



ENERGY EFFICIENCY AND USING LESS

a social sciences and humanities
annotated bibliography



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Executive summary

The challenge

- Technological progress and changes in energy supply are not sufficient for a transition to a low-carbon energy system; demand also needs to be considered. Energy efficiency and reducing total consumption - the topics of this bibliography - are typical elements of a demand side approach.
- The uptake of energy efficient technologies, and understanding how we might use less energy, represent big challenges for researchers, policymakers, practitioners and end-users themselves.

The aim

- European energy policy has so far mainly relied on research from Science, Technology, Engineering and Mathematics (STEM) disciplines. Energy-related Social Sciences and Humanities (SSH) have been significantly underrepresented. This bibliography aims to discuss different disciplinary perspectives on energy efficiency and using less and to demonstrate their relevance for energy policy.

Coverage

- A major focus of this bibliography is on behaviour and behavioural change. The bibliography highlights the diversity of end-users and their needs, the impacts they experience, abilities, as well as the range of sites where energy is consumed.
- It also looks at how SSH research addresses more structural elements of demand - such as markets, institutions, and policy - and how these interact.

Key findings

- There is no such thing as a one size fits all approach; different disciplines frame the problems of energy efficiency and using less differently, and do not always agree. Economics is very highly represented in research about energy efficiency, closely followed by Sociology. Other disciplines such as Urban Studies and Industrial Design are slowly becoming part of the work.
- Most disciplines focus mainly on mainstream types of users and use. Fewer studies focus on the exceptions - deviants, others, non-users or energy poor, excessive users - or low-energy practices such as sleep, music making or sports.
- Electricity is the main focus of most social science research on energy use and efficiency, possibly due to a focus on monitoring savings which is more difficult for gas and energy for hot water use.
- There is an overrepresentation of work on feedback devices and smart meters, in contrast to more everyday technologies such as water heaters or washing machines. Several studies urge for more study of this everyday material culture because it strongly shapes how users can engage in using less or using more efficiently; some technologies are simply built to have high energy use.
- Less research is done on the responsibility of stakeholders (other than the end-user) for the energy transition, especially the market. It is argued that markets are not neutral or depoliticised, but bear responsibility for the energy transition too.
- Dominant areas of research include: a focus on the gap between awareness and actual energy behaviour action; and rebound effects, which may arise when increased energy efficiency leads to lower costs for energy which in turn may lead to increased energy consumption.
- New areas of research include new demand side initiatives, services/business models and markets such as peer-to-peer, DIY, and community approaches to engagement.
- Most demand side approaches in the policy domain focus on cost reduction, education and communication. Insights from Social Sciences such as Sociology, Anthropology, Urban studies, Ethics, and Science and Technology Studies see less uptake in the policy domain.



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Introduction

A taste of energy-SSH

This annotated bibliography on 'competitive, secure, low-carbon energy supply' is one of four annotated bibliographies created as part of the EU Horizon 2020 Platform *Social Sciences and Humanities for Advancing Policy in European Energy* (SHAPE ENERGY)¹. SHAPE ENERGY aims to develop Europe's expertise in using and applying energy-related Social Sciences and Humanities (energy-SSH)². Compared to Science, Technology, Engineering and Mathematics (STEM) research on energy, energy-SSH has been significantly underrepresented in informing European energy policy. In funding SHAPE ENERGY, the European Commission is supporting a better integration of energy-SSH into the policy process.

The aim of the annotated bibliographies is to give non-experts (such as policymakers, practitioners, and academics from a range of disciplines) a taste of the diversity of energy-SSH research in, or of relevance to, Europe. They thereby contribute to making the capabilities of energy-SSH more visible and they provide a convincing statement of the policy relevance of perspectives from the Humanities and Social Sciences. However, it is important to note that energy-SSH represents a diversity of disciplines, and many different, sometimes contradictory, perspectives and approaches to energy-related issues.

As part of the SHAPE ENERGY scoping work package, the annotated bibliographies will also feed into other SHAPE ENERGY activities, such as 18 multi-stakeholder workshops in cities across Europe, an Early Stage Researcher programme, Horizon 2020 sandpits, and the SHAPE ENERGY 2020-2030 research and innovation agenda. The scoping work package also includes four cross-cutting theme reports with practical recommendations for how to be sensitive to gender, multi-stakeholder interests, energy justice, and active consumers, which readers may be interested in. Both the theme reports and the annotated bibliographies may be useful as teaching resources.

The four energy topics

The annotated bibliographies cover the four main energy topics that the SHAPE ENERGY project spans:

1. Energy efficiency and using less
2. Competitive, secure, low-carbon energy supply
3. Energy system optimisation and smart technologies
4. Transport sector decarbonisation

These topics have been selected based on their relevance for EU-policy; in particular, they are inspired by the priorities set out in the Strategic Energy Technology (SET) Plan³ and consequently the Horizon 2020 energy work programme priorities. Hence, the bibliographies focus on the potential contributions of energy-SSH to these particular challenges. Although these four energy topics are very broad and can incorporate much of the existing energy-SSH, it is clear that through selecting these topics, other possible topics have been left out. Further, due to the broadness of the four topics, a comprehensive presentation of all energy-SSH research of relevance for the topics was, of course, impossible. Many very interesting articles had to be omitted. The bibliographies therefore present a selection of energy-SSH literature based on criteria such as impact (citations), quality assessment, disciplinary and regional diversity.

¹ shapeenergy.eu

² SHAPE ENERGY will work across the full range of Social Sciences and Humanities, including energy-related research (both current and potential) within: Business, Communication Studies, Development, Economics, Education, Environmental Social Science, Gender, History, Human Geography, Law, Philosophy, Planning, Politics, Psychology, Science and Technology Studies, Sociology, Social Anthropology, Social Policy, and Theology.

³ Commission Communication 2015/6317/EC Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation, [online] Available at: https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_ACT_part1_v8_0.pdf [Accessed 21 May 2017].



How to use the annotated bibliographies

Each annotated bibliography is divided into several sections, which again contain several subsections on different sub-topics. Each subsection provides a list of references, based on published literature including books, journal articles, working papers, reports, etc. Short, accessible annotations are provided under each reference that summarise key points, such as the questions being asked by the authors, the approach taken, headline findings, and/or policy relevant recommendations. They are (of course) not a substitute for reading the original publication, but rather provide a 'window in' that the reader can then follow up, if desired. Longer, more academic abstracts are usually available online. An email request to the author(s) may be a good way to obtain to full text documents, which are not public.

Note that the four bibliographies are independent documents and one reference may feature in more than one bibliography.

Coverage

The annotated bibliographies aimed at both disciplinary and geographical diversity (within Europe) when selecting references. However, there is a clear dominance of some disciplines, particularly Economics, in energy-SSH research. Therefore, we intentionally added other disciplines that are not so visible and cited. There was a balance to be struck between including seminal work, and yet emphasising work that is also important, but so far not so visible. In addition, it is not always possible to easily determine which discipline(s) an author sees their work as sitting within. Given that energy-SSH research operates at the intersection between SSH and technology, the bibliographies not only include work by scholars from SSH-disciplines, but also work by scholars from STEM disciplines, who used methods from the Social Sciences and Humanities to approach their particular research problem. Furthermore, although most bibliographies have authors from different disciplines, our own disciplinary bias needs to be mentioned.

Geographical diversity was similarly difficult to achieve. There is a clear Western/Northern European (and particularly UK) dominance in energy-SSH research, and English language publications may achieve a wider readership. Again, a balance needed to be found between including seminal work and highlighting research from underrepresented regions, particularly Eastern Europe, and languages other than English. Whilst doing the search work for the bibliographies, we also discovered that, for example, google scholar automatically filters results based on which country you are from. This of course contributes to geographical and language bias.

As the four energy topics both differed in span and disciplinary coverage, and the expertise of the authors differed, each merited a slightly different approach to searching and compiling of the research literature.

The topic of this bibliography: energy efficiency and using less

The topic of energy efficiency and using less is very broad. To avoid overlap with other bibliographies, we focused explicitly on the demand side of the energy system, and in particular on energy efficiency and using less at specific residential and non-residential sites. The research showcased here looks at ways to increase energy efficiency across different technologies, practices, and end-user behaviours. We included work looking at reducing primary energy demand (e.g. through people using less) in addition to increasing technology efficiency (i.e. technologies using less). This incorporates ideas of energy 'sufficiency', consideration of how European society's activities might better stay within the natural limits of our biosphere.

Methodology

With respect to our approach to searching and inclusion/exclusion criteria, this bibliography includes both seminal work (including highly cited publications from journals with high impact factors), and publications which have been more 'invisible' and underrepresented (both in terms of disciplines, topics, European regions and languages). We also particularly drew on the peer-reviewed publications from the regular European Council for an Energy Efficient Economy (eceee) events, which bring together researchers, business and practitioners to discuss cutting-edge efficiency issues. Through these processes, we



sought to show the diversity of approaches across energy-SSH research within this topic and what kind of questions and problems energy-SSH researchers are seeking to deal with. We used our partners in the SHAPE ENERGY project, experts in their fields, to help us find appropriate sources and to feed into the choices of sections and subsections.

Structure

The five main sections thus focus on: the use of energy, the users, distribution issues (costs and benefits), market issues, and conclude with governance issues. Within each section are several subsections, each with its own mini introduction. Papers are ordered following their order of appearance in the introduction.



1. Using energy

In this section, we discuss many elements broadly related to behaviour around energy efficiency and using less, and how behaviour changes. Different disciplines have different ways of looking at behaviour, and what might need to be done and by whom to change it. In the subsections below, we highlight some of these different perspectives. A special subsection is dedicated to a particular strand of research that focuses on the deliberately different concept of practices, instead of individual or collective behaviour. Further subsections focus on issues such as the rhythm of energy use, engagement and empowerment, and acceptability of energy technologies such as ICT, open data and feedback. We end this section with a brief exploration of the impact of global issues such as climate change on behaviour at the local level.

1.1. Behaviour

Behaviour is one of the most challenging topics Social Science and Humanities researchers focus on. An interest in behaviour and behaviour change stems from the acknowledgement that technological progress alone will not help us achieve a more sustainable energy system. More sustainable use is necessary as well, also called the 'behavioural wedge' of energy reduction strategies. However, there is a huge gap often observed between on the one hand awareness, and on the other hand actual action based on that awareness. Many different disciplines have their own perspective on what energy behaviour (both habits and more one-off decisions) is and how to change it. Behaviour and changing it can be tackled on the level of the individual and his or her direct personal situation, and several of the references below (Dietz et al., 2009; Gaspard and Martin, 2016; Garabauau-Moussaoui, 2009) demonstrate how different elements may impact behaviour, such as stage of life, motivations, demographics etc. Others stress that more structural forces such as the social, material and institutional environment are interlinked with behaviour (Ehrhardt-Martinez and Laitner, 2009; Marechal, 2009; Chatterton and Wilson, 2013; Duijn et al., 2013).

In order to change energy behaviours, equally varied solutions are proposed. One of the discussions attracting much attention at the moment is about the potential of financial incentives and whether people act rationally or predictably irrationally. Some research demonstrates that people may prefer to buy something technical that will help them become more energy efficient or use less, then to change their habits (Poortinga et al., 2003). What we found in researching this bibliography is that most of the research focuses on understanding the complexities of behaviour change by focusing on mainstream users. Only a few studies investigate the deviants (McDonald et al., 2006). What all disciplines do agree on is that there is no such thing as a one size fits all approach, and that different disciplines may be relevant for different problems. Many studies also advocate that different policy measures are necessary, targeting both household actions and the more structural elements around the household and that all disciplinary perspectives are relevant and necessary for this (Kollmuss and Agyeman, 2002).

Dietz, T., Gardner, G., Gilligan, J., Stern, P. and Vandenberg, M., 2009. Household actions can provide a behavioral wedge to rapidly reduce U.S. carbon emissions. *PNAS*, 106 (44), pp. 18452–18456.

This study investigates the potential for reduction of energy use and emissions through behavioural change, both adoption and the different use of technologies. The researched group consisted of US homes and non-business travel. The results demonstrate that up to 20% of the emissions of households could be avoided by action on the household level.

Gaspard, A. and Martin, S., 2016. *Changer les comportements. Faire évoluer les pratiques sociales vers plus de durabilité*. Angers, France: ADEME.

The issue of behaviour change and more generally the evolution of our lifestyles is considered key to the sustainable transition. It is widely acknowledged that technological progress alone will not help us achieve the emission reductions for greenhouse gases that we need. Although there is more or less consensus on the need to create more sustainable practices, how to go about it is more complex to define.



Garabauau-Moussaoui, I., 2009. Behaviours, transmissions, generations: why is energy efficiency not enough? *Proceedings of the 2009 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm.*

This sociology paper provides an innovative approach to the way behaviours are analysed with the purpose of helping policy makers to understand and negotiate the behavioural complexity involved in using and saving energy. Based on an analysis of several qualitative studies in France, the paper shows how behaviours are dependent on the energy consumer's stage in the life cycle (age). It finds that information, policies and energy-efficient technologies are understood and embodied by people according to their age and their life histories.

Ehrhardt-Martinez, K. and Laitner, J., 2009. Breaking out of the economic box: energy efficiency, social rationality and non-economic drivers of behavioural change. *Proceedings of the 2009 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm.*

This Social Psychology/Behavioural Economics based paper provides evidence that it will take more than high prices to achieve maximum energy savings. It reviews a variety of studies by social psychologists and behavioural economists which show that people often act in ways that may be better described as socially rational and predictably irrational. The paper, co-authored by a sociologist and an economist, explores how individual behaviour is shaped by the social context and presents an alternative framework for modelling efficiency behaviour.

Marechal, K., 2009. The crucial role of habits in energy consumption: an evolutionary approach on changing current patterns. *Proceedings of the 2009 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm.*

This paper introduces an evolutionary perspective to energy behaviour and argues that structural forces embedded in socio-technical systems constrain and shape consumers' choices. This results in the formation of habits that may be counter-intentional, explaining the apparent paradox that energy consumption is not declining despite rising environmental awareness. Policies aimed at reducing energy consumption must address consumer performance in the context of habits. The author reviews habit-oriented research and finds that the joint use of feedback and commitment strategies appears promising.

Chatterton, T. and Wilson, C., 2013. Characterising domestic energy related behaviours. *Proceedings of the 2013 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm.*

Policy interventions intended to reduce energy usage through some element of behaviour change tend to be designed from the perspective of a single model of behaviour, most typically based on economic rationalism. The authors performed an interdisciplinary review of behaviour change research in the UK along four key dimensions: Actor, Scope, Durability and Domain. This rich analytical framework was presented to policy makers in workshop settings. The results showed that this framework was successful at dislodging a priori commitments to one-size-fits-all approaches to behaviour change.

Dujin, A., Maresca, B. and Védie, M., 2012. *Changer les comportements. L'incitation comportementale dans les politiques de maîtrise de la demande d'énergie en France.* Paris: CREDOC.

This research paper's purpose is to analyse how incentives spread in public policies dealing with energy demand management, as well as to observe how it translates in households' actual behaviour, and whether it is efficient. The concept of behaviour change comes from Social Sciences and is invading public policies. Its objective is to have citizens adopting behaviours that fall in line with common good.

Poortinga, W., Steg, L., Vlek, C. and Wiersma, G., 2003. Household preferences for energy-saving measures: A conjoint analysis. *Journal of Economic Psychology*, 24 (1), pp. 49-64.

This Economic and Psychology discipline study stresses that the influence of physical characteristics of energy-saving measures on their acceptability is largely ignored. The authors analysed the preferences for different types of energy-saving measures and found that the energy-saving strategy was most influential with respect to acceptability of energy-saving measures. In general, technical improvements were preferred over behavioural measures and especially over shifts in consumption.



McDonald S., Oates, C., Young, W. and Hwang, K., 2006. Toward sustainable consumption: researching voluntary simplifiers. *Psychology & Marketing*, 23 (6), pp. 515–534.

This Psychology article focuses on those individuals that have decided to not be part of the consumerism pattern most present. These individuals try to have as little an impact as possible and make use of as little resources as possible. This type of individual is called a 'voluntary simplifier' by the authors. This study aims to understand the complex decision making processes of these individuals to better help attempts towards more sustainable consumption.

Kollmuss, A. and Agyeman, J., 2002. Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental education research*, 8 (3), pp. 239–260.

The awareness-action gap is a topic often tackled by many of the disciplines in the social sciences and humanities. This interdisciplinary reference describes a large number of these approaches, from psychological to sociological ones. The authors conclude that not one discipline, framework or diagram is able to provide a conclusive answer, but that the field could benefit from a good overview of all possible approaches.

1.2. Practices

Recently, a specific field of research has emerged on the topic of practices, strongly based in the sociological discipline. Different approaches have evolved, with different frameworks (Gnoth, 2013; Shove et al., 2014; Jensen et al., 2011; Zelem and Beslay, 2015; Subremon, 2014). What these approaches all have in common is that they move away from an individual perspective on behaviour and behavioural change, and that they stress the interplay of technology and material culture, institutions, norms and values and other factors in creating practices (Naus et al., 2015). Within this field of research, power relationships are explicitly focused on, both on the level of household dynamics, and society at large (Royston, 2015). This field of research also explores how time, rhythm and other dynamics interconnect with practices; topics that are discussed in more detail in the next subsection. The practices approach stresses the need to design interventions that address the complex interplay when creating more energy efficient practices (Radanne et al., 2016).

Gnoth, D., 2013. Moving home and changing behavior – implications for increasing household energy efficiency. *Proceedings of the 2013 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm.*

This paper investigates the interplay between motivations and material culture on changing behaviour in new homes based on 16 case studies in New Zealand. Each case represents an 'energy culture' within the New Zealand population and offers opportunities for identifying potential interventions depending on their grouping. The study finds that past experience and differences in perceived comfort levels can have considerable influence on the types of energy-related changes that occur after a family moves into a new home.

Shove, E., Walker, G., Tyfield, D. and Urry, J., 2014. What is Energy for? *Social Practice and Energy Demand. Theory, Culture & Society*, 31 (5), pp. 41 – 58.

This article is one of the foundational articles on practice theory applied to the energy field. It explores the different theories of practice and demonstrates how energy use and production is interlocked in many practices.

Jensen J., Christensen T. and Gram-Hanssen, K., 2011. Sustainable urban development – compact cities or consumer practices? *Danish Journal of Geoinformatics and Land Management*, 46 (1), pp. 50–64.

The authors suggest that in addition to the sustainability solution to build 'high and compact', consumer behaviour of the household needs to be taken into account as well in urban planning. A bottom up approach focusing on daily practices is necessary to achieve this behaviour change. Practice theory is introduced as a way to complement urban planning to understand consumption and to inspire local authorities.



Royston, S., 2015. Active consumers? Everyday innovation and adaptation for efficiency in thermal comfort services. *Proceedings of the 2015 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm.*

In everyday life, people perform, reproduce and recreate many different practices, which have implications for patterns of energy demand. This paper examines thermal management in the home based on an analysis of online sources (forums, articles and blogs with comments). It uses practice theory to explore everyday innovations and presents results that highlight processes of scripting, appropriation, tinkering and bricolage, showing how everyday adaptation and innovation are bound up with materials, know-how, shared understandings and rules.

Naus, J., Spaargaren, G., van Vliet, B. and Van der Horst, H., 2014. Smart grids, information flows and emerging domestic energy practices. *Energy Policy*, 68 (May 2014), pp. 436–446.

This article presents a conceptual framework for analysing the different ways in which the smart grid shapes household energy consumption. There are three types of information flows that influence existing power relations: between household members, between households and energy providers, and between local and distant households. These information flows raise serious privacy concerns as well. Not only between the household and other actors, but within the household as well (e.g. between parents and children). The authors do not give clear-cut policy proposals but argue that decision-makers should concentrate on creating fertile conditions for the emergence of more sustainable practices for instance through the endorsement of citizen-cooperatives and advisory services.

Zelem M. and Beslay C., 2015. *Sociologie de l'énergie. Gouvernance et pratiques sociales*. France: CNRS Alpha Editions.

In addition to being a controversial societal and political issue, energy has become in the last 15 years a highly significant research topic. As debates on the energy transition are intensifying, this book aims at gathering scientific analyses from researchers working in different fields. Their main objective is to share for the first time in a single volume all the knowledge and theoretical approaches on governance and social practices in the energy sector.

Subremon, H., 2014. *Usages de l'énergie dans l'habitat : la transition énergétique vue d'en bas*. Direction du numéro 96 de la revue Flux. France.

