ENERGY SYSTEM TRANSITION THROUGH STAKEHOLDER ACTIVATION, EDUCATION AND SKILLS DEVELOPMENT

ENTRUST

Synthesis of socio-economic, technical, market and policy analyses

Deliverable D3.4

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About the ENTRUST Project

ENTRUST is mapping Europe's energy system (key actors and their intersections, technologies, markets, policies, innovations) and aims to achieve an in-depth understanding of how human behaviour around energy is shaped by both technological systems and socio-demographic factors (especially gender, age and socio-economic status). New understandings of energy-related practices and an intersectional approach to the socio-demographic factors in energy use will be deployed to enhance stakeholder engagement in Europe's energy transition.

The role of gender will be illuminated by intersectional analyses of energy-related behaviour and attitudes towards energy technologies, which will assess how multiple identities and social positions combine to shape practices. These analyses will be integrated within a transitions management framework, which takes account of the complex meshing of human values and identities with technological systems. The third key paradigm informing the research is the concept of energy citizenship, with a key goal of ENTRUST being to enable individuals to overcome barriers of gender, age and socio-economic status to become active participants in their own energy transitions.

Central to the project will be an in-depth engagement with five very different communities across Europe that will be invited to be co-designers of their own energy transition. The consortium brings a diverse array of expertise to bear in assisting and reflexively monitoring these communities as they work to transform their energy behaviours, generating innovative transition pathways and business models capable of being replicated elsewhere in Europe.

For more information see **http://www.entrust-h2020.eu**

Project Partners:

University College Cork, Ireland
- Cleaner Production Promotion Unit (Coordinator)
- Institute for Social Science in 21st Century

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Executive Summary

The information presented in this deliverable summarises the outputs from three distinct strands of research carried out for the ENTRUST Horizon 2020 research project. This research is exploring the energy system from multiple perspectives. They include the more traditional, techno-centric market approach; and public policy oriented appraisals; in addition to applying innovative engagements that capture human-centred perspectives of people experiencing the intersecting nexuses that comprise the energy system.

Aim

Decisions on how the energy system is transitioning to low-carbon configurations will have, and is having, very real impacts on society and how people live their lives. In order to understand these societal intersections with the material configurations of the energy system, ENTRUST has sought to identify where many of these intersections arise, how they are created and then negotiated, within a complex nexus of choices, freedoms and controls that comprise our shared relationships with energy and the structures that support it. The objective of this document is to integrate the findings arising from this research and to feed into:

- ongoing collaborations with the project's six case-study communities; to further
- explore the potential of novel energy transition pathways; and
- to develop content for the forthcoming *Energy Communities* knowledge and communication platform.

The research discussed in the document was conducted for three work packages (WPs), as outlined below, and is presented here using a combined approach that draws synergies between the various strands discussed within each WP, *viz.,*

- Work Package 2: Mapping of the Energy System;
- Work Package 3: Socio-demographic Analysis;
- Work Package 4: Policy Analysis.

In addition to summarising these reports, the authors present the findings from each within at thematic synthesis of the issues identified across the three WPs, which are organised within following four key pillars:

- Technological characterisation;
- Business model perspectives;
- Energy Policy;
- Energy and the citizenry.

Observations and conclusions

The deliverables summarised in this report represent a substantial body of work and their findings clearly demonstrate that it is no longer feasible to differentiate the "social" from the "technical" dimension of the energy system and still have a just and sustainable energy transition. We acknowledge that the creation of a

sustainable energy pathway necessarily involves the development and mobilisation of a complex array of contributing factors which are themselves complex and have multiple socio-environmental implications. As such, understanding this process involves multiple approaches and disciplines. This research offers a wealth of deep, rich data and information from the social sciences that help those driving the energy transition construct and frame this process in a more equitable way than it potentially has been heretofore.

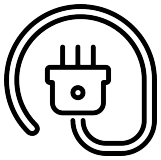
- Plans to decarbonise the energy system in a European context require extensive development and growth of alternative energy sources and understanding what has been achieved to date in this context is critical to future development.
- The EU, as an influential international player, has helped mediate visions for the future of the energy system. However, large disarticulations remain with regards to how member states envision their path to sustainability.
- Strong consensus exits in using renewable energy to achieve sustainability goals. However, there remain a number of obstacles which have prevented these alternatives becoming the "game changers" they potentially can be.
- Evidence from this research suggests that progress, relative to the decarbonisation of the energy system in Europe, has not met desired targets and expectations. For instance, there are large differences in the way energy sustainability is understood and interpreted by people at national level. For instance, the liberalisation model, which is largely supported at EU level, has been (re)interpreted by member states to fit national agendas causing dissonant outcomes at the supranational level.
- Public engagement with these shifting energy landscapes is telling in a number of ways. For instance, public attitudes to energy technologies are mediated by a number of socio-demographic and place-based factors. Gender, age, socio-economic and community contexts are important variables when understanding public perceptions of the different energy sources available. For instance, attitudes towards nuclear energy can vary based on gender and community contexts according to our research.
- These differences, often operate in an interlinked manner and are also evident in the way people engage with energy in their everyday lives. The making of spaces, in particular the making of home is strongly determined by the roles individuals engage with over the course of their lives – such as mothers, fathers, carers, guardians, independent elders – that can lead to differing understandings of what energy means to them.

These insights are valuable for understanding the potential impacts that the energy transition can, and will, have on different segments of the population. Technological, market and policy changes have different effects at local level for different cohorts of people. Therefore, there are very real potentials for creating new forms of social exclusion from emerging energy systems that fail to recognise the differentiated ways in which people experience and ultimately engage with them.

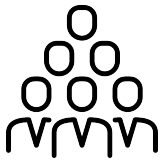
1 Introduction

1.1 Background

The information presented in this deliverable represents the outputs from three distinct strands of research within the ENTRUST project. This research is exploring the energy system from a traditional techno-centric market perspective, from a public policy orientation, and from a human centred point of view. The objective of this document is to integrate the findings arising from this research and to feed into: ongoing collaborations with the project's six case-study communities; exploration of potential novel energy transition pathways; and the development of content for the forthcoming *Energy Communities* knowledge and communication platform. The research discussed in the document was conducted in three work packages as outlined below.



Work package 2 undertook an extensive characterisation of energy system actors resulting in a basic map of energy systems, consisting of key actors, a description of their key roles, and critical strategic points of interaction, consistent with a practice based approach. Actor-network theories were applied to develop insights into stakeholder interactions and in so doing consider energy-using individuals, communities and the energy supply chain as a cascading, interlinked ecosystem/network of linked and interacting stakeholders. The work package involved a comparison of energy system profile for diverse energy technologies, including an analysis of how synergies can be found between them regarding evolution, market, policies and uptake and/or acceptance. Three deliverables were produced in this work package, namely: D2.1 Energy System Stakeholder Characterisation, D2.2 Energy Technological Review, and D2.3 Report on novel business models and main barriers in the EU energy system. Summaries of these deliverables are included in section 3 on pages 11 to 19.



Work package 3 provided an in-depth understanding of human behaviour and practices in relation to energy use, and how they are affected by a variety of socio-economic factors, including in particular: gender, socio-economic privilege and age. The component tasks included comprised an initial mapping of socio-economic factors affecting energy practices and detailed analyses of energy-related behaviour, practices, perceptions and attitudes in the six case-study communities. The research was informed by an intersectional approach, conscious of the mutually constitutive relations that exist among social identities, including gender. This WP will proceed in tandem with WP5, using its communities of practice to study energy practices and attitudes towards energy technologies. In addition to this report which is an output of this WP, there were three other deliverables produced in this work package: D3.1 Initial mapping of available socio-economic data on energy practices, D3.2 Intersectional analysis of energy practices, and D3.3 Intersectional analysis of perceptions and attitudes towards energy technologies. Summaries of these deliverables are included in section 3 on pages 20 to 30.

Work package 4 produced an update of the current situation in terms of policies and regulations associated with the energy system in a range of European countries – the five largest energy using countries, viz., France, Germany, Italy, UK and Spain along with Ireland, which offers a contrasting context as a small country, dispersed population, in an economic upturn. Building on the stakeholder identification in WP2, an analysis was conducted of the national

dialogues, the main public discourse focus and their main barriers to deploy low carbon energy measures. An analysis of energy behaviour change initiatives was produced providing insights on success factors and commonly encountered barriers. The whole energy system and existing infrastructures in each country was considered to assess the potential 'Europeanisation' of the Energy policy landscape. A comparision was made of the different policy frameworks, considering for example, the inputs that have driven the implementation of these policies, from technology, social or market domains including the ex-post evaluation of its effectiveness and discourse analysis of the processes shaping key national and European policy documents. The findings from this work combined with input from WP2 (energy technologies) and WP3 (socio-economic analysis) was used to develop a best practice policy tool-kit. Five D4.1 Report on policy & regulation landscape, D4.2 Recommendations on Europeanisation of national policy dialogues on energy pathways, D4.3 Review of market-driven approaches in sustainable energy policies, D4.4 Review of behaviour change initiatives, and D4.5 Policy tool-kit. Summaries of these deliverables are included in section 3 on pages 31 to 50.

Two concepts – intersectionality and practice theory – are central to the work presented in this report, particularly the work in WP3 but also in integrating the work from the other strands. Appendix 1 offers a fuller treatment of intersectionality bringing together and building on the analyses in our research. The appendix explains the meaning of the concept; explores its foundation in feminist theory and its evolution; and discusses its significance as a research paradigm and its relevance for developing a methodology guiding qualitative research. Appendix 2 provides an introduction to practice theory, which enables an understanding of how practices inherently shape people's engagements with, and reactions to, the energy system. This in turn facilitates a reconceptualization of how such relationships can be better adapted to support the required energy transition.

Thematic synthesis and other approaches were used to integrate the findings arising from these aforementioned reports to offer a more holistic perspective on the energy systems reflecting: the central and vital role of energy in everyday living; the technological foundations of the production, storage distribution of energy; the role of the energy market and the nature of business models utilised within it; the importance of public policy and governance of this important component of modern society. The outcome of this work is presented in Section 4 'Understanding the energy System' on pages 51 to 88.

1.2 Methodology

As outlined above there are, to date eleven outputs from work packages 2, 3 and 4. These documents are inherently very different: with those from WP2 which provided an overview of energy technologies and the energy marketplace being very descriptive in nature; those from WP3, which were concerned with the people and the communities in which they live were far more explorative, while the outputs for WP4 focusing on the policy landscape could be considered perhaps somewhere in the middle of this continuum. Given the very differing nature of the reports, synthesising them was a complex and time-consuming undertaking, which involved all the partners participating in the three work packages. The task consisted of a structured collaborative review process, which comprised both workshop review and deskwork.

A workshop-based review, provided the researchers with an opportunity to come together and explore the different themes that they were able to identify from their respective outputs in each work package. This enabled individual researchers to play to their strengths and maximise their contributions, using their specific skill sets and expertise, but also to learn new perspectives from the other researchers present. Consequently, this minimised the silo effect such complex and differing research engagements can often bring about.

Our methodology for synthesising the quantitative and qualitative research conducted across the three work packages has been informed by our collective understanding that, in keeping with the overall spirit of ENTRUST, we could not present the diverse range of data we uncovered into the rationalist models one sees in syntheses of purely quantitative research. The quantitative research employed in these work packages was done to help both frame and further contribute to the range and depth of meanings, experiences and perspectives of the participants. As Barnett-Page and Thomas (2009) suggest, methods for qualitative synthesis vary depending on the research discipline and context of the work being carried out. They refer to a number of synthesis methods one can take, including adopting one or a combination of approaches including: meta-ethnography, grounded theory, and thematic synthesis (Thomas & Harden 2008) all which all have strengths that speak to the work we have tried to do here. As Lynn Doyle (2003) suggests meta-ethnography not only offers the potential as a method of enquiry but also the has the capacity to be used as a process to extend democratic principles. Doyle goes on to state that unlike meta-analysis, the samples used in meta-ethnography are "purposive rather than exhaustive because the purpose is interpretive explanation and not prediction. Meta-ethnographers reconceptualise new interpretations for the collective that may differ remarkably from the component parts" (2003, p.326). Thomas and Harden (2008, p.3) interpret Doyle's assessment to mean that it may not be necessary to "locate every available study because, for example, the results of a conceptual synthesis will not change if ten rather than five studies contain the same concept, but will depend on the range of concepts found in the studies, their context, and whether they are in agreement or not". Consequently, they see greater value in aiming for "conceptual saturation" as opposed to focusing on electronic searches of databases alone. Indeed, their assessment in some ways mirrored our own experience producing D3.1 '*Survey of socio-demographic data on energy practices*' (Gaffney et al. 2015), where the dearth of rich qualitative data in the large data archives of both national and supra-national repositories. Also, as part of the process synthesising the three work packages we removed any information that was duplicated, impractical to assess, and rephrased items for greater clarity and relevance to the objectives of this report. The different methodologies that informed each deliverable, along with the methods applied when engaging in the respective research work, are outlined in Section 2.

1.3 Deliverable structure

Besides this introductory section, the document comprises: Section 2, which presents an overview of the eleven deliverables prepared in work packages 2, 3 & 4; Section 3 considers the energy system from a number of perspectives (technological, business models, policy, and a more human centric view); while Section 4 attempts to draw conclusions from the preceding section. In addition there are two appendicies, which offer introdcuctory texts for two concepts central to the work of the ENTRUST project, namely intersectionality and practice theory.

2 Overview of research reports

2.1 Energy system stakeholder characterisation

Dallamaggiore, E., Boo, E., Aze, F., Lennon, B., MacSweeney, R., Gaffney, C., Dunphy, N.P., Landini, A. & Otal, J. (2016). *Energy System Stakeholder Characterisation*. Report prepared as a project deliverable (D2.1) for ENTRUST H2020 project (grant agreement no. 657998). Cork: University College Cork.

Extract from project 'Description of Action'

'ENTRUST embraces a holistic system approach that aims to provide concrete answers to the problems that societies face in their attempts to operate within sustainable energy systems and create low-carbon economies. The energy system is part of a broader societal system and therefore there can be more stakeholders and driving forces outside the energy system itself that could be vital for the analyses purposes of the proposed project. Thus, it is vital that this task is co-ordinated by a multi-disciplinary team that appreciates the complexity of the factors that could play a role in the transition towards a more sustainable energy era. ANT theories will be applied to analyse how the growth and structure of knowledge are linked to the interactions of actors and networks. The result from this stakeholder analysis sets the scope for the subsequent work packages. … This task aims to identify the main stakeholders at European and national level, e.g., EU organisations (EURELECTIC, EDSO, industriAll Europe, EPSU), politicians and decision makers, public governments, product and service providers, financiers and other funding organisations, users and user groups (including families, vulnerable road users, socially or physically disadvantaged group), non-governmental organisations and other actors (e.g., so-called change champions) who directly or indirectly influence the future, the needs and the design of a renovated energy system.'

