as emerging technologies for energy conversion. We quantify the primary energy use and annual CO₂ emission of different bioenergy and fossil alternatives. We then calculate the cumulative CO₂ emission and climate effects in terms of cumulative radiative forcing for the fossil and bioenergy systems. The results show that primary energy use, CO₂ emission, and cumulative radiative forcing vary strongly between the studied alternatives. The use of biomass should be considered in the context of the overall energy system, and in relation to the development of energy conversion technologies and potential integration between different energy sectors. This may identify pathways that are primary energy efficient and that give climate benefits in both the short and the long term. The use of bioelectricity and electric vehicles instead of biomotor fuel-based vehicles gives about twice the transport distance per unit of consumed woody biomass. Integrated energy systems that supply a package of energy services including electricity, heat and transport distance reduce the primary energy use and increase the climate benefits of woody biomass. The replacement of coal for heat and [...].

Lifestyle, efficiency & limits: modelling transport energy and emissions using a socio-technical approach ⁴⁻³⁶⁵⁻¹⁷

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Keywords

transport, transport policies and measures, end-use demand, scenarios, climate change mitigation, co-benefits, carbon emissions

The Paris climate change agreement and ‘dieselpgate’ emissions scandal in the US have prompted policy makers, regulators and industry to re-evaluate strategies to meet climate change mitigation and air quality goals. While a wide range of supply and demand policies have been proposed at both national and subnational/local levels, implementation and even the supporting research evidence have been lagging ambition in many parts of the world. It is well known that societal transport energy consumption and related emissions are influenced by technical efficiency, the carbon/pollutant content of energy and by ‘lifestyles’ and socio-cultural factors. However, only a few attempts have been made to operationalise these insights into models of future transport energy demand or even scenario analysis. In particular, insights into human behaviour, lifestyle change and the important role of individual attitudes and perceptions are often overlooked by policy makers. This paper addresses this gap in research and practice by presenting a quantitative scenario exercise using an integrated transport-energy-environment systems model to explore four contrasting futures for Scotland that compare ‘lifestyle’ change and socio-cultural factors against a low carbon technology focussed transition pathway using a socio-technical approach. We found that radical demand and supply strategies can have important synergies (and potential trade-offs) between reducing life cycle greenhouse gas and air quality emissions. Lifestyle change alone (without an EV transition) has a similar effect on transport carbon and air quality emissions than a transition to EVs with no lifestyle change. Yet both have limits to meeting future targets, which may only be achieved with a combined strategy of radical change in travel patterns, mode choice, vehicle occupancy and on-road driving behaviour with high electrification and phasing out of conventional petrol and diesel road vehicles.

Implementation of energy strategies in communities

4-382-17

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Keywords

accompanying measures, case studies, community, implementation, policy recommendations

More than 70 % of global greenhouse gas emissions are attributed to human activities in cities. Thus, cities can play a major part within the CO₂ emission reduction goals set by the Paris Agreement. The domains of urban and energy planning have been identified as important processes by which to reach these CO₂-reduction goals. However, many previous approaches have focused on a single building or technology and have often led to suboptimal solutions or failure of the implementation process. To successfully support the implementation of energy strategies within urban areas, wider scale solutions have to be found so as to more efficiently integrate the powers of urban and energy planning.

Within the IEA Energy in Buildings and Communities Program (EBC), the Annex 63 – Implementation of Energy Strategies in Communities – aims to provide recommendations for an optimized urban and energy planning process that supports decision makers as well as energy and urban planners. Therefore, existing processes, legal frameworks and case studies within urban and energy planning in communities were analysed. Within this paper, results of the Annex 63 are shown and discussed to serve as orientation for decision makers and other interested persons in the field of urban energy planning.

Eco-visualization: an exploration of the concept and its practical implications 4-406-17

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Keywords

visualisation, technical innovation, awareness, behavioural change, behaviour, feedback, eco-visualization

Persuasive technologies have the potential to change users' attitudes and behaviors towards more sustainable resource use. Visualizations are important to create awareness of resource use, but to enable users to assess the environmental consequences of their actions, the visualization must relate to the (eco-) systems of which the user is part. The resulting eco-visualizations hold the potential to spur reflections both at the individual, group and societal level. Four examples of eco-visualizations are analyzed and lessons learned are summarized. We found that the successful design of eco-visualizations requires a user centered and iterative approach. We further found that much can be gained by being inspired by works in critical design. In conclusion, we find that eco-visualizations have a strong persuasive potential towards more sustainable resource use and to spur societal debate.

EDI-Net: A smarter approach to city-scale energy management ⁴⁻⁴²¹⁻¹⁷

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Keywords

data, data monitoring, energy analysis, communication, community

Energy metering data is becoming ‘smart’ – sub-hourly and downloaded at regular intervals in a day – but the software which is used to display such data remains ‘dumb’. Such software relies on the experience of the analyst to identify instances where consumption is outside of a typical pattern. The analyst must trawl through data looking for problems. Though alarms can be set in ‘dumb’ software – these alarms are also dumb – typically an energy manager sets maximum and minimum thresholds and is notified when they are exceeded.

This paper presents ‘smart’ software and advocates for a more innovative approach to energy management. The software maintains a detailed model of consumption patterns across a whole portfolio of buildings and communicates energy performance in a user friendly way. Rather than simply alarming on peaks and troughs it can track unexpected levels of consumption and manage a list of exceptions. The approach opens up energy management to a wider community of stakeholders through the use of simple visualisation, coherent information architecture and a flexible communication platform.

It is now possible to analyse large volumes of consumption data automatically with software, notifying the energy manager only when something unexpected occurs. With a continually evolving model of consumption patterns across the entire portfolio smart software can present stakeholders with interactive, high-level views on the performance of the portfolio as a whole whilst allowing a user to ‘drill’ down to see the detail on demand. Reports can be designed for energy experts or for other professionals such as finance managers and decision makers enabling better communication across an organisation and more effective energy management.

The Energy Data Innovation Network (EDI-Net) project is developing an approach to energy management which engages a community using modern, scalable communication tools with an ambitious approach to modelling, analysis and visualisation of large datasets.

Consumer behaviour and the plug-in vehicle purchase: A research gap analysis

4-431-17

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Keywords

electric vehicles, policy, research review, consumer motivation

With mass adoption and a “cleaner” electric power mix, battery electric vehicles (EVs) and plug-in-hybrids (collectively plug-in electric vehicles, PEVs) can significantly reduce the CO₂ emissions from transportation and the local air pollution hazard confronting a large number of Americans who live near busy roads. While fuel costs and tax breaks are the most oft-cited incentives for PEV ownership, PEVs bring additional benefits to consumers. Depending on the vehicle, PEVs can be: convenient to charge, as they are typically fueled overnight at consumers’ residences rather than at public stations; inexpensive to fuel and to maintain (e.g., electric motors have less parts than traditional engines, EV “consumables” like brakes tend to last longer, etc.); fun to drive, as electric drivetrains provide full torque quickly; and safe to drive, as battery weight tends to lower the vehicle’s center of gravity and improve handling. Despite these benefits and considerable investments by OEMs in PEVs, plus great interest by U.S. electric utilities, U.S. market expectations for PEVs are dampened by concerns about low consumer salience, given sustained low oil prices and the improved fuel economy of traditionally-fueled vehicles, as well as reduced incentives at the State and Federal level. Under these circumstances, growing the U.S. market for PEVs to increase their public and private benefits requires understanding how consumer behavior relates to the PEV purchase process. In this paper, we structure a research review on this subject using a framework that is well-established in academic marketing circles but is novel in the context of the PEV purchase process. The purpose of this approach is to highlight what is well known about this process and reveal important knowledge gaps for future research.

The decline in car use. A long-lasting effect? French and Canadian young adults' relationship with mobility ⁴⁻⁴³³⁻¹⁷

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Keywords

young adults, automobiles, transportation, lifestyle, commuting, social practices, France, Canada

Many Western countries are thought to have attained a car peak, this being especially true of urban areas. The car is viewed as having lost some of its appeal, with other modes of transport gaining favour. The change in people's means of getting about can mostly be seen among the young, who are using cars less and are less inclined to take the driving test than in previous decades. One view is that the reduced tendency to obtain a driving licence is merely a delay which will gradually be made up for later on, even though it does seem probable that the numbers of people holding a driving licence remain lower. It is on this point that we have chosen to focus our attention, based on a qualitative survey carried out in Lyon (France) and Montreal (Canada), showing how mobility has evolved in the case of young adults aged around thirty. The article questions the relationship with the automobile and the reasons for the change in social practices by exiling the daily uses of different modes of transport.

PANEL 5

Buildings and
construction technologies
and systems

The effects of the entry into force of a new electric tariff on Italian residential households equipped with a PV power plant

5-014-17

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Keywords

time use, residential sector, photovoltaics, policy, prosumers, prosumer markets

In 2016 Italy got a new electric tariff. This paper compares the old tariff to the new one and explains the details of the reformation process for two types of domestic end users who can be considered representatives of the whole Italian residential population equipped with a PV power plant.

The results show that the “traditional” solution (i.e. based on the use of fossil fuels for cooking, heating and producing hot water) is always more cost effective for a residential customer than the “all electric” one (i.e. in which electricity is used to satisfy all energy demands) with a PV power plant with the old tariff. On the contrary, the new tariff allows the “all electric” solution with a PV power plant to be both more energetically advantageous (taking primary energy consumption into account) and economically profitable than the “traditional” solution.

Improving energy performance through an energy measurement and monitoring plan ⁵⁻⁰⁵⁸⁻¹⁷

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Keywords

measurements, control and monitoring devices, voluntary guidelines, buildings, industry, energy management system

Organizations are able to better control their energy costs and increase their competitiveness by setting up energy performance actions. Voluntary energy management standards, such as ISO 50001, often refer to the measurement of energy as an important improvement of energy performance, but do not detail how a measurement and monitoring plan should be implemented in practice. The impact of having an efficient measurement system has been demonstrated by different studies, however, in practice it remains very difficult to define, measure, record and analyse the data related to energy performance evaluation due to the lack of standard protocols.

This article presents the state-of-the-art methodology currently being developed as a new standard with a CEN-CENELEC joint working group, for the industry and building sectors. The case study, which consists in a student accommodation of 148 flats, is used to show the improvements that could be obtained by setting up the previously introduced methodology.

Achieving university campus sustainability with nearly zero energy building retrofits

5-063-17

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Keywords

public buildings, energy efficiency improvements, lighting, zero energy buildings, renewable generation

University campuses are normally constituted by large buildings responsible for significant energy consumption. Furthermore, Universities face several challenges due to the shrinking budgets and rising energy costs. These pressures are a clear motivation to implement energy efficiency programs. University buildings are also suitable as demonstration sites of sustainable renovation, since they will be directly visible examples for the students that will soon use their knowledge in the community.

In the last five years, the University of Coimbra took several measures to foster energy efficiency, such as energy audits, large-scale retrofit of lighting systems, power factor correction and general improvements in electrical loads. Recently, the University of Coimbra has also started to install PV power in several buildings.

The Electrical Engineering Department has been the testbed for the installation of new technologies. The building was constructed in 1996 and is composed by 9 floors, with a total area of about 10,000 m² and an electricity consumption of about 520 MWh/year. During the last 5 years, the lighting (previously mostly based on T8 lamps) was gradually replaced by LEDs. Additionally, the control of the lighting and HVAC by Building Management System also achieved significant electricity savings of about 10 % of the total electricity buildings consumption. The next step will be to transform the building in a nearly Zero Energy Building, by installing PV panels with enough capacity to ensure a large share of the yearly electricity consumption.

This paper presents the building renovation plan, presenting details of the technical design and assessing its impacts. With such renovation plan, 20 % of energy savings were achieved with 37 % of the consumed energy ensured by onsite photovoltaic generation.

Remote energy auditing: Energy efficiency through smart thermostat data and control

5-065-17

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Keywords

homes, audit, end-use consumption, electricity use, smart metering, thermostats

We describe the development of “remote energy audit” techniques using data from a pilot study in 500 dwellings in Ontario, Canada. This pilot study provided a unique combination of data sets: smart thermostat, occupancy events, and smart meter data, combined with basic information on household characteristics and weather data. With knowledge of building physics and occupant energy use behaviours, we deployed a variety of data analytic techniques to derive insights into household energy use characteristics. These included partial end-use disaggregation of electricity, opportunities for energy savings via dynamic thermostat setback, and an estimate of the relative thermal efficiency of the house structure. The results on these metrics emphasize the heterogeneous nature of energy performance even across households in the same region. Such individualized remote audit information may be a relatively inexpensive way for utilities to target energy efficiency programs and messaging towards households more likely to yield benefits.

The role of lighting in deep energy retrofitting in European shopping malls 5-069-17

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Keywords

daylight, LED, light tubes

Energy retrofitting solutions applied in building envelopes of shopping centres often involves additional insulation layers on the building facade and roof as well as substituting the old windows with better performing ones. Such measures increase the thermal insulation of the envelope and reduce the energy need for heating. Analysis of 11 shopping centres in Europe reveal a lack of availability of indoor natural daylight, especially in shops and sales areas.

This paper investigates retrofitting solution for lighting in a shopping mall in Trondheim, without and with measures taken on the building envelope. Internal daylight and internal illuminance levels were measured together with detailed monitoring of energy use and indoor air quality.

Different cases were modelled to simulate the use patterns and control strategies of artificial lighting in the shopping centres by considering occupancy hours and type of activity (luminance levels), in order to cover different possible combinations, which are used in the energy and daylight simulations.

Existing conditions of a representative shopping centre (pre-retrofitting) were modelled based on the energy use measurements, and energy and daylighting simulations were performed. Combinations of use pattern and facade variables were used for the daylight and energy simulations in the retrofitted shopping centres to evaluate the influence on the electricity use of lighting, and heating and cooling energy needs of the combinations of the scenarios. There is a trade-off, which is quantified in terms of reduction in electricity use and increase in heating demand. Besides the straight forward end energy use savings (electricity), lighting retrofitting has implications for heating and cooling end energy use and primary energy savings. Shopping centre managers need to collaborate closely with shop owners/managers on energy retrofitting measures if the full potential is to be enabled.

Using smart energy storage to increase self-consumption of solar-generated electricity and reduce peak grid load at household and community level ⁵⁻⁰⁹¹⁻¹⁷

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Keywords

energy supply and demand, storage, household electricity, photovoltaics, energy flexibility

This paper evaluates how distributed smart storage can bring energy flexibility in a community by reducing average peak load and increasing self-consumption of local solar photovoltaic (PV) electricity at an individual household and aggregated community level, as part of a new community energy research project in a socially-deprived community in south-east England. The research study brings together solar PV power and (behind the meter) smart energy storage across a cluster of 82 households and community centre to create a virtual localised energy grid within the existing infrastructure. The batteries are linked to solar PV in each house, and also have internet connections allowing them to be virtually coupled, so as to ensure that the maximum amount of solar generated electricity is used within the community. The methodological approach of the evaluation comprises dwelling surveys, energy audits, householder interviews, monitoring and evaluation of high frequency household electricity consumption, PV generation, battery charge and discharge data. Householder feedback shows that even in a socially disadvantaged community, as well as being anxious over rising energy bills, householders are still concerned about climate change and the future of energy supplies. In the monitored households, average daily electricity consumption ranges from 2.9 kWh to 21.7 kWh, and is found to be positively related with dwelling size, number of occupants and number of appliances used. Although 155 MWh of solar PV electricity has been generated within a year across 47 households, electricity consumption and generation profiles show that in most households, generation exceeds consumption, but peak generation does not match peak consumption. Analysis of the contribution of smart battery show that self-consumption of PV electricity has increased by 6 % and 12 % in the summer and winter periods respectively. The study seeks to demonstrate the [...].

Energy neutral living in Amsterdam, Lyon and Helsingborg: practical results and household assessment

5-093-17

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Keywords

behavioural change, advanced metering, Energy Performance of Buildings Directive (EPBD), EU Next Buildings project, carbon-neutral housing, household consumption, residential buildings, smart metering, Lyon

In anticipation of the 2020 target in the EU Energy Performance of Buildings Directive, several European cities are experimenting with 'nearly zero energy' (NZE) buildings in newly developed city districts. As stipulated by earlier research, such plans include a combination of well insulated dwellings, smart local grids and local production of renewable energy. In the EU 'Next-buildings' research project, NZE building examples from Amsterdam (the Netherlands), Lyon (France) and Helsingborg (Sweden) are brought together and compared.

Common to the three building projects are high insulation standards and solar PV as source of local renewable energy. Amsterdam 'Blok O' and Helsingborg Kvarteret Isbanan are connected to local district heating, while the Lyon 'Hikari' building has a rapeseed boiler and includes an advanced energy management system. Special features are district cooling in Amsterdam and a façade PV system in Lyon. The first residents arrived in 2015 in Hikari and the first lots of Amsterdam, while full occupation was reached by mid-2016.

As part of the Next-buildings project, we are monitoring the energy use of residents and investigate their experiences. Monitoring includes both total energy use and net energy use, including renewable production in/on the building. Reported residents' experiences relate to motivations to move into the new neighbourhoods, their perceptions about positive and negative qualities of their new dwellings, and whether they make active use of smart energy devices. This information is collected through surveys and focus group meetings.

The paper describes the results of the monitoring exercises in the three city districts, the challenges faced and resident's proposals for improvement. We conclude [...].

Cost-effective options for nearly zero energy renovation of municipal buildings ⁵⁻¹²²⁻¹⁷

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Keywords

public buildings, Energy Efficiency Directive (EED), financing, zero energy buildings, deep renovation

The European Energy Efficiency Directive demands strict energy efficiency measures for the public sector. Many of the municipal buildings in Southern Europe require deep renovations to become nearly Zero Energy Buildings (nZEB), but the compliance with the directive is difficult for the public sector due to the required investments. CERTuS is a project involving Municipalities, energy service companies and financing entities from all economically stricken Southern European countries. The objective of CERTuS is to stimulate the growth of the energy services sector and to help stakeholders gain confidence in investments on the public section, by developing representative deep renovation projects and innovative financing schemes that can act as models for replication.

In Portugal, three nZEB renovation projects were prepared for the Municipality of Coimbra, being the selected buildings the Town Hall (building listed and protected by UNESCO), the Municipal Library and an Elementary School. The renovation designs were mainly focused on the retrofit of lighting and HVAC and on the integration of photovoltaic generation. With such renovation, it will be possible to achieve savings on the final net energy consumption of 80 %, 97 % and 98 % and simultaneously, 70 %, 95 % and 96 % of the consumed energy will be ensured by renewable energy sources, for the Town Hall, Library and School, respectively. Energy service models and suitable financing schemes were adapted for each renovation scheme. For these three buildings, the 'Shared Savings' type of ESCO contract can be feasible with 5 % annual yield for the Municipality, being the suggested financing plan a mix of ESCO equity, senior debt and VAT facility.

The neglected practice: uncertainties encountered by occupants in a new energy efficient building ⁵⁻¹²⁵⁻¹⁷

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Keywords

energy efficiency gap, user perspective, socio-technical, energy use, social practices

Technical and performance related uncertainties that come with an increased number of components and system complexity are often thoroughly examined and tested in demonstration buildings. On the contrary, and despite the energy research literature stressing the importance to understand the requirements and context of the users, the uncertainties that occupants encounter while adapting to new energy efficient buildings are seldom examined and identified in depth.

This paper will highlight the usefulness of seeing the technologies for buildings from the users' point of view. From a social practice perspective and the concept of domestication the paper examines various types of uncertainties encountered by occupants when managing technologies for buildings, such as bedrock heat pump, photovoltaic panels and LED-lighting, in a new energy efficient house.

The result demonstrates that it is demanding and tiresome to tackle uncertainties and learn how to handle technologies for building, as well as to contact professionals for support. It might in fact be more convenient to "leave it as it is", with the consequences that no one is managing the technologies. Instead of assuming that carrying out this practice is straightforward, it would be better to work on an approach where this is not the case. In fact, the later approach creates much better conditions for extended learning and product development than the former.

Effects of different techno-economic regimes on viability of deep energy renovation of an existing Swedish multi-family building ⁵⁻¹³³⁻¹⁷

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Keywords

deep renovations, energy savings, refurbishment, deep renovations, energy efficiency measures, existing buildings, cost effectiveness

This paper presents and demonstrates a method for analysis of cost-effectiveness of energy efficiency measures for buildings. Based on the method, cost-optimal energy efficiency measures are calculated considering total and marginal investment costs as well as net present value of energy savings for the measures under different technical and economic scenario. The method is applied to a 1970s Swedish multi-family building to explore the profitability of different energy renovation measures when implemented individually or in packages. The measures analysed include improved thermal insulation for exterior and basement walls as well as attic floor, improved new windows, efficient electrical appliances, efficient water taps, and exhaust air ventilation heat recovery systems. Our results show that the economic viability of the retrofit measures is sensitive to the techno-economic parameters used including, real discount rates, energy price increases and technical lifetime of retrofit measures. Still, about 34–51 % reduction of final heat demands is economically viable for the analysed building. Resource-efficient taps is the most cost-effective measure while improved thermal envelope insulation for exterior walls is the least cost-effective among the measures analysed for the studied building. This study shows the significance of different technical and economic parameters in achieving deep-energy savings from renovation of a building in a cold climate.

Life cycle primary energy use of nearly-zero energy building and low-energy building ⁵⁻¹³⁵⁻¹⁷

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Keywords

zero-carbon technologies, life cycle analysis, primary energy, optimisation

Energy legislations are increasingly driving towards buildings with very low operation final energy use as part of efforts to reduce energy use and climate impact of the built environment. In this study we analyse the life cycle primary energy use of a recently constructed Swedish conventional 6-storey apartment building and compare it to variants designed as nearly-zero energy building or as low-energy building with a combination of improved thermal envelope and passive design strategies. We maintain the architectural design of the constructed building and improve the thermal properties of the envelope to achieve a low-energy building and also nearly-zero energy building including solar thermal collectors. We consider scenarios where the building variants are heated with renewable energy using cogenerated district heating, also complemented with solar heating system. We follow the life cycle of the building versions and analyse their total primary energy use, considering the production, operation and end-of-life phases. The results show that the relative significance of the production phase increases as buildings are made to achieve very low operational energy use. The production phase accounts for 17 % of the total primary energy use for production, operation and demolition of the constructed building for a 50-year lifespan. The corresponding values for the nearly-zero energy and low-energy building variants ranges between 30 to 31 %. Overall, the life cycle primary energy use for the nearly-zero energy and low-energy building variants are about 30–35 % lower compared to the constructed building.