This paper presents a theoretical and empirical overhaul of the notion of lifestyles, and uses it as a framework of analysis of the issues the energy transition project is facing. It is argued here that the notion of lifestyles is often reduced, particularly in the energy transition project, to a single dimension of user behaviour and energy consumption, and thus excludes the material and normative frameworks that guide individual and collective practices.

Radanne, P., Tuuhia, V. and Cheron, M., 2016. *L'impact des transitions énergétiques et de la lutte contre le changement climatique sur le quotidien des familles*. Paris: 4D, Our Life 21.

This report presents the lessons learned from a new method of calculation on sustainable lifestyles and from an approach based on participative, immersive and empathic foresight. Details are also given on family lifestyle archetypes that would be coherent with a world maintaining global warming under 2°C.

1.3. Time and rhythm of energy consumption

Investigating how temporal rhythms influence energy demand patterns is a field of study where social geographers, time sociologists and practice theorists are increasingly interconnecting (Shirani et al., 2013). This type of research demonstrates how specific energy demand patterns are linked to practices that have specific daily, weekly, seasonal rhythms (Torriti, 2017; Spurlin, 2015; Jalas, 2002). Some authors working on this topic take a different focus and investigate how to escape from this energy consuming rhythm, especially the 24/7 consumerism, and how for example sleep (Crary, 2013), but also low energy consuming practices such as making music or doing sports, can be an active refusal strategy to consume energy (Jalas, 2012).



Shirani, F., Butler, C., Henwood, K., Parkhill, K. and Pidgeon, N., 2013. Disconnected futures: exploring notions of ethical responsibility in energy practices. *Local Environment*, 18 (4), pp. 455–468.

This article focuses on the ethics of how past-present-future connections impact on the way people think about energy consumption, and what this means for issues such as responsibility. Interviews were held to find out if connections with younger generations in a family change practices and views.

Torriti, J., 2017. Understanding the timing of energy demand through time use data: Time of the day dependence of social practices. *Energy Research & Social Science*, 25 (March 2017), pp. 37–47.

This article identifies the time dependence of social practices at specific points of the day, week, year, and how this shapes the timing of energy demand. The author investigated the social practices of preparing food, washing, cleaning, washing clothes, watching TV and using a computer. Washing was found to be the most time dependent, and using computers the least. Furthermore, Tuesdays, Wednesdays and Thursdays had the highest time dependence for all six practices, and the author also identifies that some energy-related practices have higher seasonal dependence than others.

Spurling, N., 2015. Rhythms and patterns of daily life from 1950–2000: the changing qualities of energy demand. *Proceedings of the 2015 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm*.

Spurling uses the sociology of time discipline to understand the dynamics of energy consumption across decades in a UK town. She demonstrates how the temporal patterning of washing, cooking and other practices – their rhythm, synchronicity, periodicity and duration – is creating patterns of demand.

Jalas, M., 2002. A time use perspective on the materials intensity of consumption. *Ecological Economics*, 41 (1), pp. 109–123.

This paper develops a time use approach towards consumption, assuming that time and money are not interchangeable and consumption time is more influential than purchasing power.

Crary, J., 2013. *24/7. Late capitalism and the ends of sleep*. London and New York: Verso Books.

This book explores the consequences for consumption of the marketplace operating 24/7 pushing us into constant activity. The book furthermore explores how human sleep can be seen to be a refusal of patterns of growth and consumerism, and can be a restorative withdrawal.

Jalas, M., 2012. Debating the proper pace of life: sustainable consumption policy processes at national and municipal levels. *Environmental Politics*, 21 (3), pp. 369–386.

This article focuses on pace of life and its influence on sustainable consumption. The author explores how slow living and wealth-in-time, could be good foci for policy processes of Local Agenda 21 (in Finland). The article furthermore investigates how expertise and lay understandings of the role of pace of life are constituted and featured in policy discussions.

1.4. Engagement and empowerment

Engagement is a topic that is approached by many different disciplines. The focus is often on researching how consumers can be empowered to be able to participate in the energy transition (Wallenborn, 2007), the energy market (Heiskanen et al., 2015), smart grids, in the development of energy technologies and so on. Power relations are often looked at, as well as the tension people can experience with respect to the many different identities they have (consumers, citizens, customers) that can even conflict within one person. Engagement is also seen as a key element of Responsible Research and Innovation, where many authors warn against the potential instrumental use of engagement instead of the responsible one (Jellema and Mulder, 2016; Marres, 2011). An interesting perspective on engagement comes from the last references, where the authors explore how engagement and participation are enabled by the everyday technologies we use for cooking, heating, smart metering etc. A novel focus is on design thinking as a bridge building discipline facilitating a better design of user engagement and empowerment in the technologies we use (Geelen et al., 2013; Fink et al., 2011). The above also relates to the concept of scripting, discussed later in subsection 1.7. 'User scripts'.



Wallenborn, G., 2007. *How to attribute power to consumers? When epistemology and politics converge*. London: Routledge.

Wallenborn explores in this paper the power (i.e. the possibilities, the freedom) consumers have to change their behaviours. He explores the various ways different sociological theoretical models of analysis define the consumers, their roles, powers and attributes in the more general framework of a consumer society. After establishing a typology of the numerous studies, Wallenborn concludes his analysis by postulating that consumers' practices and behaviours are currently shaped through performative models of individuals, and finally makes the case for the implementation of collective devices that would redistribute the current relationship of power.

Heiskanen, E., Matschoss, K. and Repo, P., 2015. *Engaging consumers and citizens in the creation of low-carbon energy markets (9-179-15)*. *Proceedings of the 2015 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm*.

Engaging consumers and the public (i.e. citizens) has become a widely accepted procedure when developing and encouraging adoption of new services, technologies and policies. In the energy domain, consumers and citizens have in recent years been engaged to participate in the development of smart grids, services and meters as well as low-carbon energy services such as micro-production of energy. Based on survey results from Finland in 2013 the authors argue that it is critical to consider the contexts and aims of the engagement when assessing its outcomes. The authors also stress the tension that consumers are likely to experience, located at the intersection of consumerism and citizenship.

Jellema, J. and Mulder, H., 2016. *Public engagement in energy research*. *Energies*, 9 (3) : 125.

Public engagement is discussed in this article as a way to deliver results that are more in-line with society's views and demands, and as a way to create collaboration that unlocks societal skills and knowledge. As such, public engagement can be argued to be key to responsible research and innovation. The authors present methods and tools for engagement that have been applied in the Netherlands and the UK.

Marres, N., 2011. *The costs of public involvement: everyday devices of carbon accounting and the materialization of participation*. *Economy and Society*, 40 (4), pp. 510-533.

In this article, the author takes a device-centred perspective on engagement. They demonstrate how everyday technologies for everyday practices, such as cooking and heating, are 'materialising' public participation. The concept of 'doability', and the investment of effort, become ways of investigating how engagement is facilitated by things.

Geelen, D., Reinders, A. and Keyson, D., 2013. *Empowering the end-user in smart grids: recommendations for the design of products and services*. *Energy Policy*, 61 (October 2013), pp. 151-161.

This article discusses the expected shift where users stop having a passive role as consumers of electricity and gain an active role as co-providers. The authors evaluate, based on a review of literature and pilot projects, and with an industrial design perspective, how technologies, products and services empower end-users to take up such an active role. The article states that product and service design can play a bridging role in supporting end-users in their role as co-providers in a smart grid, and as mediator between policymaking and engineering. Several recommendations are provided for product and service designers towards fostering the role of co-providers.

Fink, K., Laborgne, P., Koch, A. and Wassermann, S., 2011. *Behavioral changes through consumer empowerment - evidence from German case studies*. *Proceedings of the 2011 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm*.

This paper presents results of an interdisciplinary analysis of the energy consumption of space heating in the household sector in Germany, drawing on experiences of building residents and practitioners on how to enable consumer empowerment. Empirical evidence is provided on the practical challenges and lessons learned on how to achieve genuine and lasting bottom-up engagement with buildings users and on how to effectively monitor and evaluate energy savings.



1.5. Acceptability and adoption

Acceptability and adoption refers to the relationships people build up or refuse to build up with new technologies and/or systems. Research, amongst other things, focuses on the different strategies people deploy in reaction to technologies and programmes aimed at reducing energy use (Judson et al., 2015). For example strategies such as resistance leading to an increase in overall consumption, a 'watchful' acceptance which may stabilise consumption levels, and active optimisation which reduces them (Souami and Kasdi, 2015). A specific focus of the work in this field is on how everyday practices at home or in non-residential settings influence the acceptance and adoption of technologies. Thus work looks at, for example, how a certain technology, such as air-conditioning, becomes needed because of the complex interplay between practices, building elements and norms (Walker et al., 2014). Other research demonstrates how pre-existing acceptance for some energy efficient technologies increases the adoption and/or acceptance of other technologies (Herring et al., 2007).

Another topic related to acceptability and adoption is user innovation, which refers to the contribution users can make to the development and better uptake or acceptance of energy efficiency and saving technologies (Hysalo et al., 2013). Peer to peer support, and self-building or Do-It-Yourself (DIY) groups are seen as particularly promising strategies (Ornetzeder and Rohrer, 2006). A relatively new focus in this research field is the site of energy communities where user innovations are entangled with the creation of communities and their identities (de Vries et al., 2016). For a more extensive description of renewable energy and smart grid related acceptance issues, we refer the reader to the SHAPE ENERGY bibliographies on 'Competitive, secure, low-carbon energy supply' and 'System optimisation and smart technologies', respectively.

Judson, E., Bell, S., Bulkeley, H., Powells, G. and Lyon, S., 2015. The Co-Construction of Energy Provision and Everyday Practice: Integrating Heat Pumps in Social Housing in England. *Science and Technology Studies*, 28 (3), pp. 26-53.

This article aims to identify how everyday practice and energy provision services shape the uptake of air-source-to-water heat pumps installed in the north of England. The study furthermore investigates how such technologies mediate and reconfigure relations between users, providers and infrastructure networks. The authors state that with respect to air-source-to-water heat pumps the space for new forms of co-provision to emerge is limited and that installation, instruction, repair and feedback create new forms of interdependence between users, providers and intermediaries. In addition, the habits around heating and hot water practices inhibit the rearrangement of these practices.

Souami, T. and Kasdi, I., 2015. Micro-transitions et écoquartiers: la recomposition des pratiques énergétiques face aux déterminismes matériels et socio-économiques. *Vertigo- la revue électronique en sciences de l'environnement*, 14 (3), [online] Available at: <https://vertigo.revues.org/15730> [Accessed 31 May 2017].

Souami and Kasdi advance the hypothesis that behavioural changes are also conducted through various micro-transitions that affect individuals, considered as being consumers, residents, local users, as well as members of a defined social group. The authors make two major observations: the automated devices expected to reduce energy footprints by setting limits to the inhabitants' margins of flexibility are currently not meeting their initial objectives; the socio-economic factors used so far to characterise the populations and to explain their behaviours are far from being operative. Indeed, the authors identify three practical change strategies (a resistance leading to an increase in overall consumptions, a 'watchful' acceptance stabilising them, and active optimisation which reduce them) which do not match any of the occupational groups or eco-social categories traditionally in use.

Walker G., Shove E. and Brown S., 2014. How does air conditioning become 'needed'? A case study of routes, rationales and dynamics. *Energy Research & Social Science*, 4 (12), pp. 1-9.

This article investigates how the practice of cooling through air-conditioning in non-domestic buildings (a hospital in the UK) shape the building and installation needs. The authors identify repeated moments at which multiple, situated forms of need become established, in the design, the refurbishment, the use and reuse of space and repair moments for example. These moments are interconnected with institutional



context and working practices of the hospital such as increased reliance on heat emitting and heat sensitive technology and intense pressure to meet operational targets.

Herring, H., Caird, S. and Roy, R., 2007. Can consumers save energy? Results from surveys of consumer adoption and use of low and zero carbon technologies. *Proceedings of the 2007 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm.*

This paper presents results from a UK Open University research project based on an extensive survey of consumers' reasons for adoption – and non-adoption – of domestic energy efficiency measures and renewable energy systems. Consumers typically adopted these systems in order to save energy, money and/or the environment, which many considered that they achieved despite some rebound effects. An important finding is that most adopters of renewable energy systems had previously adopted two or more energy efficiency measures.

Hyysalo, S., Juntunen, J. and Freeman, S., 2013. User innovation in sustainable home energy technologies. *Energy Policy*, 55, pp. 490–500.

This article investigated user inventions in heat pump and wood pellet burning systems in Finland in the period 2005–2012. The authors focused on user innovations that improved either the efficiency, suitability, usability, maintenance or price of the heat pump or pellet systems. More importantly, the authors argue that these innovations are the result of mismatches between the system and the variation in users' homes. This user innovation can be an important contribution to the development of distributed renewable energy technologies. Of particular importance is the advanced peer support provided in popular user run Internet forums.

Ornetzeder, M. and Rohracher, H., 2006. User-led innovations and participation processes: lessons from sustainable energy technologies. *Energy Policy*, 34, pp.138–150.

This paper explores how and if a higher level of user led innovation and/or participation in the design and process planning, are potential strategies to improve the development and dissemination of sustainable energy technologies. The authors draw on several case studies, e.g. solar collectors and biomass heating systems—and sustainable building technologies. Self-building groups were highly successful in creating improved and widely disseminated technologies.

de Vries, G., Boon, W. and Peine, A., 2016. User-led innovation in civic energy communities. *Environmental Innovation and Societal Transitions*, 19 (June 2016), pp. 51–65.

A new topic of research in user innovation is the role energy communities play as sites for user innovation. This article focuses on the interplay of social, symbolic and technological innovations and the configurational work emerging on the community level, combining off-the-shelf technologies with novel ideas, such as business models for local energy provision. These processes are accompanied with learning processes at the community level, both in terms of evolving technical identity and community building activities.

1.6. ICT, data, and feedback technologies

A growing body of research on Information Communication Technologies (ICT) and open data can be identified. The most mature type of research is the analysis of the environmental impact of ICT. Some authors state that ICT provides great potential for energy efficiency because it allows for an immaterial economy and can help create and sustain more sustainable practices and lead to energy reduction, both in the residential and non-residential sector (Laget, 2008; Blomqvist and Thollande, 2015). Indeed, several authors explore this notion further to investigate, for example, how design methodologies and perspectives on cooperative play, gamification and social media can contribute to behavioural change in energy consumption (Cagri et al., 2014; Rotmann et al., 2011). Other authors however are more cautious and state that this potential for ICT to facilitate more efficient behaviour or reduction is strongly dependent on wider economic and political context (Beloglazov et al., 2012). In addition, our growing dependence on data, including for example cloud computing, creates enormous energy demand, which also needs more sustainable practices (Ropke and Christensen, 2012), as well as posing real privacy concerns.



A closely related topic is the use of ICT and data to influence energy behaviour through Home Energy Management Systems (HEMS) and feedback devices. This is one of the most written about topics across Social Science and Humanities disciplines, and hence forms a substantial subsection here. Engagement with the ICT based devices in the home, from the smart thermostat, to smart appliances to complete HEMS is a main focus of much of the research being performed, and goes back several decades (Brandon and Lewis 1999). In the past decades, many researchers have focused on identifying the best type, frequency, comparison and/or other form of feedback (Buchanan et al., 2015; Yang and Newman, 2012; Fischer, 2007) and what household characteristics should be taken into account when designing feedback (Vassileva et al., 2012). More recently, researchers have investigated what behaviour underlies the monitored savings in reaction to feedback; some have concluded that this is usually habitual behaviour, not investment behaviour and that a lack of acknowledgment of this can result in counterintuitive outcomes (Felicetti et al., 2015; Ehrhardt-Martinez et al., 2015; McCoy and Lyons, 2017). A strand of literature focuses of course on issues around privacy, but also on power and access. It is argued by many for example that not only should users be involved in designing the feedback and smart metering devices that will enter their homes, but that the data generated by the devices should remain the property of users at all times (Klopfert and Wallenborn, 2011). Another interesting finding is that when energy use becomes more visible because of monitoring and feedback, people also can become more frustrated with the lack of policy support for using less (Hargreaves et al., 2013). Interestingly, most studies focus on electricity monitoring and feedback, and much less on gas and energy for water use and its impact on energy efficiency.

Laget, M., 2008. Le numérique, simple mue du libéralisme ou avènement d'une économie soutenable. *Netcom*, 22 (3/4), pp. 189–208.

This Economic and Information Sciences based article proposes an interesting perspective on the role of data in making our energy system more energy efficient or even supporting using less. Data is an immaterial economy and consumes very few materials and dissipates almost no energy. In addition, ICT can aggregate numerous and diverse individual expectations into complex collective choices. As such, it can help the creation of new forms of citizens' accountability which would be consistent with the daily implementation of a sustainable agenda.

Blomqvist, E. and Thollande, P., 2015. An integrated dataset of energy efficiency measures published as linked open data. *Energy Efficiency*, 8 (6), pp. 1125–1147.

The authors argue that linked open data and integrating data from different sources in the industrial sector, (e.g. energy audit programmes) offer new approaches for energy efficient measures and support tools. Yet, due to a lack of knowledge an integrated database of energy efficiency measures has not been developed. Hence, the authors provide an example to present its potential. Furthermore, they argue that this type of research can contribute to the energy-efficiency gap. More research and online data sharing is needed.

Castri, R., De Luca, V., Lobsiger-Kägi, E., Moser, C. and Carabias, V., 2014. Favouring behavioural change of households' energy consumption through social media and cooperative play. In: *Behave Energy Conference*, Oxford – UK, Available at: <http://repository.supsi.ch/5541/> [Accessed 31 May 2017].

This paper presents an overview of design methodologies and perspectives on cooperative play, gamification and social media contributing to behavioural change in energy consumption. Social media coupled with mobile connectivity opens up a whole new range of opportunities for participative action-oriented approaches to engage a large number of end-users in energy-savings activities. The sharing aspect of social media has a persuasive effect, creates collective awareness, enables visualisations and bridges the gap between collective and individual behaviour. Mixed-method research is needed to understand social playing dynamics.

Rotmann, S., Sandhu, A. and Chrisite, L., 2011. Making energy efficiency research relevant: A note on the evaluation of social media as a tool for engaging energy practitioners and consumers. *Proceedings of the 2011 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm*.

This paper reviews social media-based efforts to share, seek input and mobilise the engagement of energy consumers with the experts – the researchers, policymakers and community practitioners. Implications are



drawn on how to use social media to generate discussion and feedback in order to inform researchers, policy-makers and community action groups involved in motivating energy savings.

Beloglazov, A., Abawajy, J. and Buyya, R., 2012. Energy-aware resource allocation heuristics for efficient management of data centres for Cloud computing. *Future Generation Computer Systems*, 28 (5), pp. 755–768.

The authors argue for the need for Green Cloud computing solutions because data centre hosting Cloud applications consume huge amounts of electricity. Hence, they offer an architectural framework and principles for energy-efficient Cloud computing without decreasing the Quality of Services. Their model demonstrates potential significant cost savings and a high potential for improved energy efficiency whilst guaranteeing flexibility in offered services.

Røpke, I. and Christensen, T., 2012. Energy impacts of ICT– Insights from an everyday life perspective. *Telematics and Informatics*, 29 (4), pp. 348–361.

This article aims to contribute a complementary perspective to the long existing work focusing on the analysis of the environmental implications of ICT with a time geography and practice theory approach. The authors argue that a perspective based on practice theory and time geography is necessary, from which everyday life takes centre stage. The article explores how the use of ICT affects practices in relation to time and space. The impact of the use of ICT is also researched in terms of the way the changes may increase energy consumption, in spite of the great potential for reducing energy consumption, but the realisation of this depends on the wider economic and political conditions.

Brandon, G. and Lewis, A., 1999. Reducing household energy consumption: a qualitative and quantitative field study. *Journal of Environmental Psychology*, 19 (1), pp. 75–85.

In this study, households had their energy consumption monitored. Participants received feedback, i.e. consumption compared to previous consumption or to similar others; energy saving tips in leaflets or on a computer; or feedback relating to financial or environmental costs. Respondents were interviewed. Income and demographic features predicted consumption but not changes in consumption, where environmental attitudes and feedback were influential. The installation of computers helped reduce consumption. People with positive environmental attitudes, but who had not previously been engaged in many conservation actions, were more likely to change their consumption.

Buchanan, K., Russo, R. and Anderson, B., 2015. The question of energy reduction: The problem(s) with feedback. *Energy Policy*, 77, pp. 89–96.