Abstract

WP2 undertakes an extensive characterisation of energy system actors within the European Union. Within this context, the objectives of this deliverable are to develop an energy actor-network typology and to appreciate the complexity of factors that can play a role in the transition towards a more sustainable energy era. T2.1 and its 'stakeholder analysis' is aimed at informing subsequent work packages in terms of mapping the direct and indirect influences on the energy system, and the actors that comprise it. To accomplish this, an extensive data gathering exercise has been conducted to develop insights on the energy models of Ireland, UK, Spain, Italy, France, Germany, and at the EU level. In addition, a number of key energy topics were studied in greater detail, and a range of discourses on the energy transition were mapped. An extended map for each of the six countries was produced. The extensive data gathering enabled the identification and exploration of areas of interest concerning the energy system, from nuclear phase out and promotion to fuel poverty, renewable energy deployment, energy independence and security, energy economics, political discourses, as well as capturing some influential socio-demographic factors. The multiplicity of fields that interconnect with, and within, the energy system indicates the complexity of the energy system itself, as well as some of the complexities involved in its transition to sustainability.

Methodology

The aim of T2.1 is to define an actor-network typology for characterising the actors that play a role in the energy system. In order to produce this typology, the relationships between individual entities and groups of entities, both human and non-human, were identified and characterised. In addition, the task required that the typology be based on an extensive mapping of the identifiable forces, drivers and actors with an influence, either direct or indirect, on the energy system. Table 1, below, outlines the research process, including the actions, methods, and rationale for this task.

Table 1: Research process

Action	Content/Aim	Link w/ Description of Action
Literature review	Placing the deliverable in a wider context	
Country overviews	Overview of each country's energy model and relations with other societal topics	Understanding each country's energy model
Actor identification	Spreadsheet map of the actors that comprise the energy system	"Identifying the main stakeholders at European and national level"; "Extensive characterisation of energy system actors"
Discourse identification	Identification of discourse of actors, directly or indirectly linked with energy.	"Actor-network theories will be applied"
Case-studies	Case-study on key energy topics, allowing a more detailed understanding using ANT	"Actor-network theories will be applied"
Actors' analyses and discourse characterisation	One page text explaining how actors evolve in the context of the energy transition and their discourses	To provide insights for building the "actor-network typologies"
Extended energy system and discourse maps	Map representing the energy system, key actors, their relationships and driving forces that impact the energy system Map representing the identified discourses, categorised.	"A basic map of energy systems will be produced consisting of key actors, a description of their key roles, and critical points of interactions." Discourse mapping is a part of the ANT: "Actor-network theories will be applied"
Lists and indicative typology of influences and actors mapped		

Key Results

The data gathering exercise conducted allowed for variety of insights on energy to emerge. These ranged from nuclear phase out and its promotion, to fuel poverty and the deployment of renewable energy technologies, to issues around energy independence and security, energy economics, political discourses, and other influencing socio-eco-demographic factors. The multiplicity of fields that interconnect with, and within, the energy system indicates the complexity of the energy transition.

One perspective is to view the energy system as essentially an instrument of the economic sector. In this case, the need for its growth and competitiveness is emphasised and linked with the competitiveness of other sectors that depend on energy. The power purchase concerns of end-users are also an important

variable, along with choices associated with fixing energy prices and the type of energy production technology employed.

From a political perspective, the energy system can be seen as having both potential weaknesses and strategic strengths, particularly in relation to an individual country's level of dependency on energy imports, and its level of exposure to geopolitical disturbances that can arise in exporter countries. Political attention is also often directed towards managing the public health risks that are inherent in the current energy system configuration – such as the link between fuel poverty and rates of respiratory illnesses, as well as public concerns about the potential risks from nuclear power.

The question of a 'sustainable' transition is also very much at the core of political narratives on the energy transition, given the link between energy consumption, energy production, and a country's sustainability in socioeconomic and environmental terms. The question of sustainability also arises in terms of managing existing energy resources, resource depletion, environmental degradation, and climate change. The word 'transition' may be problematic in and of itself since it may not convey the same meaning to everybody. Some may understand this term to mean a complete change of paradigm, while others may understand it to mean a gradual adaptation, including increased efficiencies, of the existing energy system. Considering this, one can also see the energy transition generating questions in terms of values, where values such as 'responsibility', 'moderation' and 'individual freedom' often inform how the transition will ultimately be realised.

The inherent complexity of the energy system is obvious when one acknowledges that all the six countries in this study have quite different energy models, even though they may share or have shared some similar characteristics – given the shared energy demands existing in each country. A notable example of this can be seen in France and Germany on the nuclear energy topic. Strongly affected by WWII, nuclear power was of strategic importance to both countries to aid rapid reconstruction, and to regain the competitiveness lost in the war's aftermath. However, as mentioned earlier, both countries have diverged drastically with Germany opting to decommission its nuclear power infrastructure, while France continues to invest in nuclear energy.

Conclusion

From a transition perspective, we can conclude that while the energy models of all six countries are different, there are shared similarities in the experiences of each of them as they proceed with their own transition. This is demonstrated by the fact that all the European member states under examination present similar discourses on the energy transition, and that, all countries have taken, at least some, steps towards a low carbon, sustainable energy system. However, it should also be noted that notwithstanding the moves to integrate EU energy markets, it does appear that national factors may result in member states making their own individual energy transitions, albeit in a some-what coordinated fashion. Similarities in experiences should not mask the (still) country-specific responses to energy choices – as exemplified by the differing ways in which countries have faced previous energy related challenges, producing quite different energy models.

2.2 Energy technological review

Landini, A., Zerbi, T., Morrissey, J., Axon & S. (2016). *Energy Technological Review*. Report prepared as a project deliverable (D2.2) for ENTRUST H2020 project (grant agreement no. 657998). Cork: University College Cork.

Extract from project 'Description of Action'

'This task aims to characterise energy system technological regime, its driving forces and main challenges and opportunities. This task will identify the main technologies used along the energy supply chain, from generation, to transport, distribution until the end user. New and emerging energy technologies, renewables, energy conservation measures (ECM) and retrofit solutions, micro-generation, etc. will be identified through a technological review, augmenting information captured through the stakeholder analysis from task 2.1. These technologies and processes will be reviewed and key performance indicators will be defined to ascertain their potential value.'

Abstract

D2.2 focuses on the technical /technological elements of the Energy Socio-Technical regime, to contribute significant and robust evidence on what constitutes a regime. In order to do this, a supply chain perspective was adopted. The rich literature on the topic was reviewed and synthesised, and on this basis, it was deemed most appropriate to apply a Key Performance Indicators (KPIs) approach to the analysis, in order to assess and characterise the energy supply chain. A best practice methodology for defining and applying KPIs was pursued; for this reason, an extensive review of the academic literature in this area was conducted and is presented in this deliverable. From this review, a means of identifying KPIs to characterise the Energy Supply Chain was developed, synthesising insights from state of the art knowledge on this. Developed KPIs represent a comprehensive and innovative means of characterising the energy supply chain according to a myriad of multi-dimensional criteria; typically supply chains are characterised only in narrow or single dimensional ways. Through these steps, evidence on the technological elements of the Energy Supply Chain is produced, enabling a fuller understanding of this aspect of the energy regime, and presenting a critical part of the case-book through which the energy socio-technical regime is defined in ENTRUST.

The technological review provided in this deliverable, together with the specific KPIs evaluation proposed at the end of each section, gives a clear understanding of the current technological forces driving the European energy system and as such is a further contribution to the multi-disciplinary characterisation approach taken in WP2.

Methodology

In order to present the technological review in a clear and structured way, the complex and interconnected structure of the energy supply chain was divided into its 4 main stages, (*i.e.,* Production, Transportation & Distribution, Storage, and End User). For each stage, an introductory description of the current situation at European level is provided, in order to give the reader a contextual view of the discussed topic. Then, the main technical solutions currently implemented are detailed, describing their functionalities, fields of implementation and other critical aspects such as, for example, environmental impact.

The information provided during those sections is then completed through the KPIs tables, which provide a clear comparison between the analysed technologies on a multiple level. Consistency throughout the deliverable was achieved thanks to the definition of specific themes for the KPIs, which were used as guidelines for all the evaluation tables. In order to better address each stage of the supply chain and each energy type particularities, though, a specific set of KPIs was defined for each considered group of technologies using Shahin and Mahbod's (2007) SMART criteria for KPI selection and application, with SMART standing for Specific, Measurable, Attainable, Realistic and Time-sensitive indicators.

Key Results

This deliverable is focused primarily on technological aspects, but is developed to sync with, and complement, outputs captured through the analysis of stakeholders produced for Task 2.1. Deliverable 2.2 reports on the research activities of Task 2.2 by concentrating on the following key areas:

- The primary technologies used along the energy supply chain across generation, transport, distribution and end-user stages are identified.
- New and emerging energy innovations are described, including new technologies, renewable energy innovations, energy conservation measures (ECM) and retrofit opportunities.
- A review of best practice for the development of key performance indicators (KPIs) is conducted to facilitate state of the art regime characterisation, with goals of consistency, integration and representativeness.
- A set of KPIs essential for D2.2 are defined in a systematic, targeted and step-wise manner; these are developed thematically to enable comparison across disparate technologies and spatial contexts.
- Discreet Key Performance Indicators are developed and applied for each of the supply chain stages. Particular attention is given to the end-user stage due to the unique character of this stage and its critical important in behaviour change initiatives.
- A comprehensive and integrated characterisation of the energy supply chain is produced.

This analysis led to an understanding of the many complexities comprising the energy system. The characterisation offered a way to handle and appraise this complexity in a manner which allows an exploration of how the energy system has evolved over time. Some of these changes have been informed by growing concerns over environmental issues and the awareness that the current situation is no longer sustainable. The traditional system, characterised by highly-centralised energy production models and by the extensive use of fossil fuels, remains dominant but important steps are being done towards a growing exploitation of clean and renewable energies. Many different solutions are already available in the market and are being successfully implemented. This is the case for wind and solar, which have seen the most important growth in the last ten years, due to their contributions in reducing GHG emissions, technology readiness and modularity. They may also prove to be a good solution for both small and plant-sized installations for highly-developed, urbanised areas and in more rural areas with limited access to the national grid.

Conclusion

The improvements that have been made to the energy system, though, have not been solely restricted to the implementation of new green technologies as a replacement for traditional fossil fuelled ones. What is also shaping its future is around Distributed Generation, with stronger interconnections between big power and heat plants and building individual solutions, with the potential for a two-way flow of energy based on the energy demand variations during the day and on the peak-load periods associated with renewable energies. The electrical grid needs to be amplified and upgraded to sustain frequent changes in electricity direction and power levels. Natural gas pipelines will also see a similar process of development to allow for changes in gas flow direction during particularly cold winters. Storage is becoming increasingly important due to the variable nature of the renewable energies such as wind and solar, in order to store energy during peak-load periods and use it back when most needed.

Another important solution is to provide electricity and heat at the same time. Combined heat and power plants can greatly improve efficiency with respect to traditional power-only plants, where a lot of process heat is wasted. The use of district heating, in combination with CHP plants, is an extremely efficient solution especially when the CHP plant is fired from renewable energies such as biomass or municipal waste, and is a solution that has been much encouraged by the EU. Despite this emphasis at the supranational level, district heating remains largely confined to Northern and Eastern regions of Europe. Another relevant point to note is the need of greater efficiency, not only in terms of energy generation, but also in energy final use. This one of the three key targets of the Europe 2020 strategy, with a proposed 20% improvement in energy efficiency.

This document also reviewed different solutions for automation and control of lighting and HVAC, with a discussion on their importance in both energy saving opportunities and provided comfort to people. Renewable energy technologies and efficiency measures are being continually introduced and existing technologies are undergoing rapid evolution. However, at least for the near future, traditional fossil fuel technologies will continue to be needed if we are to provide a secure and stable energy system throughout the European Union.

2.3 Report on novel business models and main barriers in the EU energy system

Boo, E., Molinero, S., Sanvicente, E., de Melo, P., Landini, A., Otal, J., Chichinato, O., Melchiorre, T. & Melia, A. (2017). *Report on novel business models and main barriers in the EU energy system*. Report prepared as a project deliverable (D2.3) for ENTRUST H2020 project (grant agreement no. 657998). Cork: University College Cork.

Extract from project 'Description of Action'

'Task 2.3 will consist on a mapping the novel business models emerging in the energy system in the review countries. This task will clarify the different elements of the business model: value proposition, cost structures, revenues, main partners, distributors, etc. for each stakeholder. Their market perception, main objectives and potential risks will be also added to this analysis. The main barriers and risks of each BM will be analysed within this task too, in order to assess its feasibility, its replication in the market and its correct integration in the energy value chain.'

Abstract

This report comprises a mapping of the emerging business models in the energy system as well as the clarification of its elements, sources of innovation, and main barriers. The first part of the deliverable introduces the game changing scenario and presents the role of business models in the sustainable energy transition. Megatrends– such as energy availability and security, resource depletion, the technological revolution and urban development – affect and challenge the energy value chains in the energy system. These trends and its multiple implications for the energy sector are discussed in this section. Also, the main barriers that slow down the transition towards a more sustainable structure are presented.

Innovation has played a key role in the energy system but most of the time the term is misunderstood and confused with others like creativity, change, or invention. Sections Two and Three define what innovation is for this project and it also gathers different classifications of innovation found in the literature that helps to categorise emerging business models. "Ten types of innovation" and "the business model innovation grid" are two powerful tools that frame different sources of innovation. From them, our own classification of innovation is created to classify the business models identified. Moreover, a review of the three framework tools currently used in the innovation ecosystem – Osterwalder & Pigneur canvas, IDEO, and Fluidminds - to characterise business models is conducted in order to define the most appropriate one for ENTRUST. These framework tools help to understand how an organisation creates and delivers value, makes money and visualises its structure.