Using machine learning and mathematical programming to benchmark energy efficiency of buildings ⁵⁻¹⁵⁷⁻¹⁷

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Keywords

energy analysis, energy saving methodology, energy saving potential, benchmarking, energy savings calculation, machine learning, mathematical programming

In this paper, we demonstrate a novel benchmarking technique to identify buildings with a potential to reduce energy consumption, taking into account both weather effects and building characteristics. The proposed method will quantify if a building's energy usage is dependent on outside temperature, and the degree of dependency over time. Our method prepares the data for analysis in a way that can improve the results from benchmarking techniques. A demonstration is performed with the use of two different data envelopment analysis (DEA) models. The first DEA model without taking into account temperature, and a second where temperature is included as a non-controllable variable. Results suggest that the that the average store is 28 % less efficient than the most efficient stores. Further, our analysis show that using our suggested analytical framework will improve the accuracy of the efficiency scores compared to more standard methods. This is an important finding suggesting that our proposed methodology has advantages over existing benchmarking methods.

Impacts of a forecast-based operation strategy for grid-connected PV storage systems on profitability and the energy system ⁵⁻¹⁶⁰⁻¹⁷

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Keywords

batteries, photovoltaics, optimisation, load management, neural network, forecast

Integrating photovoltaic (PV) electricity generation into the German energy system is proving to be a growing challenge due to its fluctuating nature. The combination of more rigid regulation for feeding PV power into the grid and steadily rising electricity prices means that energy storage devices are becoming more attractive to private households as a way of upping their energy self-sufficiency. At the same time, storage systems make the household's power purchasing strategy more complex. For these reasons, control concepts are required for PV and storage systems that ensure system-friendly operation as well as considering the household's primary objectives. This paper presents a three-part model for the forecast-based load management of a battery storage system in combination with a PV system. In the first modelling step, forecasts of hourly electricity demand and solar generation are created using artificial neural networks. In a second step, the model optimizes the energy flows considering a real-time price tariff based on EPEX Spot in addition to its main task of using the forecasts to maximize on-site self-consumption. In the third step, a control algorithm adjusts the actual energy flows if forecast deviations occur. The study shows that the model enables system-friendly operation of the battery storage as well as intensified usage. As an added value, the forecasting approach presented is closer to reality than the otherwise frequently used optimization algorithms that assume perfect foresight of electricity load and generation. It therefore provides a real-world basis for planning, but also shows that the inevitable forecasting errors are reflected in higher electricity bills. Considering the inaccuracy of forecasting and the related higher cost for falling short on the provision of electricity for the individual household, we conclude that households should be paid higher rewards (e.g. by higher price top-up payments at peak demand or supply) if they supply electric energy in times of higher demand and store energy if there is abundant supply.

An optimum renovation strategy for Swedish single-family house envelopes: The implications of climate zones and the age of the houses ⁵⁻¹⁶⁵⁻¹⁷

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Keywords

renovation, simulation, building envelope, cost effectiveness, building retrofitting, optimisation, optimum renovation

As a result of EU's legislations for reducing energy demands in buildings, a large number of studies have been done about cost-effective renovation of building stocks in EU. To complement the available results, in this work we take into account the microeconomic perspective of building owners, whose major challenge is to decide about limited budget allocation for energy renovation. Therefore, this work presents results of optimal and cost-effective energy renovation of single-family houses in Swedish building stock.

The houses are categorised based on the year of construction (about 1970s, 1980s and 1990s) and their location (i.e. four Swedish climate zones). The space heat demand of representative houses for each age category and climate zone is simulated to analyse optimum renovation. A reformed method of NPV is employed in order to, simultaneously, analyse the cost-optimum renovation measures of the house envelope and their cost-effectiveness.

The results indicate that the space heat demand in the representative house of 1970 is reduced from 28 % in climate zone 1 to 25 % in zone 4, when all measures are implemented to a cost-optimal level. The results of similar exercise for the houses of 1990 suggest "do nothing" scenario for energy renovation to cost-optimal level, considering discount rate of 3 %. However, if the necessity of renovation is determined, then the reduced space heat demand is from 13 % in climate zone 1 to 8 % in zone 4. As far as the cost-effectiveness is concerned, the optimum renovation of attics for the houses built during early 1970s appears to be the most cost-effective component followed by the attics of the houses built during 1980s. Renovation of exterior walls and windows to a cost-optimal level are not cost-effective, regardless the year of construction. The findings suggest strategy to prioritise the energy renovation of [...].

Investigating the business case for a zero-energy refurbishment of residential buildings by applying a pre-fabricated façade module

5-166-17

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Keywords

refurbishment, zero-carbon houses, business case

The ambition to renovate the post-war building stock to an energy-neutral quality is getting a lot of attention from social housing corporations and other institutional owners, financial organizations, and users. An effective renovation plan must significantly improve the current energy performance of a target building towards nearly zero-energy levels. A number of facade solutions have been developed in recent years to solve the problem of large-scale renovation of housing. In the Netherlands, several exemplary renovation projects have the ambition to achieve an energy-neutral objective. One such project is the 2ndSkin Façade refurbishment approach for post-war residential buildings.

Nevertheless, the market intake of such renovation is currently very slow, as housing associations are reluctant to invest the increased cost of a zero-energy refurbishment, despite the energy savings and ongoing benefits for the occupants.

Within the framework of the research project 2ndSkin, this paper presents a pre-fabricated and integrated façade module that provides the possibility to improve energy performance up to zero-energy use, while ensuring minimum disturbance for the occupants, both during and after renovation. Based on the proposed integrated refurbishment solution, the study presents a financial breakdown of this case-study concept – including options to lower the initial investment – in order to outline a more attractive business case. Firstly, three design variations, ranging from a standard external insulation upgrade to a zero-energy renovation, are compared, using a range of positive, average, and negative values for a series of financial and economic parameters. Subsequently, the financial performance of a zero-energy renovation investment is calculated for three different apartment properties with diverse market values, to determine the circumstances that can justify an energy renovation investment. [...]

Integrated and sustainable energy concepts for urban neighbourhoods – a generic approach based on Austrian experiences

5-189-17

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Keywords

urban planning, energy supply and demand, residential buildings, life cycle cost (LCC), heat pump, geothermal

Larger Austrian cities are confronted with the necessity to develop new districts and to revitalise existing neighbourhoods. This process includes the development of new energy supply systems. Conventional in Vienna usually are gas grids for decentralised use on the one hand and district heating systems on the other hand. But both systems remain unsatisfactory: The simple gas supply is not in line with sustainability and green house gas (GHG) emission reduction goals, whereas district heating (with combined heat and power (CHP) as one major source) is confronted with serious economic problems due to changes at the electricity markets and municipal utilities thus refuse to enlarge their district heating systems.

The paper describes the process for selecting alternative heat supply concept for a new urban settlement. The assessment of locally available renewable resources and infrastructures sets the basis for the identification of technically feasible options. After definition of specific heat supply ideas, concept design phase leads to dimensioning of elements of the heat supply concepts. Based on the technical description an environmental and economical assessment was carried out. The different technical and energy-economical energy concept options are assessed by means of a life-cycle cost analysis.

This generic approach was applied in the concept phase of the development of a new neighbourhood area in the City of Vienna called Donaufeld. In this feasibility study several technical options for heat supply were developed together with experts within the administration of the city and the municipal energy supplier.

Main outcome of the project are life-cycle costs for every heat supply concept. Alternative concepts with heat pumps and geothermal probes as main elements have similar life cycle costs than district heating. These concepts have a high share [...].

Household thermal routines and their impact on space heating demand patterns

5-192-17

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Keywords

domestic, heating, patterns of energy use, practices, demand side management (DSM), thermal comfort

Patterns of home heating demand during the day have significant implications for the design of energy networks and will be an important consideration in the introduction of low carbon heating systems such as heat pumps.

In homes in the UK it is very common to operate space heating intermittently; the heating is usually switched off when the occupants are asleep at night and when they are out during the day. The strong association between heating operation and household routines leads to a morning peak in demand which, if it persists following electrification of heating, will require significant reinforcement of electricity supply networks.

This paper examines factors that underlie current UK home heating practices. A unique dataset of heating controller settings from 337 UK homes with smart heating controllers allows investigation of how patterns of heating operation in individual homes contribute to daily patterns of space heating energy consumption at the group level. A mixed method approach is followed, combining quantitative analysis of data with interviews with householders, drawing on insights from social practice theory. The peak level of space heating demand is found to be higher in the morning than the evening.

The concept of thermal routines is introduced, bringing a time dimension to the consideration of domestic thermal comfort and recognising that demand for space heating is linked to patterns of practices in the home, which are themselves linked to social routines, e.g. timing of work and school. The results from this study suggest that household thermal routines around 07:00 in the morning are a particularly important consideration for a transition to future energy systems with a high proportion of low carbon heat. Factors that currently limit flexibility of heating demand in the UK are identified and the implications for a transition to low carbon heating sources are discussed.

Hydronic balancing and control – how to overcome the global challenge of reducing energy use in multifamily housing

5-235-17

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Keywords

heating systems, energy efficiency improvements, renovation, savings potential, awareness, automatic balancing, room controls

Reducing energy consumption and greenhouse gas emissions in the building stock is one of the key challenges to achieve the climate change mitigation objectives agreed in Paris, and reduce air pollution in cities. This paper provides an analysis of a key ingredient of any solution: getting basic aspects of automatic balancing (meaning the continuous control of flow and pressure in the piping system and radiators leading to the optimal generation, distribution and emission of heat throughout the building) and room temperature control right in multifamily buildings with central, water-based heating systems. These aspects are a key driver for the overall energy performance of buildings, as they have, across different types of heat generators, a significant impact on the efficiency of heat generation, distribution and emission, and for the comfort and health of building occupants. Despite capital-light investment needs with fast pay-back, it is an aspect that today is usually neglected both in renovation and in new-built markets, making it a largely “forgotten” element of the energy transition.

The paper shows that the vast majority of existing and new buildings lack most basic features, provides an overview of key principles and technologies, and discusses some key market barriers. It presents estimates for energy and cost savings, required investments and pay-back from a building owner/tenant perspective. It argues that getting the basics right helps to meet expectations on energy performance after deep renovation and for near-zero energy buildings in actual use. The paper concludes that the on-going revision of buildings energy efficiency legislation should tackle this forgotten dimension, to enable progress towards political long-term decarbonisation objectives.

The paper is organized as follows: first, an overview of latest research on energy saving potentials of individual room temperature control and balancing, and their economics is given. The findings are put into perspective with field test on [...].

A smarter way to electrify heat – the balanced energy network approach to demand side response in the UK ⁵⁻³⁰¹⁻¹⁷

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Keywords

heat pump, heat storage, demand response, storage, low carbon technologies

The Climate Change Committee states that the UK's 2050 carbon targets are unachievable without a near complete decarbonisation of the heating sector. With heating at nearly half the UK's energy use this represents a staggering challenge for the built environment; particularly the ageing existing stock. Any path to low carbon heating requires considerable electrification of heat, and meeting the electric demand through a greener grid.

This paper presents early results from a Balanced Energy Network (BEN) demonstration project at London South Bank University that offers a novel approach to electrifying heat.

BEN is a heat pump driven network that uses a low temperature heat network to link buildings together, and makes use of demand side response to communicate with the national grid and use electricity at optimal times. This essentially turns the heat pumps and the buildings themselves into distributed storage systems that provide a low cost balancing service for the national grid.

This paper is presented in two main parts: 1) A description of the two buildings in the LSBU campus where two heat pumps are installed in parallel to the existing gas boilers. And 2) Calculating/simulating the potential revenue of utilising the DSR potential from the heat pumps at a constant COP and the heat storage (a hot water storage tank) in three different flexibility markets: FFR, STOR and UoS. The implications of expanding BEN networks will be explored in the context of increased capacity for demand side response as a load shifting tool across the UK.

Demand response in the service sector – setting course for energy flexibility and efficiency

5-326-17

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Keywords

demand side management (DSM), efficiency, policy recommendations, survey, building technology, load management, electricity, smart grid, demand response, service-sector

The increasing share of renewable energies in electricity generation is within the scope of the energy transition. Among other things, this will lead to a more volatile generation of electricity. A more flexible energy demand could contribute to handling the resulting challenges in electricity grid management. The service sector is one of the target groups for utilising flexible demand, also called demand response (DR). Supermarkets, hotels and office buildings can be found in regions throughout Germany. This could be an advantage regarding the compensation of grid instability in any region, compared to more locally focussed industrial enterprises. First estimations point out considerable unused DR potentials for the service sector. However, currently there is less knowledge about flexibility options in the service sector than in industry. Moreover, market barriers such as a missing adequate regulatory framework offering attractive incentives prevent that the potentials are tapped.

Therefore, in this paper, we first analyse survey data from 1,000 companies of the service sector in Germany to identify subsectors that have a high share of flexible cross-sectoral technologies in electricity consumption. Data indicates that the subsectors trade, restaurants and hotels as well as office-like buildings are the most promising subsectors of the service sector regarding demand response potential, since they have a high stock in flexible cooling appliances, air conditioning and ventilation. In a second step, we conducted stakeholder interviews, to find individual barriers in each of the identified subsectors as well as possible starting points and incentives. They indicate that framework conditions promoting demand response measures seem to be improving, e.g. technical standards and latest regulatory revisions. However, still unapt or missing regulatory framework conditions, low profitability and a lack of knowledge regarding flexibility potentials and marketing mechanisms seem to be the main barriers. This indicates that in order to tap the [...].

Shaving the peaks through statistical learning: smart use of solar energy and storage solutions ⁵⁻³²⁷⁻¹⁷

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Keywords

storage, energy systems, energy demand, energy cost, energy supply and demand, statistical learning, load management

This paper demonstrates how big-data, statistical learning and simulation of local energy production and storage, can contribute to reduce costs and shift energy consumption from the main power line to locally produced solar energy and battery storage during peak hours. This is demonstrated by using more than 5 million of hourly energy meters readings from 600 Norwegian grocery and large hardware stores. Many of the Norwegian grid operators use fixed peak-load tariffs, thus shaving the peaks will result in decreased energy costs. Our aim is to find the largest peaks; where the most potential for cost reductions can be found. To isolate the stores with the largest variation from hour-to-hour we suggest using the coefficient of variation (CV); we demonstrate this by calculating CV for 600 stores and use the results to rank and identify stores with both large variation and little variation in energy consumption. Further, three of these stores are used in solar photovoltaic (PV) production and energy storage simulations. The simulations will highlight the cost savings between stores with different CV values. Results suggest that by using such methodology, we can reduce total energy costs, and at the same time lower energy loads through peak shaving and phase shift.

Design strategies to minimise heating and cooling demands for passive houses under changing climate

5-342-17

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Keywords

climate change, space heating, cooling, primary energy, passive houses, overheating, design strategies

In this study, we analyse the heating and cooling demands of a multi-storey residential building version, designed to the passive house criteria in Southern Sweden and explore various design strategies to minimise these demands under different climate change scenarios. The analysis is performed for recent (1996–2005) and future climate periods of 2050–2059 and 2090–2099 based on the Representative Concentration Pathway scenarios, downscaled to conditions in South of Sweden. Design strategies include efficient household equipment and technical installations, bypass of ventilation heat recovery unit, window solar shading, building orientation, window size and properties, besides mechanical cooling. Results show that space heating demand reduces, while cooling demand increases as the risk of overheating under the future climate scenarios. The most important design strategies are efficient household equipment and technical installations, solar shading, bypass of ventilation heat recovery unit and window u-values and g-values. Total annual final energy demand decreased by 40–51% and overheating is avoided or significantly reduced under the considered climate scenarios when all the strategies are implemented. Overall, the total annual primary energy for operating the building versions decreased by 49–54%. This study emphasises the importance of considering different design strategies and measures in minimising the operation energy use and the potential risks of overheating in low-energy residential buildings under future climate scenarios.

Comparing energy systems in California and Sweden: A pilot-study to further develop a methodology for prediction of overall demand response potential in Northern Europe ⁵⁻³⁶⁷⁻¹⁷

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Keywords

built environment, demand response, demand side management (DSM), renewable energy

The share of electricity generation from renewable resources (e.g. wind and solar) is increasing, as a consequence of environmental targets, to avoid the imminent risks of climate change. Renewable generation is less predictable and controllable than conventional generation, which introduces new challenges for the energy system as a whole. Consequently, demand side management is gaining increased attention for its conceivable potential of providing needed operational flexibility to the energy system. However, little is still known about the size, accessibility and cost of using demand side flexibility on a broader scale. To attain better knowledge, this paper proposes a conceptual framework for how a forecasting tool, previously developed for California, could be adapted in a Swedish demand response potential study. This tool would enable prediction of the demand response potential on a system wide scale. The tool can then be used by researchers and policy makers in order to understand the size of the resource, prioritize research needs and to support policymaking.

Estimating energy consumption by purpose and analyse standby power in non-residential buildings in Japan ⁵⁻³⁷³⁻¹⁷

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Keywords

energy savings, commercial buildings, audit programme, energy management system, standby power, estimation

The purpose of the study is to support energy saving endeavors in small and medium-sized non-residential buildings. The study measures the energy consumption of 18 non-residential buildings (2 banks, 2 City halls, 1 convention hall, 4 elderly nursing homes, 2 food plants, 2 school lunch facilities, and 5 restaurants) in detail, and develops an estimation method of their energy consumption by purpose. This study also analyse the measured data, and finds that standby power accounts for a large part of electricity.

To achieve energy savings in non-residential buildings estimating energy consumption by purpose is important since it will allow designers to calculate in how many years high efficient will pay back the investment more correctly. The correct estimates encourage the building owner to renew equipment.

Measuring the energy consumption of each purpose is very expensive, and non-residential building's owners cannot afford to pay for this type of assessment. The estimation method uses commonly available data, such as monthly energy consumption, to estimate energy consumption by purpose at a low cost. The study measures the energy consumption of each purpose, analyses these data, and develops the method. The method separates building energy consumption into AC, domestic hot water, lighting, cooking, transformer loss, and other devices. The difference between the estimated consumption of each purpose and the measured consumption can be as high as 17 %. The estimated value of each purpose is close to the actual consumption, and the method can show the energy consumption of each purpose with a low cost. The study analyses the standby power of two city hall buildings by using the measured electricity consumption data in detail. In this study, standby power consumption is defined as electricity consumption that is consumed despite a not-working day. The electricity consumption, which is not considered to be standby power [...].

Some basic insight about the cost optimal opaque thermal insulation in buildings without overheating or cooling (e.g. transalpine Europe) ⁵⁻³⁷⁴⁻¹⁷

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Keywords

thermal insulation, life cycle cost (LCC), building retrofitting, deep renovations, Directive on Energy Performance in Buildings (EPBD), economic analysis, envelope optimization, U-value, passive houses, nearly zero energy building (NZEB)

In the pursuit of nearly zero energy buildings, it appears a widely held belief that technological progress and cost reductions due to large-scale application will allow to achieve in an economic manner new buildings (or new building elements) with an extremely low energy demand (similar to so-called passive houses). This often results in very ambitious roadmaps, including scenarios for deep renovation of the building stock.

This hypothesis seems to materialize for major aspects such as heat generators (highly efficient condensing boilers), efficient ventilation systems and good envelope air tightness. However, cost optimal calculations performed in all EU member states usually result in economic thermal transmittances much higher than those typically found in passive houses (e.g. by a factor of 2).

The paper first derives the simple analytical formulas that provide a clear understanding of the different factors that influence the cost optimal insulation thickness. They are applicable to buildings that are not subject to meaningful overheating and/or do not need active cooling (such as most dwellings in transalpine Europe). They can be useful for setting requirements in public regulations.

The paper then illustrates in a graphical manner the influence on the economic optimum of several variables, such as the initial minimum cost of insulation, the marginal cost of extra thickness, the energy price and the upgrading of an already semi-insulated component. Among other things, the analysis shows that when components are (initially or during renovation) insulated, the full cost optimal insulation level should be achieved at once, because later retrofitting of suboptimal insulation usually becomes uneconomical. [...]

Measuring building occupancy through ICT data streams ⁵⁻⁴¹²⁻¹⁷

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Keywords

offices, user behaviour, building technology, occupancy

Understanding building occupancy is becoming important for sustainable building operations. Specifically measuring and predicting building occupancy are required for demand controlled ventilation, dynamic scheduling of occupancy states, as well as predicting disturbances in model predictive control schemes. Proposed methods for directly or indirectly measuring occupancy have often required installation of numerous additional sensors. However, data collected through information and communication technology (ICT) systems have the potential to provide the same information without the need for additional infrastructure. This work accesses how well various ICT data streams can reflect building occupancy counts as compared to a commercial occupancy counter.

Three separate ICT data sets reflecting Wi-Fi connected mobile devices, desktop computer activity, and security access control counts were gathered for an office building in London. These data sets were used to develop ICT based estimates of occupancy and were then compared to values reported by a commercial occupancy counter for a week in December. The comparison showed that each of the ICT data sets reflects the overall pattern of occupancy usage. The magnitude of the counts, however, differed from that of the commercial counter. The measurements show that the computer activity data severely under estimates occupancy, upwards of 40 % during peak hours. The Wi-Fi connected mobile devices and repaired security access control counts, however, consistently report occupancy counts within the error of the commercial counter during high occupancy periods, indicating that these ICT data sets could be used to measure building occupancy.

Optimization design of light shelf for visual comfort and energy savings in an office space ⁵⁻⁴²⁸⁻¹⁷

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Keywords

energy savings, light shelf, visual comfort

Visual comfort is important for the building occupants' wellbeing. Visual comfort can be filled with natural lighting (daylighting) and artificial lighting. Efforts to optimize natural lighting can be achieved through façade design, and percentage area of window. However, the problem of the visual comfort is high light intensity and glare at some places. Light shelf is a passive strategy to minimize glare, expanding the area of daylighting and increase the time that meet the visual comfort.

This paper discusses the light shelf design that can fulfill the optimal visual comfort and lighting energy savings for an office space with the case studies Prasetiya Mulya office. The methodology of research used is quantitative research with simulation modeling (DIALUX 4.13, 2016). Through following steps; (1) Making a model of office space based on case studies: Prasetiya Mulya office, Jakarta; (2). Making three models with different light shelf dimension; (3) Simulating and analyzing the light intensity value for each model that meet office visual comfort standard: 350 Lux (Indonesia National Standard, 2010), glare value and optimal energy saving.

The result show that light shelf design can meet optimal visual comfort and save energy for artificial lighting. With right design of light shelves, we can expand daylighting area that meet visual comfort, minimize glare and increasing energy saving in the office.