The authors argue that the current In-Home Displays such as smart meters are not designed to encourage user engagement. The information on energy consumption that these in-home-displays provide is not sufficient to induce the desired energy savings. Energy savings are overestimated and they fail to take into account rebound effects. Since In-Home Displays are going to play a major role in energy savings, more research needs to be done on creating effective feedback mechanisms taking into account the shortcomings the authors have outlined.

Yang, R. and Newman, R., 2012. Living with an intelligent thermostat. Advanced control for heating and cooling systems. *Ubiquitous Computing*, 12 (5), pp. 1102–1107.

This article focuses on how improved interfaces, facilitated by machine learning, sensing, and networking technology, as well as eco-feedback features of the NEST, a thermostat, changed the interactions between users and their home system. The authors even demonstrate that the thermostat could engage users in such a way that they adapted to the thermostat. However, energy savings might not have been maximised because of a combination of control over the system and limitations of the technology. The authors argue that continuous involvement from users is critical, particularly allowing input from users during use.

Fischer, C., 2007. Influencing electricity consumption via consumer feedback: a review of experience. *Proceedings of the 2007 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm*.

This landmark paper reviews and analyses international experiences with the use of feedback to encourage energy-efficient behaviour. The effectiveness of frequency, duration, content, breakdown, medium



and way of presentation, comparisons, and combination with other instruments are assessed. The most successful feedback has the following characteristics: it is given frequently and over a long period of time, provides an appliance-specific breakdown, is presented in a clear and appealing way, uses computerised and interactive tools, and may involve historic or normative comparisons.

Felicetti, C., DeRose, R., Raso, C., Felicetti, A., Ammirato, S., 2015. Collaborative Smart Environments for energy-efficiency and quality of life. *International Journal of Engineering and Technology (IJET)*, 7(2), pp. 543–552.

Home Energy Management Systems offer a proven and alternative tool to reduce energy consumption at the household level according to the authors. According to these authors however, user habits are not taken into account adequately. Hence, the paper offers an interoperable architectural framework to monitor and manage energy consumption in households working on automated decision-making capabilities and quantitative forecasting methodologies to predict future energy consumption.

Ehrhardt-Martinez, K., Laitner, S. and Donnelly, K., 2011. Changing habits, lifestyles and choices: The behaviours that drive feedback-induced energy savings. *Proceedings of the 2011 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm.*

A number of studies have attempted to quantify savings from the provision of feedback, but very few have investigated the types of behaviours that underlie feedback-induced energy saving. This paper reviews evidence from several feedback studies, which suggests that most of the energy savings achieved through feedback programmes results from changes in behaviours (energy management) rather than through investments. The paper describes and assesses the types of behaviours that are motivated by feedback.

McCoy, D. and Lyons S., 2017. Unintended outcomes of electricity smart-metering: trading-off consumption and investment behaviour. *Energy Efficiency*, 10 (2), pp 299–318.

This article investigates how smart metering affects residential energy efficiency investment behaviour in Irish households. Counterintuitively the authors found that when households were exposed to time-of-use pricing and information stimuli, while reducing overall and peak usage, this resulted in the unintended effect of reducing investment in energy efficiency measures within the home.

Vassileva L., Odlare, M., Wallin, F. and Dahlquist, E., 2012. The impact of consumers' feedback preferences on domestic electricity consumption, *Applied Energy*, 93 (May 2012), pp. 575–582.

This article discusses a Swedish study aimed at understanding whether the design of feedback should incorporate household characteristics such as income level. The income proved to be a very influential factor determining electricity consumption in high and low income groups. Furthermore, web based feedback resulted in being the most effective with approximately 15% electricity savings.

Hargreaves, T., Nye, M. and Burgess, J., 2013. Keeping energy visible? Exploring how householders interact with feedback from smart energy monitors in the longer term. *Energy Policy*, 52 (January 2013), pp. 126–134.

This article discusses how householders interact with feedback on their domestic electricity consumption in a field trial of real time displays or smart energy monitors. What became apparent in this trial is that smart energy monitors do make energy visible in a household, but that this also means that the limits to action become visible. The authors also found that in time the use of the metering devices and feedback fades, moves to the background. An important finding is that many householders, when becoming more aware, also become frustrated by the absence of wider policy and market support.

Klopfert, F. and Wallenborn, G., 2011. *Empowering consumers through smart metering. Report for the BEUC, the European Consumer Organisation, 22 December 2011.*

Klopfert and Wallenborn examine the diverse point of view of consumers and analyse whether smart meters can be useful to consumers from an environmental sciences and sociological perspective. Most importantly, the authors state that consumers need to be able to make choices and not be confronted with standards they were not involved in developing. The authors also state that users should be allowed to access their data for free forever, and should be able to decide to whom the data is transferred.



1.7. User scripts

Efforts to improve energy efficiency have traditionally been dominated by two approaches: the Engineering, or the Behavioural Sciences approach. In the Engineering approach, the focus is mainly on developing and delivering energy efficient technologies that should bring energy savings. The behavioural approach aims to change the behaviours of energy consumers, often by providing price signals and information to change consumers' attitudes towards energy saving. In practice, both approaches have faced difficulties in realising their full potential of energy savings. The notion of scripts can help bridge this gap between the Engineering and Behavioural Sciences approaches. This notion, first described by Akrich (1992) describes how designers inscribe their visions about the envisioned future practice of use in the design of new technologies, which results in a design that encourages or forces certain behaviour while counteracting other behaviours (Jelsma and Knot, 2002; Jelsma, 2004; Wilhite, 2007; Lilley, 2010). These technologies can break existing routines and replace them with others. The envisioned use is based upon various ideas, views, values, intentions and assumptions of the designers about the future users of the technologies (Gaye and Wallenborn, 2015; Thronson, 2017; Royston, 2015). This includes views and assumptions about the context in which the technology will be used as well as assumptions about the future users of the technology, which may be called 'user representations', fictive, or imagined users (Ivory, 2013; Maranta et al., 2003). A differing perspective on empowerment comes from Wilhite and Wallenborn (2013) who argue that people's exposure to personal and culturally mediated experience embodies knowledge (and meanings) and this in turn affects the ways we perform energy-consuming acts. The literature shows that the notion of scripts and embodiment can help bridge the gap between the behavioural and engineering approach since it connects the design of new technologies with how these technologies shape use practices.

Akrich, M., 1992. The De-description of Technical Objects. In: Bijker, W.E., Law, J., eds. 1992. *Shaping Technology, Building Society*. Cambridge (MA): MIT Press, pp. 205–225.

Akrich has developed the concept of script to describe the agency of technological artefacts. The basic idea behind this concept is that human action is mediated by (specific design characteristics such as shape, mechanism, signals, etc. of) non-human artefacts in their environment. When designing a technology designers make hypotheses about the users. Designers 'inscribe' or materialise these predictions about envisioned use into their products, leading to products with scripts that have a facilitating force on user behaviour. However, scripts do not determine users' behaviour completely. Users can interpret the script in different ways than how it was envisioned by the designer, leading to a broad range of ways in which the technology can be embedded by users in their use practice. The concept of scripts of Akrich can be used to connect the relationships of the designers of technologies and its users.

Wilhite, H., 2007. Will efficient technologies save the world? A call for new thinking on the ways that end use technologies affect energy using practices. *Proceedings of the 2007 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm*.

The paper addresses the theory of technology-behaviour interaction, arguing that both the technology and behaviour-focused perspectives on reducing energy have oversimplified the ways that technology scripts and socio-cultural contexts interact to affect energy-using practices. The concept of distributed agency is introduced to capture the theoretical link between technology and behaviour. The potential for rethinking longer term policy to promote sustainable energy consumption is explored.

Jelsma, J. and Knot, M., 2002. Designing environmentally efficient services, a 'script' approach. *The Journal of Sustainable Product Design*, 2 (3), pp. 119–130.

Jelsma and Knot explore in their article in what way the design and organisation of services may lead to people using these services as intended by the designer. This is important since the environmental benefits largely depend on who actually use the service, and how they are being used. The notion of 'scripts' is central in this approach, which states that behaviour is influenced by the material environment that is 'scripted'. The script concept argues that users will use a product or a service in the intended way if the script matches with their 'use logic'. Jelsma and Knot describe complications relevant to applying a script approach to services, and possible ways of experimenting to further explore its applicability in this new field.



Jelsma, J., 2004. The Engineering Approach and Social Aspects of Energy Use: Mind the Gap, but Can It Be Closed? *Proceedings of the 2004 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm.*

Attempts to decrease energy consumption in households consists basically of two separate approaches. First there is the Engineering approach focused on developing and delivering energy efficient technologies that often do not perform as good in the world of consumers as they do in laboratories. Secondly, there is the 'behavioural approach' often aimed at providing price signals and informing to consumers in order to influence their attitudes towards energy saving. However, despite much efforts energy usage by households continues to rise. Jelsma outlines the knowledge-landscape of both approaches that dominate the field of energy conservation. He also provides a new perspective (including notions like scripts, delegation, domestication, and design- and use logic) that looks how technologies (with scripts) shape human behaviour by breaking existing routines and replace them with more sustainable ones.

Lilley, D., Bhamra, T., Haines, V. and Mitchell, V., 2010. Reducing energy use in social housing: examining contextual design constraints and enablers. *6th International Symposium on Environmentally Conscious Design and Inverse Manufacturing, Sapporo, Japan.*

This paper reports on the results of a research project called 'Carbon, Control and Comfort' of which the aim was to engage occupants in the design of control systems they appreciate, that they can use to get comfortable and that result in energy savings because it makes more effective use of the technology and fabric of their homes. The authors argue that occupants need to be engaged in a meaningful and effective way in the design of technologies in order to achieve substantial energy savings in housing.

Gaye, G. and Wallenborn, G., 2014. Multidisciplinary Smart Grid Research and the Design of Users. In B. Penzenstadler & W. Lohmann (ed.s), *ICT4S (Workshops)*. CEUR-WS.org. pp. 29–31.

Gaye and Wallenborn advance in this article that the current models used by engineers and economists tend to design and restrict end-users to a very limited set of features. The current individualist basis inspired by the economists' perspective, combined with a large technological grid derived from the engineers' perspective could be replaced by more desirable configurations. These would rest upon community levels, direct exchanges of electricity among neighbours and ecological interests. Interpersonal relationships and higher trust among concerned actors would permit an enhancement in the system's flexibility.

Thronsen, W., 2017. What do experts talk about when they talk about users? Expectations and imagined users in the smart grid. *Energy Efficiency*, 10 (2), pp. 283–297.

The study suggests that three different narratives about smart grid users exist. The economics narrative aims to use economic incentives to facilitate user rationality, the technical narrative aims for automating consumption and thus bypassing the users, and finally there is one narrative consisting of a social science inspired critique that evaluates imagined users and how they correspond with real users. Thronsen further states that users should be included in the development process since engineers and economists are unable to imagine users perfectly and thus unable to develop a smart grid that will actually work well in practice.

Royston, S., 2015. Active consumers? Everyday innovation and adaptation for efficiency in thermal comfort services. *Proceedings of the 2015 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm.*

Royston presents the results of an online study on thermal management at home, and more specifically on exploring everyday innovations, adaptations and techniques that people use in order to limit their energy use while maintaining a warm home. Some concepts from Psychology and Behavioural Studies were used. But Social Practice Theory and Science and Technology Studies, including concepts like scripting, social practices and appropriation, help to understand practices related to efficient warming of their homes. The study shows that people use both formal methods as well as more diverse improvised ways to warm their homes in an efficient manner.

Ivory, C., 2013. The role of the imagined user in planning and design narratives. *Planning Theory* 12 (4), pp. 425–441.

Ivory explores the role of the 'imagined user' in planning and building design narratives. The author uses material about the design of a social-housing scheme in Manchester in the mid-1990s to demonstrate how



users and their characteristics, wants and fears were constructed by planners and designers, and how these 'imagined users' were used in design and planning narratives. According to Ivory, the 'imagined user' plays a central role in the interaction between potentially conflicting parties in this planning and design decision-making process. The different imagined users and the related fears, hopes and desires reflect the worldviews of the people that deploy them.

Maranta, A., Guggenheim, M., Gisler, P. and Pohl, C., 2003. *The Reality of Experts and the Imagined Lay Person. Acta Sociologica* 46, pp. 150–165.

The authors argue that in a knowledge society experts have to provide scientific facts and information, suggestions for feasible solutions, and guidance. These experts have conceptions of lay people (e.g. the 'imagined lay person') they should assist in coping with a world entangled with various technologies. The authors state one major problem for experts: providing expertise that makes sense for both experts and laypeople. The authors conclude that there is no single strategy for dealing with this problem. But they do suggest a solution to the problem of experts: they should not think of experts as knowledgeable and lay people as ignorant, but instead they should rethink the situation as a plurality of tasks and competences that people have.

Wilhite, H. and Wallenborn, G., 2013. *Articulating the body in the theorizing of consumption. Proceedings of the 2013 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm.*

In mainstream theory on energy consumption and efficiency, the focus has been on mental states, meaning, and rational choice. The demand for goods is both disembodied and decontextualised from social and material worlds. These reductions hinder the development of new thinking in energy savings policy. In this paper, the authors argue that people's exposure to personal and culturally mediated experience embodies knowledge (and meanings) and this in turn affects the ways we perform energy-consuming acts.

1.8. Global impact on local level

Although providing one of the rationales behind aiming to use less energy, European based research into the impact of climate change (including perspectives and experiences on the local level) on energy efficiency and using less is a topic for which we found few sources. One focused on the history of the energy crisis and its impact on the local level of energy use (Debeir et al., 1991). Another source addresses how the growing focus on global warming has affected the use of energy in households (Aune et al., 2016). Most literature in this domain however exists for African, Asian and Oceanian countries. This literature addresses experiences of climate change and strategies around energy efficiency and using less, which relate to diseases, health and health indicators, droughts, flooding, forest, forestry, crops, farming, heat stress and measures relating to city planning, adaptation strategies, and disaster risk reduction.

Debeir, J., Deleage, J. and Hemery, D., 1991. *In the servitude of power: energy and civilisation through the ages.* London: Zed Books.

In this book the authors look at the energy crisis by addressing economic, social and ecological interdependencies to see what roles energy will play in the future of humanity. They move beyond conventional approaches that look at empirical cases and that have a rather one-dimensional way of analysing the energy crisis. They discuss various energy structures in different regions around the world at different times in history. This way they aim to look at the energy crisis from an alternative, broad and historical perspective.

Aune, M., Godbolt, Å., Sørensen, K., Ryghaug, M., Karlstrøm, H. and Næss, R., 2016. *Concerned consumption. Global warming changing household domestication of energy. Energy Policy*, 98 (November 2016), pp. 290–297.

This paper addresses how the growing focus on global warming has affected the domestication of energy (consumption) of households. Two periods are compared in which respectively little (1991-1995) and a lot of public attention (2006-2009) was given to global warming. In the first period, energy culture was dominated with concerns about comfort and convenience. In the second period, people seem to be more



concerned and many people said that they save energy. However, also in this period the main focus of people was still on comfort and convenience. From this the authors conclude that climate concerns did bring some but not very radical changes in the way people think about, use and save energy in their daily life. The increased climate concerns did lead to feelings of guilt that were at the same time tempered by their ideas on how hard it is to change.



2. Users of energy

This section focuses on several issues related to stakeholders. These include how to make sure that energy efficiency and using less approaches are designed to fit different people's needs, and are sensitive to the many different sites where change might be needed - not only related to residential buildings, but also schools, offices, small and medium enterprises etc. Another important focus of this section is on the changing roles of users and stakeholders, many are becoming producers of energy as well as consumers, both individuals as well as communities. Further, questions about leadership, champions and ambassadors are key to address. Questions posed by SSH research in this area range from how to find and engage champions, to understanding the role of intermediary organisations and stakeholders such as sports clubs and others, in creating a better uptake of energy efficiency and using less approaches.

2.1. Different people, different approaches?

This topic covers the influence of different characteristics of buildings and user segments on energy efficiency and using less. The characteristics most often used in the literature are: socio-economic status, environmental attitudes, environmental behaviours, attitudes towards policy, age, income, education, psycho-social characteristics, cultural norms and gender of users and residents, size and composition of the household and physical characteristics of dwellings (Wyatt, 2013; Urban and Scasny, 2012; Sutterlin et al., 2011). In addition, gender can have an influence on the cultural norms and perception of residents regarding energy efficiency measures (Tjorring, 2016). Research is conducted within different disciplines, amongst others Anthropology and Economics.

Wyatt, P., 2013. A dwelling-level investigation into the physical and socio-economic drivers of domestic energy consumption in England. *Energy Policy*, 60 (September 2013), pp. 540-549.

The physical nature of the dwellings and the socio-economic characteristics of occupants have an influence on the domestic energy consumption and energy efficiency measures have an influence on energy consumption. These findings should be considered when developing public policy regarding energy measures. The findings are important for progress in built stock energy efficiency.

Urban, J. and Scasny, M., 2012. Exploring domestic energy-saving: the role of environmental concern and background variables. *Energy Policy*, 47 (August 2012), pp. 69-80.

The focus of the research is residents' environmental concern and the effect of this concern on their energy saving curtailments and efficiency investments. The research uses a multi-country setting and results can be compared across different countries. The authors suggest that people with higher environmental concerns are more likely to take energy-saving measures and are more likely to install energy-efficiency retrofits in dwellings. Socio-economic and demographic variables have mixed effects on investments. Variables that have effects are age, household income, education, gender and size of the household. The research has a social-psychological perspective. It is recommended to exploit the role of environmental concerns as a factor of energy saving in energy policies.

Brounen, D., Kok, N. and Quigley, J., 2012. Residential energy use and conservation: Economics and demographics. *European Economic Review*, 56 (5), pp. 931-945.

The authors argue that more attention ought to be paid to the economic behaviour of residents instead of the current focus on physical and technical aspects of energy behaviour. They compare the extent to which energy use is determined by the physical characteristics of a dwelling with the influence of demographic characteristics of residents. The results suggest that gas consumption is largely dependent on the physical characteristics of a house, whereas electricity consumption depends on the household composition.

Gaspar, R. and Antunes, D., 2011. Energy efficiency and appliance purchases in Europe: Consumer profiles and choice determinants. *Energy Policy*, 39 (11), pp. 7335-7346.

This article investigates three phenomena: the factors consumers consider when purchasing electrical appliances, the differences between consumer profiles regarding the factors they consider and the factors that drive consideration of the energy efficiency of an appliance. Results suggest that consumers



firstly consider costs, followed by quality and energy consumption. Environmental practices are positive predictors for energy efficiency considerations. Based on the profiles, the researchers recommend certain kinds of persuasive messages and retail employee training. The results could also inform the development of energy labels.

Vassileva, I. and Campillo, J., 2014. Increasing energy efficiency in low-income households through targeting awareness and behavioural change. *Renewable Energy*, 67 (July 2014), pp. 59–63.

This article looks at the best ways of changing energy behaviour within low-income households. Providing energy consumption feedback should be based on households' characteristics and needs. The preferred ways for receiving consumption feedback were letters and in-home displays. Money and environmental factors were important drivers for saving energy. The location of households and the age of consumers affected the level of knowledge about energy saving. There is still great potential to increase energy efficiency in low-income households.

Sutterlin, B., Brunner, T. and Siegrist, M., 2011. Who puts the most energy into energy conservation? A segmentation of energy consumers based on energy-related behavioral characteristics. *Energy Policy*, 39 (12), pp. 8137–8152.

The article describes different groups of energy consumers. The consumers are divided into different groups based on the characteristics of their energy-related behaviour. The researchers argue there are six energy consumer segments. They further argue that, because of their use of a broad spectrum of behavioural characteristics, they were able to create a more precise image of different energy consumer types. Marketeers and policy makers can and should develop segment-specific strategies for motivating users to save energy.

Tjorring, L., 2016. We forgot half of the population! The significance of gender in Danish energy renovation projects. *Energy Research & Social Science*, 22, pp. 115–124.

This article looks at the way people live their everyday lives and how it affects their choices involving energy renovation. The research uses an Anthropological approach and the results are based on the study of 10 Danish families. The results show that gender is a significant factor in multiple ways. Firstly, because men and women have different everyday practices, they perceive energy renovations differently. Secondly, cultural norms have an influence on what men and women do in the home and how the roles are divided. Energy renovation was considered to be a male subject. Instead of using the usual financial incentives and technical solutions, policy makers should therefore also focus on gender roles and cultural norms.