Section Four of the report examines the emerging business models corresponding to the four energy-intensive sectors selected in the scope of ENTRUST (buildings, urban transport, energy production and the manufacturing process industries). For each business model identified an overall description, some real cases and the business model framework created for Entrust are presented. In addition, an analysis is conducted to identify which type of innovation is occurring in every sector and at what specific stage of the value chain.

Methodology

The approach taken for this deliverable has been to present the work into three parts, which address key components of the work associated with T2.3, and as outline below:

The role of business models in the energy transition: This part presents an energy system that is continuously changing in terms of key trends and the main barriers towards a sustainable future. Also, how business models are changing the current scenario and why they are important is explored.

Business model innovation in the energy system: In this section, the concept of a business model from different authors is explained to understand better its importance. The main framework tools are presented and a specific canvas for ENTRUST is created from them. All the elements of the canvas are also explained in detail. The importance of innovation is included in this chapter. A combination of two different classifications of innovation from the literature serve as an input to create a new classification of innovation sources for ENTRUST.

A benchmark of innovative business models: Firstly, for each of the four sectors studied in this deliverable (energy supply and production, buildings, manufacturing process industry, and urban transport) an evolution of the value chain is presented. What the new stages and entrants are and how the new business models can in turn be placed on the value chain. Moreover, a mapping of innovative business models has been carried out, with each business model incorporating a brief description, presenting with some real cases, and explaining what their innovation source is. Also, the canvas created for ENTRUST is included in each business model to frame it and comes from Osterwalder & Pigneur's (Osterwalder & Pigneur 2010) business model canvas, as presented below.

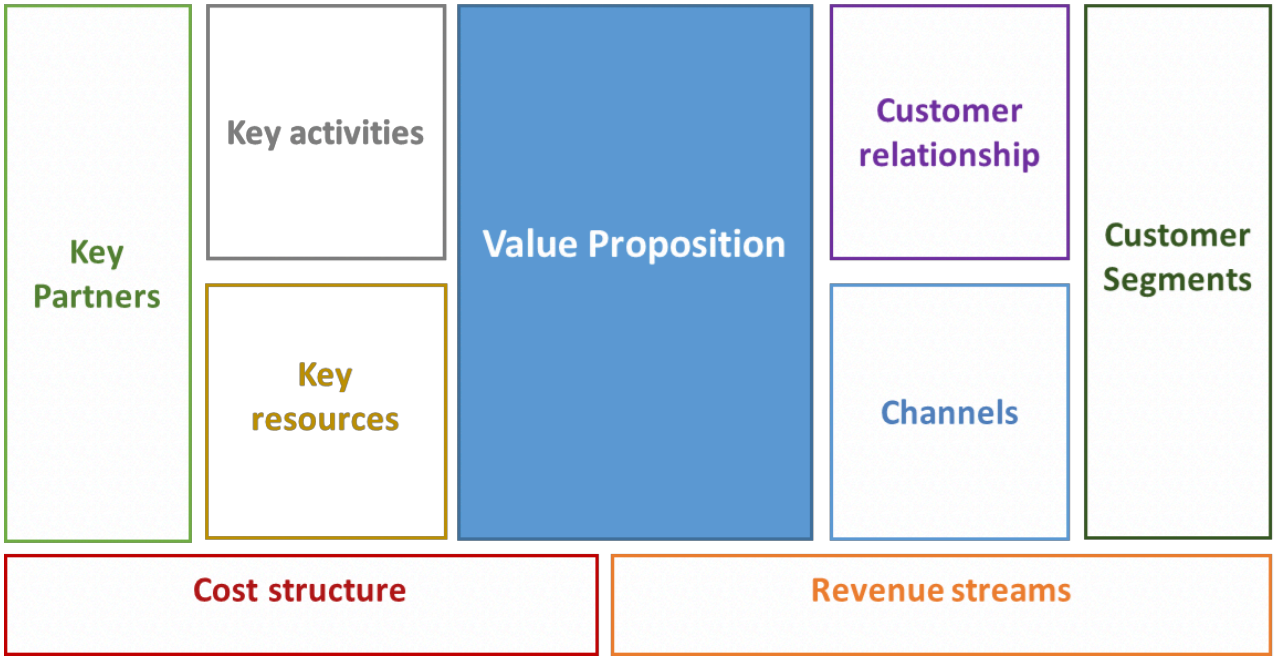


Figure 1: Representation of Osterwalder & Pigneur's business model canvas (Osterwalder & Pigneur 2010)

Finally, an analysis of the main trends of innovation in every sector is carried out.

Key Results

The European energy system is moving towards a more sustainable structure. To achieve this goal, changes in the value chain of the four sectors studied – energy supply and production, buildings, industry, and transport – are currently happening. From our innovation analysis, some trends stand out:

Energy supply and production is mainly innovating at the new stages of the value chain such as storage and electric devices and appliances. Technological and configuration changes are the main trends that are shaping the current business models, in which interconnection and customer engagement are key. The main barriers that the sector has to confront are related to the intermittency of renewables, balance of supply and demand, and the necessity of energy storage. In terms of deployment, UK seems to be the leader towards novel business models. Business innovation in the building sector is occurring all along the industry value chain, starting with the re-design of project delivery models, energy performance solutions, and leading to deep renovation. The built environment paradigm shift is pulling building users at the centre of the ecosystem and therefore, service oriented business models are leading the way towards a greener building industry, in which cross sectoral collaboration is considerable. In the industry sector, innovation is focusing on re-designing energy and resource efficient production systems and leading to extended producer responsibility in the form of remanufacturing, and recycling. In addition, circularity and optimisation are the main innovation sources. Concerning transport or urban mobility, the aim is at developing new mobility alternatives and digital infrastructure that enables their integration. Improving customer experience and creating new configurations are playing a fundamental role to achieve an affordable and sustainable urban mobility system, in which partnerships and customer engagement are also significant. Car-sharing services and real-time mobility are the main trends in all countries reviewed.

Conclusion

From the analysis, it is concluded that emerging business models are innovating within the four archetypes proposed – configuration, technology, experience, and financing. However, three subtypes stand out over the others (partnerships, PSS-functionality and customer engagement). Partnerships between companies are enabling the developing of new offerings for customers. In addition, firms provide more and more services instead of products, encouraging right behaviours and satisfaction of users' needs. The last trend is customer engagement. Innovative business models foster the commitment of customers, making them more conscious about energy usage and consumption.

The complexity of building relations with other companies and investors across the different countries also emerged from this analysis. Regulatory influences, potential legal limitations and social acceptance are factors that could influence the implementation of disruptive business models, depending on the country. To sum up, the transition of the energy system is happening now, and is being boosted by the innovation on business models. It brings not only new ways of interaction between companies, customers and all the actors present in the value chain but creating new stages and roles. Therefore, the business model mapping and innovation analysis carried out in this deliverable is a useful guideline to understand the main trends that push a sustainable energy transition.

2.4 Survey of socio-demographic data on energy practices

Gaffney, C., Lennon, B., O'Connor, P. & Dunphy, N.P. (2015). Survey of socio- demographic data on energy practices. Report prepared as a project deliverable (D3.1) for ENTRUST H2020 project (grant agreement no. 657998). Cork: University College Cork.

Extract from project 'Description of Action'

'This task will involve carrying out an initial mapping exercise of available information on socio-economic factors, which influence energy behaviours and practices in six countries DE, ES, FR, IE, IT & UK (the five largest energy using countries along with Ireland, which offers a contrasting context as a small country, dispersed population, economic upturn etc.). The subsequent report will provide a baseline of current knowledge, beyond which the research outlined in this WP will advance.'

Abstract

This report is an initial mapping exercise examining the available information on socio-demographic factors, which influence energy behaviours and practices in six European countries: France, Germany, Ireland, Italy, Spain and the United Kingdom. It both catalogues and characterises the principal datasets available to researchers in each country, as well as indicating specific research projects that provide information on the socioeconomic and socio-demographic aspects of energy behaviour. The report aims to provide a baseline from which ENTRUST can proceed in developing a deepened understanding of how human behaviour around energy is shaped by both technological systems and socio-demographic factors, in particular gender, age and socioeconomic status. It prepares the ground for the detailed analyses of energy-related behaviours, practices, perceptions and attitudes in the five communities of practice, which forms the substance of WP3. Section 1 outlines the purpose of the report as well as the theoretical perspective adopted by ENTRUST and how this relates to current social science work in the field of energy research. Section 2 details the methodology adopted: a systematic literature review utilising a 'Boolean' keyword search; and snowballing from reference lists deploying both a 'backward' and a 'forward' snowballing methodology. Section 3 presents the results of the literature review on a country-by-country basis. It lists the key quantitative and (where available) qualitative datasets relevant to energy-related behaviour and practices in each country. It also summarises some of their key characteristics. The principle conclusion is that the datasets tend to be disaggregated according to relatively narrow sets of socio-demographic and socioeconomic variables matched with only selected forms of energy use. What is absent is any dataset that disaggregates statistics for energy use according to a comprehensive array of socio-demographic characteristics, and which incorporates the whole range of energy-related behaviours that include both energy use within the home as well as related to travel and other uses. Section 4 offers some general observations on the results of the literature review from a European perspective. Section 5 is an indicative bibliography of energy research in the social sciences, drawing on the literature review and with a focus on studies relevant to project research aims.

Methodology

While acknowledging the dearth of research in this area, the objective of this task is to catalogue the information that is extant on the socio-demographic factors that influence energy behaviours and practices

in six countries. In keeping with ENTRUST objectives, a particular focus has been given to the socio-demographic factors of gender, socioeconomic status, and age. There are two primary aims for this task: (a) to identify the national and large-scale data sources that are utilised by researchers investigating energy behaviours; and (b) to identify specific research projects that provide socio-demographic details on energy behaviours. As this literature search is a 'secondary study'—a study that aims to reflect both the current state of research on a specific topic, as well as identify gaps—best practice recommends a comprehensive search utilising a dual approach: a systematic literature review; and snowballing from reference lists (Kitchenham & Charters 2007). The procedure utilised for the systematic literature review was a 'Boolean' keyword search [this is treated in more detail below]. The 'snowballing' procedure was dual-aspected, and utilised both a 'backward' and a 'forward' snowballing methodology (Webster & Watson 2002). In order to optimise utility, and to facilitate easy access to the relevant material located through the search strategies described below, the results were collated, and a simple database was created to organised them into a user-friendly format. This database (included in the appendices of this report) characterises the information collated, including: the country of reference, the title of the dataset/study/article, and the source of the datasets and reports. A brief description of the material referenced, as well as the web address, were included along with information on the availability of the data.

The sources of information that were used to map the available literature and identify the relevant datasets were academic databases. There are strengths and weaknesses to all databases, and so it is appropriate, and advisable, to access a multitude of databases in order to avoid the limitations that can be experienced if a keyword search is confined to a single academic database (Falagas *et al.* 2008; Meho 2006). In order to avoid these limitations three academic databases, judged to be the most appropriate were utilised in the search strategy. These databases—Science Direct, Web of Science, and Scopus—belong to commercial providers and require an access fee/institutional access. Consideration was given to using Google Scholar as it has the widest availability, and has the advantage that it can be accessed for free. However, Google Scholar has been subject to considerable critique including that: it has incomplete, inaccurate citations; it includes non-scholarly material; it has multiple versions of an article, including unofficial, incomplete pre-publishing draft versions of articles; and it lacks clarity about how it selects and ranks material (Jacsó 2010). As Falagas *et al.* (2008, p.342) note, 'its use is marred by inadequate, less often updated, citation information'. Given the significant problems that have been identified, Google Scholar was rejected as an appropriate database.

Key Results

The research strategies utilised in this mapping exercise uncovered a number of large datasets for each country that were utilised by researchers investigating energy use and behaviours. In keeping with European Commission objectives for open data[1], the majority of countries across the EU have created portal websites

[1] The EU has a policy of making freely available any type of information held by EU institutions and bodies with a view to generating value through re-use of public sector information. One of the pillars of Horizon 2020 is an open data strategy to make freely available datasets from all EU member states. There are a number of portals through which these datasets can be accessed. For example, the European Union Open Data Portal, http://open-data.europa.eu, provides a metadata catalogue giving access to data from the institutions and other bodies of the EU. Another portal, http://publicdata.eu, is a pan European data portal that aims to provide a single point of access to official open datasets from across Europe, and it has nearly

on public data that provide information about statistics produced by government departments and state organisations such as the SILC (Survey on Income and Living Conditions). The EUW SILC is part of an EU wide initiative initially launched in 2003 by Eurostat with six EU states, and Norway. It was formally launched in 2004 in fifteen countries and expanded in 2005 to cover all of the then EU 25 Member States, as well as Norway and Iceland. It was launched in Bulgaria in 2006, and expanded to include Romania, Switzerland and Turkey in 2007. Statistical information from the EUWSILC is used to monitor the Europe 2020 strategy. Access to the anonymised microdata is possible, but for scientific purposes only. The data identified in this report tend to be disaggregated according to relatively narrow sets of socio-demographic and socioeconomic factors matched with selected forms of energy use. What is absent is any dataset that disaggregates statistics for energy use according to a comprehensive array of socio-demographic characteristics, and which incorporates the whole range of energy related behaviours that include both household energy consumption within the home and extends to including all household travel, *etc.* also. The data sources collated in this initial mapping exercise are presented in the Appendices of **D3.1** (Gaffney et al. 2015), with the following sections providing an overview of the information found and the experience of identifying the sources of data – a separate sub-section is used for each of the study areas, viz., European Union, France, Germany, Ireland, Italy, Spain and the United Kingdom. The report includes an indicative bibliography that catalogues some key theoretical approaches to energy research, insightful critiques of the energy research paradigm, as well as original research that is informed by the social sciences. This material provides a rich resource that will contribute to the development of ENTRUST, and inform its engagement with the research communities.

Conclusion

The principle conclusion drawn is that the datasets tend to be disaggregated according to relatively narrow sets of socio-demographic and socioeconomic variables matched with only selected forms of energy use. What is absent is any dataset that disaggregates statistics for energy use according to a comprehensive array of socio-demographic characteristics, and which incorporates the whole range of energy related behaviours that include both energy use within the home as well as travel and other uses. Also absent is a holistic conceptualisation of the embodied energy citizen in their inter-subjective, sociocultural world. Also, there is a dearth of gendered analyses of energy practices in the EU and OECD nations. The majority of research that offers a gendered analysis of energy practices tends to focus on the experiences of women and girls in the developing world. It is recognised that gender does have an impact on energy practices— although quite what those impacts are, and their relevance for energy research, require both clarification and further analyses.