PANEL 6

Buildings policies, directives
and programmes

Free riding and rebates for residential energy efficiency upgrades: A multi-country choice experiment ⁶⁻⁰²¹⁻¹⁷

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Keywords

adoption, energy efficient technologies, free rider, rebate

The cost effectiveness of programs designed to upgrade energy technologies can be significantly affected by free riding. This paper assesses ex ante the effects of free riding on the cost effectiveness of a rebate program promoting the adoption of energy-efficient heating systems, relying on contingent valuation choice experiments carried out through identical representative surveys in eight EU Members States. The analysis distinguishes between strong and weak free riders: strong free riders plan to adopt a new heating system in the next five years anyway; weak free riders decide to purchase once made aware of an attractive technology package (and therefore would not need a rebate to adopt). The mean minimum rebate households require to adopt differs substantially across countries and, on average, amounts to slightly more than half of the heating system's purchasing price, suggesting generally high opportunity costs for premature upgrading of heating systems. The minimum acceptable rebate and weak free ridership vary with income, environmental identity, and with risk and time preferences. At a rebate level that corresponds to half the purchase price of the offered heating system, the share of free riders was estimated at 50 percent for most countries, with the share of weak free riders typically higher than that of strong free riders. Public spending costs per reduced ton of CO₂ differ considerably across countries and only compare to high social costs of carbon.

What will you pay for an “A”? – a review of the impact of building energy efficiency labelling on building value ⁶⁻⁰³³⁻¹⁷

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Keywords

building energy certification, labelling, consumer behaviour, energy performance certificates, process, property price, building value

Energy labelling of buildings to rent or buy has been widespread in OECD countries for over a decade. The main objective is to help occupiers to make an informed choice in their building selection; a desired secondary impact of this is to increase the market value of more efficient buildings and hence provide an incentive to supply them.

The EPBD has provided the main mechanism in the EU; it required Member States (MSs) to introduce building labels, Energy Performance Certificates (EPCs), to be available to renters and buyers at the point of legal agreement. A DG Energy commissioned report on the impact of EPCs was published in 2013 (Mudgal et al 2013).

Since then a new requirement was added in the 2010 recast of the EPBD; the EPC has to be included in advertisements of buildings to let or buy. Also, a plethora of new reports and papers have been published on the impact of building labelling in the EU, possibly due to large volumes of data on property transactions and building efficiency becoming more available.

This paper has reviewed recent research on residential property in Europe, examining 15 papers covering 15 countries. The main finding is that the initial deduction that higher energy efficiency results in higher property prices is confirmed: all but one study found that to be the case, over a wide range of climates, and at different scales e.g. cities, regions and countries.

The review has also illustrated how difficult it is to do these investigations – detailed data are needed to eliminate the effect of factors which could co-correlate with energy efficiency and muddy the results. Further, the use of multiple factors requires large samples in order to get significant results. More studies and analysis need to be done to draw more far-reaching conclusions.

German Energiewende – different visions for a (nearly) climate neutral building sector in 2050

6-040-17

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Keywords

buildings, renewable energy, refurbishment, building refurbishment, German Energiewende

The building sector plays an important role for the goals of the German Energiewende (energy transition). In order to contribute to the Energiewende adequately the building sector has to be almost completely decarbonised in the long-term. Our analysis investigates how the German building stock can be transformed into a nearly climate-neutral state by 2050.

Using a stock modelling approach based on a typology of the German residential and non-residential building sector we develop different visions (target states) of what a nearly climate-neutral building stock could look like. All developed target states achieve the overall goal of reducing the non-renewable primary energy demand in 2050 by at least 80 % with respect to 2008. In order to span a broad target corridor, the target states differ in the two central target dimensions: efficiency (reduction in final energy demand), and energy/technology supply mix (especially the herein contained share of renewable energies). Additionally, using the energy system model REMod-D the interactions of the building stock, as defined by the different target states, with the energy system as a whole are investigated.

We explore the differences between a target state focussing on efficiency measures (all buildings which in principle can be renovated are refurbished to the maximum extent possible) and a target state where efficiency is partly compensated for by an increased use of renewable energies. We learn that from a cost perspective no clear recommendation can be derived as to which target state should be given priority. This means that other criteria become more relevant, such as social acceptance regarding the different measures, or the challenges that arise from rolling out additional renewable energy capacity on top of the expansion of renewable energy that is necessary to achieve the climate goals in other sectors (e.g. electricity generation, transport). Based on our analysis we develop policy recommendations aimed [...].

Healthy Home Barometer – a survey among European citizens 6-076-17

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Keywords

health, residential buildings, survey, EU project, energy behaviour, renovation

The Healthy Homes Barometers from 2015 and 2016, present key findings from a pan-European study investigating European citizens' attitudes and behaviour regarding home comfort, energy consumption and environmental impact. The Healthy Homes Barometers are published by the VELUX Group. The first Barometer was published in 2015, based on 12,000 Europeans respondents in 12 countries (Austria, Belgium, Czech Republic, Denmark, France, Germany, Hungary, Italy, the Netherlands, Norway, Poland and the UK), while the second barometer from 2016 had two additional countries (Spain, Switzerland) giving a total of 14,000 European respondents. The number of respondents from each country was set to ensure statistical representation, and the surveys represent more than 430 million Europeans.

In 2015, the Healthy Homes Barometer showed that Europeans rated their home environment as more important to their health than a healthy diet or being physically active. Curiously enough, this concern did not seem to spur much action. Europeans worry about their indoor climate, but do little to improve it – by frequent airing, for example. The next step was to identify how the home actually affects Europeans' health. Can we “afford” not to have healthy homes? The 2016 Healthy Homes Barometer identified five key characteristics of a healthy home: good sleeping conditions, comfortable indoor temperatures, fresh air, satisfactory levels of daylight, and appropriate levels of humidity. Another finding is that the drivers for renovation is home wellbeing and energy savings. The barometer give considerable insights of what Europeans consider to be a healthy home, which should be reflected when policies, directives and legislative proposals are developed, since buildings are made for people, and targets for healthy indoor environment should be treated similar to energy performance targets.

The structuring of air source heat pumps' prices in a retrofitting residential buildings market: what did I pay for? 6-090-17

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Keywords

refurbishment, prices, residential buildings, heat pump, abatement

The recent European energy proposals for the revision of the Energy Efficiency and the Energy Performance of Buildings Directives emphasize the importance to drive investments into the renovation of building stocks and to stimulate the refurbishment demand. Moreover, the challenge of acquiring data about retrofitting is reasserted because the lack of reliable data is detrimental to the perception of cost-effectiveness. Especially it is well known that refurbishment prices are, according to various papers, subject to large uncertainty and can sometimes be controversial even if public subsidies are available.

In this paper, we evaluate the main determinants of prices. Their structuring is a complex phenomenon blending technical, economical and organizational sides. For such purpose, we analyzed hundreds of invoices concerning the installation of heat pumps in existing buildings.

In order to model the influence of the different variables on the up-front cost paid by the households, we developed general linear statistical models (ANCOVA) blending qualitative and quantitative variables. The variables taken into account are:

- Technical: living area, type of building (multi or single family), coefficient of performance, installed power;
- and economic: company description (number of employees, main activity and sales network), average household's income linked to location, brand of equipment installed.

Our results confirm the importance of economic variables (such as brand or sales network) beside the technical variables in the explanation of prices. Our results also quantify the relative role of each variable. Half of the prices' variation is explained by the models and it is a huge step in the understanding of retrofit prices in order to better orientate the public subsidies.

How will buildings' energy demand look like in 2100? Quantifying future energy service demand from buildings 6-097-17

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Keywords

scenario study, activities, demand analysis, global projections, shared socio-economic pathways (SSP)

The demand for energy in buildings shows strong heterogeneities for different states of economic and technical development, as well as for different climate zones and life styles. In developed countries, final energy is used primarily for heating, while cooking plays the leading role in the developing countries. Further, natural gas and electricity fuel advanced economies when biomass prevails in other regions. These differences result from manifold factors – income levels, climate, behaviour, etc. –, for which the future development across the 21st century is highly uncertain. This uncertainty, in turn, diffuses to the future evolution of buildings energy demand.

To investigate plausible futures for buildings energy demand until 2100, this paper develops an energy demand model for buildings – EDGE – and applies it in an analytical scenario framework. EDGE projects energy demand for five energy services –, lighting and appliances, space heating, space cooling, cooking, and water heating –, eleven regions covering the world and seven fuel types. The long-term uncertainty is addressed with a comprehensive scenario framework developed over the last years in the integrated assessment community (O'Neill et al., 2014). The so-called shared socio-economic pathways (SSPs) framework bundles qualitative and quantitative assumptions about key factors for buildings energy demand – e.g. income levels, technology development, environmental awareness – to span a wide set of likely future societies. These differentiated socio-economic developments provide crucial assumptions for energy demand.

The analysis identifies the future key energy services for the aggregated buildings energy demand across two SSP scenarios. Results show the transformation of the buildings energy landscape driven by the rise in the demand for appliances, light and space cooling, and they show a strong electrification of the sector.

Building renovation delivers South-East Europe gas security ⁶⁻¹⁰⁴⁻¹⁷

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Keywords

building refurbishment, building retrofitting, deep renovations, demand side management (DSM), gas, infrastructure, modelling, energy security

Security of gas supply is a political issue of considerable importance in South-East Europe, identified as the only region in Europe with a significant gas security issue in the event of an interruption of supply through Ukraine. While the Security of Gas Supply Regulation aims to ensure deliveries of gas to protected customers (i.e. households), its operation in a real crisis is unknown. Consumers, including business and public sector buildings not covered by the regulation, would not be able to rely on it to meet their heating needs in case of a serious supply disruption, as has been witnessed in recent years when supplies from Russia to Ukraine were cut. In order to better understand the risks faced by gas consumers, this study explores the vulnerability of the building sector to gas supply interruptions in specific countries of the region, through the prism of the Building stock Vulnerability Indicator (BVI), developed by BPIE. The BVI takes into account the importance of the use of gas in the building sector, along with the dependence on imported gas and its import routes. The results show that most countries of the region are at least moderately vulnerable, with Hungary and Slovakia found to be severely vulnerable. Rather than adding gas supply infrastructure, which ultimately INCREASES dependence on imported gas, this study shows how energy security can be considerably improved by drastically reducing demand for gas through a dedicated and targeted building renovation programme throughout the region, covering the following countries: Albania, Bosnia & Herzegovina, Bulgaria, Croatia, Macedonia, Greece, Hungary, Kosovo, Montenegro, Romania, Serbia, Slovakia and Slovenia. In addition to improving energy security, such as approach yields a good return on investments and in addition provides considerable employment opportunities, while helping to tackle the serious health, air quality and fuel poverty issues suffered by many citizens in the region.

Balancing efficiency and renewables in the federal building strategy: Results from modelling potentials and restrictions in a national heat market with high spatial resolution

6-119-17

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Keywords

barriers, bottom-up analysis, building envelope, building refurbishment, building stock, modelling, renewable energy, U-value, sufficiency

In the discussion of the nearly zero energy building stock, an important question is the right balance between energy efficiency (EE) measures and renewable energy sources (RES): Whereas the “efficiency first” principle requires lowering the building energy demand prior to implementing a RES supply, other stakeholders argue that RES are available cheaply and abundantly and could help avoid deep interventions in the building stock.

Within the context of the German Federal Building Efficiency Strategy (ESG), a detailed modelling of the German building target (minus 80% nonrenewable primary energy demand until 2050) has been carried out by the authors, identifying the restrictions and potentials of EE measures based on detailed statistical, GIS based and empirical information. Guiding questions were: What is the absolute minimum of U values of buildings from a technical, life-cycle and economic point of view? Which reduction of energy demand can be achieved? How long will the refurbishment of the whole building stock take at least? In addition to this EE perspective, the rather generic studies of RES potentials available in the literature were critically re-assessed, trying to improve the data quality of the potential contribution of RES to the target. This implies detailed, spatially resolved analyses of solar thermal energy, heat pumps, biomass, and district heating.

A comprehensive data framework for supporting public action regarding the energy renovation of Madrid's listed buildings stock ⁶⁻¹²⁶⁻¹⁷

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Keywords

building refurbishment, Energy Performance of Buildings Directive (EPBD), heritage

European cities often have a large stock of buildings legally protected for cultural reasons that keeps growing. Most of them are used in a conventional way by a variety of socio-demographic profiles (for instance some parts of Madrid's historic centre are poorer than others) so there is no reason to think that, on average, their users have different comfort needs – or are ready to pay more in their energy bills – to those living or working in standard homes or offices.

Therefore, owners and occupiers could be interested overtime in improving the energy efficiency of these heritage buildings, so conflicts with their conservation may arise. However, there are no data available to assess their impact on the EU energy and environmental goals for the residential and services sectors.

Meanwhile, the EU legal framework keeps delaying dealing with this problem. The Energy Performance of Buildings Directive allows Member States to exclude legally protected buildings from compliance with any energy efficiency requirements when there is a conflict with conservation. And the Energy Efficiency Directive also exempts them from a series of provisions for public authorities.

We studied a listed stock of +500 legally protected buildings with cultural value in the Recoletos Area in Madrid, using our own GIS model based on publicly available information and some data already owned by various public bodies. Most of them were residential, multi-apartment buildings, some of them with some offices in them, in a high-income area which represents a highly active real estate market.

This study allowed us to identify the energy renovation opportunities in each building's thermal envelope, showing that the aggregated area of not protected elements is larger than that of the protected ones for the buildings in the sample analysed.

The analysis performed is useful for two reasons: first, it shows that a general exemption of heritage buildings from energy efficiency requirements is not [...].

Optimizing the control of energy use in technical building systems – why energy and climate policies should fill regulatory gaps

6-128-17

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Keywords

energy efficiency assessment, optimisation, efficiency, energy performance of buildings, technical building systems

This paper presents an analysis of the role of improving technical building systems (TBS) for space heating, domestic hot water, air-conditioning and ventilation for the energy and climate objectives of the EU. The scope of the analysis is optimizing system performance by control of energy generation, distribution and emission of heating and cooling energy in residential and non-residential buildings. It considers technologies that “get the basics right”, and achieve “high performance” both from a hydraulic and a connected ICT perspective. First, the paper summarizes the results of new, independent research on EU aggregated GHG emission and primary energy saving potentials. Then, the paper explains key functionalities, benefits and added-value of existing technologies, and shows that energy efficient technical building systems is a very attractive investment case. The third part illustrates barriers that impede investments in technical building systems. Finally, as an input to the on-going revision of the EU energy efficiency acquis, the paper recommends policy measures that would overcome typical barriers for investments into upgrade of technical building systems, and assesses the interaction between investment into technical building systems and thermal upgrade of the buildings envelope, on the path towards the EU’s 2050 GHG reduction objectives.

Property transfer tax reform – a game changer for energy efficiency retrofits? 6-129-17

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Keywords

building retrofitting, taxes, investment decision-making

The selling and purchasing of a home is a critical trigger point for making refurbishments to a property. Buying a property is usually associated with paying a Property Transfer Tax (PTT), which can amount to significant costs to the purchaser. In this paper, we explore the potential for linking PTT to the energy performance of the building that is being sold and/or any energy efficiency improvements carried out after purchase. To our knowledge, such a mechanism currently does not exist anywhere in the world and, if designed carefully, it could provide an important demand driver and financing mechanism for energy efficiency. An energy efficiency PTT would need to strike the appropriate balance between stimulating demand amongst consumers, while also ensuring the scheme is revenue neutral to the finance ministry. In the paper, we investigate how PTT would need to be designed in order to achieve both aims.

We use two case studies (Germany and the United Kingdom) to illustrate how an energy efficiency PTT could work in practice. The two countries have very different PTT mechanisms in place, although the volumes of revenues are similar. In Germany PTT levels are set at the regional level by the Länder whereas in the UK England, Wales & Northern Ireland set the same rates but Scotland uses different rate bandings.

Based on the two case studies, we present ideas for as well as the potential and the challenges of a PTT reform that is based on the energy efficiency of sold properties. We also set out further research needs and policy recommendations to put this concept into practice.

Policy strategies for achieving large long-term savings from retrofitting existing buildings

6-138-17

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Keywords

building refurbishment, building retrofitting, building regulations, policies and measures, building sector

In order to achieve long-term targets for energy savings and emissions reductions, substantial savings will be needed from existing buildings. For example, a recent analysis for the U.S. examines aggressive strategies to cut carbon emissions in half by 2040 and finds that in order to achieve this emissions reduction target, more than half of existing buildings will need comprehensive energy efficiency retrofits. Germany is targeting an overall primary energy consumption reduction of 50 % in 2050 including increasing building renovation rate to 2 % per year. In France, ambitious targets have also been set for existing buildings: 50 % reduction of primary energy consumption in 2050 compared to 2012 level.

Multiple countries have realized the importance of comprehensive building retrofits and have begun to adopt policies to spur these improvements. For example, Germany is emphasizing grants and loans through the KfW development bank, complemented with building and heating system labels, a new “heating check” programme and possible technical renovation requirements. France has established a goal of bringing all buildings up to “A” performance level (on their A–G scale) by 2050 in order for them to be sold or leased, with lower performance levels required as soon as 2020. In the U.S., the focus has been on a combination of rating and disclosure of energy use, financing, and technical assistance. Focused community approaches show promise.

This paper summarizes the efforts, successes and challenges, future directions and savings of building retrofit policies in the three countries. We conclude by contrasting the three countries and discussing areas of opportunity for these and other countries.

Lessons from Europe, North America, and Asia: financing models that are facilitating building energy efficiency at scale ⁶⁻¹⁴⁶⁻¹⁷

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Keywords

energy efficiency financing, business models, case studies, buildings, policy, financing, capital markets, scale-up

A critical component of achieving energy and carbon dioxide reduction goals set forth in The Paris Agreement is reduction of energy usage in buildings, which account for over one-third of all global energy consumption. While it is widely understood that curbing energy usage in buildings at the scale necessary to limit climate change requires involvement from capital markets, few structures exist in the market today for institutional investors to deploy capital, resulting in the absence of energy efficiency as an asset class. In general, capital markets would operate where projects can be efficiently aggregated, standardized, and assessed for credit quality; conditions that are challenging to achieve in certain market segments. This paper will discuss work being carried out by a consortium of scientists, bankers, and policy analysts from Lawrence Berkeley National Laboratory, Rocky Mountain Institute, Citi, and the International Finance Corporation to develop and pilot new policies, tools, and financial products that can facilitate building energy efficiency investment at scale. This paper will include an assessment of the most critical barriers the deployment of private capital for building energy efficiency projects in Europe, the United States, and China; recent examples of success; and lessons from current exploratory work in the United States and China to pilot new mechanisms that allow capital markets to better assess and bear the technical and credit risks of projects.

From prescriptive to outcome-based – the evolution of building energy codes and standards in China

6-156-17

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Keywords

buildings, energy efficiency policy, codes and standards, outcome based code

China consumes approximately 20 % of primary energy in its building sector. It is estimated that energy use in buildings will continue to increase in the future due to the fast urbanization process. Codes and standards are widely believed as one of the most effective ways to improve efficiency and reduce energy use and CO₂ emission in building sector. China started to develop its own prescriptive building energy codes and standards in the late 1980s. Using the 1980s buildings characteristics as the baseline, the national prescriptive building codes in China have achieved 50 % and 65 % energy efficiency improvement. However, buildings meet the prescriptive codes requirements may not yield actual operation energy performance. Many buildings have demonstrated good energy performance in design stage, but not performed well in their operation stage. In order to fill in the performance gap between prescriptive standard and actual performance, China has developed an outcome-based building energy standard trying to regulate actual building energy use in buildings.

This paper reviews international best practice on outcome-based building codes. Based on previous study of prescriptive building codes in China, this paper presents the gaps between China's prescriptive code performance and the proposed outcome-based code requirements. To fill the gaps, the paper discusses certain operation measures that influence building energy use in the operation stage, and possible solutions to help buildings complied with prescriptive code performance to meet the proposed outcome based code requirement as well. Finally, this paper discusses about current barriers and feasible policies to solve the issues of compliance and enforcement of the proposed outcome based code.

Energy savings potential for space heating in public buildings in Slovakia ⁶⁻¹⁸⁷⁻¹⁷

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Keywords

public buildings, energy savings potential, energy model, scenario study, space heating

Public buildings, being approximately 15,000 in number and largely neglected in terms of maintenance and major renovation, may provide a considerable energy savings and mitigation potential in Slovakia. Although several programmes have been providing funding for major renovation in public buildings in the last decade (through structural funds and other sources such as BIDSF and Munseff programme), and public sector is undergoing a reform aimed at its down-scaling, vast majority of the public buildings are still in a poor technical state. The paper shows the results of an analysis of energy savings potential in public buildings in Slovakia until 2030. The analysis is based on a bottom-up model used for a similar analysis in Hungary (Korytarova 2010). Both models use performance-based approach to modelling energy consumption. The model was updated and adjusted to national conditions. Scenario assumptions of the two models differ as well. The analysis utilises inter alia the results of a sample of approximately 250 energy audits. The analysis shows that increasing the annual retrofit rate to 3 % for the whole public building stock may not be economically effective, not even in the long run (2050). Due to currently high specific investment costs cost effectiveness can be reached only with lower rates. The research implies that first, suitable policies must be implemented, especially those ensuring quality of renovation projects as well as significantly higher share of buildings renovated to highly energy efficiency levels. These may include financial mechanisms providing support depending upon projected or achieved savings. Only then, rates of renovation can be increased, e.g. through provision of new funding. The analysis was conducted within the project “Support for instruments for the introduction and optimization of measures in the area of energy efficiency in public buildings”, which was financed by structural funds and operated by Slovak Innovation and Energy Agency.

Technologies and policies for GHG emission reductions along the supply chains for the Swedish construction industry

6-215-17

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Keywords

zero-carbon houses, policy instruments, construction industry, supply chains, steel, cement

As the energy performance of the existing and new built building stock keeps improving and with reduced carbon intensity of electricity and fuel supply and increased electrification, the share of the construction process in the climate impact of buildings and infrastructure will increase. The aim of this paper is to discuss how innovative technologies, business models and innovation support mechanisms can accelerate the transition towards zero-emission practices in the construction and building materials industries. The focus is on the production, supply and final end-use of cement/concrete and steel.