2.2. Non-residential sites

Literature under the topic of non-residential sites includes work from those authors that write about energy saving and efficiency in buildings that are not used for living. The examples below discuss energy efficiency in schools, office buildings, Small and Medium-size Enterprises (SMEs), and industry. The commercial sector is subdivided in trade, commerce, services and primary manufacturing in the examples below (Olsthoorn et al., 2017; Trianni et al., 2014). The research is conducted within different disciplines, like Ergonomics, Economics and Econometrics, but can also be multi-disciplinary (Olsthoorn et al., 2017; Christina et al., 2014). It uses frameworks build on socio-technical approaches, systems perspective, agency theory, absorptive capacity literature and the multi-disciplinary behaviour change wheel. The research focuses on the relation between process and product innovation in a company and the application of energy efficiency technologies, benchmarking of energy efficient schools, the effectiveness or success of different types of interventions at saving energy in offices, drivers and barriers for the application of energy efficiency measures and well-being of users in energy efficient office buildings (Pereira et al., 2014; Staddon et al., 2016; Ornetzeder et al., 2016).



Gerstlberger, W., Knudsen, M., Dachs, B. and Schröter, M., 2016. Closing the energy-efficiency technology gap in European firms? Innovation and adoption of energy efficiency technologies. *Technological Management*, 40 (April-June 2016), pp. 87–100.

Manufacturing firms need to adopt energy efficiency measures to reduce their energy use according to the Green Agenda for 2020 set by the EU. This research suggests that companies that invest in technical process innovations and product innovation are more likely to adopt energy efficiency technologies. Hence, more research needs to be done to understand the policy implications. Moreover, the EU should increase the synergy between product innovation and the introduction of energy efficiency technologies.

Pereira, L., Raimondo, D., Corgnati, S. and Da Silva, M., 2014. Energy consumption in schools – A review paper. *Renewable and Sustainable Energy Reviews*, 40 (December 2014), pp. 911–922.

In this article, an international benchmark of energy consumption in schools is developed. The authors argue that schools have an educational function and a social responsibility, and should therefore pay attention to their energy performance. The results are based on real operation conditions in schools - from data that has been made public - and a literature survey on energy consumption.

Staddon, S., Cycil, C., Goulden, N., Leygue, C. and Spence, A., 2016. Intervening to change behavior and save energy in the workplace: a systematic review of available evidence. *Energy Research & Social Science*, 17 (July 2016), pp. 30–51.

There is still great potential to save energy in office buildings and working environments. This article researches the types of energy related behaviour change interventions that are most successful in working environments. Their framework is based on the behaviour change wheel. Results suggest that the most successful interventions to change behaviour are those that create social and physical opportunities. Decision-makers have to consider the effects of social influences in the workplace. Evaluation of interventions is needed to determine the success of different techniques.

Christina, S., Waterson, P., Dainty, A. and Daniels, K., 2014. A socio-technical approach to improving retail energy efficiency behaviours. *Applied Ergonomics*, 1 (12), pp. 324–335.

This article is about energy-related technologies and strategies and their incorporation into organisational life. The authors use a socio-technical framework to guide their research. They find socio-technical and goal setting factors that can obstruct or enable energy efficient behaviours. They describe a practical operational intervention and issues arising from goal conflict in the workplace. They argue their research contributes to the achievement and sustainability of sustainable behaviour in the workplace.

Olsthoorn, M., Schleich, J. and Hirzel, S., 2017. Adoption of Energy Efficiency Measures for Non-residential Buildings: Technological and Organizational Heterogeneity in the Trade, Commerce and Services Sector. *Ecological Economics*, 136 (June 2017), pp. 240–254.

The paper empirically analyses enablers and barriers to the adoption of energy efficiency measures in the trade, commerce and service sector. The research is based on econometric analyses. Organisational attributes that contribute to the capacity to implement energy efficiency measures have a positive effect whereas principal-agent (different benefits and costs for owner-tenant) relationships have negative effects. Barriers for all energy efficiency measures are rented spaces, high investment costs, and other priorities.

Trianni, A., Cagno, E. and Farne, S., 2014. An empirical investigation of barriers, drivers and practices for energy efficiency in primary metals manufacturing SMEs. *Energy Procedia*, 61, pp. 1252–1255.

This article aims to create a better understanding of the barriers and drivers for implementing energy efficiency measures, since energy efficiency measures are scarcely implemented, especially in SMEs. The results suggest that economic and information barriers are important. The authors argue that external drivers are perceived to be more important than internal drivers. It is recommended that greater attention be paid to training of competences of end users.



Sekki, T., Airaksinen, M. and Saari, A., 2017. Effect of energy measures on the values of energy efficiency indicators in Finnish daycare and school buildings. *Energy and Buildings*, 139 (March 2017), pp. 124–132.

The authors investigate whether the right indicators are being used to measure energy efficiency after applying energy efficiency measures in schools and day-care in Finland. They recommend indicators that are more user-driven and better reflect the reality of a building's operational phase energy efficiency. This requires alternative indicators. Further, they argue that tools should be developed that reflect real time data of energy and occupancy for better energy management.

Ornetzeder, M., Wicher, M. and Suschek-Berger, J., 2016. User satisfaction and well-being in energy efficient office buildings: Evidence from cutting-edge projects in Austria. *Energy and Building*, 118 (April 2016), pp. 18–26.

This paper is about the energy use and well-being of users in energy efficient office buildings. This means the authors investigate the relation between energy use and user satisfaction, well-being and comfort. The authors suggest that extremely low levels of energy use are linked with high levels of well-being. They further argue that well-being and energy performance in office buildings are the result of complex processes that involve material and social elements.

2.3. Changing roles and new players

New initiatives, services and markets that can accelerate energy transition are emerging. Research focuses on several topics. Firstly, 'pioneering consumers' and 'pioneering customers' can be mobilised for new energy services with use of the right peer group-relevant marketing (Matschoss et al., 2015). These 'pioneering consumers' often have different expertise and needs than other consumers. Another topic is 'prosumerism', which offers more flexibility to energy users (Parag, 2015). Thirdly, local authorities become operational stakeholders and take ownership in the process of remunicipalisation (Rudinger, 2017). A lot of energy efficiency measures are taken within renewable energy initiatives. Most local citizen initiatives and new players focus mainly on producing and consuming renewable energy instead of energy efficiency (Muller et al., 2011). Autonomous initiatives have a relatively large potential to have an influence on the energy transition (Rae and Bradley, 2012). It is recommended to focus on the community level, which will then have an influence on the individual level (Heiskanen et al., 2010).

Matschoss, K., Kahma, N. and Heiskanen, E., 2015. Pioneering customers as change agents for new energy efficiency services—an empirical study in the Finnish electricity markets. *Energy Efficiency*, 8 (5), pp. 827–843.

The researchers argue there is a lack of research on what the market potential of new energy services could be in end-user markets. They write about the pioneering consumers that use these new energy services and compare them with the mass market. They find several differences, like expertise and ahead-of-the-market needs. The results are relevant for more effective marketing techniques. One can offer consumers more useful products and peer-group relevant marketing.

Parag, Y., 2015. Beyond energy efficiency: A 'prosumer market' as an integrated platform for consumer engagement with the energy system. *Proceedings of the 2015 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm.*

This paper explores the concept of 'prosumerism', important in emerging smart markets for energy. A 'prosumer market' integrates supply choices and demand options, allowing energy users the flexibility to choose which energy services they want to provide. The paper outlines the 'prosumer market' concept, situates it in the current policy landscape, discusses optional designs and structures, and highlights directions for further investigation.

Rudinger, A., 2017. *Local energy ownership in Europe. An exploratory study of local public initiatives in France, Germany and the United Kingdom. France: Energy Cities.*

This is a report by Energy Cities about the remunicipalisation initiatives in the energy sector in Europe. Remunicipalisation means that local authorities become operational and take agency in their efforts to



further the energy transition. The study aims to explain the momentum for the phenomenon. The initiatives involve renewable energy, energy efficiency or sustainable mobility projects. Lastly, they discuss the reasons of local authorities for setting up a local public operator.

Muller, M., Stampfli, A., Dold, U. and Hammer, T., 2011. Energy autarky: A conceptual framework for sustainable regional development. *Energy Policy*, 39 (10), pp. 5800–5810.

This article presents the potential of energy Autarky based on locally renewable energy resources by providing some examples from Austria, Germany and Switzerland. Demonstrating that these types of initiatives have multiple benefits, such as local cooperation between administration and civil society actors and organisation of local and regional support. Moreover, it inspires communities to take their energy policy to the next level. Further research is needed to understand the success factors of such projects.

Rae, C. and Bradley, F., 2012. Energy autonomy in sustainable communities—A review of key issues, *Renewable and Sustainable Energy Reviews*, 16 (9), pp. 6497–6506

Similar to the previous citation these authors argue that a more holistic approach to the energy transition is necessary. They claim that energy autonomy within sustainable communities has a much broader effect on sustainable development as a whole. The social and political consequences of these initiatives have a high impact, hosting a range of social, financial and environmental benefits. More research on demand side management in these types of projects is needed.

Heiskanen, E., Johnson, M., Robinson, S., Vadovics, E. and Saastamoinen, M., 2010. Low-carbon communities as a context for individual behavioural change. *Energy Policy*, 38 (2010), pp. 7586–7595.

This article discusses the influence of communities on individual behaviour. It is recommended that energy users be approached in their role of citizens rather than just consumers. The researchers analyse different types of communities and the way they offer solutions to problems involving behaviour change. They offer recommendations regarding the design and support of communities.

2.4. Leadership, champions and ambassadors

Research within the topic of leadership, champions and ambassadors focuses on pioneers, best practices and actors that can spread new developments. Some examples are the role of community leadership in the development of grassroots innovations (Martiskainen, 2017). Social and sustainable motives often drive these innovations. Another example is the evaluation of English pioneer places of the Green Deal (Marchand et al., 2015). Relatively little has been written on this topic.

Martiskainen, M., 2017. The role of community leadership in the development of grassroots innovations. *Environmental Innovation and Societal Transitions*, 22 (March 2017), pp. 78–89.

This article discusses the role of community leadership in the development of grassroots innovations. The framework is built on literature on community leadership, grassroots innovations and niche literature. They focus on skills and knowledge of community leaders and the drivers of grassroots innovations. These drivers consist of social and sustainability motives. Community leadership can stimulate grassroots innovations.

Marchand, R., Koh, S. and Morris, J., 2015. Delivering energy efficiency and carbon reduction schemes in England: Lessons from Green Deal Pioneer Places. *Energy Policy*, 84 (September 2015), pp. 96–106.

This article is mainly an evaluation of the Green Deal, an English governmental program designed to increase energy efficiency in English households. They use one local authorities' experience with the Green Deal as a case study. They find that awareness and understanding of the program is low. The main motivation of residents to participate in the program is saving money. They experienced improved warmth and quality of their home. The researchers hope that the evaluation can contribute to better energy efficiency programs in the future.



2.5. Intermediaries

Another area of recent interest has been the concept of 'intermediaries' – actors who lie beyond the traditional research foci of energy users, energy suppliers, or energy regulators/policymakers, but nevertheless play a central role in energy efficiency efforts (Moss, 2009; Maneschi, 2013; Parag and Janda, 2014). Research ranges across: the role of intermediaries in expanding the market for energy service contracts; the role of intermediaries in governance; banks and advisors as intermediaries; and the differences between intermediaries and middle-actors (Nolden et al., 2016).

Moss, T., 2009. Intermediaries and the governance of sociotechnical networks in transition. *Environment and Planning A*, 41 (6), pp. 1480–1495.

Moss argues that “very little attention has been paid as yet to the roles of other actors ... who do not fit neatly into one of the three categories of provider, user, or regulator” (p. 1480-1481). This paper thus focuses on such 'intermediaries', such as regional energy agencies, non-profit consultancies, or support services for SMEs. Through case studies drawn from both the water and energy sectors, he examines how intermediaries (i) emerge, (ii) work between other groups, (iii) develop interests, and (iv) have impact. Moss has a particular interest in exploring the role of intermediaries in governance – that is collective action or decision-making, which is not solely government-led.

Maneschi, D., 2013. Widening the scope? How intermediary actors can shape energy consumption. *Proceedings of the 2013 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm*. pp. 2367–2379.

This article provides a useful review of the concept of 'intermediaries', including a table on varying definitions. The paper describes findings from a case study regarding the role of banks and advisers in financing energy efficiency home improvements. In doing so, they illustrate how the “diffusion of energy efficiency technologies ... cannot be attributed to a restricted group of actors, but is the domain of various professionals competing for space and power” (p. 2370). Maneschi explores how such (potentially unexpected) actors may thus play a central role in energy efficiency policies.

Parag, Y. and Janda, K., 2014. More than filler: Middle actors and socio-technical change in the energy system from the 'middle-out'. *Energy Research & Social Science*, 3 (September 2014), pp. 102–112.

Parag and Janda distinguish between the concepts of 'middle actors' and 'intermediaries', by observing that intermediaries are often seen simply in relation to others, rather than with their own agency and differing agendas. The authors propose a new framework for considering the role of middle actors through exploring their agency (ability to make their own decisions) and capacity (ability to act on those decisions). Through an examination of three sets of middle actors – religious congregations, building professionals, and commercial partnerships – a new 'middle-out' approach is put forward as needed to complement/contrast with top-down or bottom-up approaches

Nolden, C., Sorrell, S. and Polzin, F. 2016. Catalysing the energy service market: The role of intermediaries. *Energy Policy*, 98 (November 2016), pp. 420–430.

This article explores the role of intermediaries in expanding UK market for energy service contracts. These intermediaries can lower the transaction costs incurred by both clients and contractors, and combine a legal framework with an organisational framework, thus facilitating contract negotiation and execution.



3. Distribution of costs and benefits

The topic of distribution of costs and benefits is receiving more mainstream attention lately. The traditional focus on poverty is most reported on, but issues around multiple costs and benefits such as health, productivity etc. are gaining importance as well. A particularly challenging issue is the landlord-tenant dilemma where costs are incurred by another party than the one benefitting from energy saving measures, but some solutions are being put forward.

3.1. The landlord-tenant dilemma

An important obstacle for energy efficiency measures is that tenants and landlords of social housing units have different incentives to invest in energy efficiency measures, which obstructs decision-making processes involving investments in energy efficiency and using less. This is also called the split incentive dilemma. While the existing building stock and especially the residential sector have great potential to realise energy savings, several disciplines, for example Economic theory, have conducted research in order to help diminish or overcome split incentive dilemmas. Most research focuses on how to stimulate investment decisions, when residents are willing to pay for measures, and which factors influence the adoption of measures (Charlier, 2015; Banfi et al., 2008; Nair, et al., 2010). Important reasons for residents to invest in energy efficiency measures are energy savings, the environment and more comfortable homes (Banfi et al., 2008). Some subjects are energy performance certificates, tax credits, financing schemes and energy performance contracts (Högberg, 2014; Milin and Bullier, 2011; Bullier and Milin, 2013). It is argued that costs and benefits should be split in a balanced way, total housing cost guarantees can help tenants to be able to agree with energy investments, that there should be incentives for all stakeholders involved. It is recommended to develop more financing schemes (Högberg, 2014).

Charlier, D., 2015. Energy efficiency investments in the context of split incentives among French households. *Energy Policy*, 87 (December 2015), pp. 465–479.

The aim of the article is twofold. Firstly, it discusses the extent to which split incentives between landlords and tenants may obstruct investments in energy efficiency measures. Secondly, it researches the influence of tax credits and energy burdens on energy efficiency measures. A bivariate Tobit model is used as a method. The results show a double burden for tenants. Firstly, they often live in energy inefficient homes, which causes high energy bills. Secondly, they do not have the ability to invest in energy efficiency measures, due to a lack of resources.

Banfi, S., Farsi, M., Filippini, M. and Jakob, M., 2008. Willingness to pay for energy-saving measures in residential buildings. *Energy Economics*, 30, pp. 503–516.

Using a choice experiment, the authors investigate the willingness of consumers to pay for energy saving measures. The group of respondents consists of homeowners and tenants. The respondents were asked to choose between their current situation and several hypothetical situations. The research suggests that consumers value the energy saving attributes. These benefits consist of energy savings, environmental benefits and an increase in comfort. The authors recommend policy makers to reduce barriers by supporting communication and information for decision-makers.

Högberg, L., 2014. *Inclusive Rent and Its Impact on energy efficiency investments*. European Commission, Joint Research Center, Overcoming the split incentive in the building sector. Sector Workshop 2014.

This report discusses the findings of a Joint Research Centre workshop in 2014. It examined solutions addressing the split incentive in the building sector. Some of the main highlights are the results of the workshop. It is argued that costs and benefits should be split in a balanced way, total housing cost guarantees can help tenants to be able to agree with energy investments, that there should be incentives for all stakeholders involved. It is recommended to develop more financing schemes.



Nair, G., Gustavsson, L. and Mahapatra, K., 2010. Factors influencing energy efficiency investments in existing Swedish residential buildings. *Energy Policy*, 38 (6), pp. 2956–2963.

This research investigates the factors that influence energy efficiency investments by homeowners. Energy use reduction was important for the majority of respondents. However, most of them apply no-cost measures. Demographic characteristics of the homeowners and physical characteristics of the buildings influence the type of energy efficiency measure applied. The authors recommend the use of economic and information policy instruments to stimulate investments.

Milin, C. and Bullier, A., 2011. Energy refurbishment of social housing using energy performance. *Proceedings of the 2011 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm*, pp. 1049–1069.

The authors argue that a barrier to the retrofitting of social housing is a lack of adapted funding. One way of funding is through the Energy Performance Contract. In that case, an ESCO invests in energy measures and repays itself through generated energy savings. However, a major obstacle for social housing operators regarding retrofitting is the fact that they cannot recoup energy savings from tenants. Therefore, the authors that a deep reorganisation of regulations and governance is needed in order the free the way for energy efficiency measures.

Bullier, A. and Milin, C., 2013. Alternative Financing Schemes for Energy Efficiency Measures in Buildings. *Proceedings of the 2013 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm*. pp. 795–805.

An obstacle to the renovation of existing buildings is the lack of financing schemes adapted to the current building stock. The authors study traditional and alternative financing schemes. Besides that, they analyse third-party investment schemes that move the burden of debt from the building owner to the building. Governments can improve the legal and policy framework, assist in development and help to build capacity in order to replicate, adapt and up-scale financing schemes for the deep renovation of buildings.

3.2. Socio-economic divide

Similar as to justice and poverty, quite some literature has been written about the socio-economic divide and energy efficiency and/or using less. The topic of socio-economic divide looks at the differences between socio-economic groups and their relation with energy use and energy efficiency measures. Often, people with lower socioeconomic status live in social housing buildings and have a greater chance to live in an energy inefficient home. Because they have lower incomes, they are less able to invest in energy efficiency measures. Besides that, if they would like to invest in energy efficiency, they have to decide on this together with other tenants and their landlords (see also in subsection 5.1. 'The landlord-tenant dilemma'). Most research focuses on the warmth and comfort level of houses and the health and wellbeing of residents (Milne and Boardman, 2000; Heyman et al., 2011). Socio-economic status often has a relation with the energy efficiency of homes. When applying energy efficiency measures, one can improve the living conditions of tenants, while at the same time achieve energy conservation. Socio-economic status can be used as an independent variable in research, but also as a dependent variable. It is recommended to pay more attention to groups with lower socio-economic status in the energy transition, to diminish the risk of more societal inequality (Mangold et al., 2016).

Milne, G. and Boardman, B., 2000. Making cold homes warmer: the effects of energy efficiency improvements in low-income homes. A report to the Energy Action Grants Agency Charitable Trust. *Energy Policy*, 28 (6/7), pp. 411–424.

The focus of the research is argued to be important to attain energy conservation and affordable warmth for low-income households. It shows a link between the average indoor temperature of a house before the installation of energy efficiency measures and the amount of the potential benefit taken as extra warmth. It is recommended that policy makers do not exclusively focus on home owners from higher income groups for energy saving.



Mangold, M., Osterbring, M., Wallbaum, H., Thuvander, L. and Femenias, P., 2016. Socio-economic impact of renovation and energy retrofitting of the Gothenburg building stock. *Energy and Buildings*, 123 (July 2016), pp. 41-49.

In many European countries, the building stock needs to be renovated. This offers opportunities for retrofitting and energy efficiency. This research makes an estimation of economic and societal challenges of this renovation to take the social aspect into account. Renovating rental houses can increase the rent for tenants. This should be taken into account when developing policy for retrofitting.