50,000 datasets available on it. Eurostat, http://ec.europa.eu/Eurostat, provides statistics for the EU that enables comparisons between countries and regions.

2.5 Intersectional analysis of energy practices

Dunphy, N.P., Revez, A., Gaffney, C., Lennon, B., Ramis Aguilo, A, Morrissey, J., Axon, S. (2017). *Intersectional Analysis of Energy Practices*. Report prepared as a project deliverable (D3.2) for ENTRUST H2020 project (grant agreement no. 657998). Cork: University College Cork.

Extract from project 'Description of Action'

'This task comprises an intersectional analysis of energy practices within the communities recruited in T5.1. This will be informed by a practice approach to the study of energy use in the context of socio-technical systems. Initially attention will focus on how energy behaviours and practices are impacted by three key socio-demographic variables: gender, socio-economic status and age. However, if other factors emerge as important during the course of the research these will be incorporated in the study. The intersectional approach will explore how multiple strands of inequality or privilege interact and mutually reinforce one another to constitute individuals' identities and shape their behaviour, and how particular aspects of identity and behaviour are mobilised by specific settings or institutions. The field research will employ a mixed method approach to capture information on how individuals use energy, including a time-use survey in the communities, a series of workshops, participant observation, and interviews. A thematic analysis of the workshop, observational and interview data using a grounded-type approach will be combined quantitative analysis of the time- use survey data.'

Abstract

This report examines the energy-related practices that take place in six case-study communities located in France, Ireland, Italy, Spain and the United Kingdom. This exploration is conducted as part of a research project exploring the 'human factor' in the energy system, within which a complementary study of the perceptions and attitudes towards energy technologies has also been produced. Both of these studies are taking an intersectional approach to the analysis, recognising that people have multiple, interdependent, overlapping axes of social identity – these studies focus particularly on issues of gender, socio-economic privilege and age. The purpose of the report is to move away from the dominant behaviouralist perspective – wherein people are treated as uniquely rational decision-makers – and introduce the very real social contexts through which they negotiate and understand their role within the energy system; with specific focus on their views on the energy technologies that comprise it. The underlying feelings, assumptions, associations and values held by the people who express them are very real influencing factors on the energy-related practices they engage in on a day-to- day basis. Therefore, this report presents an intersectional analysis of energy practices within the six case-study communities recruited in Task 5.1, correlating results with key variables that drive individual as well as collective behaviours and practices, and focuses in particular on the socio-demographics attributes/identities of gender, socio-economic privilege and age.

Methodology

In our approach to developing an understanding of people's attitudes and perceptions of the energy system, as well as their energy practices, and in particular their domestic energy practices, we have pursued and developed a methodological approach that centres people within the matrix of the energy system – understanding that the energy system is a multi-faceted socio-technical system inextricable from the social

and economic ordering of the society it has evolved with; and that people should be understood as being multiply positioned at the intersection of complex and overlapping norms of identity that are also interwoven with, and within that socio-technical energy system.

The research team employed a mixed-methods approach comprising in-depth semi-structured interviews, focus groups, participant observation and time-use surveys. This primary data was further augmented by a detailed desk-based research programme, which in turn informed our interpretation of the results coming from the primary sources. Quantitative and qualitative analytical tools have been applied to further extrapolate the data, with a thematic analysis informed by a range of appropriate qualitative analytical approaches for the primary research material further complimented with a targeted time-use survey in the six case-study communities, recruited for WP5. These communities include Secondigliano [IT], Le Trapèze [FR], university students [IE], Gràcia [ES], Dunmanway [IE] and Stockbridge [UK].

The concept of intersectionality was used to conceptualise and incorporate the multiple strands of identity that intersect and socially position participants both within their own 'life-world', as well as within their wider social world; and in the case of ENTRUST within the socio-technical energy system. Intersectionality informs the research process, and is also utilised as a key component of the narrative analysis of the qualitative data. Focussing on people's practices provided a lens both on how people use energy in their everyday lives, as well as the meaning that people's everyday practices hold for them – for example, having freshly laundered clothes, showering daily, keeping their family home warm – offering an opportunity to develop a more explanatory analysis of people's engagements with energy and the energy system, and so potentially provide insight that will help to develop pathways to a sustainable energy transition

Key Results

Categorisations and social divisions based on gender, socio-economic privilege and age can be useful ways of looking at energy practices in order to understand where and how energy interactions become conflated with identity issues or are the object of processes of inequality and privilege which frame and reproduce particular relationships with the energy system. However, these factors are often sidestepped in policy as well as research. Our own previous review of existing literature conducted for Deliverable 3.1, where we mapped and examined available information pertaining to socio-demographic factors that influence the energy system, shows that existing datasets, and much of the research in which these are based, tend to be disaggregated according to fairly narrow sets of socio-demographic and socioeconomic variables matched with often selected forms of energy use (Gaffney *et al.* 2015). Furthermore, the report also shows that it is often the case that there is an absence of more holistic conceptualizations which incorporate more subjective notions of energy behaviour and which engage with less tangible and quantifiable expressions of energy practices (Gaffney *et al.* 2015).

Our findings which include a breakdown of qualitative information based on our semi-structured interviews, focus groups, participant observation and the quantitative data from the time-use surveys, shows that there are significant disparities based on gender and socio-economic privilege which have a definite influence in how people behave in relation to energy. For example, there is a gender gap in relation to time spent doing laundry and cleaning duties which demonstrate that women are the main actors in performing these duties. Furthermore, this gender aspect is not just a reflection of household labour divides and time management

but also speaks of patterns of gender based norms and values. There are, of course, more than gender aspect to laundry practices and the data also shows that socio- economic aspects have a real influence in how participants perceive and act, for example, poverty is seen to lead to the development of a range of strategies which are at once a reflection of lack of choice and an example of coping mechanism in the face of financial hardship. The connection between wealth and community cohesion in our findings suggests that social capital derived from networks of support and ability to collectively articulate common needs is both uneven across our communities. We have identified a range of community supports and initiatives which have a potential effect in terms of mitigating against experiences of poverty and social inequality. This was particularly evident in our community in Gràcia.

Age related practices, provide additional insights, which shows that a range of age specific factors are valuable for understanding individual and community interactions with energy. We have seen in this instance, that practices and attitudes to energy are influenced by multi-generational experiences of the energy system. Furthermore, they are also driven by self-perceptions of age and adaptation which considerably frame how participants position themselves in relation to changes in energy systems into the future. However, while age is a strong reference to consider in relation to social practices, there are issues pertaining to gender and to socio-economic privilege which have intersecting influence. It is important to highlight that these are often interlinked and have worked to produce different effects in different areas. For instance, we have seen in Stockbridge examples of energy poverty in old age leading to loss of home and independence while in Secondigliano we noted that the immediate impact of energy poverty for younger cohorts included limitations in terms of access to education and employment opportunities.

Conclusion

The findings show that multi-generational perceptions of energy over time are based on different values and experiences of the energy system. This is to an extent representative of the evolving nature of the energy system. However, we have also noted that traces of older values, structures and experiences still permeate current day practices related to energy. In this sense, energy practices can be best understood as an ever-changing palimpsest. Whereby new objects and practices are superimposed on earlier ones, but where significant traces remain of these previous energy regimes which are oftentimes an integral and foundational component of present day interactions. In similar fashion, generational ideas of gender and socio-economic privilege are both uneven and are complicated by layers of meaning which reflect the evolving nature of energy and social interactions with it.

2.6 Intersectional analysis of perceptions and attitudes towards energy technologies

Dunphy, N.P., Revez, A., Gaffney, C., Lennon, B., Ramis Aguilo, A, Morrissey, J., Axon, S. (2017). Intersectional Analysis of Perceptions and Attitudes Towards Energy Technologies. Report prepared as a project deliverable (D3.3) for ENTRUST H2020 project (grant agreement no. 657998). Cork: University College Cork.

Extract from project 'Description of Action'

'The research team will also carry out an intersectional analysis of perceptions and attitudes towards energy technologies, including nuclear power. This will initially involve a general survey in the communities, followed by workshops and in-depth interviews, with both quantitative and qualitative analysis of the results. The aim will be to identify not only explicit attitudes, such as various degrees of support or opposition for particular technologies, but the underlying feelings, assumptions, associations and values which shape them. The results will be correlated with socio-economic factors, initially focusing on the three variables of gender, socio-economic status and age identified above.'

Abstract

It is increasingly clear that current energy systems are increasingly unsustainable from a variety of environmental, economic and social perspectives (Grübler 2012). The challenge of climate change, in particular, has focused attention on energy and it is widely acknowledged that in order to avoid the worst-case climate change scenarios a substantial move away from carbon based fuels is required (Capros *et al.* 2011). An elemental energy transition on such a scale will result in significant societal transformation and so there is therefore a good argument for a rethink on how future energy systems are planned and implemented. The scale of likely societal transformation required for the transition to be successful, will mean that people need to be acknowledged as not just consumers of an energy product but as legitimate stakeholders in the socio-technical energy system. The choice of energy technologies that heretofore has been very much seen as technological question, however in the context of changes that such choice will mean in people's everyday lives, it can reasonably be argued that envisaged decarbonisation of the energy system is fundamentally not a technical problem, but rather it is as much a sociological puzzle as it is an engineering one.

Achieving the goals of the EU Energy Union will require the social acceptance and acceptability of energy projects required for the transition, such as wind and solar power developments and the enhancement of transmission grids to integrate a greater share of renewable energy. However, many such projects encounter strong public opposition, to an extent that threatens to significantly slow down Europe's energy transition (Cohen *et al.* 2014; Enevoldsen & Sovacool 2016). 'The current trend, in which nearly every energy technology is disputed and its use or deployment delayed, raises serious problems for investors and puts energy system changes at risk' (European Commission 2011b). There is therefore a substantial need to understand the perceptions and attitudes of citizens towards the energy system as a whole and its components energy technologies. This report is designed to contribute to this perceived gap in knowledge.

The work presented in this deliverable provides an analysis of the perceptions and attitudes of people in the case study communities towards energy technology. The analysis takes an intersectional approach – in that it takes account of the multiple interdependent and over lapping social positions that people hold (particularly in terms of gender, socio-economic privilege and age). Intersectionality acknowledges that each person has multiple attributes which intersect within the person, and which intersect with social norms, social institutions, and social structures – and these all impact on a person's life expectations and experiences – both positively and negatively. These life experiences are the very things that impact on how people perceive the world and influence the attitudes that they hold.

Methodology

Crotty (1998) defines methodology as "the strategy, plan of action, process of design lying behind the choice and use of particular methods and linking the choice and use of methods to the desired outcomes" and contrasts this with methods, which he describes as the means used to gather and analyse data relating to a research question. The aim of a methodology is to, as Moses and Knutsen (2012, p.5) say, is to investigate the concepts, theories and basic principles and reasoning underlying research.

Morgan and Smircich (Morgan & Smircich 1980) posit that research is inherently based upon three assumptions, namely: ontological assumptions, on the nature of reality; epistemological assumptions, on the nature of knowledge; and methodological assumptions, that inform the framing and approach to gaining knowledge on a subject. The set of assumptions adopted by a researcher – whether explicitly or by default – establish a paradigm (Kuhn 1996) or world view (Creswell 2014), under which the research will be conducted. In this research, following (Hancock 2007; 2013), we have adopted intersectionality as research paradigm, it is a conceptual approach to research that allows an investigation of the simultaneous effects of "categories of difference", and their intersections, and in so doing overcomes the limitations of other approaches to research. It takes into account the complexity of social locations, as well as the impact of social location on health, well-being, and life chances. In Table 2 below, Hancock (Hancock 2013) summarises three different forms of approach to researching the organising structures of society such as gender, race, class and other categories of difference, and demonstrate the benefits of an intersectional analysis in comparison to other, more restricted approaches.

The history of research on the energy system shows that it has been dominated by technocratic and technologically focused approaches to assessing initiatives aimed at reducing energy consumption with an over-concentration on technical remedies to reduce energy consumption (D'Agostino *et al.* 2001). Conversely, the majority of the limited research that has inquired into the human factor in the energy system is further limited in the range of analyses. Primarily, this research has drawn on reductive models of human behaviour that tend to predominate in economics and related disciplines (Sovacool 2014) – such as the problematic Homo Economicus, described above. In addition, most of the research on the human factor in the energy system has been largely quantitative in nature *(Ibid.)*. Further to these limitations there has been a significant lack of focus on women in the energy system, and on a gender analysis more generally, with some notable exceptions (Fraune 2015).

Table 2: Three Empirical Approaches to Conceptualising Categories of Difference (Hancock 2013)

	Unitary Approach	Multiple Approach	Intersectional Approach
No. of relevant categories	One	More than one	More than one
Posited relationship between categories	None	Predetermined and conceptually distinguishable relationships	Relationships are open empirical questions to be determined
Conceptualisation of each category	Static as individual or institutional level	Static at individual or institutional level	Dynamic interactions between individual and institutional factors
Case makeup of category/class	Uniform	Uniform	Diverse, members offer differ in politically significant ways
Approach to intersectionality	Lip service or dismissal	Intersectionality as testable explanation	Intersectionality as paradigm/ research design

Intersectionality brings a new approach to the way that problems are identified, how they are conceptualised, researched, interpreted, and analysed (Hancock 2007) (note: Appendix 1 of this report provides an overview of the concepts and ideas associated with intersectionality). Describing intersectionality as "a body of normative theory and empirical research", Hancock offers an accessible, guide to conducting intersectional research. She outlines the six key assumptions that are foundational to an intersectional analysis of a particular research issue:

1. Examining complex social and political problems involves analyses along more than one axis of difference such as gender, race, or class;
2. However, while all relevant social categories should be included, no presumption should be made as to the nature of the relationship between any particular category – "the relationship among the categories is an open empirical question" (Hancock 2007). While, for example, class and gender may be analysed together, it should not be assumed either that they are independent of each other, nor that analysing both will fully capture all aspects of an issue;
3. It is understood that categories of difference are not fixed, but rather are "dynamic productions of individual and institutional factors" (Hancock 2007). The categories of difference are maintained, and challenged in complex interchanges between individuals and society;
4. There is significant diversity within each socio-demographic group which has an impact on policy development, its reception, and its impacts;
5. Intersectional research integrates multiple levels of analyses of individuals, their interactions within communities as well as with society and social institutions, and in the case of ENTRUST, the energy system;

6. Intersectional research requires theoretically informed empirical research that integrates multiple methods applying an intersectional approach across all aspects of the conduct of the research project (Hancock 2007).