Understanding building renovation passports: customised solutions to boost deep renovation and increase comfort in a decarbonised Europe ⁶⁻²²⁷⁻¹⁷

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Keywords

audit, auditor tool, policy recommendations, renovation, overcoming barriers, non-energy benefits (NEBs), energy performance certificates, deep renovations, comfort

Increasing the current EU annual renovation rate from 1.2 % to 2–3 % is essential to ensure a highly-efficient and fully decarbonised building stock by 2050. Increasing building renovation rates while aiming at achieving “deep renovations” is of paramount importance. Building owners face multiple barriers to improve the energy performance of their buildings. Together with difficulty in accessing finance, one of the most often cited barriers is the lack of knowledge about what to do, where to start, and which measures to implement in which order.

Despite their potential, Energy Performance Certificates (EPCs) have a limited market penetration and their acceptance by the users varies across member states. Thus, their relevance for owners and their stimulating effect for the renovation of buildings is limited. While increased thermal comfort and air quality, higher levels of natural lighting and improved health of occupants are among the most important benefits and drivers for renovation, they are not currently covered by EPCs.

Based on three initiatives from France, Belgium and Germany, this paper explores the notion of Building Renovation Passport (BRP) as an evolution of EPCs and initiate a dialogue to promote its introduction across the EU. Aiming at creating a comprehensive and user-friendly instrument to support building owners with personalised instructions on their renovation options, the BRP outlines a long-term step-by-step renovation roadmap for a specific building, resulting from an on-site energy audit fulfilling specific quality criteria and indicators established in dialogue with building owners. Building owners receive a user-friendly, personalised renovation plan, presenting all the expected benefits of renovation, including non-energy benefits. Combined with a logbook, a repository of information on aspects like energy consumption and production and financing opportunities, BRP can become a [...].

European shopping centre building stock – a pathway towards lower energy consumption via innovative energy policy

6-229-17

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Keywords

shopping mall, energy efficiency assessment, policy instruments, energy saving potential, energy model

The European shopping centre building stock offers a high energy saving potential and good ground to implement energy efficiency measures. Looking at macro-economic parameters such as sales growth and shopping centre floor area per capita, the stock of shopping centres is expected to grow especially in the European transition economies while remaining stagnant in the saturated markets of western and northern Europe. The energy demand for lighting, refrigeration, ventilation, space cooling and heating, is correspondingly growing in these transition markets. On the other hand, in the saturated markets, the major challenge is to renovate the existing building stock of shopping centres. Both, new and retrofitted buildings require technology solutions and a corresponding policy framework to enhance energy efficiency and the use of renewable energy sources, while improving indoor environmental quality that is of primary importance for the attractiveness of the sales place. In this paper, the current and future energy demand in the European shopping centre building stock is assessed to 2030 using (i) specific power consumption and operating duration for lighting, appliances, refrigeration and ventilation, (ii) shopping centre categories' gross leasable area, (iii) developments in building renovation and new construction and (iv) standard and advanced energy efficiency technologies. A number of policy scenarios on the future total energy demand are derived showing the impact of the most important drivers such as renovation rates and implemented energy efficiency solutions. The paper provides recommendations on how to increase the use of energy efficiency measures in European shopping centres, thus assisting the sector to contribute to the European 2030 climate and energy targets addressing the following stakeholders, owner/tenants, real estate [...].

A case study of deep retrofit in mixed tenure (rented and owned) UK social apartment blocks

6-283-17

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Keywords

governance, deep renovations, social housing

Apartments in multi-occupancy buildings account for 40 % of Europe's homes. Levels of refurbishment in apartment blocks are often lower than in single-family houses, in part because of the complexity of reaching agreement and sharing the costs between the multiple owners of a typical block. Governance arrangements – the way ownership is structured and building management is undertaken – have a direct impact on what is possible in terms of low energy retrofit but have been under-analysed by energy efficiency researchers. This paper provides a case study of how the legally constituted governance arrangements impact on a deep retrofit of one type of building – social housing tower blocks in England.

In social housing blocks in England, the social housing provider typically owns the building and rents out most of the flats to tenants on low incomes. However, it is also usual for some of the flats to have been sold into the private sector as 125 year “leases”, thus sprinkling privately owned flats in with rented flats. Under the terms of these leases, the private flat owners (leaseholders) have to pay service charges for the upkeep works to the building carried out by the social housing provider. These service charges can be challenged at a tribunal if the leaseholders consider them unreasonable.

Oxford City Council are carrying out a refurbishment programme that includes significant energy efficiency improvements on five tower blocks, but the substantial service charge bills have led to opposition from some leaseholders and has received national press attention. This paper assesses the governance arrangements in the five Tower Blocks and how they are affecting the delivery of the planned energy-related measures. As well as the legal issues we discuss how the council and leaseholders (who have to pay their share of the costs) perceive the benefits of the upgrade and the legal arrangements.

Article 19 of the Energy Efficiency Directive requires EU member states to address split incentives for energy efficiency between the multiple owners of buildings. [...]

To what extent do “ambitious” scenarios of energy demand in the building stock reflect COP21 Paris targets?

6-366-17

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Keywords

energy efficiency programmes, housing energy consumption, smart metering, information and communication technologies

COP21 led to an agreed target of keeping the increase in global average temperature below 2 °C compared to pre-industrial levels. The EU-contribution to this target will require GHG-emission reductions of at least 80–95 % from 1990-levels until 2050. Due to the high potential for decarbonisation, the building stock will have to achieve at least the same level of reduction. Policy makers are asked to develop a corresponding framework. Important for assisting decision makers in this context are policy driven scenarios.

The research questions of this paper are: (1) Do long-term scenarios (and in particular those labelled as ambitious) of energy demand in buildings reflect the COP21 target? (2) If not: What are reasons for the gap? (3) What can we learn for policy making?

The method builds on following steps: (1) Analysis of GHG-emission reduction in scenarios from the policy driven bottom-up model Invert/EE-Lab carried out recently for various European countries in several EU and national projects (e.g. ZEBRA2020, progRESsHEAT, Tender for DG Energy on Mapping of Heating/Cooling, etc.); (2) compare scenarios among each other and analyse whether the scenarios lead to an achievement of GHG-emission reductions in the range of 80–95 % until 2050; (3) identify reasons for possible gaps in GHG-emission reductions like insufficient stringency of building codes, deficient economic incentives etc. and (4) derive conclusions regarding policy making.

Results show that scenarios labelled as being “ambitious” e.g. in ZEBRA2020 for several EU MSs achieve GHG-emission reductions of 56 %–95 % until 2050, but only three of them above 85 %. The reason is that policies have been developed together with policy makers, who were not willing to go beyond certain stringency of modelled instruments. In particular, this was the case for regulatory [...].

Building deep energy retrofit: Using dynamic cash flow analysis and multiple benefits to convince investors

6-369-17

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Keywords

deep renovations, investment decision-making, building stock, multiple benefits, life cycle cost (LCC), benefit analysis

Deep energy retrofit (DER) of the existing building stock is a meaningful strategy to reduce fossil fuel consumption and CO₂ emissions. However, the investment volumes required to undertake DER are enormous. In Europe, cumulative demand for DER is estimated at close to 1,000 billion EUR until 2050. Public expenditures and political measures can help to stimulate DER, but substantial private investments are required to achieve significant results.

In this paper, we analyze the economic and financial implications for investors renovating an office building to the 'Passive House' standard. This is achieved by applying a dynamic Life Cycle Cost & Benefit Analysis (LCCBA) to model the cash flows (CF). The model also includes an appraisal of debt and equity-financing implications, and a multi-parameter sensitivity analysis to analyze impacts of input parameter deviations. In the second part of the paper, we use the 'Multiple Benefits' (MB) concept to identify project-based co-benefits of DER, to make the business case more attractive. We categorize the identified MBs in: 1) monetary, 2) un-quantified project, and 3) societal benefits.

Results show that the DER project cash flow over a 25-year period achieves a 21-year dynamic payback with an IRR of below 2 %. Levelized Cost of Heat Savings is 100 EUR/MWh with a 70 % capital expenditure and 15 % interest cost share. The Loan Life Cover Ratio comes out to 1.2. To make the business case more attractive, pecuniary MBs identified are increased rents, real estate values, (employee) productivity, and maintenance costs and CO₂ savings, in addition to societal benefits.

Compared to simpler economic modeling, the dynamic LCCBA cash flow model provides solid grounds for DER business case analysis, project structuring and [...].

A blind spot of European policy? Energy efficiency policies for low-income households

6-383-17

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Keywords

Energy Performance of Buildings Directive (EPBD), Energy Efficiency Directive (EED), barriers, subsidies, residential sector, energy efficiency policy, energy poverty, low-income households

To reach the target of an almost carbon neutral building stock in the European Union by 2050, as proposed by the low-carbon roadmap, it is crucial to include all residential buildings into these efforts. However, at the moment, only few energy efficiency (EE) policies in Europe focus on or actively include low-income households (LIH), which represent about 17 % of households in the EU (as defined by earning less than 60 % of their respective national median equivalised disposable income). Social policies to alleviate the precarity of fuel poverty exist in nearly all Member States. Though these policies may be successful in alleviating fuel poverty, they can actually counteract the incentive for investing in EE.

This paper stems from research performed by the authors for the ITRE Committee on EE policies for LIH (EP, 2016). In this paper, we analyse the current EE policy landscape in the EU and its Member States with regard to how they address LIH. After presenting barriers to efficiency in households, we refer to the capability of EE policies to remove specific barriers for EE investments in LIH, as well as their environmental, economic, and social benefits. These benefits are often discussed as “multiple benefits” of EE and include, beyond their contribution to the achievement of energy and climate targets, positive impacts on employment, GDP, competitiveness or energy security and beneficial social impacts as e.g. alleviation of fuel poverty, better health and well being or an improved living comfort. We then give recommendations for future policy design in the EU Member States and the recast of important EU Directives (EED, EPBD, Eco-Design and Energy Labelling Directives), while considering special design elements for LIH without neglecting rebound effects and other counter-productive effects.

PANEL 7

Appliances, products,
lighting and ICT

Should the next standby power target be 0-watt?

7-004-17

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Keywords

standby power, energy standards, storage, appliances, electricity consumption, energy harvesting

The standby power use of appliances continues to consume large amounts of electricity. Considerable success has been made in reducing each device's use, but these savings have been offset by a huge increase in the number of products using standby power and new power requirements for maintaining network connections. Current strategies to reduce standby have limitations and may not be most appropriate for emerging energy consumption trends. A new strategy for further reductions in standby, the "Standzero" option, encourages electrical products to be designed to operate for short periods without relying on mains-supplied electricity. Energy savings are achieved through enhanced efficiency and by harvesting ambient energy. A sensitivity analysis suggests many appliances could be designed to operate for at least an hour without relying on mains power and, in some cases, may be able to operate indefinitely at zero watts until activated.

State of residential energy consumption in Southeast Asia: need to promote smart appliances because urban household consumption is higher than some developed countries ⁷⁻⁰¹³⁻¹⁷

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Keywords

domestic appliances, database, end-use efficiency, Southeast Asia, international comparison

Energy use in Southeast Asian countries increases annually, and will continue to rise with improving living standards. However, data collection related to residential energy consumption lags behind, and understanding the state of consumption is challenging.

In 2015, we conducted a field study on residential energy consumption in Malaysia, Thailand, Vietnam and Cambodia to indicate how improved lifestyles result in increased energy consumption compared to the other developed countries in Southeast Asia and Japan. To analyse these relationships, we surveyed energy use and people's lifestyle, including equipment ownership and methods of use. As a result, we found that energy consumption of lighting, plug loads, cooling and cooking in urban areas of Southeast Asia approaches that found in developed countries and in some cases exceeds this. In other words, energy consumption in emerging countries has become a more critical issue than in developed countries.

In this paper, we explain the variance in energy consumption of developing, emerging, and developed countries, due to differences in housing, equipment, income, and lifestyle. Next, we explain the new energy efficiency policy in Thailand, Energy Efficiency Development Plan 2015. EEDP 2015 is the most advanced policy in Southeast Asia that includes an Energy Efficiency Obligation. We also discuss the importance of strengthening of MEPS, energy efficiency labelling and promotion of smart appliances. Eventually, we aim to collect and analyse energy consumption patterns in households in several Southeast Asian countries, to create a database with the results from [...].

Electricity consumption of cold appliances, washing machines, dish washers, tumble driers and air conditioners. On-site monitoring campaign in 100 households. Analysis of the evolution of the consumption over the last 20 years ⁷⁻⁰¹⁹⁻¹⁷

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Keywords

end-use metering, household consumption, EuP Directive, energy labelling, user behaviour, end-use efficiency, washing machines, dishwashers, cold appliances

Monitoring campaigns have shown since 20 years that domestic electricity consumption structure has drastically changed and is in constant and rapid evolution. Unitary consumptions of most appliances have decreased, mainly thanks to EU directives. But these energy savings have been compensated by new additional consumption, possibly because of increase of ownership level, appliance size, as well as emergence of new devices.

To explore in detail the structure of electric household consumption in France, massive monitoring campaigns have regularly been carried out. In 2015/2016 a campaign has been done in 100 French households in which the electricity consumption of cold appliances, washing machines, dish washers, tumble driers and some air-conditioners has been monitored at 10 minute intervals for 1 year.

This study assesses the different factors that influence the consumption:

- Technical features due mainly to stock renewal and European Eco design and Energy Labelling Regulations.
- Possible behavior changes related to evolution of social practices.
- It shows that during the last 20 years:
- The total household electricity consumption is stable.
- Cold appliances consumption has been divided by a factor 2, but reduction in energy consumption is not the same for all types of appliances.
- Washing machine and dish washer electricity consumptions have been [...].

Is it time for a European market surveillance coordination body? Redefining monitoring, verification, and enforcement of European product policy ⁷⁻⁰²⁹⁻¹⁷

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Keywords

market surveillance, appliances, energy efficiency assessment

Less than 1 % of the European market is currently verified via testing as either reaching the minimum performance standards laid out by the Ecodesign Directive, or that the energy class declared is indeed correct. Despite this, the complexity of these regulations is set to grow, both in terms of the number of products covered (Ecodesign work plan 2015–2017), and the range and scope of areas within each product regulated (possible combination and inclusion of circular economy – resource efficiency).

Member States are the sole bearers of the responsibility of market surveillance, yet despite tireless efforts, are barely able to scratch the surface in terms of the work needed to be done to reduce the estimated 15–25 % non-compliance rates found in this sector. With up to 100 TWh of lost savings at stake, and possibly many times more than that in the future, is it time to consider a more formal and centralised market surveillance body that would assist and facilitate market surveillance actions across Europe?

Such a coordinating body would not take over the role of the national MSAs, nor would it have or need the authority to impose sanctions on non-compliance. Instead it could draw upon the success of pan-EU projects such as Ecopliant, EEpliant, ATLETE, ATLETE2, ComeOnLabels, MarketWatch, INTAS, and ComplianTV. These projects have shown that central coordination both improves cooperation, and helps to better identify key causes of non-compliance and identification of suspicious products.

This paper outlines the potential model for a European coordination body, and highlights key areas where such a body would improve market surveillance across the whole of Europe.

EEPLIANT 2014 – Energy Efficiency Compliant Products 2014 project ⁷⁻⁰³⁸⁻¹⁷

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Keywords

market surveillance, LED, heat pump

The EEPLIANT 2014 project runs from March 2015 to June 2017 and aims to facilitate and support the cooperation of national and regional market surveillance authorities in the area of energy efficiency and ecodesign labelling.

This is being achieved through coordinating the monitoring, verification and enforcement activities of 13 Authorities across the EU from 12 member states: Austria, Belgium, Bulgaria, Denmark, Germany, Lithuania, Malta, the Netherlands, Poland, Slovenia, Sweden, and the United Kingdom. They are the responsible and competent bodies to take legal action on noncompliant products.

In addition to laboratory testing, the project also includes technical documentation inspections, defines surveillance best practices and shares these among the participating authorities; also other authorities within the EU and professional stakeholders are being kept informed.

The project is coordinated by PROSAFE and is funded by the European Union' mechanism Horizon 2020. It is estimated that the joint action will achieve energy savings of 86 GWh. The programme is in the process of investigating some 200 products.

EEPLIANT 2014 focuses on three product groups:

- LED lamps;
- Imaging equipment;
- Space heaters and combination heaters.

These products are taken from the market – shops and other distribution channels, just as regular consumers would do, and their compliance with the energy efficiency related requirements is inspected by the responsible market surveillance officers and measured in laboratories. In case noncompliance is found, the market surveillance authorities take appropriate enforcement action.

The project has been designed not only to assist authorities in verifying energy consumption of specific products, but also to facilitate the cooperation with other stakeholders, such as industry associations, in achieving higher rates of overall [...].

Bringing the home in the lab: consumer relevant testing for household electrical products

7-039-17

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Keywords

energy efficient products, appliances, testing, standardisation, measurement and verification, consumer behaviour

Product testing is widely used to assess the characteristics, e.g. performance, energy consumption of a product. The procedures for executing the tests, including measurements and processing of measurement results, can be contained in standards. Standards should – amongst other – ensure that product tests are carried out in a uniform, standardized way so that the results accurately reflect product characteristics and differences between products in case several products are tested, and are not due to variations in conditions. Therefore, standards should produce results that are repeatable, reproducible and valid at a reasonable cost.

A number of stakeholders have questioned the validity of several standards: the results that these standards provide are different from what a consumer may experience in practice. In the end this can have negative consequences for the trust of consumers in the policy instruments (energy labels, minimum efficiency requirements) that use these standards and an energy savings deficit compared to what was expected by policy-makers. They call for standards that better reflect 'real-life' conditions, meaning those conditions that consumers experience at home. However, unlike the other criteria that standards should meet, there is no methodology to assess the correspondence to real life (validity) of a standard. This paper develops such a methodology and presents the results for several household electrical appliances: washing machines, refrigerators and vacuum cleaners.

Energy efficiency insight into small and medium data centres: A comparative analysis based on a survey ⁷⁻⁰⁸⁶⁻¹⁷

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Keywords

energy efficiency assessment, demand response, smart grid, information and communication technologies, data centres

Data centres are the backbone of a growing number of activities in modern economies. However, the large increase in digital content, big data, e-commerce, and Internet traffic is also making data centres one of the fastest-growing users of electricity and such consumption is expected to vastly increase in the next decade. The total energy consumption of data centres corresponds to almost 1.5 % of the global electricity consumption, and had an average annual growth rate of 4.3 %. Therefore, it is very important to increase the energy efficiency in data centres with actions such as power usage management, server consolidation, energy efficient components and systems.

Small and medium data centres account for more than 50 % of the total electricity consumption in this sector. In fact, surveys indicate that this data centre profile waste more energy than larger facilities. Nevertheless, existing studies tend to be focused on the energy related issues for large data centres rather than small and medium data centres. In order to analyse and propose changes to this current perspective, a survey was designed to provide insight into the current reality in terms of energy efficiency actions in small and medium data centres in Brazil the USA, and Portugal. The survey was sent to key decision makers with technical responsibilities for these data centres.

This paper aims to present best energy efficiency practices, using two surveys from literature as relevant source of data and results to compare with the conducted survey, analysing the main opportunities and challenges in small and medium data centres energy efficiency. It highlights that while data centres are recognized as a central part of organizations' energy efficiency strategies, many are improving energy efficiency rather slowly compared with the metrics, evidences, and case studies published by academia and industry.

Reliability of the European energy label for heating appliances – optimization of test standards for heat pumps ⁷⁻¹³⁰⁻¹⁷

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Keywords

labelling, heat pump, testing, measurement and evaluation, efficiency standards, Directive on Energy Labelling, heating

The European standards EN 14511 and EN 14825 are representing standardized procedures for testing the energy efficiency of heat pumps and air conditioners with electrically driven compressors for both space heating and cooling. In this study, these standards are analyzed and validated. It was figured out that the currently used methods implicate high complexity and high financial effort. Test laboratories claim that for certain types of construction, e.g. air sourced heat pumps, the standard procedures show deficits in delivering repeatable and reproducible results in inter- and also intra-laboratory tests. In order to clarify the circumstances and to identify the deficits more in detail, a round robin test with independent and accredited laboratories was initiated. The aim is to develop an optimized test procedure that improves the feasibility of the testing procedure and finally its application. This study should lead to a more repeatable and reproducible testing procedure, which is also compatible with the state of the art in heat pump technology and real operation conditions.

How standards can better reflect consumer relevance on the example of range hoods ⁷⁻¹³¹⁻¹⁷

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Keywords

Energy Labelling Directive, efficiency classification, standards, domestic appliances, testing, range hoods

The EU's Ecodesign and Energy Labelling Regulations for domestic cooking appliances became legally binding in 2015. To determine the classes on the energy label, the regulations refer to the European Standard for performance measurements of range hoods EN 61591. The standard EN 61591 has been analysed and evaluated within the National Action Plan on Energy Efficiency (NAPE), a government programme that aims to increase the energy efficiency in Germany. The analysis revealed several drawbacks of the test standard. The standard used for the evaluation of range hoods is composed of methods for determining: (i) volumetric airflow, (ii) odour extraction, (iii) effectiveness of the lighting system and (iv) grease absorption. Currently, the grease absorption class is obtained by heating up oil and water in a pot, which creates vapour and splashes of grease. In this paper different alternative methods for the evaluation of the grease absorption efficiency will be discussed. In the proposed test method an atomizer nozzle is used. Consequently, the exact amount of atomized oil is known and the ratio of filtered to atomized oil can be measured. Thereby the proposed new method is able to take into account aerodynamic designs and leaks. Furthermore, it enables to alter the classification guideline of the energy label to give more significant and consumer relevant declarations. It allows manufacturers to develop innovative grease absorption methods with little airflow. This study revealed that it can be beneficial to review more of the existing standards in the light of improving their consumer relevance.

Harmonisation of MEPS and energy labelling in Latin America and the Caribbean

– opportunities and challenges 7-219-17

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Keywords

domestic appliances, abatement, harmonisation, energy labelling, developing countries, standardisation, product policy

As in most developing countries and emerging economies, the demand for electricity is increasing rapidly in Latin America and the Caribbean (LAC), and energy efficiency (EE) potentials are large. Besides climate change mitigation, EE can contribute to meeting diverse development goals in the region, including enhanced energy security and social improvements. Minimum energy performance standards (MEPS) and energy labelling have been recognized as two of the most effective and efficient policy measures to address product EE, and programs have been introduced by most countries in the LAC region. However, unlike the EU regulations, MEPS and labelling programs in the LAC region are national and largely lack harmonisation between the various countries. In particular, a lack of availability of competent services and alignment in quality infrastructure, needed for measuring the energy output of products, testing their performance as well as assuring and certifying their quality, hampers an effective implementation of EE programs. The lack of harmonisation poses considerable challenges for product manufacturers, importers, retailers and end consumers and largely reduces the effectiveness of the programs. This paper describes how strengthening the national and regional standardization bodies, metrology institutes, conformity assessment bodies and regulatory agencies and supporting interaction between them can help to make EE programs more effective. The results draw upon a project funded by the German International Cooperation and executed by the German National Metrology Institute PTB, in which a variety of capacity building activities, including workshops, training measures and interlaboratory comparisons were conducted in the region between 2011 and 2015. We analyse how these activities can contribute to a harmonisation of MEPS and labelling in the LAC region. We conclude by providing recommendations for further interventions to support effective EE policy.