Heyman, B., Harrington B., Merleau-Ponty, N., Stockton, H., Ritchie, N. and Allan, T., 2011. Keeping warm and staying well. Does home energy efficiency mediate the relationship between socio-economic status and the risk of poorer health? *Housing studies*, 20 (4), pp. 649-664.

This research investigates the relation between socio-economic status, health and energy efficiency. They use a statistical analysis. Worse health was related to lower socio-economic status. The authors conclude that home energy efficiency makes an important contribution to the relation between health and socio-economic status. Both objectively and subjectively measured data point to this relation.

3.3. Poverty

There is great potential for improving living conditions of poorer households while at the same time a decrease in energy use can be realised. Quite some literature discusses energy poverty or fuel poverty. Energy poverty means that households cannot fulfil their energy needs or that residents spend a relatively large part of their income on energy. Energy efficiency is now one of the factors used to define the liveability of homes. Several disciplines, for example Sociology, pay attention to this topic. Research discusses warmth and comfort levels in homes of low-income groups, differences in factors like seasons and environments and distributional effect of policy. It is argued that still more attention should be paid to energy poverty in policy.

Beretta, I., 2014. La fuel poverty: quale contributo della disciplina sociologica allo studio del problema, *Quaderni di Sociologia*, LVIII, 66, pp. 127-136.

The author writes about the concept of fuel poverty and how it could be linked to more general problems involving human rights and freedom. Authorities in Europe have only recently started to use the concept. According to the author, this means that energy efficiency is now seen as an indicator of a liveable building. However, it is also argued that there is a lack of policies that specifically address the problem of fuel poverty. The article aims at increasing awareness and finding out whether the discipline of Sociology could play a bigger role.

Darby, S., 2012. Metering: EU policy and implications for fuel poor households. *Energy Policy*, 49 (October 2012), pp. 98-106.

The paper discusses the influence of EU policy on the development of smart metering on fuel poor households. The focus lies on electricity metering, active demand and smart grids. The paper starts by elaborating on the EU policy background, the multiple functions of smart meters and the implications of a new generation of smart meters for equity issues. Next, the author discusses the implications of changes to smart metering for the fuel poor.

Day, R., Walker, G. and Simcock, N., 2016. Conceptualising energy use and energy poverty using a capabilities framework. *Energy Policy*, 93 (June 2016), pp. 255-264.

This is mainly a theoretical paper on the conceptualisation and definition of energy poverty. The authors argue it is useful to look at it from a capabilities perspective. Capability theory seeks to provide for an alternative way of conceptualising the purpose and aims of economic development, beyond material wealth. They argue it provides a more accurate understanding of the relationship between energy and wellbeing, both in the Global North and the Global South. Besides that, it can be adapted to fit local contexts and it can be applied to multiple sides of intervention. Further research could work on a more specific capabilities framework.



Moser, S., 2013. Poor energy poor: energy saving obligations, distributional effects and the malfunction of the priority group. *Energy Policy*, 61 (October 2013), pp. 1003–1010.

This paper identifies the distributional effects caused by an Energy Efficiency Obligation (EEO) scheme which occur when energy efficiency measures are implemented (phase of delivery) and when its costs are passed on to the society (phase of financing). In the phase of delivery, suppliers prefer to implement measures at the property of those final customers which allow them to minimise their costs. In EEO scheme limited to the domestic sector, experts assume distributional effects which leave high income households better off and low-income households worse off. If not limited to the domestic sector, the implementation focuses on large-scale projects in the non-residential sector. In the phase of financing, the costs are passed on to less competitive households and small enterprises. Alternative approaches are proposed (efficiency funds by the government and suppliers together, and multipliers for measures for energy poor customers).

Guertler, P., 2012. Can the Green Deal be fair too? Exploring new possibilities for alleviating fuel poverty. *Energy Policy*, 49 (October 2012), pp. 91–97.

Britain's 'Green Deal - Warm Front' government scheme and the introduction of an incentive for renewable heat all contribute to a change in how energy efficiency and fuel poverty objectives are approached in Great Britain. The paper investigates whether Green Deal Finance (GDF) could provide benefits to fuel poor households. The conclusion is that a flexible design of the GDF is needed for the programme to be effective.

Urge-Vorsatz, D. and Herrero, S., 2012. Building synergies between climate change mitigation and energy poverty alleviation. *Energy Policy*, 49 (October 2012), pp. 83–90.

This paper aims to identify a synergy between combating climate change and energy poverty alleviation. The authors argue that deep energy efficiency in buildings provides for the most significant synergy. They further argue that neither of the two problems can be solved on their own merit, but there is great potential for integrating the two policy goals.

Hong, S., Gilbertson, J., Oreszczyn, T., Green, G. and Ridley, I., 2009. A field study of thermal comfort low-income dwellings in England before and after energy efficient refurbishment. *Building and Environment*, 44 (6), pp. 1228–1236.

The paper is mainly an evaluation of the 'Warm Front' energy efficient refurbishment scheme implemented in England. The authors investigate its effects on comfort levels in the winter in low-income dwellings. The results show that mean indoor temperatures increased. This also led to more households feeling thermally comfortable.

Katsoulakos, N., 2011. Combating energy poverty in mountainous areas through energy-saving interventions. *Mountain research and development*, 31 (4), pp. 284–292.

The authors define energy poverty as the inability to cover or difficulty of covering one's energy needs. They argue that mountainous areas are especially vulnerable, because mean temperatures are generally lower and they often have a challenging economic environment. The researchers investigated ways of reducing the use of conventional energy, which decreased the risk of energy poverty. Results show that energy saving measures and the use of biomass can both contribute to diminishing the risk of energy poverty. Improving energy policy can have environmental, social and economic benefits.

Dubois, U. and Meijer, H., 2016. Energy affordability and energy inequality in Europe: implications for policymaking. *Energy Research & Social Science*, 18, pp. 21–35.

The specific forms of energy services deprivation differ between European countries. Supply conditions (e.g. investments in networks) and the general economic situation affect the affordability of energy. On macro level is analysed which households groups are more vulnerable. In some countries, the most vulnerable groups are affected eight times more, but in other countries, the overall poverty is high and no specific groups can be distinguished that suffer more. The impact depends on whether there is overall poverty in countries (Eastern, Southern Europe), or low energy efficiency in houses, or low-income households. For large-scale renovations, EU funds can be used; also the monitoring of best practices among low household incomes can be continued. General European measures can be related to the economic situation, but otherwise per country and on micro level should be established whether income measures or energy efficiency measures (including financial models for renovation or addressing obstacles on demand site) have the highest social efficiency.



3.4. Multiple benefits

Multiple benefits of energy efficiency such as improved health, increased productivity, satisfaction, and well-being are growing in importance for many stakeholders in the energy field (Heyman et al., 2011; Foy, 2012). These benefits can provide the rationale needed to convince funders, investors and users to undertake energy efficiency. The 2014 IEA report and the 2014 report from the World Green Building Council propagated a lot of research on this topic and were conducive to a lot of attention on the European policy level for this topic (Kerr et al., 2017). Of course, which rationale is meaningful when, where and to whom is important to understand. The multiple benefits discussion so far focused mainly on energy efficiency and less so on using less, although of course the economic benefit is widely investigated in both. The other side of the coin, the adverse effects of lack of energy efficiency on health and income (energy poverty) were already investigated for many years (see subsection 3.2. 'Socio-economic divide' for more detailed discussions).

IEA, 2014. *Capturing the multiple benefits of energy efficiency*. Paris: International Energy Agency.

This report is the first comprehensive attempt at analysing the multiple benefits of energy efficiency. It is underpinned by a review of existing evidence. The book provides knowledge and understanding of the nature and scope of the multiple benefits and provides practical guidance on how to apply policy development and assessment tools to account for these impacts. The book focuses on five benefit areas for which enough evidence was available and which are important policy priorities in IEA countries: macroeconomic development; public budgets; health and well-being; industrial productivity; and energy delivery. Health benefits represented 75% of the overall benefits.

Kerr N., Gouldson A. and Barrett J., 2017. *The rationale for energy efficiency policy: Assessing the recognition of the multiple benefits of energy efficiency retrofit policy*. *Energy Policy*, 106, pp. 212–221.

Considering retrofit policy in different contexts, the paper characterises the policy rationale in each case, assessing what the evolution of the key perceived benefits. The analysis identifies differences between cases resulting from a complex mix of political, social and economic influences and finds that different rationales on benefits will have relevance at different times, for different audiences.

World Green Building Council, 2014. *Health, well-being and productivity in offices: The next chapter for green building*. WGBC report.

This report outlines the findings from an extensive study on the impact of making office buildings more energy efficient and sustainable and performing deep retrofitting. The report demonstrates the impact of increased indoor air quality, lighting and proximity to daylight on productivity improvements, of improved thermal comfort and noise control on satisfaction and how control over thermal comfort increases productivity.

Heyman, B., Harrington B., Merleau-Ponty, N., Stockton, H., Ritchie, N. and Allan, T., 2011. *Keeping warm and staying well. Does home energy efficiency mediate the relationship between socio-economic status and the risk of poorer health?* *Housing studies*, 20 (4), pp. 649–664.

This article investigates the relationship between energy efficiency of a home, socio-economic status and health. Energy efficiency improvement is found to positively impact health of occupants and can make an important contribution to tackle the strong correlation between lower socio-economic status and poorer health.

Foy, K., 2012. *Home is Where the Health Is: The Convergence of Environmental Justice, Affordable Housing, and Green Building*, ExpressO, [online] Available at: http://works.bepress.com/kevin_foy/1/ [Accessed 31 May 2017].

This paper focuses on the impact of energy efficiency of a home on the health and wealth of occupants. It explores how the other costs associated with living in the housing: the cost of heating and cooling impact on the affordability of housing. It also argues that some costs, e.g. the costs of adverse health effects need to be taken into account. For example, poor air quality inside a home can exacerbate asthma or cause other breathing and cardiopulmonary problems. The author argues that energy efficient, i.e. green housing addresses these additional costs.



4. Market and institutions

This section focuses on structural and market related elements that can have an impact on energy efficiency uptake and using less energy. There is a strong focus on business models, including social corporate responsibility. Furthermore, several debates are held on the rebound effect, and whether or not degrowth, decoupling of energy use and economic growth, can be attained. This chapter ends with a discussion of responsibility and how market and other institutions deal with the issue of responsible innovation and the use of energy. It also reflects upon how on a societal level, norms, values and institutions influence the quantity and efficiency of energy use.

4.1. Business models

With the increasing political and societal attention for energy efficiency uptake and services, many parties have started thinking about making business of energy efficiency and or using less. New business models are emerging and being explored. Authors are also investigating the impact of particular policy instruments on the viability of specific business models (Al-Saleh and Mahroum, 2015) or how public support can help businesses become more service oriented (Plepys et al., 2014). Innovative financing schemes are explored, such as revolving funds where savings are reinvested in further energy efficiency (Gouldson et al., 2015) and can lead to cost neutrality of retrofitting schemes. Some very innovative research is being done on business model innovation for energy efficiency and using less, for example by Hiteva and Sovacool (2017) on how to use the justice approach to innovate business modelling and incorporating value such as influence on decision-making, participation and fair process. Or, by Bocken et al. (2014) on new archetypes of sustainable business models focused on amongst others energy efficiency, where both stakeholder interests, societal and environmental needs are balanced. Nilsson et al. (2012) also advocate the need for new business models that focus on delivering the services energy generates instead of on delivering energy itself.

A specific focus of many business models is around the decentralised supply of energy (Burger and Weinmann, 2012), such as for example on the sharing economy (Lombardi et al., 2017; Lorenz et al., 2012), especially in connection to collectively storing energy generated with renewables or in combination with electric vehicles that can be used as storage (Freeman et al., 2017). Some authors also investigate new models such as the industrial ecologically equipped area where specific attention exists for saving energy (Gallo and Gianfrate, 2011). A last strand of sources is on Corporate Social Responsibility, where companies aim to build up a greener image amongst their customers and shareholders by focusing on amongst others energy issues (Porter and Kramer, 2011). Some companies even go as far as trying to either certify their products with energy efficiency labels, or even get the whole company to be certified for its energy efficiency and or environmental performance (Luekefett and Binder, 2012).

Al-Saleh, Y. and Mahroum, S., 2015. A critical review of the interplay between policy instruments and business models: greening the built environment a case in point. *Journal of Cleaner Production* 109 (December 2015), pp. 260–270.

This article is analysing policy instruments (sticks, carrots and sermons) introduced with the aim of promoting the development of green business models. The researchers found that business models focused on greening the built environment that emerged in reaction to sticks were about buck-passing (passing costs to others and skirting around the stick of regulation. Business models emerging in response to carrots were opportunistic and aimed at capturing a temporary gain, those that emerged in response to a sermon (such as awareness campaigns) diffused, even when they could make use of subsidies. What this demonstrates is that a different kind of policy is necessary to create truly green business models. Policies that aim at creating shared value across the value chain.

Plepys, A., Mont, O. and Heiskanen, E., 2014. European policy approaches to promote servicizing. *Journal of Cleaner Production*, 97 (15 June 2015), pp. 117–123.

The article explores where and how public policy supports or steers markets toward 'servicizing' solutions and where and when policy support for these is merited. It reviews several existing policy instruments to



support servicising on European, national and local (municipal) levels. The paper concludes that current market is biased against forward looking business models that do not bring immediate benefits. Secondly, powerful market players oppose these business models because they challenge the competitive advantage of mass production. Part of the policies the paper focuses on are about energy efficiency. These policies focus on funding academic research and supporting stakeholder forums. The more concrete examples of policies promoting servicising can be found on the local level where authorities can take more responsibility, such as EPC and public procurement.

Bocken, N., Short, S., Rana, P. and Evans, S., 2014. A literature and Practice review to develop sustainable business model archetypes. *Journal of Cleaner Production*, 65 (February 2014), pp. 42–56.

This article explores new sustainable business models that allow companies to operate with greater sustainability. It focuses on 'the triple bottom' approach that incorporates environment, society and stakeholder interests. The author demonstrates how different archetypes of these new type of business models can drive competitive advantage. Some of the archetypes focus on maximising energy efficiency; or delivering functionality rather than ownership; encouraging sufficiency.

Hiteva, R. and Sovacool, B., 2017. Harnessing social innovation for energy justice: a business model perspective. *Energy Policy*, in press.

This article is one of the first articles looking at how to incorporate elements of environmental justice around energy efficiency, such as equitable distribution of costs and benefits, affordability, due process and greater participation in decision-making, into business modelling. The above-mentioned elements can be seen as value that is relevant to many users and as such incorporating these into business modelling is a new way of looking at creation of multiple value. The authors counter intuitively argue against upscaling and stress the need for locality and the need for the development of skills, knowledge and social capital on a local level as part of a business model.

Nilsson, H., Bangens, L., Goven, B. and Andersson, B., 2012. We are lost if we don't develop new business models. *Proceedings of the 2012 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm.*

This paper discusses the need for new services that address the real service energy provides and that focus on the real needs of users and not only costs. The authors in particular stress the need for new business models that allow for cooperation between many companies in delivering multiple value to the energy end users.

Gouldson, A., Kerr, N., Millward-Hopkins, J., Freeman, M., Topi, C. and Sullivan, R., 2015. Innovative financing models for low carbon transitions: Exploring the case for revolving funds for domestic energy efficiency programmes. *Energy Policy*, 86 (November 2015), pp.739–748.

This article is one of the first aimed at exploring the potential of revolving funds (recovering savings and reinvesting these in further energy efficiency measures). The authors found that for the UK retrofitting market the use of revolving fund could be very cost effective, even leading to cost neutrality of schemes. The only drawback is the need for large up-front investments and a relatively long payback time.

Lombardi, P. and Schwabe, F., 2017. Sharing economy as a new business model for energy storage systems. *Applied Energy*, 188 (February 2017), pp. 485–496.

Energy storage systems are the candidate solution to integrate the high amount of electric power generated by volatile renewable energy sources into the electric grid. The simulation of the business model developed showed that a sharing economy-based model may increase the profitability of operating a battery storage system compared to the single use case business model. Additionally, larger battery dimensions regarding power and capacity were found to be profitable and resulted in an increased revenue stream.

Burger, C. and Weinmann, J., 2012. *The decentralized energy revolution: Business strategies for a new paradigm*. UK: Palgrave Macmillan.

The global energy system stands at the verge of a far-reaching paradigm shift. The established model of centralised supply services will be challenged by new, decentralised technologies, with Germany being an international role model for energy efficiency and renewable energy generation.



Lorenz, S., Putz, M. and Schlegel, A., 2012. Energy efficiency 2.0 - New business models for the industry, *ZWF Zeitschrift für Wirtschaftlichen Fabrikbetrieb*, 107 (9), pp. 599-602.

The energy transition is changing the context for industry. So far, efforts towards more energy efficiency were focused on reductions of the energy demand. The rapid expansion of renewable energies adds at least one new aspect: volatility in the energy supply. This is a fundamental change in the energy sector, since the majority of currently used primary energy is available in stored state and can be released as needed. It offers opportunities for new business models, especially in load balancing.

Gallo, P. and Gianfrate, V., 2011. Policies for industrial settlements: A new model of ecologically equipped area. *Procedia Engineering*, 21 (2011), pp. 1006-1014.

Industrial ecologically equipped area model (APEA) has a key role to consolidate and attract businesses with a high level of technological content and, on the other hand, to contrast an indiscriminate occupational situation in productive areas based on logistics and heavy industry, which has a low added value and great environmental impact. The APEA model aims to developed innovation in production, strengthening research and development already carried out by leading companies in the territory, focusing attention and using available resources to save energy and concentrate on renewable sources as an opportunity for a wide range of innovations not only linked to the energy field, by also to production processes, the civil sector and transport.

Freeman, G., Drennen, T. and White, A., 2017. Can parked cars and carbon taxes create a profit? The economics of vehicle-to-grid energy storage for peak reduction. *Energy Policy*, 106 (July 2016), pp. 183-190.

Electric car owners are not inclined to participate in vehicle-to-grid (V2G) energy storage for peak reduction due to high costs of vehicle's battery degradation. This type of energy efficiency is becoming increasingly important for energy storage for grid operators hence policies need to ensure that the tax benefits and financial nudges are more appealing. The authors present data for different types of cars and demonstrate the different economic prospects of V2G. Arguing that further research is needed to explore policy measures that increase savings potential of V2G participants on the microeconomic level.

Porter, M. and Kramer, M., 2011. Creating a Shared Value. How to reinvent capitalism—and unleash a wave of innovation and growth, *Harvard Business Review*, January-February 2011.

The authors claim that there is a transition from CRS (corporate social responsibility) towards CSV (corporate social value). Whereas CRS is more a side-business, CSV is an integral approach in which societal and economic progress are connected; joined company and community value creation. In addition, externalities should be included in actual product costs such as energy use and logistics. This requires different procurement methods and a radical reorganisation of economic transactions

Luekefett, H. and Binder, U., 2012. Corporate sustainability - Green image via company-related environmental labelling. *Electronics Goes Green 2012+*. Berlin, pp. 1-4.

In this article, the authors discuss the impact of environmental product labelling by companies. The article discusses how basing a green reputation of labelling of their product can be very time consuming, which is why company certification in terms of energy efficiency is now potentially preferred by companies.

4.2. Rebound effect

In practice, the relation between energy efficiency and actual energy savings is not as straightforward as is expected when looking at theories from Engineering Sciences, Economics and Psychology (Némoz and Wallenborn, 2012; Galvin, 2014). Different paradoxes surrounding energy efficiency may lead to lower energy savings or environmental benefits than predicted. These paradoxes, often referred to as rebound effects, may work in various ways. Rebound effects may arise when increased energy efficiency leads to lower costs for energy which in turn may lead to increased energy consumption (direct rebound effect) or to increased consumption of alternative goods (indirect rebound effect) which are produced and transported and thus represent embodied energy (Copiello, 2017; Galvin 2014; Maxwell et al., 2011). There are also economic-wide effects that can lead to an increase in energy consumption (Copiello, 2017). However, some



argue that instead of looking at the rebound effect it would be better to look at the total energy consumption, especially because lower income groups often use far less energy but tend to show higher rebound effects (Galvin, 2015). There is an ongoing debate on the extent to which the higher energy consumption is caused by rebound effects or by economic growth and rising incomes, especially among low-income groups (Saunders, 2013; Galvin, 2015). The literature shows that currently there are not only different definitions of rebound effects, but there is also no consensus on how rebound effects should be calculated (Galvin and Sunikka-Blank, 2016; Gillingham et al., 2014). Next to this there can also be positive side- and spill over effects related to energy efficiency, which are often neglected (Hertwich, 2008; Gillingham et al., 2014).