Key Results

A series of emerging themes have been developed from the data produced from our community engagements. In keeping with the objectives of task, T3.3, this discussion gives particular emphasis to the attitudes and perceptions expressed by participants from the different communities regarding the range of large-scale energy technologies currently available in the energy system, that are expressed by participants from the different communities. These themes are laid out as follows:

The (in)visibility of energy: The complexity of the human factor in the energy system reflects the wider complexity of the energy system itself, yet the seamless existence of energy – electricity in particular – in the lives of people renders it not just invisible, but almost imperceptible. In fact, energy infrastructure is often only made "present" in people's lives by its absence – during an electricity blackout, or the aftermath of a particularly destructive storm for example. However, this present ubiquity is stronger in some national electricity grids than it is in others. This invisibility and the ubiquitous nature of current fossil-fuel based energy infrastructures have deep-rooted consequences for our collective efforts to change to renewable energy sources. Renewable sources of energy production are more visible over greater swathes of landscape, in a way that the older fossil-fuel and nuclear power stations are not.

Power and the control of the energy system: The issue of power (political as opposed to energy-related) and the control of the energy system emerged as a significant issue across every community. Concerns about the control of the system can, broadly speaking, be described as coalescing on two levels, that is, concerns have been raised about the system on the macro structural and political level; as well as on the community and individual level – these can be loosely categorised as those with "power", and those without.

Across all of the communities, there was a desire expressed to move to a sustainable energy system. While it is not clear that people recognise the scale of what is involved in moving to a sustainable energy system, particularly in achieving the longer-term targets agreed in the Paris Climate Accord (2017), nonetheless there was both a desire for a sustainable system, as well as an optimistic outlook on its probability – albeit not spread evenly across all communities. However, this enthusiasm was tempered by the impression that the power to bring about a sustainable energy system lay with the powerful few, such as energy lobbies and policy makers, and not with the powerless many who comprise the majority of energy consumers.

Views on energy technologies: Attitudes towards technology among the six communities are somewhat diverse, as illustrated by Table 3 below. An analysis of these divisions suggests that social aspects such as gender, so-called socio-economic status and age may have a role to play. The experiences conferred by one's gender, disparities in socio- economic privilege, and stage of life all effect the manner in which people (both individually and as communities) respond to and perceive specific energy technologies. Research also suggests that a diversity of socio-demographic characteristics such as age and education in different variations can potentially have impacts on experiences and attitudes towards energy sources.

Table 3: Factors observed to impact on attitudes toward energy technologies

	Key communities	Personal factors	Other factors
Solar	Gràcia, Dunmanyway, Le Trapèze	• Perception of privilege linked to use of solar • Perception of solar as most nature source of energy	• High expectation of greater tax incentives • Concerns over security, maintenance, and longevity of solar technology at household level
Wind	Dunmanyway, Stockbridge, UCC	• Largely divided stance on value of wind energy • More evenly spread of intersectional response rate	• Energy justice debate linked to valorisation of local responses • High energy visibility: links to both negative and positive impacts to landscape
Nuclear	Le Trapèze, Secondigliano, Stockbridge	• Male dominated theme • Divided opinions with significant numbers of those in favour and opposed	• Proponents largely favouring an energy mix policy • Less visible form of energy
Fossil fuel	Le Trapèze, Secondigliano, Stockbridge	• Suggestive of gender attitude differences • Increased recognition of oil dependency	• Energy security and peak oil framing most narratives • Growing concern regarding use of dirty polluting energy

The intersectional approach in this task will explore how multiple strands of inequality or privilege interact and mutually reinforce one another to constitute individuals' identities and shape their behaviour, and how particular aspects of identity and behaviour are mobilised by specific settings or institutions.

Conclusion

By considering these different aspects influencing attitudes toward energy technologies we are thus able to capture a wider and more in-depth understanding of the complex social contexts that intersect with experiences and perceptions among individuals and communities. These findings are supported by previous research which demonstrate that public attitudes and acceptance of energy technologies are heterogeneous and often confined to smaller groups of people which distinct socio-demographic characteristics (Devine-Wright 2007; Rijnsoever *et al.* 2015).

2.7 Report on policy & regulation landscape

Boo, E., Dallamaggiore, E., Pasqualini, T., Dunphy, N.P., Lennon, B., Meade K., Chinchinato, O., Axon, S., Otal, J. (2016). Report on [Energy] policy & regulation landscape. Report prepared as a project deliverable (D4.1) for ENTRUST H2020 project (grant agreement no. 657998). Cork: University College Cork.

Extract from project 'Description of Action'

'This task aims to achieve a complete picture of the policy and regulation landscape in the six countries included in the scope of analysis: France, Germany, Ireland, Italy, … UK and Spain. The existing policies and the main factors that have triggered them will be mapped, considering existing infrastructures, the energy system, the main stakeholders, the main energy targets, etc. They will be analysed all along the supply chain, generation, transmission, distribution and commercialisation, but also in the demand side (energy consumption in households, main limits and characteristics). Market-based instruments as the European Union Emission Trading Scheme (EU ETS) to reduce greenhouse gas emissions will also be part of the scope of this task. The task will also define key performance indicators, to enable the comparison between the different countries. Interviews with key European stakeholder as utilities, public governments, EU and international associations on energy, etc. will be organised to obtain real market insights.'

Abstract

This deliverable provides an up-to-date picture of the current situation concerning the policies and regulations related to the energy system in a range of European countries. Key technological, social and market factors are scrutinised in order to understand the various energy policy frameworks in Ireland, Spain, the United Kingdom, France, Italy, and Germany. An analysis of the national dialogues in each of the member states is provided with a particular focus on the key public discourses, along with an assessment of the main barriers hindering low carbon measures, in each country. The sustainable energy transition paradigm, that involves a gradual shift from conventional energy sources to renewable, more region-specific ones, is assessed using new institutionalism theory. This theory fits quite well into the overall approach being taken by the ENTRUST project and has helped the authors to gain a deeper understanding of how the political system deals with the complexity that is ingrained in the energy transition. Also, how the frameworks within which socio-political institutions and policy paradigms operate and influence the direction and speed of the transition is explored. As key influencers in the energy transition, institutions play a key role in governing the behaviours on multiple levels, from individuals to the communities they participate in. The term "institution" is somewhat amorphous in its usage. It has been commonly used to describe both the formal entities setup to regulate people (*e.g.,* supranational and national governments and the public services they provide) and the more informal practices associated with individual and group customs or behavioural patterns that have been valorised by societies over a period of time (*e.g.,* national cuisines, and adherence to specific religious or secular festivals). This relational perspective on how social order is both created and maintained is important as it helps us to gain a better understanding of the factors that contribute to the strengths and weaknesses of the various policies being implemented across the EU to promote the energy transition.

Methodology

The task was divided in two parts, with each case study comprising a country analysis and energy policy and regulation landscape overview. A template was sent to consortium partners with instructions on how to complete the first section on country analysis. The period chosen for study comprised the post-war period, after World War II, out to 2050 with an emphasis on key dates and factual data only. A short introduction to the energy system, its infrastructures and history, summarised by two pictures called "National Energy Overview in Country X" and "Country X Strategy in energy Policy Making" where key policies with their strategic rationale and causal factors are presented.

- The energy system of the country, with an emphasis on policies and regulations linked to energy supply, covering: an overview of the energy system of the country; and regulations and facts according to energy source.
- Key policies with regards to certain demand sectors (construction, transport and industry), and other policies impacted by energy policy.
- Some elements representing the energy and policy landscape.

While not specifically mentioned in the DOA, a short synopsis of the European Union context and the development of an integrated EU energy policy have also been completed. Market-based instruments such as the European Union Emission Trading Scheme (EU ETS) to reduce greenhouse gas emissions were also incorporated into the overall scope of this deliverable. In addition, it defined key performance indicators that enabled us to compare the situation in each of the countries being analysed. Interviews with key European stakeholders such as utilities, government officials, and EU and international energy association representatives were also consulted to obtain real market insights. The second part of T4.1 established five KPIs relating to the success factors identified by new institutionalism theory. The important role of institutions and political and economic paradigms in shaping the energy transition and their influence on environment and climate policy integration frameworks are also recognised. The KPIs are presented below:

Key performance indicator	Components
KPI 1: Energy transition definition	• What are the main ideas of the energy transition? Are there official definitions? • Is it mainly economic – a short-term cost cutting, cost-efficiency measure – or is it also focused in the long term, considering social and health impacts? • Is there a real discourse? • Who's involved?
KPI 2: Urgency and pressure on the energy transition	• Is climate change considered an urgent matter? • What is the total number of policies in the last 2 years favouring energy transition, supply/demand ratio, *etc.*?
KPI 3: Policy integration	• Are policies in silos? Are there links with other policies in other sectors? • Is there a focus on specific technologies while neglecting others? • Are there inconsistencies among various policies with regard to the energy topic?

Key performance indicator	Components
KPI 4: Institutional structure	• Are public institutions linked to energy fragmented? • Is there a lack of transparency? • How engaged are the public in energy policy making?
KPI 5: Initiatives on new sustainable technologies and social innovation	• Is there a political commitment to reducing the price of new sustainable technologies and to industrialise processes favouring sustainable solutions? What actions have been undertaken to support innovation and governance change?

Key Results

The research carried out for this deliverable indicates that there are numerous interlacing factors influencing energy policy-making and the transition potential of one country. These factors include, while are not exhaustively presented below, are as follows:

- The economic and financial situation
- Geographical and geophysical characteristics
- Energy system design and energy demand
- Institutional structure, institutional openness to lobbying and administration efficiency
- Energy market structure
- Political orientations
- Previous policy outcomes and policy practices
- Transport and construction sectors practices and design
- Economic development
- R&D and technical development
- Public opinion and participation
- Major external events (such as external energy shocks, world economic crisis, international political events, *etc.*)

Each country has responded differently to these factors and their combinations, which helps explain the variety of energy systems in place – of policy-making and transition potentials. All these factors influence energy policy-making and the transition potential, but they do not do so in the same way and with the same intensity.

Applying new institutionalism theory, the following Success Factors to transitioning were determined:

- New practices are less costly or more profitable
- The risks of such practices and outcomes are sufficiently mitigated
- Institutional arrangements are inclusive
- New practices and outcomes are seen as opportunities for investors and are not too costly for the different energy user groups
- New policies for transition are self-reinforcing (economically and politically)
- Climate change is perceived as a major crisis
- Policy paradigm is consistent and gives strong values to sustainability

In this respect, Germany seems to have the most promising political orientations, while Spain appears to lag behind. The UK and France present some strong elements in favour of energy transitioning but this is mitigated somewhat in UK, given that the Conservationist Party is currently in power there and have a different viewpoint on energy transitioning, one which is less favourable. Also, in light of the Brexit vote the UK's transition towards a low-carbon economy has been thrown further into doubt. Ireland has developed an interesting energy policy that shows that its political orientations are largely favourable to an energy transition. Italy's institutional political orientations have led to the development of an energy policy that should deliver an energy transition, but it appears a little less consistent when compared to other countries in the study.

Conclusion

The insights and findings from this deliverable offered a suite of interesting perspectives that we were able to take forward to task T4.2, which sets out to develop an assessment of Europeanisation in national policy dialogues. Results from studies using new institutionalism theory on low-carbon energy transition have found that the current policy paradigms and institutional formations have indeed influenced the current state of energy systems towards a neoliberal economic paradigm to (Kuzemko 2013a; 2013b). This has been proven true across Europe, with the latest development in the EU common energy policy, the Energy Union package completing the EU energy market liberalisation process started in the 1990s. According to Ranci (2003), liberalising the whole EU energy sector was the only way to achieve an integrated market, which is one of the central ideals in EU policy-making. However, the liberalisation process took long a long time to be realised. The liberal stance from the Commission was not always compatible with Member States' national interests and in the first decades of European integration, European institutions' ability to act was somewhat limited. Jegen (2014) shows that the EU managed to establish a European energy policy by referring to areas of key competences other than energy, and inscribed its power in new treaties and by encapsulating its liberal views and objectives under the "Competitive, Sustainable and Secure (CSS)" energy market framework (Jegen 2014). Jegen estimates, along with others, that the CSS frame has been successful because it has been taken over and incorporated into the everyday discourses of national policy makers (Jegen 2014; Jacquot & Woll 2008). Also, it should be noted that the ambiguity of this framework has allowed national actors to emphasise the specific elements that were congruent to their own national interests (Chester 2010), resulting in different degrees of institutionalisation of the CSS framework within the various Member States.

2.8 Europeanisation of national policy dialogues on energy pathways

Aze, F., Dallamaggiore, E., Salel, M., Boo, E., Dunphy, N.P., Lennon, B., Gaffney, C., Revez, A., Axon, S., Otal, J., Chinchinato, O., Melchiorre, T. & Costantini, V. (2016). *Europeanisation of national policy dialogues on energy pathways*. Report prepared as a project deliverable (D4.2) for ENTRUST H2020 project (grant agreement no. 657998). Cork: University College Cork.

Extract from project 'Description of Action'

'Europe's energy systems are deeply integrated, and this needs to be reflected in the national policy dialogue. This task will carry out a discourse analysis of key national policy documents in each state to assess the degree of 'Europeanisation' of the energy policy landscape. In addition, this task will carry out replicability analysis on the most interesting policies mapped in task 4.1. By identifying the main factors influencing the success of a specific policy or regulation, it will be possible to extrapolate the most promising ones at EU level.'

Abstract

Building on the initial mapping of policies produced for T4.1, T4.2 assessed the degree of Europeanisation of the energy policy landscape in individual member states examining key national policy documents, as well as assessing their potential alignment with communities' initiatives and visions. This task measured the extent to which this reality is recognised in national policy dialogues. In order to accomplish this, the task assesses the degree of Europeanisation of the national energy policy landscapes, primarily via the analysis of key policy documents. In addition, T4.2 carries out a replicability analysis of the most interesting policies mapped in T4.1. Through the identification of the key factors which drove the success of these specific policies, T4.2 aims at showcasing the best practices that are replicable at the European level.

Europeanisation is intertwined with the concept of European integration (EI), so it is not uncommon to find debates in the literature on what differentiates them. According to Schmidt, EI incorporates policy construction and formulation at EU level, which includes the interaction between national and subnational actors, while Europeanisation corresponds to the impact of the EU on domestic structures, specifically economic policies and policy-making. This point of view supports, to some extent, Radaelli's definition of the two concepts: while EI implies "the understanding of a process in which countries pool sovereignty", Europeanisation focuses on "what happens once EU institutions are in place and produce their effects" (Radaelli 2003, pp.8–9). However, the boundary between both concepts can become blurred due to the fact that Europeanisation has a dual function as both an independent variable in domestic politics, and as the processes by which domestic structures adapt to European integration (Howell 2004).