Durability testing procedure for washing machines – approach and first learnings 7-233-17

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Keywords

washing machines, indoor air quality, durability, stress testing

Durable products allow to reduce the consumption of raw materials long-term and to contribute to waste minimization. Thus, durability plays a key role to enhance circular economy and resource conservation, for example in the category of electrical and electronic equipment. However, it was observed that the average lifetime of these products has decreased over recent years. We identified the washing machine product group as a relevant case study for the development of a durability test, and as a potential trigger to systematically address durability in the design of products. The main objective of this research was to develop a procedure to test minimum durability performance of washing machines, on which limitations and potentials for future improvements would be highlighted. The procedure was developed to potentially be used in policy.

The durability test was developed considering the whole product tested under overstressed conditions. A series of spinning cycles with fixed unbalanced loads was run on two washing machines, to observe failures and performance changes during the test. Even though no hard failures occurred, results clearly showed that not all of the washing machines are able to sustain such a test without abrasion, or performance deterioration. The proposed test allowed to have results in a relatively short amount of efforts and time, which makes it compatible with policy constraints.

However, the attempt to mimic the stress induced on a washing machine by doing a high number of pure spinning cycles with fixed loads did not allow equal testing conditions: The actions of the control procedure regarding unbalance loads differ from machine to machine. Therefore, future developments will need to replace the series of spinning cycles with various washing programmes, and the fixed unbalanced loads with real loads, paying attention to limit the time required by the test. The outcomes of this research can be used as a basis to develop standardized [...].

Accounting for durability in least life cycle cost methods 7-244-17

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Keywords

Directive on Eco-design (EuP/ErP), life cycle cost (LCC), minimum energy performance standards (MEPS), LED, lighting, durability, product lifetime

In the European Union (EU), mandatory durability ecodesign requirements have recently been set for vacuum cleaners and lighting products. Durability standards for additional product groups are expected in the future and it is also envisioned that durability issues will be integrated in the EU energy labelling scheme. Durability standards can bring environmental benefits, but there are several methodological challenges, not least regarding the trade-offs between different product attributes. In this paper, we review previous literature and studies examining durability and increased lifetimes for products, with a focus on the case of LEDs. We analyse the methods suggested and assumptions used and compare these to an innovative method for calculating an attribute-adjusted least life cycle cost (LLCC) when durability is included. Then we analyse the case of LEDs available in an online market in 2016 and model optimal lifetimes in relation to life cycle costs. The model identifies factors influencing optimal lifetimes. The statistical error of the regressions does not allow for calculation of the optima with precision, but the calculation is illustrative that the LLCC optima for the range of LED bulbs considered is close to 25,000 hours. The model also indicates that greater durability is important for cases with smaller discount rates and more intensive use of the product. We discuss the usefulness of the method and its application and development in context of policy development of durability standards, as well as future research that can complement this approach. The initial results indicate that, at least from an LLCC perspective, longer lifetimes than currently required by standards may be desirable, so we also discuss the advantages and disadvantages of using three different policy instruments to stimulate increased durability.

EU product policy and consumer purchase decisions – empirical evidence from eight EU member states ⁷⁻²⁵⁹⁻¹⁷

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Keywords

product policy, labelling, appliances, consumer behaviour, lighting, survey

EU product policy has contributed to driving purchase decisions towards more efficient products by influencing consumer purchase behaviour. However, sales data show that the uptake of energy efficient solutions differs considerably between the various EU member states, despite the fact that the regulation is the same. In order to make product policy more effective in influencing consumer behaviour, it is important to obtain an improved knowledge of how consumers make purchase decisions. We analyse data from a large-scale household survey that was conducted in eight EU member states (DE, FR, IT, ES, PL, RO, SE, UK) in June 2016. In each country, a representative sample of 1,500–2,000 participants was asked about their purchases of washing machines, refrigerators, dishwashers and light bulbs. The survey contained questions on a variety of external and internal factors influencing consumer purchase decisions including attributes that directly influence decision-making (purchase price, energy cost, energy label, social influence, influence of retailers, environmental friendliness, financial support, performance and design) as well as indirect factors such as gender, income level, attitudes, values and beliefs. We use descriptive and inferential statistics to analyse the role of these factors in purchase decisions and compare the results across the various countries. We find that the role of the different factors varies between the countries but only slightly between different population groups according to age, income or education. For household appliances and lighting, purchase criteria are rated similarly overall but energy consumption is most important for lighting while the purchase price is most important for appliances.

Behaviour, practice – whatever? A theory-agnostic framework for describing and informing demand-side response ⁷⁻³¹¹⁻¹⁷

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Keywords

demand response, demand side management (DSM), theories, behaviour, practices, framework

Different theoretical perspectives present diverse interpretations for why and how people may (or may not) be able to vary their electricity consumption patterns, and often propose different approaches to facilitating demand-side response (DSR). The framework set out here is suggested as a way of matching and marrying these various approaches with the goal of exploring how to achieve the maximum possible demand response which people are happy and able to provide.

The framework is based around ‘electricity-relevant dimensions’, or factors which may be considered to be associated in some way with a person or people’s electricity use – activities engaged in, location, room temperature, and so on. Within each dimension, at any instant in time, certain states (such as ‘walking’ or ‘watching TV’ for activity) are more or less possible/acceptable than others for a variety of reasons. Effective DSR is understood as involving influencing adoption of those states with lower (or higher, as necessary) electricity outcomes at certain times, from a ‘phase space’ of possible options.

This paper describes how the framework can be used to consider the role of DSR interventions with their roots in different theoretical positions, such as changes in material conditions or competencies (associated with social practice theory), or in the framing of messages to activate loss-aversion (behavioural economics). It is intended to prompt consideration of how such approaches (and their proponents) could work together to optimize the potential of DSR programmes and policies, and is illustrated throughout with real and hypothetical examples.

The application of extended product approach (EPA) in ecodesign measures – a case study on water pumps ⁷⁻³²¹⁻¹⁷

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Keywords

standardisation, energy saving technologies, system analysis, harmonisation, extended product approach, motor driven units

The application of the Extended Product Approach (EPA) in energy efficiency measures for energy related products (ErP) has long been discussed as one of the methodological approaches that can maximize energy saving potentials for ErPs. However, the EPA has so far only been applied to very few products at regulatory level. This paper presents the results of a review study of the ecodesign requirements for water pumps used in buildings and industrial processes, which is one of the priority product groups in ecodesign measures. When using EPA at regulatory level it is important to define the scope, which in this case it was the 'pump unit', i.e. the pump and the electric motor (and a drive, which is optional). Thereafter, a methodology for testing and calculation of energy efficiency requirements for the pump units in the current regulation (i.e. clean water pumps) was developed. The yearly energy savings potential from applying this methodology to these pump units was calculated as 37–40 TWh by 2030, but the greatest challenge was to extend this methodology to other pump units not in the regulation (i.e. swimming pool pumps and wastewater pumps). This is because the calculation of the energy efficiency in the EPA methodology is based on flow-time profiles so far only standardised for clean water pumps. In order to define them, it is important to characterise the hydraulic behaviour of the pumps in the systems they operate, both at a constant or varying flow demand. So far until now there is not much common knowledge of system aspects for swimming pool and wastewater pumps at varying flow demand. Because of this lack of common knowledge, some assumptions were made for these pump units which resulted in small potential energy savings. More effort is thus needed in defining suitable usage strategies and quantifying system aspects for swimming pool and wastewater pumps, so that an energy efficiency methodology at EPA level can be developed which incentivizes the application of variable flow so more potential savings can be achieved.

Living up to expectations? Monitoring the effects of ecodesign and energy labelling in Germany

7-345-17

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Keywords

evaluation, Ecodesign Directive (EuP/ErP), Energy Labelling Directive, regulation

Ecodesign and Energy Labelling are policies based on extensive ex ante impact assessment. Preparatory studies project potential savings for each product group. Impact assessments re-estimate them for concrete regulatory alternatives. The bulky “Ecodesign Impact Accounting” harmonized all this data in order to provide a comparative assessment of energy savings (VHK 2015). However, retrospective accounts of what has actually been achieved are much scarcer. The authors of the paper have been involved in a study for the German Ministry of the Economy, trying to pinpoint national level savings that can be associated with Ecodesign and Labelling for six product groups (boilers, water heaters, light sources, electric motors, household cold appliances, and ventilation units). Ecodesign (ECO) scenarios have been compared to Business as Usual (BAU) scenarios, using national sales and energy consumption data wherever possible. This provides more reliable insights than before, especially for those product groups that have been regulated for some years so that actual market developments could be taken into account. The assessment suggests considerable savings in ECO as compared to BAU. However, they are consistently smaller than what could be expected if the EU-wide Ecodesign Impact Accounting figures had been scaled down for Germany. Also, ECO vs. BAU savings do not always mean that total energy consumption decreases over time. The paper discusses possible reasons for the differences between national and EU savings, and suggests future policy avenues to deal with the increase in total energy consumption.

Using webcrawler techniques for improved market surveillance – new possibilities for compliance and energy policy ⁷⁻³⁵⁴⁻¹⁷

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Keywords

market surveillance, monitoring, ecodesign, energy labelling, webcrawler data

In recent years, web crawler techniques have been developed at a rapid pace. With intelligent software, it is possible to scrape large volumes of data from publicly available data sources at the Internet, basically in real time. In the realm of product policies, such as ecodesign and energy labelling, this offers alternative means to track products available at the marketplace, when compared to more traditional data collections offered by companies like GfK. Thus, typical information on products and model names, claimed performance on functionality and energy use, and finally purchase price, is thus affordable and relatively easy to collect in real time. With advanced modelling based on ranking (popularity indexes at sites like e.g. Pricerunner) it is even possible to estimate the sales volumes.

The new possibilities thus offered are currently being explored for policy evaluation and improved policy design, as well as for developing new and improved consumer tools when choosing and buying energy using products.

This paper focus on another use, namely on how webcrawler techniques can increase the effectiveness of market surveillance. In the “NordCrawl” project, under the Nordic Council of Ministers, market surveillance authorities (MSAs) from the Nordic countries work together to develop a web-based application which each MSA can use to monitor their respective national market.

The advantages include the following aspects:

- Reduced cost for data collection
- Higher coverage and a better representativeness of the market (market picture)
- Data collection in real time
- Improved sampling strategies when choosing products to check, be it random or targeted sampling [...]

Lessons learned from international energy labelling programs for strengthening the China Energy Label program ⁷⁻³⁶³⁻¹⁷

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Keywords

energy labelling scheme, policy implementation, appliances, best practice, barriers, China

China first introduced the China Energy Label, its mandatory energy information label, in 2005 and it has expanded over the last eleven years to cover 33 key energy-using products. This energy labelling program, along with the complementary mandatory efficiency standards and subsidies for efficient products, have contributed to driving market transformation with growing shares for efficient products and appliances. While successful, policy and technical barriers to effectively implementing the China Energy Label, particularly in terms of compliance, exist. Key barriers include an incomplete legal basis, unclear responsibilities, lack of effective information sharing and distribution, lack of necessary resources and lack of systematic monitoring of compliance. This study reviews some of the longest existing and most successful international energy labelling programs in order to identify remaining gaps in the Chinese program and recommend specific areas for improvement.

We conducted an international technical review of the U.S. EnergyGuide and U.S. ENERGY STAR labels, the Australia Energy Label, the European Union Energy Label, and the Japan Top Runner and Energy Saving Label programs to identify success factors and best practices for the following programmatic elements: legal basis and institutions, technical specification and development, implementation, enforcement and penalties, financial and human resources, technical capacity, information sharing, program evaluation and stakeholder participation and involvement. Based on a qualitative evaluation of the actual barriers and challenges to the implementation of the China Energy Label, we conducted a gap analysis between the China Energy Label and international best practices to identify areas for improvement. Specific policy recommendations for improving each programmatic element of the China Energy Label to strengthen the program are provided.

Measurement of automatic brightness control in televisions – critical for effective policy-making ⁷⁻⁴²²⁻¹⁷

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CLASP Europe, United Kingdom/Belgium

Keywords

television, Ecodesign Directive (EuP/ErP), testing, Energy Labelling Directive, standardisation, energy efficient technologies

Display luminance (“brightness”) is the largest energy consuming function in televisions and monitors. Subjective research on televisions in households has shown that displays can be dimmed when room ambient light levels are naturally reduced, to achieve lower product power consumption while not diminishing the quality of the viewing experience. This energy-saving feature is most commonly called ‘automatic brightness control’ (ABC) and works by dimming the display’s brightness in relation to the room illuminance.

In Europe, manufacturers are given a small (5 %) power allowance when calculating the energy efficiency index for the energy label class, if the model has enabled and effective ABC under low light conditions. In the United States, the ENERGY STAR® program offers manufacturers a nominal allowance for ABC based on summing 25 % of the on-mode power requirement of the display at four nominal illuminance levels. The stark difference between the power allowances in these two leading economies is due in part to the lack of a good practicable test method and ability to characterize and quantify an optimum energy saving benefit of ABC.

CLASP funded research to develop a novel and repeatable approach to the measurement of television power consumption and display luminance versus controlled ambient illumination under ABC control. This paper describes and illustrates the test setup and data logging equipment to capture the television’s power consumption and screen luminance characteristics under a full range of ambient light levels, from <2 lux to >300 lux.

This test method was applied to a small sample of televisions, and test results are provided. The test method provides insight into how the ABC algorithm is written in the television software, with some televisions progressively reducing screen brightness as the ambient lighting levels are lowered, and others simply having one large step reduction at a low level of room illumination. From an energy perspective [...].

Circular economy principles – quantifying the additional greenhouse gas savings potential of products covered under ecodesign ⁷⁻⁴²⁴⁻¹⁷

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Keywords

resources, Ecodesign Directive (EuP/ErP), change of behaviour, emission reduction, durability, circularity

In December 2015, the European Commission adopted an ambitious Circular Economy Package designed to accelerate Europe's transition towards a circular economy. The Commission expects this transition to boost global competitiveness, foster sustainable economic growth and create new jobs. In the context of these wider goals, the authors conducted a study to prepare a first-order estimate of the greenhouse gas emission savings that could be delivered by applying circular economy principles to all products covered by the ecodesign and energy labelling regulations.

The circular economy principles modelled in this analysis were: improved recyclability, extended service life, service economy approach (e.g., product leasing, pay-per-unit-of-service) and improved refurbishment. The potential impact of extended service life, service economy approach and improved refurbishment was estimated for each product group individually. For improved recyclability, product groups were divided into five categories – white goods, lighting, electronics, motors and motor systems, and heating and cooling products. A representative product was selected from each of these five categories for a product-specific analysis and the findings for improved recyclability were then extrapolated to the full product category.

This paper presents results for each of the five product categories. Consumer electronics were found to have the largest greenhouse gas savings potential, particularly for recyclability and extended service life. And, for service economy approach, the study also found the average efficiency of the leased products was the most critical parameter influencing emission savings.

Building on these findings, this paper offers suggestions for next steps – including developing product metrics, stimulating recycled materials markets and developing more detailed market feasibility studies.

Global Lighting Challenge: Changing the world through public-private partnerships

7-427-17

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Keywords

lighting, LED, campaign, public private partnerships

Lighting accounts for 15 % of global electricity consumption and 5 % of global greenhouse gas emissions. Accelerating the transition to energy efficient lighting could be one of the most significant short-term initiatives to improve economic and climate conditions around the world. In recognition of this tremendous potential, the Global Lighting Challenge (GLC) was launched in December 2015 by the Clean Energy Ministerial and the US Department of Energy.

The GLC is a race to reach cumulative global sales of 10 billion high-efficiency, high quality, and affordable lighting products, such as light-emitting diode (LED) lamps. Since its launch, the GLC has built a public-private volunteer coalition of more than 50 governments, manufacturers, retailers, and expert groups working together to accomplish its 10 billion product goal. We put market actors on the same side of the climate change project by promoting businesses who make commitments, and showcasing governments who make endorsements. We have persuaded global industry leaders such as Cree, Philips, and IKEA and smaller groups such as San Francisco Airport and Urban Volt to make commitments. Some governments, such as Sweden and India, have launched their own nationwide LED lighting campaigns. The GLC also looked to collaborate with other international efforts such as the SEAD Initiative's Global Efficiency Medal competition, which is pushing the boundaries of energy efficiency by recognizing innovative new industrial and outdoor lighting technologies. We believe that a major key to success is the focus on building a public-private partnership to reach the COP21 Paris Agreement goals.

This paper presents a theory of change for international campaigns by discussing the difficulties and benefits of building a volunteer coalition on a global scale that seeks to accelerate the transition to energy efficient lighting. We believe that it is very important both socially and economically, to unite public and private groups to the same side of major world issues.

Policies for emerging technologies: solid state lighting examples from SSL Annex member countries ⁷⁻⁴²⁹⁻¹⁷

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Keywords

LED, lighting, Ecodesign Directive (EuP/ErP), regulation, emerging technologies, policy-making, rapidly evolving technology

Every policy-maker knows that setting regulations on emerging and rapidly evolving technologies is difficult. The pace of innovation can be so rapid that it exceeds the natural pace of policy making. And, compounding this problem, new issues and challenges emerge which require careful study to arrive at appropriate responses and interventions. Solid-state lighting, as a new product technology area, is the embodiment of this challenge. Policy-makers seeking to transform their markets and promote more energy-efficient solid-state lighting have to address issues of scope, exemptions, measurement challenges, requirements, and many other qualities and performance features. This paper draws upon the experiences and offers case studies from the IEA 4E SSL Annex member countries who are actively working on energy-efficiency and performance requirements for SSL retrofit lamps and luminaires.

The paper highlights a portfolio of market transformation policy and programme tools used around the world support and sustain the market for high quality, energy-efficient LED products. Across all the key segments of the supply chain, governments and energy-efficiency programmes can play an important role in raising awareness of efficiency opportunities, while helping to build demand for and stimulating supply of quality energy-efficient, quality lighting.

Brief case-studies are offered in this paper highlighting lessons learned and programmes developed across the membership of the SSL Annex. The initiatives are classified into four categories: (1) quality assurance; (2) communication approaches; (3) manufacturing support and (4) incentives for buyers. Sharing these best-practice case studies will hopefully stimulate other governments to take action, and develop their own portfolio of initiatives to promote high-quality LED lighting.

PANEL 8

Monitoring and evaluation:
building confidence
and enhancing practices

The SHOWE-IT project, an experience sharing on ICTs services in social residential buildings ⁸⁻⁰⁰²⁻¹⁷

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Keywords

energy efficiency programmes, housing energy consumption, smart metering, ICT

According to the European Commission (EC), houses and buildings considering their whole life cycle are responsible for 40 % of total EU energy consumption. Buildings are also the largest source of greenhouse gases emissions, accounting for 36 % of overall European CO₂ emission.

Taking into account that 85 % of the total energy consumption within a building life cycle is due to building operation phase, savings related to uses of buildings seem to have the highest potential impact for a consumption reduction. According to Buildings Performance Institute Europe, in 2009 European households were responsible for 68 % of the total final energy used in buildings where as much as 70 % of the energy is used for space heating. Considering global sustainability challenges and in link with the 2020 targets (20 % energy demand reduction, 20 % CO₂ reduction and 20 % of energy from renewable sources), ICTs enabler technologies are expected to become a key solution for the reduction of energy consumption in residential housing in the upcoming years.

ICTs based solution developed and tested in the SHOWE-IT project provide the home automation and consumption monitoring in the residential housing sector with the goal of achieving 20 % reduction in gas and energy consumption. The SHOWE-IT project provided an excellent opportunity to try in a real-life environment a system, which was meant to become an optimal combination of technologies to address the energy reduction challenges in the residential buildings.

Over the lifetime of the project it became clear that a combination of off-the-shelf technologies does not always perform as expected. The project offered many lessons which are to be considered in the future development and application of ICTs based technologies for the residential housing sector. This paper presents and shares the learning and the experiences obtained during the SHOWE-IT project from [...].

Evidence, drivers and sources of distortions in the distribution of building energy ratings prior to and after energy efficiency retrofitting ⁸⁻⁰⁰⁸⁻¹⁷

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Keywords

energy performance certificates retrofit, bunching

Energy performance certificates (EPC) provide a measure of and raise the awareness of the energy efficiency of homes. The Sustainable Energy Authority of Ireland (SEAI) operates a grant aid scheme to incentivise residential energy efficient retrofits known as the Better Energy Homes (BEH) scheme, which was implemented in 2009. Since June 2010, participating homes have been required to undertake independent Building Energy Rating (BER) assessments of the home prior to and after the completion of energy efficient works. This study analyses the distribution of pre- and post-works BERs among participant households, using a regression discontinuity design to examine the significance of discontinuities at each BER grade threshold and to estimate the number of affected BERs in our sample. We find evidence of bunching at the more efficient side of thresholds of post-works BERs, while no evidence of bunching on the more efficient side was found among pre-works BERs. There exists slight evidence of bunching on the less efficient side of certain thresholds in the pre-works distribution. Counter-factual distributions around each threshold are estimated to examine the number of dwellings which may have been affected by potentially incorrect assessments. We analyse whether adjustment of BER assessments is systemic and whether market forces provide an incentive to adjust assessments. Results show significant evidence of the misrepresentation of Building Energy Ratings but this is not found to be systemic. We also examine potential sources of adjustment, finding discontinuities in certain parameters coinciding with the areas where bunching is found to occur.

Adapting an English methodology to assess health cost benefits of upgrading energy inefficient French dwellings ⁸⁻⁰⁶⁴⁻¹⁷

Dr Véronique Ezratty, Professor David Ormandy, Marie-Hélène Laurent, Anne Duburcq, Carole Lenchi, Laurene Courouve, Fabienne Boutière, Pierre-André Cabanes & Jacques Lambrozo

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Keywords

housing, cost benefit, health, domestic, France

There is a growing bank of evidence on the health and well-being gains from alleviating energy inefficiency in housing. The gains are strongest for vulnerable groups such as those on low income, and, in particular, the elderly, children and those with existing respiratory illness. To date, the health costs attributable to energy inefficiency and energy precariousness have not been calculated in France where more than 5 million households (12.5 million people) are estimated to be energy vulnerable. However, the health costs associated with energy inefficient dwellings have been estimated in England based on the Housing Health & Safety Rating System (HHSRS) a health-based risk assessment system, incorporated into English law in 2006, and unique in Europe.