Némoz, S. and Wallenborn, G., 2012. Comment comprendre les effets rebonds dans la consommation domestique d'énergie? Pour une socio-anthropologie des pratiques en transition. In: Poirot-Delpech S., Raineau L. eds, *Pour une socio-anthropologie de l'environnement*. Paris: L'Harmattan.

Energy efficiency policies tend to rely too much on the idea that it is sufficient to introduce new technology or specific information, for the public to adopt it, and for expected changes to occur. However, empirical evidence indicates that the energy savings in practice are much lower than what would normally be expected within Engineering Sciences, Economics and Psychology. Energy efficiency policies are called into question as issues are raised by rebound effects, which result from them. By developing a Socio-Anthropological analysis of rebound effects, the objective is to contribute to the knowledge of what makes everyday energy practices more energy efficient.

Hertwich, E., 2008. Consumption and the Rebound Effect: An Industrial Ecology Perspective. *Journal of Industrial Ecology*, 9 (1-2), pp. 85-98.

Often environmental protection measures have unintended effects on society. One reason is the rebound effect, which shows how responses in behaviour or in the system to cost reductions that result from energy efficiency improvements can offset some of the environmental benefits. The authors look from an industrial ecology perspective and state that we have not only look at energy use, but also at the possible positive and negative side effects of measures that originally only aim for only solving one problem. Also, spill over effects of positive environmental behaviour may occur, for instance when the costs and impacts of environmental friendly products are further reduced. In many cases only the negative rebound effects are taken into account while positive effects are neglected. The authors believe that the focus on rebound effects should be extended by taking into account all relevant positive and negative side- and spill over effects.

Galvin, R., 2015. The rebound effect, gender and social justice: A case study in Germany. *Energy Policy*, 86 (November 2015), pp. 759-769.

Galvin states that less economically privileged groups tend to show the highest rebound effects after energy efficiency measures. While some studies show that policymakers are reluctant to support energy efficiency measures focusses on this group. However, economically disadvantaged groups often consume far less energy. Next to this it is found in an empirical study that females have much higher rebound effects compared to males, but at the same time males consume far more energy and produce most greenhouse gas emissions. Galvin uses these resonating findings to underpin his argument that policy should focus on absolute consumption levels rather than on the size of rebound effects, and that policy makers should be more careful when they try to interpret rebound effects.

Gillingham, K., Rapson, D. and Wagner, G., 2016. The Rebound Effect and Energy Efficiency Policy. *Review of Environmental Economics and Policy*, 10(1), pp. 68-88.

The authors clarify in their paper what the rebound effect is based on how existing literature consider it. There are different ways of considering the rebound effect, leading to different estimations on its magnitude and to different implications for policies. It is argued that policy makers should aim for a broad objective of maximising economic efficiency and take into account the positive effects on welfare instead of limiting their focus on minimising the use of energy or maximising. According to the authors the macro-level rebound, economic and welfare effects of policy measures aimed at energy efficiency or a reduction of greenhouse gas emissions need to be taken into account.



Copiello, S., 2017. Building energy efficiency: A research branch made of paradoxes. *Renewable and Sustainable Energy Reviews*, 69 (March 2017), pp. 1064–1076.

Copiello describes three paradoxes related to building energy efficiency. The Jevon's paradox tells that lower demand and thus lower costs for energy may cause an increase in the consumption of energy and/or other consumption goods, also called the rebound effect. This paradox may boost economic development. The second paradox is the energy price control or the price-profitability paradox, which tells that investing in multiple energy efficient solutions (implicit in EU policy) may contribute to lower consumption and thus lower prices, which in turn makes the same investments less profitable. The expectation of lower energy prices may already act as a disincentive to further investments in energy efficiency measures. The third paradox tells about the need to adopt energy-intensive materials (embodied energy) in order to achieve substantial energy savings in operation. The authors recommend to look at absolute energy savings regardless of efficiency gains.

Galvin, R., 2014. Making the 'rebound effect' more useful for performance evaluation of thermal retrofits of existing homes: Defining the 'energy savings deficit' and the 'energy performance gap'. *Energy and Buildings*, 69 (February 2014), pp. 515–524.

Many concerns are raised regarding the increases in energy consumption that often follow energy efficiency improvements, called the rebound effect. The study in this paper has identified three different definitions for rebound effects in domestic heating, which are the 'classic' rebound effect, the 'energy savings deficit' and the 'energy performance gap'. Applying the different definitions to calculate the rebound effect for retrofitted apartments gives very disparate results, which could explain the big differences in calculations of the rebound effect in many studies. These differences have caused much confusion and miscommunication.

Galvin, R. and Sunikka-Blank, M., 2016. Quantification of (p)rebound effects in retrofit policies – Why does it matter? *Energy*, 95 (January 2016), pp. 415–424.

Very often calculated energy ratings of older homes are higher than their average energy consumption for heating. Because of this, the energy savings caused by thermal upgrades are in many cases lower than expected. This phenomenon is called the 'prebound effect'. Galvin and Sunikka-Blank explore the links between the rebound and prebound effects. They also aim for quantifying these two behavioural effects on energy consumption. Their calculations show that the rebound effect often overlooks high levels of consumption while only focussing on the reduction or increase of energy consumption. Cases in which there is a high prebound effect in combination with low income it may indicate fuel poverty, while the rebound effect is less relevant in these cases. The prebound effect can help identify houses and households that are suffering from fuel poverty and may increase awareness among policymakers that they have to take into account that estimated payback times may be higher in reality.

Saunders, H., 2013. Is what we think of as 'rebound' really just income effects in disguise? *Energy Policy*, 57 (June 2013), pp. 308–317.

Saunders examines in his paper whether the high energy consumption despite energy efficiency gains are caused by either increases in consumer wealth or by energy efficiency rebound effects. In many cases energy efficiency improvements do not lead to the expected energy savings. Often the rebound effect is seen as a major cause. But increasingly not the rebound effect is blamed for the rise of energy consumption but instead economic growth and rising incomes were seen as the main driver. However, Saunders gave nine key conclusions from his findings that suggest that not income effects but the rebound effects are the main cause for the rise of energy consumption.

Maxwell, D., Owen, P., McAndrew, L., Muehmel, K. and Neubauer, A., 2011. Addressing the rebound effect. European Commission DG Environment.

This report reviews the existing know-how and practice related to the rebound effect in EU policies. It reports on different definitions such as direct-, indirect- and economy wide rebound effects. It furthermore reports on the existence and significance of the rebound effect. Because of difficulties to measure them and the varying impacts of rebound effects in different interventions the debate on magnitudes is still ongoing. The authors end with providing implications for policies for addressing rebound effects, while recognising that there may be big differences between different types of interventions. These implications may guide policy makers towards achieving higher environmental benefits.



4.3. Degrowth and decoupling

The concepts of degrowth, decoupling and other ideas related to a shift to less resource-intensive economies are included in this section. The topic of degrowth and decoupling have been particularly explored within the Economics literature and we discuss the contribution of Bithas and Kalimeris (2013) as one example. The term 'degrowth' grew out of the Francophone notion of 'décroissance' - as discussed by the seminal work by Latouche (2003) and later Wallenborn (2009). A useful review of the concept is also given by Martínez-Alier et al. (2010), Capellan-Perez et al. (2015). Csereklyei and Stern (2015) state however, that only a weak coupling can be identified between economic growth and increased energy consumption, especially in rich countries. Finally, Wilhite (2016) criticises the discussion on green economy and low carbon transitions where insufficient attention is paid to the role of technologies and other material culture that embodies high energy use. Decoupling should thus also take place on the level of household technologies.

Latouche, S., 2003. Pour une société de décroissance. *Le monde diplomatique*, pp. 18–19.

This seminal work introduces the concept of eco efficiency already in 2003, discussing how growth for growth's sake is no longer sustainable. Not only does it lead to social inequalities, it also severely endangers the earth's biosphere. Energy reduction and reallocation of energy should be at the core of our approach to energy.

Bithas, K. and Kalimeris, P., 2013. Re-estimating the decoupling effect: Is there an actual transition towards a less energy-intensive economy? *Energy*, 51 (March 2013), pp.78–84.

In this study, the authors question whether or not modern economies are becoming less dependent on natural resources, and moving towards service economies (dematerialisation of production). This breaking of the link between natural resource use and GDP is known as 'decoupling'. The central argument of the paper concerns the use of an Energy / GDP per capita ratio instead of an Energy / GDP ratio, in estimating decoupling potential. It is argued that this better accounts for factors such as the energy embodied within goods. The authors find this approach gives estimations for decoupling potential, which are less optimistic than previous research has suggested.

Wallenborn, G., 2009. Développement durable ou décroissance? *La revue nouvelle*, 64, pp. 33–43.

Sustainable development and degrowth have common origins in the links they establish between environmental and development issues. Yet, degrowth (which has emerged in particular in the francophone literature as 'décroissance') presents itself as a radical criticism of consumer society and capitalism, and thus in some ways opposed to 'development'. Wallenborn, who has written widely on this topic, proposed that studying degrowth history could help us better understand sustainable development, in the same way that studying sustainable development's history could highlight how degrowth emerged. In this article, he discusses how tensions between these two concepts are very likely to structure societal debates to come. Indeed, to choose one over the other means could imply picking reform over revolution, or top-down over bottom-up approaches.

Csereklyei, Z. and Stern, D., 2015. Global energy use: Decoupling or convergence? *Energy Economics* 51 (September 2015), pp. 633–641.

The authors demonstrate that energy use per capita increases can be traced back to economic growth and to convergence in energy intensity. They also point out that energy use does not decline over time in rich countries. They've used a single equation framework that includes of growth, decoupling, convergence, and other time-related effects. By doing so, the researchers confirmed the weak decoupling thesis, but found no sign of strong decoupling. Arguing that there is merely a weak correlation between income and energy consumption.

Martínez-Alier, J., Pascual, U., Vivien, F. and Zaccai, E., 2010. Sustainable de-growth: Mapping the context, criticisms and future prospects of an emergent paradigm. *Ecological Economics*, 69(9), pp. 1741–1747.

In this highly cited article, the authors explore the emergence of visions of degrowth, or "an equitable and democratic transition to a smaller economy with less production and consumption" (p. 1741). The authors provide a useful review of the concept, and explore how different communities have developed interrelated concepts



(e.g. 'décroissance/de-growth', 'sustainable de-growth', and the 'steady state economy'), and some of the differences in the literature relating to each of these. The paper also calls for greater understanding and common frameworks between research communities exploring these ideas, and the grassroots activist organisations striving to achieve them.

Capellan-Perez, I., Mediavilla, M., Castro, C., Carpintero, O. and Miguel, L., 2015. More growth? An unfeasible option to overcome critical energy constraints and climate change. *Sustainable Science*, 10 (3), pp. 397–411.

Current scenarios of economic growth are not only undesirable but also not feasible according to the authors who point out that access to cheap and abundant energy will end. Their analysis is based on the System Dynamics model WoLiM; an integrated approach to analyse the economy, energy and climate dynamics together. The authors state that degrowth is necessary to avoid two undesirable scenarios: replacing oil and gas with coal, or let the economy do its work in setting constraints. The first will deeply disturb the climate, the second will destabilise peace, democracy and equity.

Wilhite, H., 2016. *The Political Economy of Low Carbon Transformation Breaking the habits of capitalism*. New York: Routledge.

In this book, Wilhite explicitly focuses on the relationship between high energy habits and capitalism and the economy of growth. He demonstrates how families and households have formed energy habits around technologies that demand high energy habits. Consequently, Wilhite criticises the discussion on green economy and low carbon transitions where insufficient attention is paid to the role of technologies and other material culture that embodies high energy use.

4.4. Responsibility division

Relatively little has been written on the responsibility of different actors in society for energy efficiency and using less. There is grey literature that covers the responsibility of the energy market and argues that the government needs to compel companies to contribute to energy efficiency and using less (Hennicke, 2013). Besides that, it is argued that markets are not neutral or depoliticised, but bear responsibility for the energy transition too (Grandclement, Pierre and Shove, 2015).

Hennicke, P., 2013. The energy market can't accept responsibility for the German energy transition: a plea for a constructive energy efficiency policy/Der markt kann die verantwortung fur die energiewende nicht ubernehmen: pladoyer fur eine zielfuhrende energieeffizienzpolitik. *Energy Efficiency Policy*, 22 (2), pp. 93–98.

The author of the article argues that politicians and policy should play a greater role in bringing the energy transition further in Germany. The author states that the market does not have the capabilities to transform the energy market on its own. Therefore, energy suppliers should be obliged to play a more constructive role in the fields of renewable energy, energy efficiency and saving energy.

Grandclement C., Pierre, M. and Shove, E., 2015. How infrastructures and consumers interact: insights from the interface. *Proceedings of the 2015 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm*.

This paper offers a conceptualisation of consumption that accounts for the embedding of technologies into the practices they support, constituting an ensemble that is difficult to remove once it is put in place. The influence of this 'infrastructuralisation' process on energy consumption is not recognised in mainstream thinking about energy demand because it is invisible to market models. Demand side management needs to account for the role of infrastructure in shaping demand.

4.5. Norms, values and institutions

The topic of norms, values and institutions covers those articles and authors that focus on the socio-psychological side of energy efficiency and energy use. The main disciplines are Psychology and Social Psychology. The selected articles use for example the 'value-action-gap' theory, environmental justice,



path dependency, social norms and 'value-belief-norm' theory to explain energy behaviour and levels of energy efficiency. They discuss topics involving attitudes, institutional lock-in, intrinsic motivations and external awards, competition and the role of information. A few examples of findings are: the degree of the difference between principles and routines (Bouillet, 2014), the support that housing corporations need to keep them motivated to build energy efficient housing (Wahlström et al., 2016), and the need to ensure the quality of participation when aiming for engaging residents in sustainable transformations of (social housing) neighbourhoods (Breukers et al., 2016). Furthermore, the incompatibility of norms and competition (Alberts et al., 2016), the predictive power of social norms and information on intended energy behaviour (Amasyali and El-Gohary, 2016) and how normative messages promoting energy conservation could lead to both intended and unintended outcomes depending on the pre-existing level of energy consumption (Schultz et al., 2007) are all discussed.

Bouillet, J., 2014. Les citoyens ordinaires face aux discours de l'énergie : l'appropriation d'un problème public. SHSWebofConferences, 9, 02001. Available at: <http://dx.doi.org/10.1051/shsconf/20140902001> [Accessed 31 May 2017].

Public opinion polls tend to highlight the discrepancy between 'statements of principle' and daily life reality when it comes to energetic or environmental matters. This article tries to explain how 'ordinary' citizens acknowledge parts of the energy-related narratives, reorganise and incorporate them in their everyday practices, and how they deal with the attached constraints and contradictions. Exploiting pieces of data collected on online forums in France, this paper exposes the differences between the normative principles officially promoted and the routines as described in private, then highlights and provides measurements of the conflictuality expressed in various aspects of energy issues.

Wahlström, Å., Berggren, B., Florell, J., Nygren, R. and Sundén, T., 2016. Decision Making Process for Constructing Low-Energy Buildings in the Public Housing Sector in Sweden. *Sustainability*, 8(10), pp. 1072.

An interdisciplinary case study conducted amongst Swedish public housing companies that are ambitious in building low-energy houses. Generally, these housings companies are intrinsically motivated to contribute to energy efficiency and energy saving in households. The increasing need for new houses can pass over the motivation to build energy-low houses. To safeguard their effort in building low-energy houses, housing companies need support and strong leadership. In particular, there is a need for new procurement procedures and evaluation of bids that include best value norms and standards, and experience return.

Breukers, S., Mourik, R., Summeren, L. and Verbong, G., 2016. Institutional 'lock-out' towards local self-governance? Environmental justice and sustainable transformations in Dutch social housing neighbourhoods. *Energy Research & Social Science*, 23, pp. 148-158.

The authors of this paper examines one particular case in which public actors initiated a programme aimed at increasing bottom-up activity and sustainably improving a deprived social housing neighbourhood by focusing explicitly on the needs of tenants. They applied the Environmental Justice framework to show how institutional lock-ins, the history of the neighbourhood and the positions of the tenants have influenced the course of this programme. This case shows that when the quality of participation is not ensured, the programme may dilute into a top-down, technology-focused approach that fails to encourage tenants to engage in bottom-up initiatives.

Alberts, G., Gurguc, Z., Koutroumpis, P., Martin, R., Muuls, M. and Napp, P., 2016. Competition and Social norms: a self-defeating combination? *Energy Policy*, 94, pp. 504-523.

Research on the effects of information feedback mechanisms on electricity and heating usage of student housing. The results are useful in contributing to knowledge about demand side management and the impact on energy use. The results show that information and norms lead to a reduction in energy consumption. However, when combining feedback and norms with an element of competition, the achieved energy reduction disappears in the long run. The researchers suggest that external awards reduce the intrinsic motivation of people. The results can inform policies around the rollout of smart meters in the UK and Europe and the way they should provide feedback. The research uses a socio-psychological viewpoint.



Fornara, F., Pattitoni, P., Mura, M. and Strazzera, E., 2016. Predicting intention to improve household energy efficiency: The role of value-belief-norm theory, normative and informational influence, and specific attitude. *Journal of Environmental Psychology*, 45 (March 2016), pp. 1-10.

This article presents a study in which a model based on the value-belief-norm theory was tested on the intention of households to make use of renewable energy. The value-belief-norm theory includes various factors related to social influence and attitude, which may influence the use of renewable energy at the household level. Their results showed that the model can be used to adequately predict the intention of performing the target behaviour. The results indicate moral norms and informational influence as being the most powerful predictors.

Liu, Y., Verissimo, D. and Farhidi, F., 2016. Using social norm to promote energy conservation in a public building. *Energy and Buildings*, 133 (December 2016), pp. 32-36.

This paper presents a field experiment that investigates the impacts of social norms on signing a petition that addresses energy consumption in buildings of a university. The results show that social norms do have an impact on the support of students for the initiative. The authors suggest that social norms could be used to influence individual behaviour in the context of signing petitions.

Amasyali, K. and El-Gohary, N., 2016. Energy-related values and satisfaction levels of residential and office building occupants. *Building and Environment*, 95 (January 2016), pp. 251-263.

The authors of this paper investigated the relation between people's values and energy use behaviour. They first looked at the relevant values that could be related to energy consumption in both residential and office buildings. After this, they investigated how important each of these values were and the extent to which occupants were currently satisfied with these values. Finally, they determined factors that were associated with the levels of importance and satisfaction such as occupant characteristics, level of control that occupants have over buildings, energy efficiency features of buildings and the behaviour of occupants.

Schultz, P., Nolan, J., Cialdini, R., Goldstein, N. and Griskevicius, V., 2007. The Constructive, Destructive, and Reconstructive Power of Social Norms. *Psychological Science*, 18 (5), pp. 429-434.

Schultz et al. examined the impact of normative messages on promoting household energy conservation. They found that these messages resulted either energy savings or undesirable increases in energy consumption, depending on the pre-existing energy consumption level of households. In this study, they managed to prevent this so called 'boomerang effect' by adding an injunctive message. The results show that interventions that make use social norms often vary in terms of effectiveness and it provides insights that can help develop more effective interventions.



5. Policy, transitions and governance

The transition to a more sustainable energy system is a complex process. And the governance, or more specifically, the manageability and thus the locus of power and agency in transitions is heavily debated, including the lack of attention to destabilising of the existing regime (Kivimaa and Kern, 2016). The patterns of transitions, and how to transition to more sustainable energy provision and use is strongly debated as well.

5.1. Transitions and governance

What most authors agree on is that to be truly effective, deep changes are necessary throughout society, not only in technology and lifestyles. Policies, norms, regulations, culture would all need to change to support a new system (Jensen and Zandersen, 2016). Many studies, and especially in Innovation Studies, and Science and Technology Studies, demonstrate how the current system is aimed at stability and opposes more radical changes and alternatives, often emerging in niches. To be effective in changing the current system it is necessary to involve as many different actors as possible, such as policy makers, technology developers, institutions, users/citizens, researchers and more.

Several authors have investigated how energy reduction is framed and researched in different ways, resulting in different estimates of energy reduction potential, and different approaches, with consequences for the thinking about what type of transition is necessary (Sorrell, 2015; Bosman et al., 2014), and how short termism may be opposing transitions (Winkel and Radcliffe, 2014).