Methodology

The methodology for this study was developed to respectively analyse the top-down, bottom-up, and horizontal Europeanisation processes that have been implemented in order to decipher the strategies in effect in six EU countries – namely France, Germany, Ireland, Italy, Spain and the UK. For each country, the analysis has involved: a review of policy making processes – the national contribution to EU policy making, the transposition of EU directives, and national policy making; a review of the evolution of the Policy and Legal System (PLS) over the period 2005-2016; and ascertaining to what extent the European energy vision is transferred to the national level. Europeanisation, as a concept, is also being referred to in the literature.

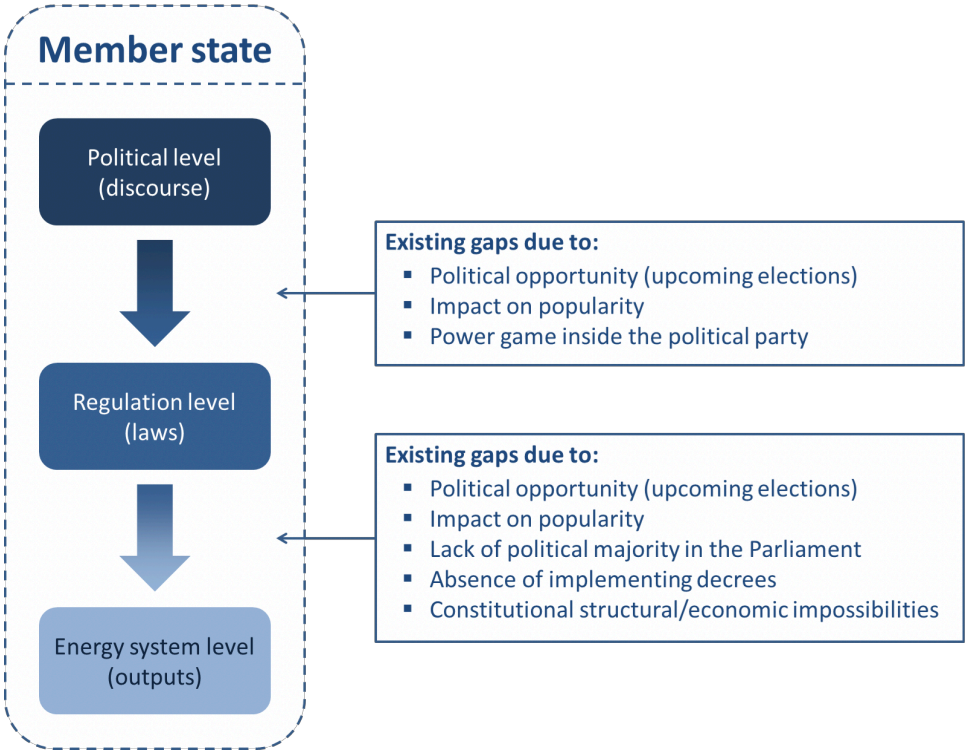


Figure 2: Levels of analysis in the policy making process in this report

Therefore, this analysis offered an in-depth assessment of the processes and strategies at stake during Europeanisation. With this objective in mind, the methodology chosen focuses on three levels of study: political, regulation, and energy system. These three levels constitute the national energy landscape in which it is possible to observe the alignment with European energy strategy. However, the identification of the Europeanisation process is not straightforward since there are differences between the three different levels. Figure 2, above, describes the three levels considered and some reasons that might explain these gaps.

The methodology attempts to analyse, respectively, the top-down, bottom-up, and horizontal Europeanisation that have been implemented, to decrypt the strategies at stake in six EU countries, namely France, Germany, Ireland, Italy, Spain and the UK. For each country, the analysis has encompassed: the review of policy making processes – (National contribution to the EU policy making, EU directive transposition and national policy making in Figure 3); a review of the evolution of the PLS over the period 2005-2016 (Policy & Legal system in Figure 3); to what extent the European energy vision is reflected at the national energy system level (Evolution of the energy system 2005-2016 in Figure 3).

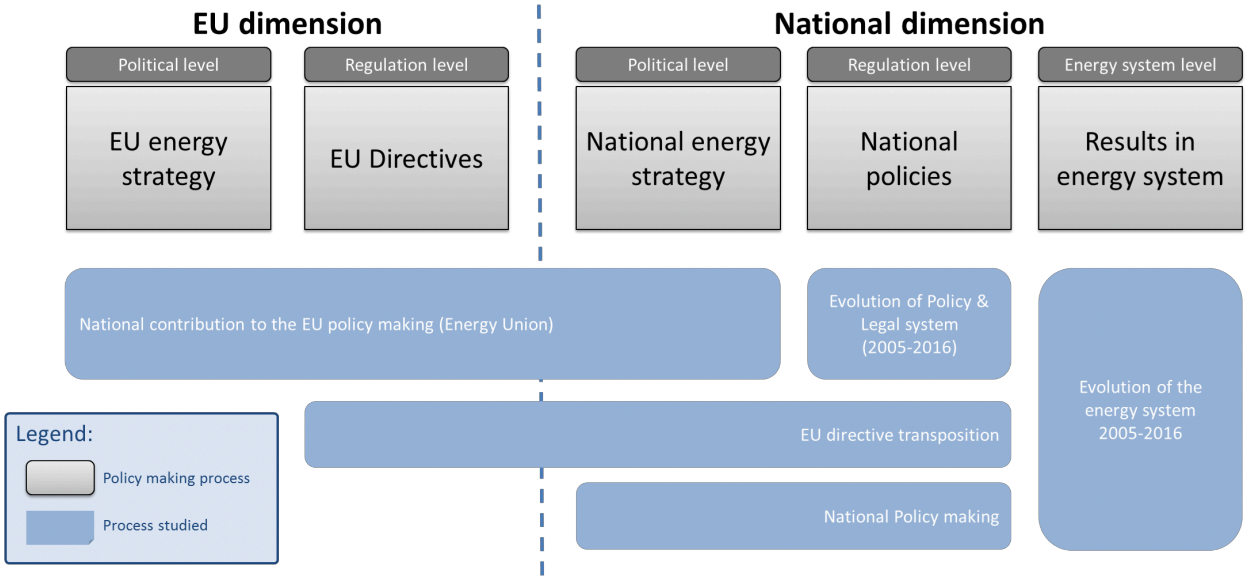


Figure 3: Analysis of the policy making process and hints of Europeanisation

Key Results

This deliverable applied Dyson and Goetz's definition of Europeanisation as a "complex interactive 'top-down' and 'bottom-up' process in which domestic polities[2], politics and public policies are shaped by European integration and in which domestic actors use European integration to shape the domestic arena" (2003, p.20). The concept here is interpreted as a political transfer process which operates on two levels – European and national (see Figure 4 below):

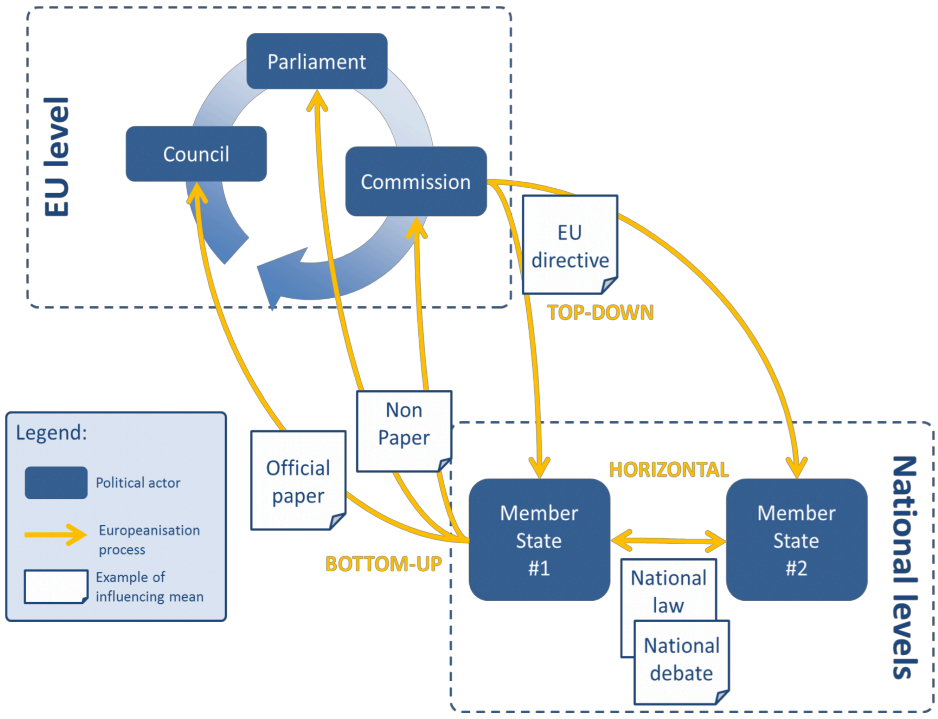


Figure 4: EU policy making and Europeanisation processes

[2] 'Form or process of civil government or constitution' (OED 2010)

Taking into account the result of the analysis carried out, this document proposes eight recommendations that could promote the alignment of national policies to more closely match the European Union energy strategy.

Table 4: Recommendations to promote alignment of national policies with EU energy strategy

Recommendation	Explanation
1: The energy topic should continue to be a shared competence between the EU and member-states	A completely top-down approach – with the European Commission having total competence on the member-states' energy systems – does not seem to be a possible alternative. The diversity of approaches to the energy system at member-state level, its impact on member-states' economy and the risk of other countries leaving the EU project highlight some of the current difficulties of this approach. A shared competence between the EU and member-states appears to be an effective solution to face common challenges related to the energy and climate sectors.
2: Finding common areas of understanding among member-states to progress in the definition of the EU energy strategy is essential	As of now, the European Commission has used the market and climate to dictate energy policy. Other topics to explore for common understanding between member-states could be: Reinforce the role of consumers via defining an EU prosumer status. It could legitimate renewable self-consumption for instance; Reduce progressively the share of the most polluting production capacity in the member-states. Targeting directly a specific source, *i.e.,* coal, nuclear, gas, *etc.* does not seem to be a good strategy as it penalises particular countries while favouring others. The research and development sector could also be used to find a common understanding among member-states. The European entity could propose a certain share of the national budget to be dedicated to sustainable R&D. R&D on climate and market could be used as a lever to indirectly shape the national energy landscape and reflect the European Commission's strategy.
3: Pursue the construction of the Energy Union to ensure a coherent and comprehensive project	A project that integrates the different aspects of energy for all member-states is a complex negotiation process, but it allows different national realities to coexist in a wider European vision. For example, both German and French energy strategies can claim to match certain aspects of the Energy Union. Defining a broader political vision is critical in order to include every member-state before making a step forward toward a more accurate energy project.
4: Reinforce consultations between EU Member States on the energy topic	Consultations on the energy topic open to other member-states could enhance dialogue between the different member-states. The elaboration of different energy strategies at national level is not necessarily problematic, but it should be discussed and well-coordinated, and could become an arena for horizontal Europeanisation.

Recommendation	Explanation
5: Introduce flexibility on the energy and climate targets to adapt to the energy context at international level	Due to globalisation, geopolitical and economic events have an impact worldwide and influence energy systems. The EU energy framework has set rigid targets to progress in the fight against climate change. However, the process would be eased if flexibility in EU energy policies was added to reach these targets in the event of a major crisis or natural disasters.
6: Extend the timeframe for transposition to ensure a better translation of the EU directives	Although the transposition process has been improved by several member-states, the analysis in this study shows that the number of infringements is still substantial. These are not generally the consequence of a retrenchment strategy operated by member-states, but are often the result of administrative delays. Consequently, an extension of the transposition timeframe could be beneficial to ensure a better translation of the directives.
7: Enhance dialogue between the EU and member-states to improve the transposition process	New communication means between the European legislative machine and its national counterpart could ease the transposition process by providing guidelines, supervision, best practices, *etc.* Information about the barriers other member-states have encountered and how member-states have overcome specific problems could be beneficial to the whole process. In addition, to ensure effective results, the Commission should check the actual decree-laws implemented at national level instead of the National Implementing Measures - the regulatory text published in the National Official Journal. Last but not least, in the carrot and stick approach, the Commission uses only the stick through fines.
8: Further studies of Europeanisation processes could address their impact at EU level and other countries	This study focused on the interactions between member-states and the EU. Further information on Europeanisation processes could be obtained by analysing the influences between the Commission, the Council and the Parliament. Furthermore, the analysis of other countries, such as Denmark or Poland could bring interesting insights to this study.

Conclusion

In can be argued that the energy systems of Member States' are all integrated to some extent. In order to meet current global uncertainties, such as energy security and climate change, the transition toward a low carbon economy requires a meaningful, coherent and comprehensive EU energy policy. One which will effectively ease the transition process and establish the main strategic goals for Member States. The creation of just such a EU energy policy is shaped largely through Europeanisation.

2.9 Review of market-driven approaches in sustainable energy policies

Salel, M., Boo, E., Lennon, B., Gaffney, C., Revez, A., Dunphy, N.P., Axon, S., Aiesha, R., Otal, J., Chinchinato, O., Melchiorre, T. & Costantini, V. (2016). *Review of market-driven approaches in sustainable energy policies*. Report prepared as a project deliverable (D4.3) for ENTRUST H2020 project (grant agreement no. 657998). Cork: University College Cork.

Extract from project 'Description of Action'

'This task will involve assembling a database of energy wide behaviour change initiatives. This will be accompanied by an analysis to identify the successes, limitations, and innovations of each initiative and relate them to socio-economic and geographic factors. The results of this task will feed into the T3.2, the intersectional analysis of energy practices in the communities of practice.'

Abstract

This deliverable's objective has been to review market-driven approaches in supporting sustainable energy policies. The first part of the deliverable provides an overview of the implementation of market-based instruments (MBIs) in the six selected countries with specific attention on identifying differences between their strategic orientations. The second part of the report highlights particularly successful applications of MBIs and identifies the best practices which can be replicated in the future application of similar instruments.