Our objective was to adapt the English methodology based on the HHSRS to provide a means to estimate the health costs associated with energy inefficient dwellings and energy vulnerability in France, and then compare this with cost benefits of thermal improvement.

Adapting this methodology, and focusing on energy inefficiency and vulnerability involved the following steps:

1. Using an energy efficiency indicator inspired from the UK Standard Assessment Procedure (SAP) to determine the number of energy inefficient dwellings where the risk to health could be deemed totally unacceptable.
2. Relating the energy inefficient dwellings to the probability of exposure to low indoor temperatures and an occurrence resulting in negative health outcomes to residents, making it possible to estimate the cost to the health sector associated with such exposure. [...]

Lessons from the United States and China for increasing transparency and harmonizing measurement and verification practices in the buildings sector 8-089-17

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Keywords

measurement and evaluation, buildings, benchmarking, measurement and verification, building retrofitting, disclosure, transparency

In recent years, municipal governments globally have determined that building energy performance benchmarking and disclosure policies are effective in encouraging the development of a strong market for building energy efficiency (Dunsky et al. 2009). A comparison of global benchmarking and disclosure policies show a range of requirements, but most typically these include requirements to disclose annualized energy and usage data using standardized rating tools on a yearly basis or at the time of sale (BuildingRating 2010–2014). While valuable, disclosure data are only really effective if it inspires action (i.e., retrofits of underperforming buildings) and quantification of impact or “net savings” of policies (i.e., gross energy savings minus free ridership plus spillover plus market effects). Both of these objectives can be difficult to achieve from annualized, whole-building energy performance metrics alone. This paper will discuss results from a new initiative under the U.S.-China Clean Energy Research Center Building Energy Efficiency (CERC-BEE) program (an initiative to support top scientists, engineers, and policy analysts from the United States and China in collaborative research to accelerate the development and deployment of clean energy technologies in the buildings sector) to jointly identify disclosure data points and develop automated building retrofit analytic tools for municipal benchmarking and disclosure programs that support better up-front assessment of retrofit opportunities; measurement and verification (M&V) of energy, cost and carbon dioxide (CO₂) reduction; and building energy policy evaluation, measurement, and verification (EM&V). The paper sheds light on how the world’s two largest economies and emitters of greenhouse gases (GHG) are increasing transparency and harmonizing M&V of building energy savings, providing lessons and opportunities for global scale-up.

More than energy savings: quantifying the multiple impacts of energy efficiency in Europe

8-108-17

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Keywords

benefits, impact assessment, air pollutants, energy security, economic impact, resources, fuel poverty, multiple impacts, multiple benefits

Energy efficiency improvements have numerous benefits/impacts additional to energy and greenhouse gas savings, as has been shown and analysed e.g. in the 2014 IEA Report on “Multiple Benefits of Energy Efficiency”. This paper presents the Horizon 2020-project COMBI (“Calculating and Operationalising the Multiple Benefits of Energy Efficiency in Europe”), aiming at calculating the energy and non-energy impacts that a realisation of the EU energy efficiency potential would have in 2030. The project covers the most relevant technical energy efficiency improvement actions and estimates impacts of reduced air pollution (and its effects on human health, eco-systems/crops, buildings), improved social welfare (incl. disposable income, comfort, health, productivity), saved biotic and abiotic resources, and energy system, energy security, and the macroeconomy (employment, economic growth and public budget). This paper explains how the COMBI energy savings potential in the EU 2030 is being modelled and how multiple impacts are assessed. We outline main challenges with the quantification (choice of baseline scenario, additionality of savings and impacts, context dependency and distributional issues) as well as with the aggregation of impacts (e.g. interactions and overlaps) and how the project deals with them. As research is still on-going, this paper only gives a first impression of the order of magnitude for additional multiple impacts of energy efficiency improvements may have in Europe, where this is available to date. The paper is intended to stimulate discussion and receive feedback from the academic community on quantification approaches followed by the project.

Effectiveness of energy renovations: a reassessment based on actual consumption savings ⁸⁻¹¹⁷⁻¹⁷

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Keywords

energy efficiency improvements, monitoring, energy savings, non-profit housing

Energy renovations offer unique opportunities to increase the energy efficiency of the built environment and for the existing housing stock, they are the most important solution. Usually, the energy savings are based on modelling calculations. However, recent research has shown that the predicted energy consumption differs largely from the actual consumption. In this paper, the effectiveness of energy measures is re-assessed based on actual consumption data. We utilize a monitoring system, which contains information about the energy performance of around 60 % of the Dutch non-profit housing sector (circa 1.2 million dwellings). We connect the data from this monitoring system to the actual energy consumption data from Statistics Netherlands on a dwelling level. Using longitudinal analysis methods, from 2010 to 2014, we are able to identify the energy efficiency improvements of the stock and determine the effectiveness of different measures in terms of actual energy savings. The results reveal the actual energy savings of different efficiency measures and highlight the significance of the actual energy consumption when a renovation is planned or realized.

Impacts and cost-effectiveness of major energy efficiency policies for existing buildings: what do we exactly know and what can we learn? 8-121-17

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Keywords

cost effectiveness, data, existing buildings, national energy efficiency action plans (NEEAPs), evaluation, energy efficiency policy, comparisons

There have been many reviews about how energy efficiency policies for existing buildings work, but more rarely about the details of their effective impacts and costs, mainly due to difficulties in accessing data. The National Energy Efficiency Action Plans enable to know what policies are implemented and how. But details about their impacts and costs can often be found in national language only, and rarely in a single report (if available at all).

This paper presents an analysis of ex-post evaluations and monitoring reports available for 13 major energy efficiency schemes for retrofitting buildings. The first part reviews the data about evaluation methods, energy savings, and costs. It describes the main data found and discusses to what extent these data can be compared. This stresses the need for in-depth study to correctly analyse the data.

The second part proposes a methodology to compare results and costs of different policies, illustrated by one pilot comparison between the Italian and the French tax credit schemes. This example shows the importance to take into account the differences in the scope and methods used to estimate the impacts and costs when comparing indicators such as cost-effectiveness ratios.

The paper concludes with a discussion about the need to promote information sharing between the Member States and evidence-based approaches for the design and management of energy efficiency policies.

A proposal to go beyond the rebound effect: how to evaluate the financial value of comfort after retrofitting?

8-134-17

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Keywords

rebound effects, value, comfort, retrofit, economic assessment

Evaluation of energy savings of retrofitting programmes are relativized due to the rebound effect. Moreover, their economic relevance (i.e. NPV calculation) is questioned because of the discouraging paybacks. The underlining question of both problems is missing consideration of comfort improvement, often hidden behind the concept of rebound effect.

Yet, it can be considered that some potential energy savings in an initially uncomfortable dwelling are assigned to achieving decent comfort. In this case, the household sets aside some of the potential savings to improving thermal comfort and thus part of the rebound effect is simply to catch up. It therefore imports to distinguish within the so-called rebound effect between the share of legitimate comfort improvement and the energy “wastage”.

We propose an approach embodied in a formula to monetize the comfort catch-up relying on the comparison of ex-ante and ex-post energy savings. This approach has been applied to regional energy efficiency programmes consisting for each participant to the realisation of one to two energy efficiency measures concerning insulation and/or heating equipment of his housing. These cases study are located in 3 different regions with different climates (oceanic, continental and Mediterranean). After refurbishment, we evaluate the level of comfort catch up according to the set-temperature and the difference between the real consumption and its potential value at a conventional set-temperature.

The methodology turned out to be quite easily applicable providing that some essential data are available (energy consumptions and set-temperatures before and after retrofit). Quantitative results of comfort catch up are in the same order of magnitude of energy savings.

Energy efficiency in dwellings: it works! Retrofitting represents $\frac{3}{4}$ of French dwellings space heating consumption 2006–2013 decrease 8-171-17

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Keywords

evaluation methods, efficiency classification, Directive on Energy Performance in Buildings (EPBD), efficiency standards

Since 2000, a significant and continuous decline in dwellings Space Heating (SH) consumption has been observed in several European countries; including France. The decrease is very fast (18 % between 2000 and 2015) and could suggest that its main cause is the change in households' behaviours. This assumption is reinforced by the important increase of retail energy prices that has been observed during the same period.

Obviously, another important cause explaining this fast decline is the improving energy efficiency of the housing stock due to the refurbishment of existing dwellings.

In order to check if the addition of retrofitting actions conducted by French households could explain the decrease of consumption by itself, an evaluation of cumulated savings due to the refurbishment of existing dwelling stock has been made.

Several national surveys exploring French housing retrofitting market have been conducted in France since 2006. Thanks to these surveys, a compilation of the retrofitting actions conducted between 2006 and 2013 has been built. During this period, the annual current flows were 3.66 million thermal insulation gestures and 1.125 million replacements of heating systems. Nearly 3 million housing per year (principal residences) was affected (10 % of the whole dwelling stock). Building insulation gestures were the majority of the retrofitting actions but the unitary efficiency (per gesture) was usually considered as low.

Three scenarios have been defined. We assume same annual number of retrofitting actions for the three scenarios. The differentiation between scenarios relies on the levels of "retrofitting intensity" (unitary energy savings per gesture): pessimistic, neutral and optimistic.

By 2013, the two realistic scenarios (pessimistic and neutral) give [...].

Reaching the finish line: Analysis of the differences between active participants and drop-outs in a behaviour change intervention

8-176-17

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Keywords

behaviour, social networks, social support, attrition

Living Lab research faces high participant drop-out rates during prolonged engagement in interventions. In a recent study, approximately 55 % of the 104 voluntary participants dropped out. Although drop-out occurs, interventions show positive behavioural impacts for the participants who remain. Therein exists the need to understand what differs between people who 'stay in the race' and those who become inactive. A 3-month field trial in Spring 2016 comparing the effectiveness of a gamified household-level electricity savings challenge provided hourly electricity consumption data and savings activities to participants. Pre- and post-intervention surveys sent to the 104 participants collected data on the reported behaviour and perception of social norms of the two groups: active (n=44) and inactive (n=22), thus N=66 completed both surveys. Thus, it was possible to differentiate the experience of the two groups to determine the impactful components of the intervention.

As reported electricity use differed significantly between the active and inactive participants, this indicated that the desired behaviour change was connected to participation. As well, the feeling of being socially supported with guidance and information during the intervention was found to relate to participants' change of behaviour towards more sustainable patterns over time with the active participants reporting a significantly increased feeling of being supported to save electricity.

This study underlines the importance of having informational social support as an intervention component to induce the behaviour change, but still asks whether informational support is a precondition to a successful behaviour change or whether it is an outcome of remaining active in an intervention. But whether the first or second statement is true, we assume that informational social support encourages participation over a longer time period.

Energy performance of buildings: A quantitative approach to marry calculated demand and measured consumption ⁸⁻¹⁸⁵⁻¹⁷

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Keywords

measurement and evaluation, methods, energy savings calculation, energy saving potential, energy consumption, energy demand, calibration of demand and real consumption

Energy Performance Certificates (EPCs) for residential buildings are supposed to inform about the efficiency of heating and domestic hot water preparation in buildings under standardised boundary conditions regarding user behaviour and climate parameters. In a way EPCs represent a virtual test rig for the building to demonstrate whether it complies with the requirements of the corresponding energy savings ordinance.

Measured consumption usually differs from the calculated demand in a typical manner, in particular when, as in EPCs, simplified calculation models and standard specifications are applied: For existing, not yet modernised buildings it tends to be lower, for refurbished or new buildings higher than calculated. Partly this can be attributed to what is called prebound or rebound effects. Of course this deviation is not desirable since calculated energy saving and cost effectiveness of refurbishment measures are over-estimated. A layperson does not really understand the difference in numbers between EPC and energy bill, f.i.

These effects were analysed in two projects. The first one referred to the Energy Performance Certificate Register for residential buildings in Luxemburg, run by the Luxemburg Ministry of the Economy, containing 20,000 records, each consisting of 174 parameters per building, including the measured consumption. The second one analysed 92 well-documented records of non-residential buildings in Germany consisting of hundreds of building parameters including measured consumption. The latter had been gathered in the research project "Teilenergiekennwerte von Nichtwohngebäuden" (TEK) financed by the German Federal Ministry of Economic Affairs and Energy.

Statistical methods such as multiple linear regression and error calculus were [...].

Monitoring the market based on sales data: Do 2015 white goods consume less energy than ten years ago?

8-206-17

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Keywords

evaluation, refrigerators, washing machines, dryers, market monitoring, sales data

Knowing the market is key for deciding on energy label classes' thresholds, minimum energy performance standards (MEPS) and revisions of these. Up to now, the European Commission has no systematic approach to monitor the market and evaluate policy measures. Our paper demonstrates the potential of systematic market monitoring based on sales data. The results support the revisions of the Ecodesign and Energy Labelling regulations. In a report to be published in March 2017, we have analysed comprehensive sales data from GfK for refrigerators, washing machines and tumble driers. The data covers the years 2004–2015 for the national markets of France, Germany, Italy, and for the whole EU market. It includes information on sales per energy efficiency class, average energy consumption, size and price.

The results show that the efficiency of refrigerators has improved by 37 % since 2004. The energy consumption, however, has decreased less than could be expected from this. For washing machines, the results confirm a strong trend to larger drums. High efficiency is strongly linked to large drums. Considering the low efficiency of small partial loads, this trend lets us question the reported energy savings. Heat pump tumble driers have continued to extend their popularity among consumers: this energy-efficient technology made up nearly half of all drier sales in the EU average in 2015. On certain national markets, their sales share can be even higher. Over their lifetime, heat pump driers are less costly than class B driers. In the revision of the Ecodesign regulation, due in 2017, a ban of driers less efficient than class A+ could save Europe around 5 TWh per year. The results further show large differences between national markets – even though the same regulatory framework applies in all EU Member States, and the same international manufacturers dominate most markets.

Retrofit 'daemons' in the process of low-carbon housing stock renovation 8-207-17

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Keywords

low-carbon buildings, residential buildings, risk management, retrofit, deep renovations, work stages, performance gap

The 'performance gap' between design and actual energy use is well recognised. Much of the debate on the performance gap focuses on the use and accuracy of building energy models or on the 'misbehaviour' of users and maloperation of measures. This paper focuses instead on the design and construction phases of retrofit projects.

Pioneering case studies in deep low-carbon refurbishment in the UK show a lack of quality assurance and poor integration of the intermediate stages between design and implementation within retrofit process. In retrofitting existing buildings there is an unseen presence of 'good' and 'evil' daemons that are 'hidden' in different retrofit work stages. The intermediate construction stages from design to delivery tend to involve the majority of unforeseen complexities that are difficult to know until work is under way. The consequence of this is not only an uncertainty in actual energy performance that challenges the ambitious carbon emissions reduction targets, but also an unwillingness to invest in low-carbon technologies due to concerns about what will actually be achieved. A more sophisticated understanding of the different types of risks within the retrofit process, from technical or economic risks to commissioning and handover related ones, is required.

Using established professional work plan frameworks, this paper first defines a Plan of Work as a continuous cycle of different retrofit workstages and roles, augmenting and assisting current professional scopes of service, not replacing them. The notion of 'risks' is used as a lens for managing and reducing unintended consequences and the performance gap. Drawing upon the evidence from academic and grey literature review, this paper then defines the types of risk(s) encountered within the different retrofit workstages by exploring evidence-based problems, concerns and 'daemons' that emerge as major contributors preventing the full potential of low-carbon refurbishments from being achieved.

Review of evaluations of policy instruments for energy efficiency in buildings in Sweden ⁸⁻²²¹⁻¹⁷

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Keywords

evaluation, energy efficiency policy, buildings, case studies

The built environment accounts for approximately 32 % of the global final energy use but also holds great potential for energy efficiency still to be harnessed (Lucon et al., 2014). To develop innovative policies for energy efficiency that are capable of realizing transformative changes, we argue that there is an urgent need for new systemic evaluation frameworks that provide learning and knowledge on how policy initiatives provide energy efficiency in the built environment. Moreover, there is a need to understand to what extent evaluation practices today apply evaluation frameworks with a systemic and transformative approach.

This paper presents a critical assessment of 30 evaluations commissioned by Swedish authorities 2005–2015 on policy instruments for energy efficiency in buildings. The assessment is based on a systemic theoretical framework developed and based on general insights from evaluation theory and transition theory. The main categories of assessment are: the data and methods applied in the evaluation, the value judgment in evaluation and the use of evaluations. The results show some important aspects of a systemic approach but also reveal room for improvements. The reviewed evaluations used multiple methods and multi-criteria analysis, providing a thorough base for evaluation. However, the design, methods and data used could be much stronger if taking a broader system approach and including aspects of side effects, attribution, rebound-effects and triangulation. The design could also more explicitly assess aspects of transitions related to visioning, experimentation and learning. The value judgment in the evaluations used one to three criteria, of which impact and effectiveness were the ones most frequently used, leaving room for further reflections and analysis. Moreover, use of the evaluations was not explicitly mentioned.

Characterization of utility programs' enrollment by income and region ⁸⁻²²²⁻¹⁷

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Keywords

evaluation, smart metering, programme evaluation, public policy

Utility programs aimed at promoting energy efficiency, demand side management, or reducing burdens on low income households have been used as key policy mechanisms to promote energy and emissions reductions and to improve the level of energy services provided. However, to date, there are few characterizations of how the adoption of and enrollment in different types of programs varies geographically, by demographic characteristics and by consumption patterns, within a utility territory. Understanding uptake can help identify equity gaps and areas for increased outreach. In this work, we use a stratified sample of approximately 30,000 households in Pacific Gas & Electric (PG&E) service territory from 2008 to 2011, complemented with demand-side management and energy efficiency program participation, and with census block level demographic information, to better understand where programs are adopted, and by whom. We find that participation in California Alternative Rates for Energy (CARE) – a program that provides lower electricity rates for eligible households that have low income – is prevalent across all climate regions, and grows substantially over time in all regions and income segments. Energy efficiency rebate programs are predominantly used by households located in census blocks that are in the high median income group, even with free efficiency measures for low-income households. The SmartAC demand response program, which requires smart meter installation, surpassed 5 % participation in high- and middle-income households in the warmer Central Valley by the end of 2010, within two years of meter installation. Overall, these results suggest that there are important demographic differences in program participation across climate regions and program types. Understanding these differences can inform deployment of similar programs by other utilities, and identify areas for additional outreach to spur appropriate adoption.

Estimation tool for national effects of MEPS and labelling – version 2.0 8-238-17

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Keywords

evaluation, energy labelling, energy savings, savings potential, ecodesign, baseline, minimum energy performance standards (MEPS), scenario study, effect simulation, web-crawler data

Within EU-28 appliance energy efficiency is addressed through end-use specific energy labelling and ecodesign requirements (MEPS, minimum energy performance standards). The assumed energy savings of these measures are assessed at EU level but seldom at National level. A simple, yet flexible tool for evaluation of ecodesign and labelling measures at national level has been developed and used for Sweden and Denmark.

The model is a classic bottom-up model establishing stock calculations based on knowledge about sales in high detail. The tool uses nation specific historical sales figures and/or stock data, distributions of sales by energy efficiency classes and assumptions about technology lifespan and natural sales development. The results are an ex-ante estimation of the future sales distribution by technologies/energy classes and the energy consumption of the future stock of appliances. A comparison with a baseline/assumed natural development provides estimates of the energy savings from ecodesign and energy labelling.

For the national energy agencies in Denmark and Sweden, it is very valuable to be able to estimate the national effect of the ecodesign MEPS and labelling schemes. For example, the national estimations can be used in energy consumption forecasts and policy evaluations.

In this paper, we

- describe the basics of the estimation tool together with important assumptions
- present energy savings estimates for several white goods groups for Sweden
- compare earlier ex-ante savings estimates for white goods with the actual development and analyse the differences
- discuss the baseline [...]

Productivity impact from multiple impact perspective

8-248-17

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Keywords

econometric evaluation, productivity, multiple impact

Full economic assessment taking all the costs and benefits is required to enable the potential of any energy policy. However, today these assessments often exclude important factors such as co-benefits/multiple impacts of any energy policy. The inclusion of additional impact into decision-making analysis may influence any policy maker to design a policy portfolio. Most of the time, multiple impacts of energy efficiency policy are not incorporated into ex-ante policy analysis due to the absence of mature methodologies.

The purpose of this paper is to provide a comprehensive methodological framework which addresses the key challenges to incorporate multiple impacts especially productivity impact into a decision-making framework.

This study first talks about the importance of incorporating multiple impacts of energy efficiency measures into decision-making framework by taking productivity impact as an example and then it identifies the key methodological gap of multiple impacts especially productivity impact accounting. Lastly, it proposes a framework to quantify and monetize productivity impact in a systematic manner.

This paper contributes to the methodological toolbox by proposing the solutions to the key methodological challenges of aggregation of multiple impacts by taking productivity impact as an example. This study proposes a systematic and analytical framework which addresses key challenges such as double counting, additionality, baseline, context dependency and distributional effect to evaluate productivity impact.

This paper is an output of Calculating and Operationalising the Multiple Benefits of Energy Efficiency in Europe (COMBI) project. COMBI project is a part of the European Union's Horizon 2020 research and innovation programme.

Quantifying the impact of green leasing on energy use in a retail portfolio: limits to big data analytics 8-256-17

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Keywords

retail, tenants, analytics, efficiency, green lease

The retail sector is a significant contributor to any industrialised economy and, as a result, a major consumer of energy. Large retailers are aware of the contribution energy makes to their operational costs and of many opportunities available for efficiency measures. However, many retailers are tenants rather than owner-occupiers greatly complicating the implementation of energy and carbon saving technologies ('energy upgrades') because of this predominance of leasehold properties. This introduces a barrier as many of the larger, and hence more impactful, energy efficiency measures require active collaboration between the (landlord) owner and (tenant) occupier for successful implementation, possibly requiring changes to either the building fabric or plant/equipment.

New mechanisms have been developed aiming to smooth this possible barrier, through the use of environmentally conscious legal instruments: either Memorandum of Understanding (MoU) between parties with existing tenancy agreements; or directly inserted clauses specifying mechanisms for collaboration between parties within new lease agreements, so called 'Green Leases' (GL). This paper aims to explore whether there are quantifiable benefits from their use.