Many actors investigate the creation of niches, experiments and how these may battle with the current system to survive and break-through. A significant number focuses on the policy frameworks that could be put in place to drive transitions top-down, and on the role of users (Verbong et al., 2016), grassroots (Seyfang et al., 2014) and middle actors such as cities (Quitau et al., 2012) in driving energy efficiency and using less transitions more bottom-up and middle-out. There is also focus on the necessity of combining different types of experiments, at different levels (Kivimaa et al., 2017). In contribution to this debate, societal actors such as Energy Cities (a partner in the SHAPE ENERGY project) aim to collect inspiring examples and tell the success stories of transitions, to motivate local authorities that seem to have potential agency to drive transitions (Energy Cities, 2016; Cihuedo et al., 2015). For a more detailed discussion of transitions and governance towards low carbon systems we refer the reader to the SHAPE ENERGY annotated bibliography on 'Competitive, secure, low-carbon energy supply'

Jensen, S. and Zandersen, M., 2016. *Societal transition towards renewable energy provision and consumption. Denmark: Aarhus University.*

Technological transition will always have to be social, political and cultural. While development of renewable energies and redesign of energy systems are necessary to reach the goal of sustainable, carbon-neutral societies, changes in energy production are not enough to bring about such a transition. It also requires considerable changes in production practices in key economic sectors and in lifestyles and behaviours that drive energy consumption. Moreover, new technologies for energy efficiency and energy production need to be integrated in household practices and can be met with social refusal or accept. And coherent policy frameworks are necessary to set in motion and guide these complex socio-technical processes.

Bosman, R., Loorbach, D., Frantzeskaki, N. and Pistorius, T., 2014. *Discursive regime dynamics in the Dutch energy transition. Environmental Innovation and Societal Transitions, 13 (December 2014), pp. 45–59.*

This article explores how incumbents in the Netherlands are discursively framing the energy transition in terms of security and affordability, thus trying to maintain status quo. The authors however do identify coalitions that are restructuring themselves, and as such are potentially indicators of successful destabilisation of the current energy regime.



Sorrell, S., 2015. Reducing energy demand: A review of issues, challenges and approaches. *Renewable and Sustainable Energy Reviews*, 47 (July 2015), pp. 74–82.

This article provides an overview of how the energy demand reduction is being framed by academic disciplines. Sorrell states that there is a need for more comprehensive, sociotechnical approaches, that provide a deeper understanding of the current challenges. The correlation between energy consumption, wealth and thus economic growth is complex and often underestimated. Behavioural interventions are underrepresented due to the dominant conception that increasing energy prices and policies creating economic barriers are absent. Hence, there is an urgent need for a large-scale transition towards a sustainable energy system. This requires fundamental changes in the socio-technical system in the short term.

Winkel, M. and Radcliffe, J., 2014. The Rise of Accelerated Energy Innovation and its Implications for Sustainable Innovation Studies. *Science & Technology Studies*, 27 (1), pp. 8–33.

This article explores the characteristics of accelerated energy innovation in the UK. These characteristics include short-term dynamics (years rather than decades), a focus on cost reduction and deployment support for large scale technologies, and a central role for the private sector and public-private partnerships. The authors argue that innovation studies should maintain a critical stance, demonstrating that this kind of innovation is predominantly regime-led and continuity-based. As such, the current innovation system is not conducive to niche-led, more disruptive theories of sustainable innovation.

Kivimaa, P. and Kern, F., 2016. Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions. *Research Policy*, 45 (1), pp. 205–217.

The article argues that transitions need both disruptive innovations as well as disruptive policies. Having studied 'low energy' policy mixes in Finland and the UK, the researchers conclude that most policy mixes focus mostly on the creation side – push and pull mechanisms for new technologies – while less attention is being paid to destabilise the existing regime. There is a need for destructive policies but also sector- and technology specific policies addressing price-performance improvements and entrepreneurial experimentation. Furthermore, long-term monitoring of ambitious energy efficiency and energy reduction goals is needed.

Verbong, G., Schot, J. and Kanger, L., 2016. The roles of users in shaping transitions to new energy systems. *Nature Energy*, 1 (5), pp. 1–7.

By adopting a transition perspective, the author argues that shared routines embedded in socio-technical systems should be at the core of an approach to the energy transition. Hence, the energy transition should be considered as a co-evolution process in which users play an active role as co-producers, legitimators and intermediaries. In addition, energy policies should go beyond awareness-raising and approach citizens as active consumers contributing to energy efficiency.

Seyfang, G., Hielscher, S., Hargreaves, T., Martiskainen, M. and Smith, A., 2014. A grassroots sustainable energy niche? Reflections on community energy in the UK. *Environmental Innovation and Societal Transitions*, 13, pp. 21–44.

The authors argue that the dominant approach when using the framework of Strategic Niche Management regarding energy transitions has overlooked the potentially high impact of grassroots initiatives. These initiatives often adopt a diverse range of sustainable actions – generating renewable energy, energy efficiency and energy savings – building tacit knowledge and strengthening community practices. These initiatives require tailored support and policies to effectively empower them and becoming valuable 'drivers for change'.

Quitau, M., Hoffmann, B. and Elle, M., 2012. Local niche planning and its strategic implications for implementation of energy-efficient technology. *Technological Forecasting and Social Change*, 79, pp. 1049–1058.

This article is a contribution from transformative spatial planning to a specific focus in transition research: strategic niche management. The authors identify local building planning by municipalities as a new type of niche where transition experiments can emerge. They suggest that this does require more strategic transformative spatial planning from the local authorities.



Kivimaa, P., Hildén, M., Huitema, D., Jordan, A. and Newig, J., 2017. Experiments in climate governance – a systematic review of research on energy and built environment transitions. *Journal of Cleaner Production*, in press.

This article explores the different typologies of experimentation based on the goal of these experiments. Experimentation is defined here as creating space for innovative solutions. The typologies are niche creation, market creation, spatial development, and societal problem solving. The authors conclude with the suggestion that based on the findings, to be effective, transitions will need systematic combination of different types of experiments.

Energy Cities, 2016. *The energy transition: new dialogues between cities & local stakeholders - Exploratory study*. France: Energy Cities.

An exploratory study for cities and diverse project leaders desiring to start a sustainable energy transition in collaboration with all stakeholders in their territory. Energy Cities selected more than ten European energy transition initiatives, as diverse as they are innovative, anticipating new forms of governance and new ways to act and collaborate. The exploratory study does not only describe their process but it also analyses the synergies between the different stakeholders and the role the municipality plays in these initiatives. It identifies the key factors of their success and replication.

Energy Cities, 2016. *The Energy Transition Chronicles*. France: Energy Cities.

Energy Cities provides local authorities with support for implementing their own energy transition process. The proposals for the energy transition of cities and towns are illustrated with around a hundred of inspirational examples from all over Europe. In this document composed of five case reports, Energy Cities goes further and tells the tale of energy transition success stories. Because it is important to show that energy transition is 'possible'. Why, how, with whom, for what results? Energy Cities interviewed local players and decision-makers to find out more.

Cihuedo, J., Jobert, A. and Grandclément, C., eds. 2015. *Energie et transformations sociales. Enquêtes sur les interfaces énergétiques*. France: Lavoisier.

This publication reflects a practice of Social Sciences applied to energy through a set of case studies. Through these studies, it is possible to identify three current trends in the energy sector: the technical innovations boom, a greater importance given to clients and the intensification of energy debates. As a contribution to energy focused Sociology, this book offers grounds for thoughts on the relations between technology, energy and society around the notion of interface between systems, citizens and experts.

5.2. Policy instruments

Policy instruments available to incentivise the uptake of energy efficiency and for using less are varied. These instruments are mostly studied by the Economic disciplines and Business Management. The first class of policy instrument discussed below are financial such as rebates (Galarraga et al., 2013), soft loans (Energy Cities, 2017) and fiscal instruments such as taxes and product subsidies (Allcott et al., 2014). Often these instruments are investigated independently. But it may be that the combination of these instruments works best to address the socio-technical system as a whole (Bolton and Foxon, 2015).

Awareness campaign and information provision is yet another policy instrument that can be used to reduce energy use or increase the uptake of energy efficiency. Previous research very often focused on the 'information deficit model' that suggested that people need either information or financing to behave more energy efficient or use less. However, new research is being conducted from a social marketing or behavioural economic perspective (Waitt et al., 2016), stressing the need for 'gamification', 'network approaches' and 'nudging or choice architecture' in designing awareness and or information interventions (Guerassimoff and Thomas, 2014). An interesting finding is that when relatively new instruments are introduced such as 'Energy Performance Contracting', people do want clear information, but in particular, they want decision-makers that are well informed and competent about these instruments (Middelkoop et al., 2017).



In terms of regulations, a clear lesson learnt from Germany is that to make significant energy savings, policy and regulations need to be integrated and not siloed (Ringel et al., 2016). Some authors indeed stress the necessity of a mix of instruments to also avoid rebound effects, both on buildings but also on a societal level. Integration does occur, but more in the form of 'Covenants' (Covenant of Mayors, 2015) or 'Green Deals'. In these cases, it is the local authorities often taking the lead in using local resources to achieve energy efficiency or reduction. The need for a mix of schemes is also discussed with respect to policy instruments such as labelling of products and buildings and 'Minimum Performance Standards' for products (Tsvetanov and Segerson, 2013; Sachs, 2012). Building codes are argued to be necessary to stimulate the market and market transformation, which is necessary alongside with for example grants, and information campaigns about the building ratings, to get people to think about renovating their home (Heiskanen et al., 2013). Linked to this is the discussion of mandatory versus voluntary standards for buildings, where findings suggest that a co-evolution of voluntary and mandatory buildings codes is necessary to avoid potential undesirable outcomes, such as increased consumption (Groesser, 2014; Energy Cities, 2011).

Sources on business support for energy efficiency and using less are available, but these are mainly focused on supporting businesses with audits and other instruments, to support their decision-making process towards becoming energy efficient. What is less investigated is how those companies delivering energy efficiency can be supported to deliver products and services in a way that it ensures effective uptake by customers. Finally, amongst the most innovative and controversial instruments are the personal carbon emission cards (Banyai, 2013; Rousseau, 2011), which might both empower people in becoming more energy efficient and using less, but which also raise issues around civil rights.

Galarraga, I., Abadie, L. and Ansuategi, A., 2013. Efficiency, effectiveness and implementation feasibility of energy efficiency rebates: The 'Renove' plan in Spain. *Energy Economics*, 40 (December 2013), pp. 98–107.

The paper proposes a methodology for a detailed ad hoc analysis of policy proposals, based on their performance in terms of economic efficiency, environmental effectiveness and implementation feasibility. The methodology is applied to study the effects of subsidies and rebates for the purchase of more efficient appliances, using 'Renove' plan in Spain as a case study. Additionally, it assesses the effect of different combinations of taxes and rebates.

Energy Cities, 2017. *Infinite Solutions Guidebook – Financing the energy renovation of residential buildings through soft loans and third-party investment schemes*. France: Energy Cities.

In this guidebook, Energy Cities' members share their experience and guide you through the process of setting up a soft loan financing scheme. The Stuttgart's 'care-free energy renovation package' and third party investment scheme are described in detail in a dedicated case study.

Allcott, H., Mullainathan, S. and Taubinsky, D., 2014. Energy policy with externalities and internalities. *Journal of Public Economics*, 112 (April 2014), pp. 72–88.

The paper analyses optimal policy when consumers of energy-using technologies undervalue the energy costs of these technologies. It demonstrates how product subsidy and energy tax work in combination to target the more biased consumers, and presents formulas for optimal policy and welfare analysis.

Bolton, R. and Foxon, T., 2015. A socio-technical perspective on low carbon investment challenges – Insights for UK energy policy. *Environmental Innovation and Societal Transitions*, 14 (March 2015), pp. 165–181.

The paper examines how the socio-technical systems approach can address the role of policy in effectively mobilising finance to achieve UK low carbon objectives. It concludes that socio-technical systems frameworks, combined with empirical analysis, can be useful to develop long-term resilient and adaptive new policies and inform wider societal debates on low carbon investment options.



Waite, G., Roggeveen, K., Gordon, R., Butler, K. and Cooper, P., 2016. Tyrannies of thrift: Governmentality and older, low-income people's energy efficiency narratives in the Illawarra, Australia. *Energy Policy*, 90 (March 2016), pp. 37–45.

The paper explores how Foucault's concept of governmentality may help inform energy efficiency programs, by paying close attention to the way in which individual energy choices create who an individual becomes. The study outlines how governmentality analysis can be used by researchers, policy makers and practitioners. It concludes that policy makers need to better understand thrift consequences and develop comprehensive, consumer oriented and insight based social marketing awareness programs.

Guerassimoff, G. and Thomas, J., 2014. Enhancing energy efficiency and technical and marketing tools to change people's habits in the long-term. *Energy and Buildings*, 104, pp. 14–24.

This article discusses the difficulty in changing energy consumption on the long term. After a short period of energy savings, consumers often return to their own habits or show a rebound effect. Interdisciplinary research is essential to understand energy consumption of a household. This enables tailored approaches such as nudge and marketing, energy management programs, gamification and network approaches.

Middelkoop, M., Vringer, K. and Visser, H., 2017. Are Dutch residents ready for a more stringent policy to enhance the energy performance of their homes? *Energy Policy*, 105 (June 2017), pp. 269–282.

This article focuses on energy consumption in residential buildings and highlights the fact that people are not necessarily interested in adopting energy efficiency measures in their homes, even if the financial benefits outweigh the costs. Their research shows that tenants and owner-occupiers are more open to energy performance standards if they receive adequate information on electronic product code-labels. Hence new policies should take this into account and ensure that decision-makers are well informed and competent.

Ringel, M., Schlomann, B., Krail, M. and Rohde, C., 2016. Towards a green economy in Germany? The role of energy efficiency policies, Germany. *Applied Energy*, 179 (October 2016), pp.1293–1303.

This article demonstrates that energy efficiency policy instruments implemented by the German government could result in significant energy savings. The authors demonstrate that ambitious energy-efficiency strategies can be exploited to a larger extent, creating new job opportunities and GDP growth. Policy makers should therefore not limit their agenda to renewable energy but reconsider adopting energy efficiency and energy saving policies. This will manage a more successful transition towards a 'Green Energy Economy'.

Covenant of Mayors, 2015. Reducing energy dependence in European cities. Covenant of Mayors Office, [online] Available at: http://www.soglasheniemerov.eu/IMG/pdf/CoM_Reducing_Energy_Dependence_for_web_eng.pdf [Accessed 31 May 2017].

This Covenant of Mayors Thematic leaflet looks at how local authorities can diminish their dependence on external energy sources through the smart use of local resources and a general decrease in energy consumption in municipal and residential buildings, urban mobility and public lighting.

Tsvetanov, T. and Segerson, K., 2013. Re-evaluating the role of energy efficiency standards: A behavioral economics approach. *Journal of Environmental Economics and Management*, 66 (September 2013), pp. 347–363.

The paper explores a potential contributing factor behind the energy-efficiency gap, namely, the possibility that consumers are 'tempted' by the low purchase price of products with low energy efficiency. This behaviour is modelled to compare the social welfare under alternative policies – energy efficiency standards, taxes, and the combination of the two. The Behavioural Economics study concludes that the combination of standards and taxes would maximise the social welfare.

Sachs, N., 2012. Can We Regulate Our Way to Energy Efficiency? Product Standards as Climate Policy. *Vanderbilt Law Review*, 65(6), pp.1631–1678.

This article argues in favour of regulation such as minimum energy performance standards (MEPS) for products, alongside other policies such as taxes, labelling.



Heiskanen, E., Matschoss, K., Krazl, L. and Atanasiu, B., 2013. Energy renovations of EU multifamily buildings: do current policies target the real problems? *Proceedings of the 2013 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm.*

This paper demonstrates the need for understanding the impact of decision-making of building owners and investors and feed this into the design of policy. Research shows that governments can support decisions with grants, but that there is also a need for schemes that stimulate the market and support sustainable market transformation, such as building codes. The article builds on work of the EU-funded ENTRANZE project, which develops policy recommendations for increasing the number of near-zero energy renovations.

Grosser, S., 2014. Co-evolution of legal and voluntary standards: Development of energy efficiency in Swiss residential building codes. *Technological Forecasting & Social Change*, 87 (September 2014), pp. 1–16.

The paper explores how technological, social, political, and economic factors interact and shape the evolution of the energy efficiency in building codes. The focus is on exploring the feedback dynamics between innovation, diffusion, and standardisation. It concludes that the co-evolution of voluntary and legal building codes have enabled a continuous improvement of the standards. Another conclusion is that several policies might cause policy resistance and result in uneconomical, counter-intuitive outcomes, e.g. lack of reduction or even increased consumption.

Energy Cities, 2011. *Communicate Your Buildings' Energy Rating. France: Energy Cities.*

The objective of the 'Display Campaign' is to show that the Energy Performance of Buildings Directive (EPBD) can be significantly accelerated if local authorities stimulate behavioural change through communicating the energy performances of their buildings to politicians, technicians, building users, different municipal departments and the public. By mid-2011, almost 500 Displayers were participating in the Campaign. Together these participants have not only produced over 33,000 posters for nearly 15,000 buildings but also implemented innovative and creative local communication campaigns on the energy performance of public buildings.

Banyai, O., 2013. The European Union regulation concerning the energy consumption of buildings-an ecological point of view. *International Review of Applied Sciences and Engineering*, 4 (2), pp.111–116.

This article argues that extra policy measures are needed to take care of rebound effects besides energy performance ratings of buildings. The authors for example argue that it is necessary to keep energy prices at high level or that introducing 'personal carbon trading system' (PCTS) might be a solution. The authors however do mention that because PCTS does not exist yet in the EU regulation it needs to be investigated if and how this instrument impacts on individual rights and the overall economic and social goals of the European Community.

Rousseaux, S., Ochoa, N. and Foucher, K., 2011. Enjeux juridiques du contrôle des émissions personnelles de gaz à effet de serre par un dispositif de carte carbone. *Développement durable et territoires*, 2(1) [online] Available at: <http://developpementdurable.revues.org/8732> [Accessed 31 May 2017].

This environmental law article discusses the innovative potential policy instrument called 'Individual Carbon Card', which is a personal carbon trading system. It is a method of controlling personal emissions and as such is under discussion with respect to civil rights issues and is subject to misconceptions. The authors provide a comparative analysis of different types of carbon card projects.

5.3. Demand-side management

Demand-side management, in spite its name, is actually the historically top-down approach to energy management from state actors such as energy companies. In recent years, demand-side management became something many different parties can undertake, but it is always aimed at reducing and or shifting the energy consumption on the local demand side level. This can be done by means of technological, economic and or behavioural interventions or a combination of these. However, in Europe, after the introduction of the liberalisation of the market, the form and providers of demand-side management are changing and



old players such as energy companies are struggling to redefine their role in light of the lack of trust from the public and conflicting mandates (Apajalahti et al., 2015). Recently, a specific form of demand-side management has emerged, aimed at shifting demand from peak moments during the day and or season or during few peak events in a year, as part of the smart grid development (Goulden et al., 2014).

This focus on peak moments and changing time of consumption is called demand response. Demand response can be achieved in various forms, from pricing energy used during peak hours or moments or providing discount for energy used outside of peak time. But also more technological forms exist, including remote control of for example appliances or installations by third parties. Many critical studies have been published about demand-side management and in particular demand response, demonstrating that these interventions place the burden of a systemic failure on the shoulders of individuals or small players. Further, these studies demonstrate that interventions, such as peak pricing, can have unjust distributional effects amongst certain groups, such as less affluent, working, less healthy people (Murtagh et al., 2014; Darby and McKenna, 2012).

In addition, studies focus on how the smart technologies often used to enable consumers to become engaged in demand-side management have to go through an appropriation process as well on the micro, meso and macro level, and that this process and its issues need more research and a better understanding (Lasalle et al., 2016). However, in the meantime and in response to this, alternatives are emerging focused on aggregating demand to a less individual level, thus empowering users and prosumers with micro grids including local demand side management, such as peer-to-peer exchange of energy from local generation. The community-led type of demand-side management projects are presented as a very valuable alternative given that these projects are perceived as more trustworthy and authentic than those set up by state and or private sector (Burchell et al., 2014).

Apajalahti, E., Lovio, R. and Heiskanen, E., 2015. From demand side management (DSM) to energy efficiency services: A Finnish case study. *Energy Policy*, 81 (June 2015), pp. 76–85.