The current energy system faces various challenges including, security of supply, climate change, and the resultant threats to human health and ecosystems. To overcome these issues, the energy system needs to transition from one based on fossil fuels to one with a more sustainable foundation, based around greater efficiencies in energy consumption and increased use of renewable energy sources (Creutzig *et al.* 2014; Verbong & Geels 2010). The transition of an energy system towards a more sustainable model depends on several aspects. The technical dimension is often considered as its main driver as no changeover could occur without an important evolution of the available technology. Whether it is renewable energy sources from a production perspective or more efficient equipment from the consumption side, both play a central role in the progressive modification of the European energy system.

Nevertheless, other aspects, just as important, shall also be considered. A technology, however good as it may be, cannot disrupt a market without the awareness and acceptance of its main actors. Therefore, the social factor has to be taken into account if a successful sustainable transition wants to be achieved. The study of human behaviour and practices raises a lot of uncertainties and remains a difficult parameter to assess.

Methodology

The work has been divided into three parts: a review of market-based instruments (MBIs) applied in the European Union, a quantitative survey of the use of these policy tools and a qualitative analysis of selected successful applications of MBIs. A state of the art review has been conducted to identify market-based instruments and several criteria were defined to ensure its reliability. To complete the MBI selection two additional instrument-specific criteria have been used. Indeed, the review of policy instruments requires a

certain experience to be relevant and a short period of time would likely not be sufficient to conclude on whether a tool actually drove behaviour changes, had significant environmental impacts, or led to any positive or negative side effects. Therefore, any instrument whose application has been interrupted or superseded within three years after its launch was not considered for the study. For the same reason, any tool started after 2012 has also been excluded.

Moreover, the quality of the analysis highly relies on the data found during the state of the art review. Depending on the sources the quantity of information available was not the same for all instruments. To ensure a minimal level of knowledge of all studied tools the following criteria have been deemed as mandatory to include the MBIs in the study:

- Category and type of instrument;
- Entry into service date (effective date);
- Instrument status;
- Related policy.

The research focused on official websites of targeted countries to list all ongoing policies and associated instruments. Websites of the European institutions or international organisations such as the International Energy Agency were interrogated to identify applications of MBIs.

The geographic scope of the study has been previously defined by the ENTRUST Description of Action as “the five largest energy using countries, viz., France Germany, Italy, UK and Spain along with Ireland, which offers a contrasting context as a small country, dispersed population, in an economic upturn”.

Key Results

The cross-analysis of the quantitative results presented in the section 3 and the qualitative observations issued from the case study descriptions of section 4 enables the drawing of first lessons learned regarding the use of market-based instruments in the European Union. The set of parameters examined during the quantitative analysis suggests that EU Member States reached a certain maturity in 2009 regarding the use of market-based instruments. Indeed, after two decades of evolution, the number of tools in operation has stabilised, along with the types of instruments used. The increasing average duration of applications also indicates that governments are better prepared to launch MBIs and use lessons learned to anticipate potential side effects

With the emerging awareness of environmental issues, several international agreements have been negotiated to both define global objectives and propose approaches to achieve them. Policy instruments played an important role and new tools such as certificates (green or white), GHG emissions allowances or feed-in tariffs were designed to specifically address environmental issues due to energy uses. Surprisingly these specific instruments have not been the most used by governments or institutions as they represent a share of less than 20% of sustainable energy policy tools.

One success factor that frequently crops up when it comes to the promotion of low-emissions vehicles is the financing of capital costs. Indeed, efficient cars are often more expensive than more conventional ones and this is especially the case with disruptive technologies such as Electric Vehicles (EVs). The price difference

between a standard car and most efficient vehicles has been identified as one of the main barriers to massive development of low-emissions automobiles. Price-based instruments are therefore the most suitable policy tools in such situations as grants, low-interest loans or even tax abatements immediately reduce the amount of investment to be provided by the buyer. The wider the market, the more flexible shall be the instrument. Thus, it is not surprising to see such parallel measures within the building sector as several kinds of stakeholders can be targeted, ranging from individuals, householders to energy suppliers, including businesses, public institutions or professional from the construction. These actors play various roles, have different goals and therefore may react differently in front of a single incentive.

The sector of energy production from renewable sources is quite different from the domains previously studied. First of all, it gathers relatively homogenous stakeholders with large energy suppliers. Secondly, the initial investment is not a major problem as actors are already used to develop large-scale power plants. In addition, the EU defined binding targets for the development of renewables sources which led to the implementation of regulations. In contrast, energy efficiency is only associated with indicative goals. In such situations, quantity-based instruments are preferred to price-based instruments by policy makers. Indeed, while the regulation ensures the achievement of the objective (*i.e.,* a given share of renewables), the instrument provides some flexibility to market actors that can either invest directly in renewable sources or indirectly finance other stakeholders by buying green certificates. Another positive aspect to be noted is related to dedicated targets that accompany such instruments and which makes all actors aware of their responsibilities instead of using pure economic levers to change their behaviours.

Finally, price-based instruments and quantity-based instruments can be applied in parallel to address global issues such as CO_2 emission limitations. It is the case for instance with the CO_2 trading scheme whose scope is defined at EU level and the carbon tax managed at national level to cover “out-of-the-scope” sectors. While the first one ensures a maximum level of emissions but does not raise revenues, the second does not guarantee direct decrease of emissions but collects revenues by incorporating in products or resource prices the cost of environmental externalities. These revenues can be further used to support other sustainable policies.

Conclusion

It is important to analyse and monitor potential interactions between price-based and quantity-based policy instruments, to ensure their efficiency. Indeed, a raise in the carbon tax may convince stakeholders to switch to more sustainable activities, leading to a reduction of their respective levels of GHG emissions. Meanwhile, it increases the number of GHG emission allowances that are not used and which become available for trading on the market, leading in its turn to a drop in the market price of allowances. Under a certain limit, it becomes economically more appealing to actors to buy allowances than invest in more sustainable technologies, making the instrument inefficient or even counterproductive.

2.10 Identification and Characterisation of Energy Behaviour Change Initiatives

Morrissey, J., Axon, S., Aiesha, R., Hillman, J., Revez, A., Lennon, B., Dunphy, N.P., Salel, M., Boo, E. (2016). *Identification and Characterisation of Energy Behaviour Change Initiatives*. Report prepared as a project deliverable (D4.4) for ENTRUST H2020 project (grant agreement no. 657998). Cork: University College Cork.

Extract from project 'Description of Action'

'Most of the policy-making efforts to obtain a low carbon energy system and reduce the environmental impact of energy consumption have focused on energy-efficient technology and renewable energy resources. However, policies focused on changing people's behaviour may also have significant impact on the energy consumption of a country. That is why all the previous tasks of this WP4, the mapping, the replication analysis, the market-driven approaches, the identified gaps, and input from WP2 on technologies and from WP3 on the human factor, will be used to create a set of policies integrated in the ENTRUST policy tool-kit. They will be classified in bottom-up, top-down and hybrid approaches. This task aims at delivering a robust set of policies to key European decision-makers.'

Abstract

With reference to several case studies across Europe, this deliverable provides insight relating to the success factors and commonly encountered barriers to energy behaviour change initiatives. Through an evaluation of a number of identified and characterised initiatives across the UK, Ireland, Spain, France and Italy, energy behaviour change initiatives are noted as being the 'holy grail' of sustainability which have the potential to influence the ways in which people use technologies as part of their everyday practices (Jackson 2005). It is well noted that behaviour, practices and culture constitute a powerful human factor in the energy system; in particular the interactions between technologies, practices and norms that lock individuals into certain patterns of (often inefficient) energy use. The result has been an increasing focus in behaviour change research, particularly on the social contexts in which people live, the routines they shape, and the extent to which people feel empowered to change them.

The deliverable has identified, and characterised, a series of behaviour change initiatives, indicating the factors contributing to their relative success in influencing energy actions. The projects reviewed here illustrate a snapshot of current practices in this area, and while these projects do not represent an exhaustive list, it is from these understandings that a number of conclusions can be drawn. As such, this deliverable has contributed to providing:

- A deeper understanding of the different models and delivery tools employed to change energy-related behaviour;
- An insight into the critical success factors that underpin best practice and successful interventions; and
- A "what works in practice" overview of different ways to change behaviour and the interventions to apply based on different contexts to avoid applying measures that do not work to modify behaviour change.

Methodology

This report reviews case studies of household 'energy use' behaviour change interventions and in doing so provides a 'snapshot' of current activity on this issue. Deliverable 4.4 (D4.4) does not provide an exhaustive list of behaviour change initiatives across EU member states or of those applied at the EU level. Rather, the deliverable illustrates a series of exemplar case studies that focus on individual and household related energy use and behavioural change initiatives that aim to reduce energy consumption. Through describing these representative exemplars, the deliverable aims to provide an overview of the typology and characteristics of those schemes and initiatives which are currently being applied across the EU, and to provide a basis for a robust evaluation of the successes and limitations of these initiatives.

The review specifically focuses on interventions that are perceived to be driven by energy and/or carbon reduction goals, and less on the wider spectrum of behaviour change initiatives encompassing sustainability and lifestyle issues. While behaviour change interventions focusing on wider sustainability issues are also related to the climate change agenda, many of these interventions are focused on a wider environmental imperative, including for example, waste reduction and recycling, sustainable transport, and local food initiatives. Data for this review were collated from publicly available sources. From a long list of over 40 case studies, 15 cases are selected to outline the inner workings of the interventions and to highlight their strengths and weaknesses. From this broader long list of examples, a sample of 4 initiatives were chosen for further in- depth study to indicate the enablers of, and barriers to, energy behaviour change initiatives. These were selected for their particular insights they offered and hence deserving further examination.

Key Results

To date, the effectiveness of behaviour change interventions has been generally limited, or even unknown, due to weaknesses in program design and evaluation of program impact on behaviour (Frederiks *et al.* 2016). According to Wicker & Becken (2013), the drivers of consumer behaviour have not yet been analysed systematically, *i.e.,* it is not known what concerns (energy availability, climate change) drive the support of particular energy-related behaviours and policies. Further, methods used to design, implement, and evaluate the impacts behavioural strategies have not always systematically addressed the reliability and validity of results reported in some studies (Frederiks *et al.* 2016). Regardless of the preferred approach to behaviour change and the proliferation of associated programmes interventions and initiatives, the impact of behaviour change on energy use is simply not occurring to the depth and widespread level required to address the climate issue (Moloney *et al.* 2010).

There is considerable debate about why different behaviour change interventions work or do not work. Existing research supports the view that behaviour is most likely to respond through the implementation of a mixture of tools and types of interventions. An examination of some key practical case study examples selected here for the diversity they represent illustrate the different contexts and interventions, and specifically in relation to energy related behaviour change. Key lessons from the selected case studies are also discussed. Each ase study is presented using the following structure: Background; Intervention Model & Evaluation. In order to group and categorise behaviour change interventions, the 'behaviour change wheel' model developed by Susan Michie *et al.* (2011) was referenced. While not explicitly focused on energy *per se*, this model is framed around nine intervention functions aimed at addressing deficits in one or more of

three conditions, **capability, opportunity, and motivation**. The outer layer of the behaviour change wheel is comprised of seven categories of policy types through which behavioural interventions are directed (Michie *et al.* 2011). Figure 5 presents an adaptation of the behaviour change wheel. This Figure (and associated definitions in Table 5) is applied throughout Section 4 of the deliverable to indicate the broad policy and intervention categories into which each of the respective case studies fall.

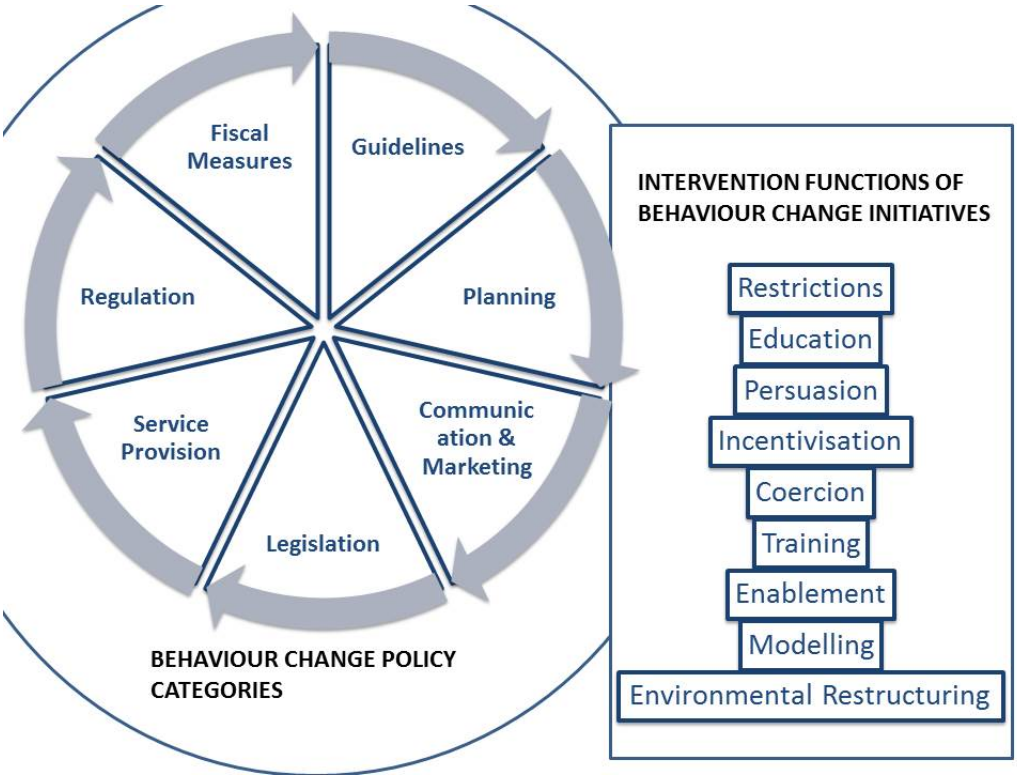


Figure 5: Behaviour Change Wheel (derived from Michie *et al.* 2011)**.**

Table 5: Definition of interventions from Behaviour Change Wheel (Michie *et al.* 2011).