Using data from a large UK retail chain we have investigated, using a number of different analytical methods, the visibility of consumption changes after the introduction of an MoU or GL for a number of different classes of stores operated. With the limited dataset available it is, however, difficult to establish a clear causal link between their introduction and statistically significant consumption changes. As such we discuss these limitations and how with the addition of further sources of information we may be able to improve on the analyses performed.

Can big data drive the market for residential energy efficiency?

8-295-17

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Keywords

data, residential, market barriers, energy performance certificates, building refurbishment

The building sector is fragmented and disaggregated; hence the availability of reliable data on building characteristics, energy use and related socio-economic factors has been challenging. However, European energy efficiency analysts increasingly have access to one major source of building level data: Energy Performance Certificate (EPC) registers.

An EPC certifies how energy efficient a building is and gives it a rating, letting the user be aware of how costly it is to get the right thermal comfort. Data from EPCs, if properly collected, archived, managed and analysed, can provide precious information and complement other sources for decision making on the energy performance of buildings. Much wider access to, and affordability of large scale data handling technologies (the “big data revolution”) makes possible the presentation of this data in accessible ways for policy makers and market actors. Intuitive analysis for predictive insight is spreading nowadays, and a number of dedicated services and open platforms are available, even in the energy sector. But to what extent do new data services overcome the barriers to the development of the market for home energy efficiency? The Request2Action (R2A) Intelligent Energy Europe project is being delivered principally by national energy agencies responsible for managing EPC databases. The project aims to drive retrofit action in the residential sector by addressing the knowledge and capacity building barriers making retrofit data available to home-owners, the supply chain and policy makers in new and dynamic ways. This paper focuses on if and how the different market actors respond to the new information being made available. Within the R2A project hundreds of stakeholders in 8 countries collaborated in providing specifications, information and evaluation that are essential to guarantee effectiveness of the data services, according to [...].

Are we heading towards a replicability crisis in energy efficiency research? A toolkit for improving the quality, transparency and replicability of energy efficiency impact evaluations 8-299-17

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Keywords

impact evaluation, energy efficiency assessment, energy efficiency gap, replication crisis, randomised control trial

Several high-profile replication failures have called into question the reproducibility of results in medicine, neuroscience, genetics, psychology and economics (Camerer et al. 2016). A paper published in *Science* found that just one third of psychology studies could be replicated when the study was run for a second time (OSC 2015). To our knowledge, there have been no attempted replications of energy efficiency studies; so can we be confident that the estimated energy savings from policy initiatives like the European roll out of smart meters will be realised? Or that electric vehicles will reduce carbon emissions by predicted levels? Or is energy heading towards its own reproducibility crisis? Researchers call for the increased use of randomised control trials (RCTs) to evaluate energy efficiency policy and the introduction of protocols or guidelines for conducting experiments (Vine et al. 2014; Frederiks et al. 2016). However, no guidelines for increasing reproducibility have been proposed. Moreover, RCTs are just one method for causal analysis and RCTs cannot answer all important causal questions. This paper will outline research methods for improved impact assessment of energy efficiency policy, including RCTs, but also quasi-experiments and systematic reviews that go beyond the conclusions of single experiments. It will then present tools for increasing replicability: pre-registration of trials; pre-analysis plans; reporting standards; synthesis tools and; publication of datasets with computer code in data repositories. Based on work by our research group at the UCL Energy Institute, we recognize that not all of these tools (mostly from medical trials) provide 'off-the-shelf' models for energy efficiency evaluations, and so consider adaptations for energy research. Our aim is to stimulate [...].

The German market for energy efficiency services

8-307-17

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Keywords

ESCO market development, energy services, market performance, market development, monitoring, energy service market

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 service market and for developing proposals for its further improvement according to the German Act on Energy Services and other Energy Efficiency Measures (EDL-G).

The BfEE has published two studies on the energy service market in general: The first was published in 2013 and focused on analyzing the supply side of the market (BfEE 2013). It confirmed that there already is a relatively well-developed market for energy services in Germany. However, given the breadth and variety of market actors and products, the market can be described as very heterogeneous. Also, the understanding of the product terms differs between actors, making it difficult to define the market and to draw conclusions about market performance. The second market study was carried out between July 2015 and October 2016. It aimed to update and specify the findings of the previous study. A significantly greater focus was placed on the research of the demand for energy services of households and small and medium enterprises (SME). The results make it possible to assess the current development of the market performance and to gain insight into the expectations and motivations as well as the awareness towards energy services.

The paper discusses available data and problems of monitoring and evaluation of the energy service market in Germany. It also deals with the idea of an ongoing monitoring study that would allow evaluating the market situation in a regular and detailed way.

A comprehensive indicator set for measuring multiple benefits of energy efficiency

8-314-17

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Keywords

capacity building, efficiency, methodology, indicators, multiple benefits

In this paper, we develop a quantitative indicator approach to measure multiple benefits of energy efficiency (MB-EE). The MB-EEs are classified into three groups: environmental, economic, and social-related MBs. The first group contains most relevant and direct aspects of energy efficiency such as energy savings and reduced GHG emissions. The second group comprises, among others, positive macro-economic impacts on economic growth, for innovation and competitiveness as well as import dependency. The third group of impacts covers aspects such as health benefits, poverty alleviation and employment. Quantitative knowledge on these MB-EE is, however, scattered and not easily accessible for the actors in the policy field. Spreading information on these benefits in an easily accessible way will contribute to the capacity building of the actors on these additional benefits. In order to achieve this goal, we develop a comprehensive quantitative indicator set consisting of 20 indicators covering the different aspects of MB-EE. We discuss the methodological approach to the indicators set, the underlying data sources and limitations. This indicator set is planned to be applied for 31 countries (EU28 plus Norway, Switzerland and Serbia) to provide a comprehensive tool of MB-EEs. This allows an in-depth comparison of developments and differences across Europe. The indicator set also supports the design of well-suited energy policies by taking into account, on an informed basis, more of the beneficial aspects of energy efficiency in future.

Comparing energy efficiency scoreboard methodologies and results 8-343-17

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Keywords

data, energy efficiency policy, policy evaluation, methodology, evaluation methods, scoreboard, scorecard

We carry out in this paper a comparison of the methodologies and results of Energy Efficiency Scoreboards. Several such scoreboards have been developed in recent years notably the International Energy Efficiency Scorecard and the State Energy Efficiency Scorecard by ACEEE and the ODYSSEE-MURE Energy Efficiency Scoreboard. We also provide an overview of other policy scoreboards in the energy field and look to lessons learned from other fields beyond energy (such as scoreboards to measure innovation or educational capabilities of countries). We analyse the methodologies used to compose the scoreboard, the possible impact of the methodologies on results, the data sources and data requirements for establishing the scoreboards, the ranking procedures, and the results. We also discuss how the scoreboards have impacted or may impact policy making.

Assessing developments in a type of German on-site energy consultation for private homes on the basis of evaluations carried out over a set time period 8-394-17

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Keywords

evaluation, building retrofitting, data monitoring, customer feedback, energy consultation programme

The energy renovation of residential building plays an important role in the German “Energiewende”. Energy consultation with private homeowners is one of the most important instruments in achieving the ambitious goals of the ‘Klimaschutzplan 2050’, which has been part of the accepted roadmap for the national strategy towards climate protection since December 2016.

The Consumer Association in North Rhine-Westphalia (Verbraucherzentrale NRW) has offered energy consultancy products to their customers since 2008 in three different projects. These include an on-site energy audit for private homeowners for a subsidised fee. The energy consultation is an essential component that is designed to improve the customer’s knowledge about the energy efficiency standards of their buildings, and to develop individual measures to lower energy consumption. An additional thermograph examination was offered in order to reach customers in a different way during several winter periods. The on-site consultation is offered mainly to owner-occupiers with single family buildings, or small to medium-sized buildings with up to six residential units.

The results of the energy consultations have been evaluated by the Institute for Energy and Environmental Research (ifeu) in collaboration with Kantar Emnid for the years 2008 (MHS project evaluated in 2011), 2013 (KEK project evaluated in 2014), and 2015 (ENerWin project evaluated in 2016). Each evaluation was based on a survey of 500 customers. In 20-minute CATI interviews the customers answered a set of individualised questions based on the measures conducted. The consistent nature of the surveys throughout the three evaluation periods enables tracking of developments over time. What were the preferred building components for insulation? Which heating systems were installed in which period? How did the energy [...].

Database for monitoring and evaluating government energy efficiency programs: a Japanese case ⁸⁻⁴⁰⁵⁻¹⁷

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Keywords

policy evaluation, database, governance, programme evaluation

To monitor the governmental support for energy efficiency and assess its progress, it is vital to keep track of basic aspects of energy efficiency programs, such as expenditures, targeted sectors, supported technologies and energy savings achieved. However, because energy efficiency programs are so diverse and are sometimes managed by various departments of a government, it is often difficult even to make a comprehensive list of the programs and to identify the total amount of public funding for them, not to mention their energy savings. In this paper, the author makes a case study of Japanese energy efficiency programs using a unique database called "Governmental Program Review Sheets" (GPRS). GPRS covers all of the programs funded by the Japanese government, of which number amounts to around 5,000, and contains basic information such as objectives, outlines, expenditures, and outcomes of each program in a standardized format. GPRS was firstly published in 2010 by the government as an administrative reform activity, and since has been being amended annually. GPRS can be a powerful database for monitoring and evaluating energy efficiency programs. By using GPRS, the paper provides comprehensive quantification of public funding to support energy efficiency in Japan, as well as their cost per saved energy, and makes some policy recommendations. The paper also tries a comparative analysis between Japan, US and Europe concerning similarities and differences of public funding for energy efficiency based on related data from literature in other two regions. The paper concludes by discussing the usefulness of program database like GPRS for making and evaluating energy efficiency programs.

M&V 2.0: hype vs. reality ⁸⁻⁴¹³⁻¹⁷

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Keywords

measurement and verification, econometric evaluation, non-compliance, data analytics

The rollout of advanced metering infrastructure has created an opportunity to derive additional value from energy efficiency programs by obtaining more timely and more granular estimated impacts than those made available through traditional measurement & verification (M&V) approaches. This paper presents two different, but related, approaches to leveraging residential high frequency energy consumption data for program management and evaluation: custom econometric analysis and third-party software tools (commonly referred to as M&V 2.0). These approaches are still relatively new, and the question remains for many utilities: how much of M&V 2.0 is hype, and how much is real?

In the fall of 2014, DTE Energy set out to better understand the true potential of emerging M&V approaches and to determine the relative benefit of these approaches in a deemed savings environment. To accomplish this, the company chose to pilot test both the econometric and software-based M&V 2.0 approaches to determine which represents the most effective method for performing M&V.

This paper presents the findings of this evaluation to-date, beginning with the market research performed to determine the potential options for packaged “M&V 2.0” type software tools capable of evaluating residential energy efficiency programs. It goes on to discuss the structure of this evaluation, including the process of establishing program goals, identifying a testbed energy efficiency program, and selecting a vendor. Last, the paper highlights lessons learned along the way, in the hopes that other utilities interested in testing M&V 2.0 approaches will find this information beneficial. Results from comparing traditional and M&V 2.0 methods are forthcoming, and may be shared at the time this paper is presented.

PANEL 9

Consumption and
behaviour

Evidence from a national grant aid scheme for residential energy efficiency retrofits: application abandonment, retrofit depth and free-riding

9-005-17

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Keywords

retrofit, grants, abandonment

In order to facilitate energy efficiency, retrofit works in the home, the Sustainable Energy Authority of Ireland administers the Better Energy Homes scheme as a means of contributing to a 20 % reduction in Ireland's energy use by 2020. At present, grant aid is available for up to four energy efficiency retrofit measures. This paper brings together findings on various aspects of the grant aid scheme, these being the abandonment of applications to the scheme, retrofit depth within the scheme and the extent to which free-riding has occurred in the scheme. We find that applications made through obligated energy suppliers, who are required to achieve reductions in residential energy consumption, are less likely to abandon an application but are more likely to be made for shallower retrofits. We find that applications for more complex retrofits and those made during winter months are more likely to be abandoned. The introduction of bonus payments for three- and four-measure retrofits did not have the desired effect in inducing these deeper retrofits, while free-riding in the scheme is found to be quite low for most measures examined.

Why do energy conservation policies mobilise the behavioural sciences rather than the social sciences? A few lessons from the emergence of the behaviour change agenda in Japan ⁹⁻⁰⁰⁶⁻¹⁷

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Keywords

behavioural change, behaviour, policies and measures, social practices, public policy, household sector

Behaviour change policies have been gaining momentum since the 2000s, especially in the energy conservation field. At the same time, studies about energy consumption behaviours and practices have been increasing. They are usually categorised into two approaches, namely behavioural and socio-anthropological, which have both gained legitimacy and become institutionalised. However, despite the availability of the two perspectives, energy conservation policies mobilise behavioural sciences much more than socio-anthropological approaches. While this issue has already been discussed by scholars, this paper sheds some light on it by drawing upon an empirical study on the rise of behaviour change in Japan's energy conservation policy. Indeed, the challenges faced by Japan, that is drastically reducing its energy consumption while supporting economic growth, are no different to those of most OECD countries. Furthermore, Japan's strategy has similarly long been dominated by techno-economic approaches. Thus, the Japanese case provides a valuable insight into how energy conservation policies change and utilise the behavioural sciences. Drawing upon literature in public policy analysis and policy transfer, I argue that the success of the behavioural sciences can be explained by the coherence of their discourse – and the “mismatch” of socio-anthropological ones – with the culture and expectations of energy conservation policymakers. Three interrelated factors explain this coherence. First, the translation of the behavioural sciences into economics increased their legitimacy and made them appear more scientific in the eyes of policymakers. Second, recent transformations in their methodology enhanced the accuracy and reliability of their results, thus providing practical tools to policymakers. Third, behavioural approaches deliver concrete levers of actions [...].

Knowledge transfer from professionals to end-users in the building hand-over phase

9-025-17

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Keywords

user perspective, end-use demand, knowledge transfer, energy efficiency gap, building hand-over phase

The Norwegian research project “Evaluation of housing with low energy need” (EBLE: 2012–16) studied the building process, measured energy use, indoor climate, and user experience in seven low-energy housing areas in Norway. The data sources in this paper were provided from seven group interviews of professionals involved in construction processes and 38 interviews of the occupant of the houses.

Previous studies found that there are gaps between calculated and measured values for energy use and indoor air temperature in new low energy buildings. The discrepancies are often especially large during the adjustment phase of the first year(s). The hand-over phase and the following period are critical as the occupants are adjusting to the building and influencing the performance of the building through their behaviour. This early phase is essentially the time during which occupants develop habits and new ways of interacting with their home. This behaviour is found to be largely impacted by the level of information about the dwelling the user has received, and sometimes directly translates into positive or negative end-user experiences.

This paper aims to investigate which processes are implemented in the hand-over phase and how this period can be used to inform and help the occupants’, both to understand and use the technologies present in the building. The main questions regard how knowledge on the building and the technology is transferred from the professionals to the occupants in the building hand-over phase. How does the occupants’ knowledge and level of information about the technologies affect the way the building is reportedly used, and thus, how does it contribute to shaping habits in new housing environments?

The findings of this study indicate that there are several unexploited opportunities in the hand-over phase, where professionals could contribute more to enabling the occupants to become proactive users who can control, understand and use their new environment in a more efficient way. A greater focus on motivating professionals [...].

Swedish prosumers in a 10-year perspective – what can we learn from a market in transformation?

9-026-17

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Keywords

prosumer markets, photovoltaics, consumption, electricity consumption, practices, socio-technical, social norms

This paper presents the reasons households have identified for installing or not installing photovoltaic panels in Sweden. It compares the results from interviews done in 2008–2009 and in 2014–2016 with homeowners in Sweden that had installed or were considering installing photovoltaic (PV) panels. The comparison focuses on the market and on what homeowners identified as motives and barriers for investing in PVs. The paper also discusses how the market for PV panels has changed over these years.

Between 2008 and 2014, the PV market has changed profoundly, with an increase in the numbers of PV companies targeting households, the introduction of subsidies for households for installing PVs, and changes in rules, which have made it easier for households to sell electricity they produce back to the grid. At the same time, the regulations have increased for the households. The reasons for homeowners installing PV vary. Environmental motives have been consistent over the years. Some reasons have changed over the time; financial incentives had become an important motive by 2014–2016. The investment costs have remained a barrier, even though they have been reduced. New barriers in recent years are, for example, problems relating to finding information about which companies exist and how much a household will receive when selling the electricity to the grid. Installation was no longer a barrier by 2014. In 2008–2009, households installed the PV panels on their own and installation was a major barrier. This had changed radically by 2014–2016, when most of the households studied had bought turn-key systems with installation included.

Are dwellers deliberative or heuristic in their decisions to invest in energy efficient renovation measures?

9-072-17

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Keywords

behavioural change, energy efficiency investments, policy-making, existing residential buildings, decision-making process, renovation, choice experiment, heuristic thinking

In order to develop behaviourally-informed policies it is important to understand the mechanisms behind investment decisions in energy efficient (EE) renovation. This study contributes to understanding both deliberative and heuristic thinking of house owners. Unlike previous research, it does not limit to testing biases in isolation, but explores the balance between deliberative/heuristic thinking. The undertaken survey (n=178) consists of two parts complementing each other: a ranking exercise and a labelled choice experiment (CE).

The ranking exercise consists in pairs of questions with arguments in favour of and against undertaking five EE renovation measures. It aims at verifying whether deliberative or heuristic thinking prevails. For example, a deliberative reasoning is “It is good for the environment to save energy”, denoting slow, self-aware thinking based on values, beliefs and personal norms. An example of heuristic thinking is “All my neighbours have changed their windows” denoting social norm bias that works as a shortcut. The labelled CE further explores motivations to undertake renovation measures. Respondents had to choose between four measures, with varying levels of the following characteristics: visual changes, thermal comfort obtained, CO₂ reduction, investment cost, hassle during renovation and source of advice.

By joining insights from both parts of the survey we can assess the consistency and draw conclusions. Results of the ranking exercise show that arguments in favour of uptake are mostly deliberative, whereas arguments against depend on whether the respondent installed the measure or not. The relevance of investment cost and reduction in CO₂ in the adoption intention was reconfirmed by the CE. Since deliberative reasoning such as monetary and CO₂ savings are already perceived as motivations while investment cost is still a barrier for those who did not install the measures, providing information on financing schemes might be more effective than underlining [...].

Making energy behaviour research relevant to policy: a tale of two studies 9-077-17

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Keywords

evaluation, evaluation methods, domestic energy, homes, research, policy, heating controls, interventions

Within a context of shrinking government resources and greater pressure on academics and other researchers to generate 'impact' from (publically funded) research there is a greater need than ever to ensure that published research is readily usable by and relevant to policy end-users. Through examining and comparing two energy related evidence reviews commissioned by the UK government, this paper presents a set of recommendations for those researchers who seek to make their publications (in both the white and grey literature) more accessible, usable and relevant to those working in policy and practice domains.

Switching off? Challenges in engaging students in energy efficiency. Findings from an EU wide energy saving project ⁹⁻⁰⁸⁴⁻¹⁷

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Keywords

behavioural change, public buildings, energy citizens, feedback, energy dashboards

The success of projects encouraging pro-environmental behaviour change amongst students in university accommodation has been well documented but typically focuses on small-scale interventions – whether geographically or temporally. This paper presents findings from an EU funded international competition, which discusses insights on a scale previously unseen. SAVES is an inter-dormitory energy-saving competition that is being run in five countries and has reached over 50,000 students over the last two years specifically, over 480 dormitories at 17 Universities. Building on the successful UK ‘Student Switch Off’ (SSO) competition run by the National Union of Students, SAVES provides engagement with students, enabling, empowering and motivating them to save energy – focusing specifically on the last stage of the ‘Awareness, Interest, Desire, Action’ framework. Smart meter data is used to run real-time energy challenges through an energy dashboard that informs students how much energy they are using, and encourage peer-to-peer learning and international cooperation through a virtual twinning scheme. This paper presents findings on the effectiveness of Student Switch Off competition, as it has been implemented in Europe. A mixed methods approach (pre- and post- intervention surveys, focus groups and analysis of energy meter data) was taken to evaluate the level of energy savings and quantifiable behaviour change delivered in students across participating dormitories and countries. Reflections and recommendations are offered towards the role of student-led competitions and energy dashboards as a method for communicating data to students.

Island stories, geographical limits and electricity system dynamics – what can we learn from a comprehensive reading of electricity supply and consumption modes?

9-092-17

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Keywords

energy supply and demand, behaviour, air conditioning, heating, sociology, territories

Current energy policies addressing climate change issues are designed to find solutions for the reduction of energy demand. Such policies are still often formulated in terms of energy efficiency, although they are now clearly targeting household practices and behaviour. In such a perspective, small islands are an interesting territorial context from which one can learn a great deal: these territories impose certain limits to energy demand, because energy production is itself limited and it is for this reason that they call for energy production and consumption to be considered together, an idea especially embodied by the notion of prosumer. But this is not all: load shedding at times of peak demand also reveals concerns relevant to both consumption and production, and behaviours towards the local production system. This is exactly what we propose to discuss in our paper by focusing on air conditioning and heating load shedding in three French island territories (Corsica, Reunion, and Guadeloupe). Despite obvious individual cultural features, they do share certain characteristics and thus constitute privileged fields of observation regarding the dynamics of electricity supply (fossil fuel up to 70 % of electricity mix and intermittent energy up to 30 % of injected power; electricity demand grows on average by 3 % a year). They might even be seen as in situ laboratories supporting the French electricity system's transition towards a more place-based approach. To this end, we propose a secondary analysis of a set of original data (63 interviews/393 questionnaires). The multi-situated sociological analysis we adopted allows us to identify common behavioural trends among households interviewed. We will start from interviewees' thermal practices, in order to analyse their logics of use. We will show that they fall within different life contexts and that they can be differentiated according to age groups or socio-economic categories. Our findings argue in favour of [...].