This article discusses the impact of the liberalisation of the energy market for the delivery of Demand Side Management programmes by energy companies. It describes how after the liberalisation, and in spite of the Directive aimed to provide economic and political motivation, set up by the European Commission energy companies struggle. Partly because to provide energy efficiency services the companies needed all elements of their company, which as however being unbundled. Additionally, the trust issue started playing up because of the commercial position energy companies now hold.

Murtagh, N., Gatersleben, B. and Uzzell, D., 2014. A qualitative study of perspectives on household and societal impacts of demand response. *Technology Analysis & Strategic Management*, 26 (10), pp. 1131–1143.

In the South of England, a study was performed amongst 21 households to identify the impact of two forms of demand response during critical peaks: 'peak pricing' and 'remote demand control'. The study aimed at identifying the impacts of demand response on the individual and society. The findings suggest that peak pricing is not a fair approach for in particular the less affluent, the less healthy, families and working mothers. In addition, the authors found that peak pricing can be very disruptive to household routines including important family routines such as having a meal together. The control from outside option was also not perceived positively either also because households felt that their demand at peak time was beyond their control but determined by forces outside of their control.

Darby, S. and McKenna, E., 2012. Social implications of residential demand response in cool temperate climates. *Energy Policy*, 49 (October 2012), pp.759–769.

This paper reviews demand response concepts and the propositions offered to households in cool temperate climates. The authors discuss the many issues that will have to be solved to enable households in cool climates do deliver the flexibility, including automated load control. Several issues identified by this study that are in need of further research is amongst other the role of the thermal loads, and the risks and opportunities associated with Demand Response.



Goulden, M., Bedwell, B., Rennick-Egglestone, S., Rodden, T. and Spence, A., 2014. Smart grids, smart users? The role of the user in demand side management. *Energy Research & Social Science*, 2 (June 2014), pp. 21–29.

This article investigates the alternative type of systems that might emerge in response to the top down smart grid development. Alternatives in which users are centre stage and where generation and control is pursued on a decentralised level. The implications of this for policy makers are discussed.

Lassalle, J., Amelot, A., Chauvin, C. and Boutet-Diéye, A., 2016. De l'artefact à la naissance de l'instrument pour la maîtrise de la consommation d'électricité: approche ergo-sociologique de la genèse instrumentale des smart-grids. *Activites*, 13 (2).

This article uses a sociological and ergonomic perspective to understand the micro (activity), meso (practice) and macro (socio-technical network) level of smart grid technologies that are aimed at providing end-users control over their demand, demand side management. This interdisciplinary approach defines the appropriation process as an instrumental genesis, which means the transition from an artefact to an actionable instrument dedicated to an activity.

Burchell, K., Rettie, R. and Roberts, T., 2014. Community, the very idea!: perspectives of participants in a demand-side community energy project. *People, Place and Policy*, 8 (3), pp. 168–179.

In this article, the authors investigated a community demand-side management energy project to understand if this type of community led projects have the potential to provide a contribution to energy efficiency and using less. What they found is that indeed, such community projects are potentially very valuable because the fact that they are local and not aimed at profit making generates much more trust and feeling of authenticity among the community than projects initiated by state and or private sector.

5.4. Justice

The combination of justice and energy efficiency and using less is covered relatively well in the literature. However, it is often unclear to which discipline the articles belong. Only a few of the articles described here use an Economic approach. The literature uses all kinds of justice theories and concepts, including: environmental justice, energy justice, social justice, distributive justice and procedural justice (Walker and Day, 2012). Often, the words 'justice', 'fairness' and 'equity' are used interchangeably. Some of the subjects of the articles are fuel poverty, equity and policy (Chatterton et al., 2016; Simcock et al., 2016; Walker et al., 2012; Heffron et al., 2015). In order to look at fuel poverty and to help marginalised groups, it is important to take into account all different kinds of justice frameworks and theories. Justice theories can also contribute to solving the 'energy trilemma', which means the competition between economic, political and environmental goals. Recommendations for future research are excessive consumption as a justice issue and low energy practices that lead to more well-being (Hefferson, McCauley and Sovacool, 2015).

The SHAPE ENERGY project will also produce a crosscutting theme report with a more detailed discussion of the concept of energy justice and recommendations for how to address energy justice in energy projects.

Chatterton, T. J., Anable, J., Barnes, J. and Yeboah, G., 2016. Mapping household direct energy consumption in the United Kingdom to provide a new perspective on energy justice. *Energy Research & Social Science*, 18 (August 2016), pp. 71–87.

This study gives more attention to exploring levels of energy use amongst the highest users in developed countries. The main interest of the study is how energy usage relates to greenhouse gas emissions.

Simcock, N. and Mullen C., 2016. Energy demand for everyday mobility and domestic life: exploring the justice implications. *Energy Research & Social Science*, 18 (August 2016), pp. 1–6.

This is an introductory article to a special issue about energy demand in mobility and domestic life and insights from energy justice. It discusses the issues of justice that arise regarding energy consumption for mobility and domestic life and it identifies current gaps in the literature. The Special Issue is divided into three themes: uneven access, unequal burdens and using less. The authors recommend the community



to pay more attention to excessive consumption and the identification of energy efficiency measures that simultaneously create more well-being.

Walker, G. and Day, R., 2012. Fuel poverty as injustice: integration distribution, recognition and procedure in the struggle for affordable warmth. *Energy Policy*, 49 (October 2012), pp. 69–75.

This article sees fuel poverty as an expression of injustice and a social equality issue, because it is about the ability to access energy services and to create a healthy indoor environment. The research uses a framework that includes all kinds of justice theories, like distributive, social, procedural and environmental justice. The authors argue that more cultural and political recognition of vulnerable social groups is required as well as a more democratic and inclusive process of decision making.

Heffron, R., McCauley, D. and Sovacool, B., 2015. Revolving society's energy trilemma through the energy justice metric. *Energy Policy*, 87 (December 2015), pp. 168–176.

The authors discuss the so-called energy trilemma, which they describe as the competing aims of politics, economics and environment. They argue that this can be resolved by energy justice. They argue the debate needs to highlight cosmopolitanism and go beyond economic thinking. They develop an Energy Justice Metric to solve the energy trilemma. It can provide a tool for decision-making on energy policy.

5.5. Monitoring, evaluating and learning

One of the challenges facing energy efficiency programmes is finding the right ways to monitor and evaluate their long-term impacts on the socio-technical system (Mourik et al., 2015). Traditionally, the focus of evaluating interventions has been on indicators that show isolated effects or impacts, such as the amount of energy saved and the number of technologies installed (Mourik et al., 2015). However, some of the literature argues that the focus should be more on outcome and process indicators that help understand how programmes change the socio-technical system (Neij and Åstrand, 2006; Pearson et al., 2014; Mourik et al., 2015; Hobson et al., 2014; Luederitz et al., 2016). This system includes the technological system, actors and institutions. The literature shows different paths to evaluating these outcomes. One way to do this is to design interventions and programmes as experiments by using randomised controlled trials in order to better understand the outcomes (Vine et al., 2014). However, often these theoretically sound evaluation practices (such as randomised controlled trials) are not possible in reality due to constraints of the programme design, limitations to time and budget available and because of the aims of the evaluation (Wade and Eyre, 2015; Mourik et al., 2015).

An alternative way is to focus more on outcome indicators that allow for learning about the impacts on the system as a whole or on collecting bottom-up data (Neij and Åstrand, 2006; Pickl et al., 2016; Mourik et al., 2015; Hobson et al., 2014; Luederitz et al., 2016). Some literature states that one essential characteristic of an evaluation approach is that it should test hypotheses about the mechanisms that cause impacts on energy consumption and on the system. Examples of these mechanisms are improved technologies, increased knowledge and awareness, changed market conditions and changed social practices (Wade and Eyre, 2015).

Monitoring and evaluation of course is also aimed at understanding how to repeat and upscale successful experiments. What is clear from the literature is the need to not only learn if an energy efficiency programme is effective, but also to learn about how and why it was effective. Several authors have focused on why and how learning should be monitored and evaluated as well to understand how to upscale.

Heiskanen and Matchoss (2016) for example discuss the technocratic and inspirational learning that occurs in experiments and how to use learning across sites to upscale. Moser et al. (2015) explore how social groups and the learning process about energy use taking place in these groups can be a way to upscale. Social learning can for example be a powerful mechanism to engage people with energy saving (MacLaury et al., 2012). Burchell et al. (2015) argue that learning should focus on creating know-how and should thus focus on development of practical skills, experience and guidance and less on education and communication. However, creating a conducive environment for capacity and know-how building is rather difficult, especially with respect to leadership and continuity of a learning network (Watson et al.,



2015). Finally Backhaus et al. (2010) demonstrate the importance of creating a learning culture amongst all stakeholders involved for the successful implementation of projects focused on energy efficiency or using less.

Pearson, A., Gruenig, M., Prah, A., Caiati, G., Efthimiadis, T. and Sitko, I., 2014. Report on drivers of societal processes of energy transition. Milesecure 2050 Deliverable 3.1. Berlin: Ecologic Institute.

This report on drivers of the societal processes of the low-carbon energy transition present an analysis of drivers and barriers of energy transition, examining factors in three domains: market, external and governance factors; social, political movement and grassroots factors and personal, cultural and site-specific factors. The analysis combines qualitative and quantitative information from literature, focus groups and expert interviews on local 'anticipatory experiences' into an assessment model to study the relevance of factors, the interconnectedness of factors and the temporal fluctuation in relevance of the factors. Results point toward social, political movement and grassroots factors as being the most relevant drivers for the energy transition. This information is meant for policy makers and academics alike.

Patterson, M., 1996. What is energy efficiency? Concepts, indicators and methodological issues. Energy Policy, 24 (5), pp. 377–390.

This article reviews persistent methodological problems in the operationalisation of energy efficiency indicators. It provides some valuable insights in how energy efficiency is being defined and measured. Pointing out critical methodological issues that need to be taken into account, such as: including value judgements, the energy quality problem, the boundary problem, and the joint production problem and aggregation indicators.

Mourik, R., van Summeren, L., Breukers, S. and Rotmann, S., 2015. Did you behave as we designed you to? Monitoring and evaluating behavioural change in Demand Side Management. IEA-DSM Task 24.

The authors state that finding the right ways to monitor and evaluate the (long-term) impacts of behavioural change interventions is one of the key challenges demand-side management interventions face. In this positioning paper, the authors explain current monitoring and evaluation practices, how different disciplinary underpinnings of the behaviour change interventions influence these practices and their main challenges and shortcomings. In short, currently interventions are mainly evaluated with single-loop learning indicators that focus on (estimations about) outputs, effectiveness and efficiency. While insufficient focus is placed on long-term outcomes that are relevant to a range of different stakeholders, which is especially problematic for evaluating systemic interventions. With this in mind, the authors suggest an alternative approach that focusses on double-loop learning, that includes both qualitative and quantitative metrics and focusses explicitly on both process and outcomes and on multiple definitions of success that are relevant to different types of stakeholders.

Pickl, N., Jellinek, R., Reidlinger, B., Ploiner, C. and Zelalic, A., 2016. Data Collection Process for Bottom-up Monitoring. multEE.

The authors provide guidance on how a data collection process can be structured in order to ensure that significant data is available for monitoring and verifying achieved energy savings. This guidance is based on best practice examples and describes different stages of the data collection process that should ideally be included. Monitoring and verification schemes are introduced that are based upon bottom-up data. This ensures that outcomes of energy efficiency measures are evaluated in the right way and can be used in future energy efficiency planning. The authors state that the suggested data collection process should not be seen as the universal method, but is to be considered as a guidance for monitoring and verification schemes for energy saving efforts of the Member States of the EU.

Neij, L. and Åstrand, K., 2006. Outcome indicators for the evaluation of energy policy instruments and technical change. Energy Policy, 34 (17), pp. 2662–2676.

Neij and Åstrand report on outcome indicators for evaluating energy policies that are necessary for improved understanding of and learning about socio-technical change. Conventional evaluation methods focus on impacts or isolated effects to describe the effectiveness of policy instruments. But these impact assessments do not show how policy instruments have affected the process of technical change. Neij and Åstrand propose a system-oriented evaluation framework complementary to conventional approaches,



to evaluate energy policy instruments by making use of outcome indicators that show (non-) changes in the socio-technical system as a whole. In their paper, they describe examples of outcome indicators that simplify the complex changes in the socio-technical system, which includes changes in technology, actors and institutions and market conditions. The authors further argue that the use of outcome indicators likely pays off in the long-run since they may increase learning and understanding of the socio-technical impacts of policy instruments, which is essential for developing more effective climate policy programmes.

Gynther, L., Mikkonen, I. and Smits, A., 2012. Evaluation of European energy behavioural change programmes. *Energy Efficiency*, 5(1), pp. 67–82.

Gynther, Mikkonen and Smits have investigated success factors and weak points of almost 100 different energy-related behavioural change programmes from 11 European countries. Of these 100 cases, 41 cases were studied in more detail. They also analysed the evaluation practices used in these cases. This analysis shows that two main types of programme evaluations were identified: process- and impact evaluation. The first is a systemic assessment of the whole process including the design, delivery and quality of services delivered to the consumer. The latter is about the different effects and outcomes of the programme such as changes in behaviour and reductions in energy consumption and CO₂ emissions. Impact evaluation techniques and third-party evaluation were also briefly discussed.

Vine, E., Sullivan, M., Lutzenhiser, L., Blumstein, C. and Miller, B., 2014. Experimentation and the evaluation of energy efficiency programs. *Energy Efficiency*, 7, pp. 627–640.

Energy efficiency programmes rarely consist of experimentation in the form of randomised controlled trials. This type of experimentation can be used to test alternative features of energy efficiency interventions and it can be used to better determine their outcomes. Randomised controlled trials and quasi-experimental methods can be used to learn what types of interventions are working or not working in energy efficiency programmes. The authors state that especially when effects on energy savings and spill over effects are very uncertain, experiments should be used. In the article, the authors also discuss a brief overview of experimental evaluation approaches relevant to energy efficiency programmes, barriers for using these experimental methods, and after this, the authors provide some recommendations for implementing social experiments in order to evaluate energy efficiency programmes.

Wade, J. and Eyre, N., 2015. Evaluation good practice: is 'good enough' better than 'perfect'? *Proceedings of the 2015 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm*.

Wade and Eyre state that using theoretically perfect evaluation practice is rarely possible in reality due to constraints of the programme design, limitations to time and budget available and because of the aims of the evaluation. In this literature review, they discuss gaps in knowledge and evaluation practices and priorities for future research. Important gaps in the knowledge about evaluating impacts of energy efficiency programmes relate to how impacts vary among different end-users and how large-scale programmes contribute to wider market transformations. They discuss benefits and limitations of randomised control trials, which are seen as the 'gold standard', and what this means for using them in practice. The authors conclude that theory based evaluation is a critical aspect that should be part of all evaluations. Thus according to the authors evaluations should test hypotheses about the mechanisms that cause impacts on energy consumption of energy efficiency programmes, like for example improved technologies, increased knowledge or awareness, changed market conditions and/or changed social practices.

Hobson, K., Mayne, R. and Hamilton, J., 2014. *A step by step guide to Monitoring and Evaluation. School of Geography and the Environment. Oxford: ECI*.

This report provides a step by step guide to monitor and evaluate community led approaches that focus on climate change or energy issues. It provides background information on core principles of monitoring and evaluation, and links for additional approaches and information. The report consists of two sections. Section one shows an overview of a logic model approach that can be used for monitoring and evaluation. A list of examples is provided on indicator themes to evaluate key issues. This approach also explicitly focusses on internal learning and goes beyond isolated effects and focusses also on more systemic changes. Section two is a template that allows the reader to use this approach to monitor and evaluate their own community led projects.



Luederitz, C., Schöpke, N., Wiek, A., Lang, D., Bergmann, M. Bos, J., Burch, S., Davies, A., Evans, J., König, A., Farelly, M., Forrest, N., Frantzeskaki, N., Gibson, R., Kay, B., Loorbach, D., McCormick, K., Parodi, O., Rauschmayer, F., Schneidewind, U., Stauffacher, M., Stelzer, F., Trencher, G., Venjakob, J., Vergragt, P., von Wehrden, H. and Westley, F., 2016. **Learning through evaluation – A tentative evaluative scheme for sustainability transition experiments.** *Journal of Cleaner Production*, in press.

The authors identified that there is a lack of broadly applicable evaluation schemes that can be used to learn from sustainable transition experiments set up by collaborative science-society initiatives. Insights from these experiments are helpful for improving the design of future transition experiments that address one or more of the interconnected challenges of economic development, ecological integrity and social justice. This article presents a tentative evaluative scheme for these experiments drawing on research on evaluations and transitions, and on insights from empirical cases. The aim is to develop a scheme that is applicable to different types of experiments; able to capture ultimate outcomes but also inputs, processes and outputs; ready to apply on experiments; and that helps making experiments more effective and efficient. The authors provide definitions, indicators, examples and justifications for all features relevant for the different evaluative dimensions (e.g. inputs, processes, outputs and outcomes).

Heiskanen, E. and Matschoss, K., 2016. **Paikallisten ilmastokokeilujen arvioimisen haasteet: Oppiminen kahdessa vähähiilisessä kokeilussa.** *Alue ja ympäristö*, 45(2), pp. 45–58.

This article discusses the different forms of learning that can occur in and from experiments: technocratic and inspirational and how learning is aggregated and shared between different sites.

Moser, C., Blumer, Y., Seidl, R., Carabias-Hutter, V. and Furrer, B., 2015. **Multiplying energy-saving behaviour in cities through formal social groups.** *Proceedings of the 2015 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm.*

This paper draws on social learning theory to assess technical efficiency measures and behavioural change involving the three Swiss cities of Winterthur, Baden, and Zug. In particular, it examines whether formal social groups (e.g. sports clubs) may function as powerful multipliers for communal energy-saving activities. Based on the findings, the authors suggest strategies on how the three studied cities may best engage consumers in energy saving.

MacLaury, K., Cole, P., Weitkamp, E. and Surles, W., 2012. **Lessons from the Field: The Contribution of Active and Social Learning to Persistent Energy Savings.** *ACEEE Summer Study on Energy Efficiency in Buildings 2012.*

This paper reports on residential behavioural energy efficiency programmes enabled by feedback and online tools. Social learning was aimed at by using comparative data, goal setting and allowing participants to ask for help explaining a specific energy consumption pattern and using community problem solving by peers. The social aspects of the website were crucial in creating new social norms and active learning. This approach was successful with a sustained (after 27 months) energy reduction of 9% on average.

Burchell, K., Rettie, R., Hill, K. and Roberts, T., 2015. **What is energy know-how, and how can it be shared and acquired?** *Proceedings of the 2015 ECEEE Summer Study, European Council for an Energy Efficient Economy, Stockholm.*

In this paper the authors state that policy focuses too much on literacy approaches which state that factual knowledge, cognitive reasoning, and ideal attitudes and behaviours and thus education and communication are the way to get people to learn about why and how to change their energy behaviour. In contrast, the paper argues that learning should focus on creating know-how and should thus focus on development of practical skills, experience and guidance.

Watson, P., Gabriel, M. and Rooney, M., 2015. **Get bill smart: A community-partnership approach to supporting low-income households to achieve home energy savings.** *Indoor and Built Environment*. 24(7), pp. 867 - 877.

This article is one of the few that focuses on how to build up capacity to participate in energy efficiency and using less behaviour for low-income households. It suggests that the role of the community in building up capacity is potentially very powerful, but that issues around emergence of leadership and ongoing networking are critical.



Backhaus, J., Mourik, R. and Breukers, S., 2010. Learning in single and double loops- Interaction as key to scientific and practical insights. Paper presented at EASST conference 2010, Trento, Italy.

This paper discusses results about 'double loop learning' from the European research project *CHANGING BEHAVIOUR*, which developed an online toolkit containing theoretical background information and practical activities aiming to improve the success of demand-side management programmes. The project had an understanding of behaviour as context-dependent, which entails a focus on learning. Energy intermediaries as demand-side management project implementers need to learn about their target group, the (social) context of their project, other stakeholders' role and motives, and about their own role as facilitators for change. However, this learning cannot remain one-sided. The target group needs to reflect (i.e. learn) about its current behaviour and its possibilities and motivations for change. Considering the importance of learning, the 'changing behaviour tools' encourage frequent interaction among project stakeholders in order to enable exchange of concerns and ideas.



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