From consumer to prosumer. Enrolling users into a Norwegian PV pilot ⁹⁻¹²⁷⁻¹⁷

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Keywords

consumption dynamics, solar energy, prosumers, user behaviour, social practices

Recent years have brought a shift in the discourse on the role of ordinary households in energy systems throughout Europe. A central aspect is a focus on prosumers; customers not only buying electricity, but producing and selling locally produced electricity back to the grid. This paper takes a closer look at the status of prosumers as they are enrolled into a solar PV pilot. The novelty of the paper is that it studies the process of enrolment from a user perspective. Through an analysis of around 1,700 applications by householders who want to become prosumers, we shed light on how these prospective users understand the role of the PV pilot as a sociotechnical project, as well as how they interpret their own future role with respect to this project. Thus, we explore both how technologies of prosumption are made sense of, and how prospective users try to attract the interest of the utility in order to be selected as pilot users in the project. We show how the applicants argue their case using the material qualities of the home, stress ownership or an interest in associated technologies such as electric vehicles, smart home technologies etc. Further, many frame participation in the PV pilot as being part of a broader life style project, where personal attributes such as education, occupation and environmental engagement are important. Our analysis indicates a high over representation of prospective participants with what we can call an engineer oriented habitus, where enthusiasm and interest in new technology serves as the main motivation for participation. This highlights design challenges for future energy pilots, as well as more general challenges that needs to be handled if the goal is to engage broader segments of the population in this kind of energy transition activities.

Changing practices of energy consumption: The influence of smart grid solutions in households

9-162-17

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Keywords

behavioural change, user behaviour, consumption dynamics, prosumers, demand response

New challenges follow with the decarbonisation of the energy system. In particular, the challenge of balancing energy production and consumption has become salient due to the intermittent nature of renewable energy sources. Some suggest solutions at a system level (e.g. using excess electricity to produce hydrogen for transport use), whereas others emphasise the role of individual consumers. The latter approach is dominant within the smart grid vision.

In this paper, we explore implications of smart grid technologies in households for the everyday practices related to electricity consumption. The analysis is based on qualitative interviews with Danish households with photovoltaics (PVs) installed in combination with electric vehicles, heat pumps or household batteries (for local storage of electricity). The main research questions are: How does the installation of local electricity production (microgeneration) influence the everyday practices? What kind of influence does the combination of PVs with other “smart” energy technologies have on everyday practices and electricity consumption patterns? A specific focus is on the time patterns of households’ energy consumption.

The analysis is based on a practice theoretical approach. It shows a surprisingly high commitment to time shifting electricity consumption, especially dishwashing and laundering. Different explanations are identified, including the characteristics related to PVs and to producing one’s “own” electricity, but also the type of account settlement scheme (hourly versus annual net metering) and the trial context play a role. Also, the study finds a broader interest in increasing the level of self-sufficiency through combining PVs with home batteries. Finally, the paper discusses a distinct (male) gendering in relation to who is most actively engaged in energy monitoring and management, and it identifies possible system implications of the findings.

Intelligent energy feedback: Tailoring advice based on consumer values 9-182-17

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Keywords

attitudes, behavioural change, consumer behaviour, customer feedback, drivers, EU project, in-home feedback, smart metering, value, advice, personalised

With the roll-out of smart meters across the EU comes the opportunity for more tailored, informative feedback to be offered to domestic consumers regarding their energy consumption. To maximise the energy saving potential of this feedback, it must be accompanied by relevant, interesting advice. In this paper, we explore a mechanism for more effectively tailoring such advice, which is being developed by the Natconsumers project. There are two strands to developing tailored advice: determining what advice to give someone, and determining how to give it. In this paper, we focus on the latter: based upon their interests and motivations, how should advice be framed for different types of people? In what terms should the message be communicated, and in what tone? To investigate this, we have conducted a survey of 4,000 people across four European countries, examining their attitudes, values and demographics. Using these results, we present an attitudinal segmentation model, which allows us to identify what types of messages will be most resonant to different segments of energy consumers. In the wider Natconsumers project, this will be linked with additional segmentation models of load profiles and household characteristics/demographics in order to create a mechanism for the generation of tailored energy efficiency advice across Europe.

The multi-dimensionality of decisions on energetic refurbishment: Results of a qualitative study covering different types of property owners ⁹⁻¹⁸⁴⁻¹⁷

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Keywords

refurbishment, decision-making process, energy efficiency investments, policies and measures, windows of opportunities, qualitative study, barriers, willingness to refurbish, motives

In order to achieve European climate targets, there is a strong need to unlock the energy-saving potential lying in the energetic refurbishment of existing buildings. Current research reveals different findings about the relevance of economic and other influencing factors.

This paper describes the key results of a German qualitative study carried out by order of KfW Bankengruppe addressing the question why some property owners decide to refurbish while others don't, with focus on the interplay between different (economic, ecologic, social, personal) arguments.

Based on a sophisticated postal screening in three German cities using a set of a priori defined criteria, 32 private property owners (landlords and owner-occupiers with differing criteria-based characteristics) have been interviewed.

Comparing the arguments of owners who realised refurbishment activities with those who did not, the qualitative content analysis identifies twelve categories of influencing factors. Although those that refurbish and those that decide against refurbishment consider similar aspects, both assess at least some of these aspects differently. Generally, it was found that every decision on refurbishment has two stages – each with specific barriers that are considered and balanced against possible benefits. In stage 1 there are six reasons for refurbishment which lead to an in-depth evaluation in stage 2 constituting the condition for actual (different) refurbishment activities. Otherwise barriers on the first stage discourage property owners from refurbishment activities.

The identified interdependences between a wide range of decision-making factors and barriers suggest that approaches to promote energetic refurbishment of [...].

Task 24: Co-creating behaviour change insights with behaviour changers from around the world ⁹⁻¹⁹¹⁻¹⁷

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Keywords

behaviour, behavioural change, co-benefits, lessons learned, collaboration, workshop, storytelling, tools

The International Energy Agency's Demand Side Management Programme's Task 24 engages a large number of global experts from many different countries, disciplines and sectors. We segment our target audience of so-called 'Behaviour Changers' into five main actors from: Government ('the Decisionmaker'), Industry ('the Provider'), Research ('the Expert'), Middle Actors ('the Doer' directly interacting with the 'End User') and the Third Sector ('the Conscience').

Each one of these Behaviour Changers has important tools at their disposal, but each also faces restrictions due to their specific mandates and stakeholders. Some of their relationships with each other, and 'the End User' whose behaviour they are trying to change, are strong whereas others have in-built systemic conflicts that need to be overcome. We designed a new 'Behaviour Changer Framework' of how to view the energy system from the human, rather than a technocratic perspective. It draws on various sociological and psychological models but adds its own unique flavour which is explored in participatory action field research settings on specific issues in each of our seven participating countries.

We run workshops on real-life behaviour change issues with relevant Behaviour Changers from each sector designing, implementing, evaluating and disseminating interventions, together. This Task is a truly collaborative effort, where co-creation, including from the End User perspective, is key. Our overarching 'language' uses narratives and storytelling and we are developing behaviour change evaluation methods that go beyond kWh and beyond energy by focusing on double-loop learning strategies and co-benefits.

This paper provides an overview of the various tools Task 24 has co-created with its global expert network, how they have been used in practice in real-life situations and pilots and what the future of a collaborative, human-centric energy system could look like.

From people to policy: integrating social sciences and design insights into renovation policies

9-197-17

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Keywords

behaviour, behavioural change, social practices, households, refurbishment, social sciences

France has ambitious, but yet unreached, goals for building refurbishment, and there is a consensus that existing policy measures will not be enough to meet objectives.

This article proposes a five-steps methodology to identify new policies in the field of renovation of private dwellings in France. Its general philosophy is to place the 'real life' individuals at the centre of policymaking so policy packages are tailored to their reality. The methodology relies on insights from complementary disciplines that have in common their ability to understand the 'real-life' individuals' point of view: social sciences and design.

This paper presents the results of Steps 1 to 3 that were implemented at ADEME in 2016. Step 1 aims at understanding the behavioural challenges that energy renovation policies need to meet. It relies on a multidisciplinary checklist derived from social sciences (economics, psychology, social psychology, sociology and anthropology). The checklist helps policy makers analysing the various facets of renovation behaviours and the associated policy challenges. Step 2 aims at identifying policy gaps in the existing policy framework and thus establishing priorities for action. In the field of renovation, these are, for example: credit and cash flow issues, the lack of policy to help households choose good quality workers, the lack of segmented communication, the lack of policy to activate social norms such as comfort.

Step 3 aims at filling in the policy gaps by generating ideas for new policies. It relies on an ideation methodology that is classically used in Design Thinking. 55 ideas for new services and policies were generated over a 3-day workshop held in 2016. An overview of Steps 4 (finalising the policy packages) and 5 (implementing and evaluating), that will take place in 2017 onwards, is provided in conclusion.

Hot (water) topics: the formation of an energy issue at home ⁹⁻¹⁹⁹⁻¹⁷

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Keywords

hot water, user behaviour, homes, domestic, residents, social practices

Domestic use of hot water has been identified as an urgent energy issue to address. In this paper, results from focus group interviews, with both residents and staff members, are presented. Results show that hot tap water use is differently shaped depending on whether you are a resident or a staff member. One thing in common was that in the focus groups it was difficult to separate hot tap water use from water use in general. Hot tap water use was not distinguished from use of cold tap water. To explore the issue further, the research on hot water was taken to residents' homes and through more in-depth qualitative methods by an artist a formation process was started. Residents started to share more detailed stories about how they lived their everyday life in kitchens and bathrooms. These stories contain childhood memories and how past experience has shaped their water use and consequently their energy use patterns. The formation of this topic continued and in the artist's interpretation of the data, three different artefacts became important: the sink, tub and toilet. These artefacts were placed in a river in the centre of a city as part of an audio walk with voices from the residents talking about their use of water. The exhibition was available during summer 2016 and the audio walk with the voices are planned to be reused and part of an exhibition in 2017.

Energy efficiency investment drivers depend on the technology: implications for policy design and modelling choice ⁹⁻²⁰⁰⁻¹⁷

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Keywords

drivers, energy efficiency investments, choice model, econometric models, policy implications, modelling assumption

In this empirical paper, we analyze how the drivers and barriers of energy efficiency investments vary with retrofitting types and discuss the implications for policy design and modelling. We use a multinomial logit choice model estimated on micro-data over the period 2007/2012 from the French annual survey "Energy Management" (EM) dedicated to households' energy efficiency investments. Retrofitting investments are distinguished between glazed surfaces insulation, opaque surfaces insulation, conventional or innovative (heat-pumps, renewable energy equipment) heating system replacement/installation and multiple-measures retrofit. The model combines both observed households and housing characteristics and subjective answers regarding motivations, circumstances, etc. We first find heterogeneous investment drivers between heating systems and building envelope insulation, especially regarding product lifetime. These results suggest that subsidizing retrofit cannot impact the timing of the decision but only the level of performance in case of investment in heating systems while it can impact both the timing and the level of performance in case of insulation, which have strong implications regarding subsidy efficiency and modelling choice. Secondary distinctions can be made between "conventional" and "innovative" heating systems given the economic profitability, the age of the building, the households' income and their socio professional category. Among other results leading to policy and modelling implications, we also identify specific drivers to multiple-measures retrofitting, such as the opportunities created by recent move-in or access to ownership or the expectations regarding the green value.

What we do matters – a time-use app to capture energy relevant activities ⁹⁻²³⁷⁻¹⁷

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Keywords

demand patterns, demand analysis, social practices, activity patterns, electricity use

High expectations rest on demand side response to aid the reliability of future electricity systems and to reduce costs. The extent of the potential contribution depends among other things on what that demand is used for. Some uses could be more flexible than others. Some may respond to price signals, others may require different forms of incentive or changes to material or social contexts. Our understanding of the temporal relationship between the activities and the resulting electricity patterns is still in its infancy.

This paper presents a novel research tool to combine electricity data collection with activity information at the household level. We critically review established methods to time-use collection and propose a range of innovations to improve their suitability for energy related research with the aim to establish ‘what people use electricity for’. Innovations include: 1) A six-way decision tree allows to discriminate 714 in-home activities with fewer than five screen interaction. 2) The recording of instances in time (‘constructive time perspective’) greatly reduces the user-interface complexity. 3) Virtual rewards have been shown to improve participation and even introduce a degree of recording competitiveness within households.

The functionality of this open source mobile app is presented alongside feedback and data from its deployments in UK households. We discuss advantages and drawbacks of this approach in relation to conventional paper-based methods and point towards future research opportunities this approach could enable.

How building regulations ignore the use of buildings, what that means for energy consumption and what to do about it ⁹⁻²⁷¹⁻¹⁷

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Keywords

residential buildings, everyday life, building codes, rebound effects, practices, social practices, socio-technical, heating, household consumption

Building regulations have been, and are still, strong policy instruments for changing the material structures of residential buildings. Hitherto, little attention has been given to how building regulations could be designed to influence household energy consuming practices in a less consuming direction. Social science research on household energy consumption for heating purposes widely acknowledges that households' everyday habits are as important as the energy efficiency of the buildings when it comes to explaining actual energy use for residential heating. It is also widely acknowledged that the energy consumption of buildings varies with the way households use them. Rebound effects have been calculated, showing that improvements in building energy efficiency are offset by changes in the inhabitants' comfort and convenience practices. Building regulations are, however, still grounded on improving energy efficiency, with no consideration of how this simultaneously influences everyday life and energy consumption. This paper critically reviews the implications this can have. It begins with a brief history of the Danish building regulations, which are among the strictest in Europe, and highlights studies and statistics to evaluate this policy. Following this, we outline where things can go amiss in the production of buildings, if a user perspective is not included. We consider three phases of a building's lifetime that are especially relevant for our discussion of the building regulations' influence on household energy consumption, i.e. in the development of new building technologies, the design and construction of buildings, and the actual use-phase. Emphasis is given to the likely effects that the building regulations can have in each of these three phases and to what happens when the user is forgotten. We then discuss what implications these insights can have for the further development of building regulations.

The role of social influence in the end customer purchasing decisions on the heat market ⁹⁻²⁷⁶⁻¹⁷

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Keywords

heating systems, decision-making process, social influence

The aim of this paper is to examine the role of social influence on the end customer behaviour in the purchase of heating products in the residential segment. The study is based on interviews and a questionnaire survey of homeowners in Hungary in 2013. Respondents are open to learn about diverse innovative heating technologies, energy types and diverse heating fuels irrespective of any purchase intention. They plan their purchase based on deliberate considerations rather than facing an emergency heating appliance breakdown. Furthermore, influence of the social environment prevails at the diverse stages of the purchase process. End customers actively conduct social search (family, friends, neighbours, colleagues, other customers with purchase experience over the Internet, etc.) besides the influencing role of the installer.

Energy labelling for the digital age: presenting a possible solution and consumer reactions

9-324-17

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Keywords

labelling, appliances, digital

This paper provides an update on the progress made so far in the Digi-Label project including consumer feedback on the concept and initial research and development activities. The project's aim is to accelerate the market adoption of energy-efficient products across Europe by developing and initiating the roll-out of an extended digital version of the European energy label. The proposed solution, branded PocketWatt, is both an internet-based tool for online use as well as a smartphone app optimised for use while shopping at local retail stores selling electrical appliances. The rationale behind this approach is to provide easy access for consumers to energy-efficiency information at the point of purchase, and to improve their understanding of the benefits of more energy-efficient products. The tool includes features like (1) an option that allows comparisons of different models available from the same retailer; (2) the possibility to customise information, e.g. to calculate running costs according to the frequency of use; and (3) a clearly presented and easily accessible/user-friendly graphical interface.

Two workshops secured the early participation and input of consumers (22 in Germany and Spain). This paper provides a summary of the findings; for example, that consumers appreciate the approach taken, and value several of the features provided. Participants also gave feedback on the draft version of the PocketWatt tool. In addition, they pointed to the need to find more ways to persuade consumers (and retailers) to make energy efficiency a higher priority when making purchasing decisions about energy-using products. This feedback was considered in the pilot phase for PocketWatt, which took place in late 2016 and early 2017.

Effectively reducing energy demand in the residential sector: A multidisciplinary approach

9-330-17

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Keywords

energy behaviour, energy end-use efficiency, energy demand, end-use consumption, system analysis, residential programmes, multidisciplinary

Energy behaviours are recognised as being of paramount importance to energy efficiency policies aimed at reducing energy demand. Tackling energy behaviours is a complex and challenging task since they: encompass multiple dimensions (e.g., usage, investment, comfort, security, provision of energy resources); are influenced by personal, social, economic, material and technological contexts; are a topic of common interest but uncoordinated action of different energy stakeholders promoting energy efficiency, thus making the design of effective programmes and policies more demanding. This work proposes a multidisciplinary approach to assess the influence of energy behaviours on residential energy consumption to support the design of an energy efficiency programme held in Portugal. Methods and techniques from engineering, social sciences and psychology were combined in a systemic manner to assess the qualitative and quantitative influence of behaviours on energy usage and identify the most relevant factors that should be addressed to effectively reduce residential energy consumption. An experimental setup of 128 households was used as case study. Household's electricity consumption was monitored using smart meters and web-based surveys, which enabled to assess environmental, material and technological, economic, social and personal variables. System modelling enabled to explore the influence of behaviours in the energy consumption activation chain and integrate the contribution of different variables. Results not only confirmed the key role of energy behaviours, but also enabled to rank variables according to their quantitative impact on energy consumption, thus supporting the need of multidisciplinary approaches to design programs and policies aimed at reducing energy demand.

Addressing human behaviour in assessments of energy efficiency in buildings

9-336-17

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Keywords

behaviour, evaluation, energy use, buildings, theories, user behaviour, review

People's daily life has a significant effect on the outcome of any policy implemented or technology introduced with the aim to increase energy efficiency in buildings. Human behaviour should constitute a key factor in evaluations of such initiatives. This paper focuses upon how research in environmental psychology can contribute to strengthened evaluations of human behaviour in relation to the introduction of interventions to increase energy efficiency in buildings. The aim is to identify key questions to further develop an interdisciplinary evaluation framework with regard to the evaluation of user behaviour and behavioural change. Based on reviews of environmental psychology research on human pro-environmental behaviour and energy use, five overarching questions that could be added to such an evaluation framework are proposed. The questions concern the use of theory to explain human behaviour, operationalization of the behaviour studied, considerations of individual and social characteristics of the target group, potential antecedents of the behaviour, and the definition of the intervention and its motivation for behavioural change. Moreover, the importance of alignment between theory, target group, behaviour, antecedents and intervention in the evaluation is stressed. The relevance of the five questions was tested in a pilot-sample of 15 evaluations carried out on interventions in buildings in Nordic countries. All questions captured large variations between studies with regard to the identification, definition and assessment of behaviour, potential antecedents, and psychological processes of behavioural change. It is concluded that the proposed questions could support thorough evaluations of interventions targeting user behaviour by pointing at strengths and weaknesses in evaluations of interventions aimed to reduce energy use in buildings by changing human behaviour.

Power efficiency classes for households – monitoring long-term effects of a power saving intervention 9-398-17

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Keywords

behaviour, feedback, household consumption, self-monitoring

In this contribution, we will present insights from the implementation of an integrated approach to power saving. Based on comparative feedback, the project “power efficiency classes for households” is designed to help households to evaluate their total power consumption and to plan and implement priority saving measures. The approach aims at jointly overcoming various barriers: lack of motivation, lack of knowledge about total consumption and most effective measures as well as lack of planning, feedback and appreciation. It features a communication campaign with four basic elements: a classification system for comparative feedback, a power audit, various communication tools supporting self-monitoring of householders, and a certificate reporting the effects of the power saving efforts at the end of the intervention period. Drawing on a field trial with 98 households in two regions of Germany, we will present some results from an exemplary implementation of the approach. Data sources are consumption measurements at the end of the intervention period, two surveys in the middle and at the end of the intervention period, qualitative interviews with participants and an additional survey one year after the end of the field trial. They show average savings of 5 % (and more in “high consumption” households) at the end of the trial. Savings even increased further after the field trial was terminated.

Disruptive low carbon innovations 9-418-17

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Keywords

innovative technologies, diffusion, user behaviour, technology choice determinants, social innovation, market transformation, innovations

Sustaining innovations improve on existing product or service attributes valued by end users. In contrast, disruptive innovations offer novel attributes, and so create a new value proposition for end users. If successful, they effectively create a new market, a new set of demands and preferences. Mitigating climate change requires disruptive low carbon innovations to challenge prevailing technologies or practices and lead to step change reductions in emissions when adopted at scale. Many potentially disruptive low carbon innovations exist today, but in small numbers. As examples, car clubs, car sharing, and reuse networks challenge mainstream consumer attributes of ownership, autonomy and status.

This paper investigates the potential for disruptive innovations to transform the market for energy-related goods and services. First, we consider the key concepts of disruption innovation, and propose a set of characteristics that define disruptive low carbon innovations. Second, we review sectoral and economy-wide studies of low carbon innovation, and use our set of characteristics as screening criteria to identify potentially disruptive innovations. We focus particularly on innovations relating to mobility. Third, we draw on innovation case studies to identify the novel attributes offered by these disruptive low carbon innovations. We assign rankings to these attributes and map how they compare across different innovations. We find that attributes common to different innovations include offering greater variety of choice, having a relational aspect, and being pay-per-use. Fourth, we use data from a small survey of innovation experts to evaluate a set of mobility-related innovations by their potential disruptiveness and their potential emissions impact. We find six mobility-related innovations that score highly on both criteria: mobility-as-a-service, car clubs, ride-sharing, e-bikes, telecommuting, and electric vehicles. These are predominantly characterised by a shift towards mobility becoming a pay-per-use service.

Who are the low energy users? Lessons for climate policy 9-432-17

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Keywords

interviews, attitudes, behaviour, household consumption, lifestyle, survey

California, like many other regions, has GHG emissions goals requiring drastic reductions from baseline levels. However, a small percentage of households already live at electricity consumption levels consistent with the state's goal of 80 % below 1990 levels. Low energy use is often associated with undesirable characteristics, such as poverty, thermal discomfort, or small dwelling size. We investigated the demographics, behaviour, and satisfaction of these low users to see what attributes best correlated with low use. We studied about 700 households drawn from the lowest 10 % of electricity consumers in Sacramento, California. Surprisingly, the low users encompassed a diverse cross section of customers. The low users were similar to the general population in terms of age, income, education, appliance ownership, and dwelling characteristics. Low-use households tended to be smaller, but not enough to explain the entirety of low usage. Surveys and interviews revealed that those in the lowest 10 % typically pursued low consumption deliberately and enthusiastically, and were aware of their status as low users. The topic of energy conservation was salient in their social conversations. They employed diverse and creative strategies to maintain thermal comfort without excess energy use, often exceeding expert recommendations. Finally, the distribution of self-reported quality of life was no different from that of the general population living at much higher consumption levels. Overall, the key determinants of low use were a positive engagement with improvisation and experimentation, and the salience of energy in personal or social life, rather than poverty or other circumstantial constraints. The association of low energy use with deprivation has been an obstacle to promoting more aggressive goals for reduction of residential use. In contrast, the population of low users should be treated as a valuable source of peer advice and lifestyle modelling.