Intervention	Definition
Education	Increasing knowledge or understanding
Persuasion	Using communication to induce positive or negative feelings or stimulate action
Incentivisation	Creating expectation of reward
Coercion	Creating expectation of punishment or cost
Training	Imparting skills
Restriction	Using rules to reduce the opportunity to engage in the target behaviour / Increase target behaviour by reducing opportunity to engage in competing behaviours
Environmental Restructuring	Changing the physical or social context

The conceptual approaches identified have been used to provide a better understanding of energy related behaviours; the range of theories lends credence to the claim that no single approach can exclusively explain and predict behaviour and consequently no single approach can explain nor change people's behaviour. Collectively these cross-disciplinary insights (from a range of psychological, economic and sociological approaches) contribute towards helping to unravel the complexity of energy related behaviours and the multitude of factors that shape them. It has also been identified that there are many tensions between theories which by the same token arguably suggest that the different models and perspectives offer complimentary viewpoints on the same theme of energy behaviours. Hence, it is observed that policies on behaviour change appear to take a pragmatic line by combining a mixture of theories in public policymaking across different EU countries to change individual and consumer behaviour across many spheres of behaviour, specifically relating to energy consumption and in dealing with the low-carbon and sustainability agenda.

Conclusion

This deliverable has classified energy-related behaviour change initiatives into 6 broad categories (community-based interventions; information and awareness based interventions; eco-districts; show-case events; energy switching; and smart-technology focused interventions) and then further categorising the interventions within the context of policy categorisations and the function of the initiatives (see Table 5) using the Behaviour Change Wheel in Figure 5 (Michie *et al.* 2011). In so doing, this deliverable has outlined that there are significant gaps between what is known to work to engage individuals in behavioural changes and what is currently being employed within initiatives reviewed here. An over- reliance on education and awareness-raising projects illustrates that such projects are not aiming for sustained behavioural changes and with no projects incorporating fiscal measures, regulations or legislation to drive behaviour change reflects a reluctance to engage widely with the diverse approaches that can drive behaviour change.

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2.11 Policy toolkit typology

Aze, F., Molinero, S., Tart, S., Sanvicente, E., Dunphy, N.P., Lennon, B., Revez, A., Morrissey, J., Axon, S., Woolford, J. (2017). Policy toolkit typology. Report prepared as a project deliverable (D4.5) for ENTRUST H2020 project (grant agreement no. 657998). Cork: University College Cork.

Extract from project 'Description of Action'

'Most of the policy-making efforts to obtain a low carbon energy system and reduce the environmental impact of energy consumption have focused on energy-efficient technology and renewable energy resources. However, policies focused on changing people's behaviour may also have significant impact on the energy consumption of a country. That is why all the previous tasks of this WP4, the mapping, the replication analysis, the market-driven approaches, the identified gaps, and input from WP2 on technologies and from WP3 on the human factor, will be used to create a set of policies integrated in the ENTRUST policy tool-kit. They will be classified in bottom-up, top-down and hybrid approaches. This task aims at delivering a robust set of policies to key European decision-makers.' [same task as pervious deliverable]

Abstract

Steering society through a responsible energy transition is an eminently political process. To date, most of the policymaking efforts to obtain a low-carbon energy system and to reduce the environmental impact of energy consumption have focused on energy-efficient technologies and renewable energy resources. In representative democracies of Western countries, these efforts have historically been limited to top-down interventions, such as legislation and regulation. However, policies focused on changing people's behaviours may also have significant impact on the energy consumption of a country. Therefore, new and alternative behavioural approaches are increasingly being developed in a range of policy areas, providing a broader mix of policy options available to policymakers. Three key policy areas featuring a strong focus on behaviour change are energy, environment and transport. The investment cycles in each of these areas tends to be long, meaning strategic decisions taken today have long-term implications for the achievement of climate-orientated energy policy goals. The ENTRUST policy toolkit is designed for policymakers and practitioners whose work ultimately seeks to engage people and influence their behaviour, resulting in improved outcomes. It presents a set of policy recommendations formulated via workshops with both ENTRUST partners and community members. These policy recommendations are aimed at reducing the environmental impact from energy consumption. The toolkit covers both the supply and demand sides of the energy sector, focusing on three energy-intensive sectors: Transport, Buildings, and Local Energy Production. Within these sectors, eight key objectives are defined. These were identified with the collaboration of local community stakeholders.

Methodology

Research undertaken on alternative forms of policymaking suggests that a participatory approach to problem solving can be highly motivational and effective in encouraging behaviour change (Kaplan 2000). The "Open Policy Making Toolkit" developed by the UK government and the French "Law for a Digital Republic" represent two examples engaging citizens in the design process. With this in mind, the ENTRUST partners set out to develop a methodology aimed at co-designing policies targeting energy behaviour change. It is inspired

by the Design Thinking approach and has been complemented by applying insights from behavioural science thinking, as well as by engaging citizens in the policy-design process.

Co-designing policies with citizens is not only aligned with ENTRUST's philosophy but also results in policies that are more widely accepted. The Design Thinking method provides a solution-based approach to solving problems and therefore was selected as the methodology to be used. It's extremely useful in tackling complex problems, by understanding the human needs involved, by re-framing the problem in human-centric ways, by creating a multitude of ideas in brainstorming sessions, and by adopting a hands-on approach in prototyping and testing (Allio 2014). Policymakers will find a step-by-step methodology for co-creating policies relating to energy behaviour change. The methodology includes 10 different steps, divided into three general stages: Understanding the context Co-creating policy options Evaluating, selecting and developing the best policy recommendations

The methodology serves multiple purposes: to obtain a more thorough understanding of the many factors that influence the way people act every day; to map existing policy interventions addressing these factors; to identify gaps and new ideas; to engage stakeholders; and to prioritise and develop the best policy mix. This methodology was specifically designed by the ENTRUST partners, and was used throughout this deliverable. It is inspired by the Design Thinking approach and has been complemented by applying insights from behavioural science thinking, as well as by engaging citizens in the policy-design process. The 10 steps outlined below are intended to be implemented consecutively. However, all the tools and steps identified have specific utilities and functionalities which can be used individually. The 10 steps are meant to be applicable to any country or region, with different focal points to accommodate for local circumstances.

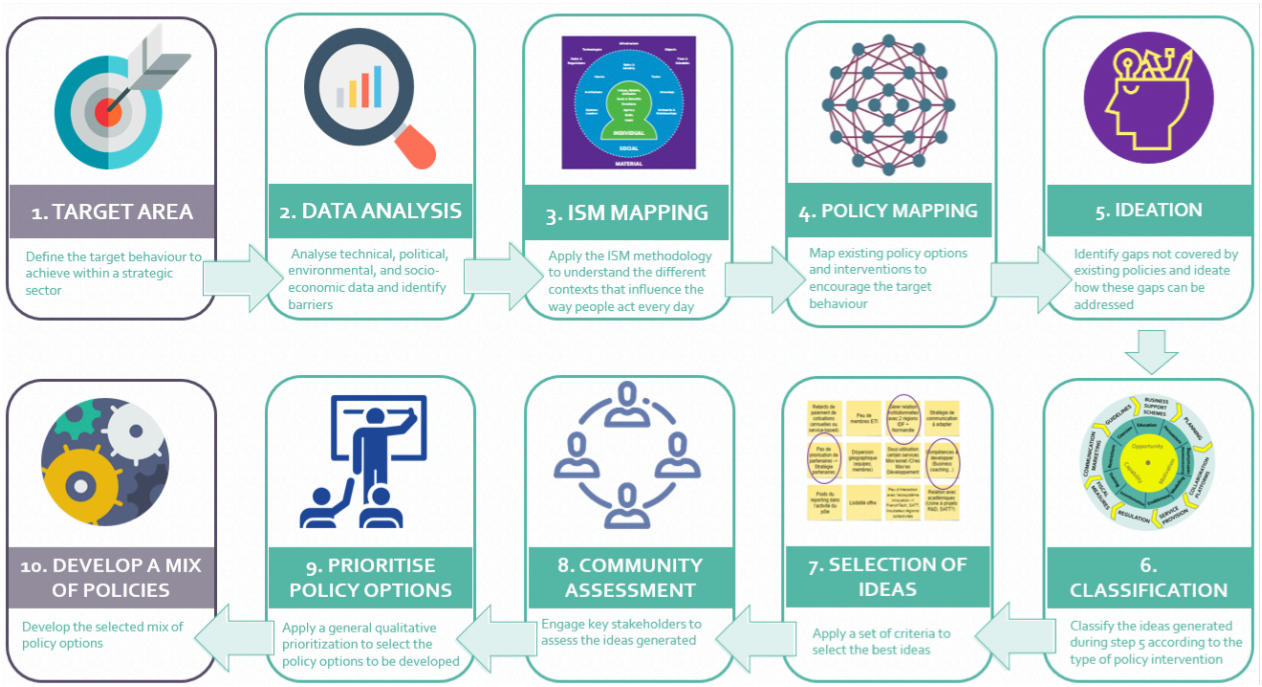


Figure 6: ENTRUST's recommended 10 step policy-design process

Key Results

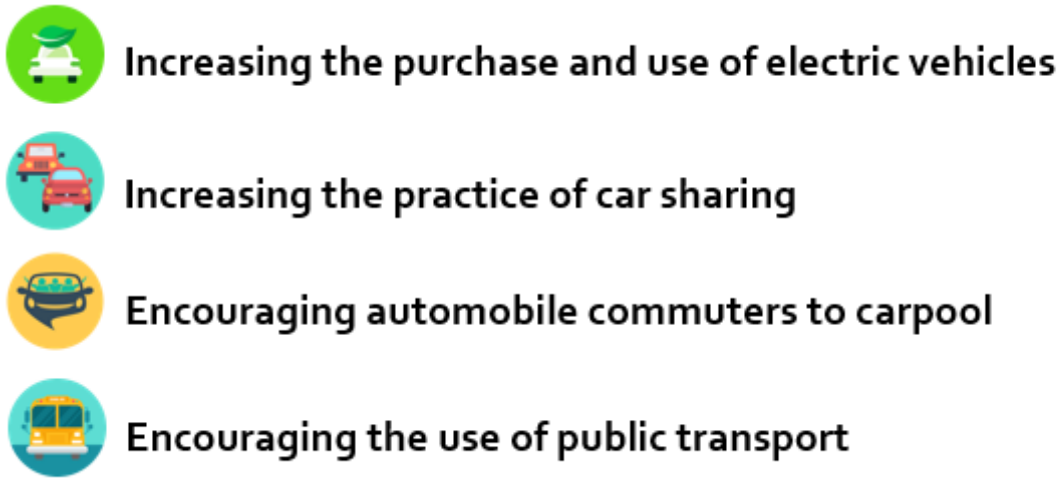
This report depicts current energy policies and regulations in six European countries (France, Spain, UK, Germany, Italy and Ireland). WP4 uses the inputs from WP2 (energy technologies) and WP3 (socio-economic

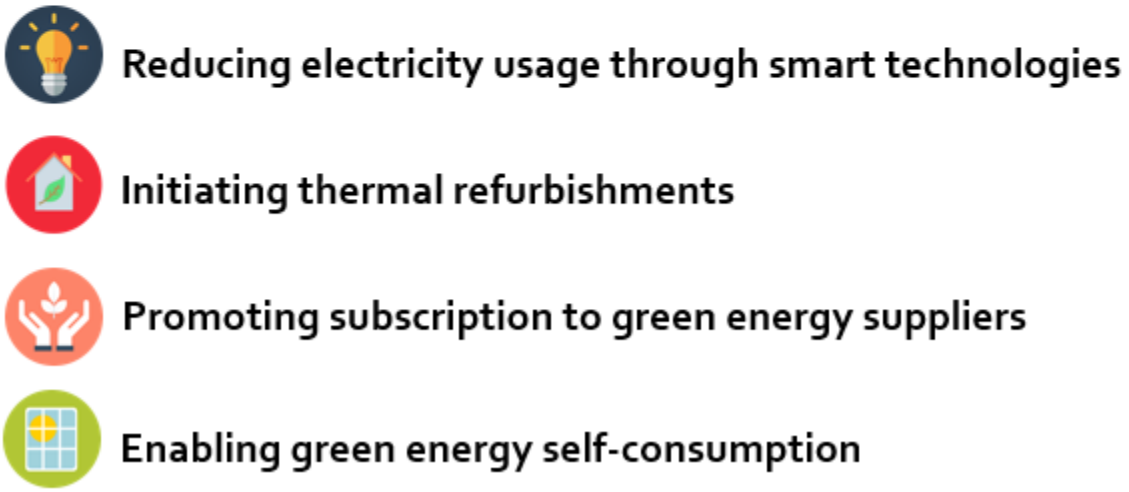
analysis) to create a best practice policy toolkit for EU Member States. As such, it serves as a key input for three ongoing WPs:

1. WP6, where it will help to define innovative energy pathways;
2. WP7, where WP4 outputs will be integrated into the energy portal;
3. WP8, where it will help to stimulate the dialogue at the national and EU level.

Steering society through a responsible energy transition is an inherently political process. To date, most of the policymaking efforts to obtain a low-carbon energy system and to reduce the environmental impact of energy consumption have focused on energy-efficient technologies and renewable energy resources. In representative democracies, these efforts have historically been limited to top-down interventions, such as legislation and regulation. However, policies focused on changing people's behaviours may also have a significant impact on the energy consumption of a country. Therefore, new and alternative behavioural approaches are increasingly being developed in a range of policy areas that provide a broader mix of policy options available to policymakers, with co-design offering significant potential. Three key policy areas featuring a strong focus on behaviour change are energy, environment and transport. The investment cycles in each of these areas tends to be long, meaning strategic decisions taken today have long-term implications for the achievement of climate-orientated energy policy goals. If a sustainable and cost-effective transition towards a low-carbon energy sector is to occur, long-term policy guidance is required.

The ENTRUST policy toolkit is designed for policymakers and practitioners whose work ultimately seeks to engage people and influence their behaviour, resulting in improved outcomes. It presents a set of policy recommendations formulated via workshops with both ENTRUST partners and community members. These policy recommendations are aimed at reducing the environmental impact from energy consumption. The toolkit covers both the supply and demand sides of the energy sector, focusing on three energy-intensive sectors: Transport, Buildings, and Local Energy Production. Within these sectors, eight key objectives are defined. These were identified with the collaboration of local community stakeholders.





Emerging from the methodology were 183 recommendations, 44 of which have been developed more fully and classified according to their approach in the Policy Canvas. The set of policies include 19 top-down, 8 bottom-up, and 17 hybrid approaches and the following mix of policy instruments: 7 regulatory frameworks, 4 planning and infrastructure, 5 fiscal measures, 10 service provision, 7 communication and marketing tools, 2 guidelines, 3 collaboration platforms, and 6 business support schemes. These can be found in the Appendices of D4.5. Policymakers should find these examples useful as they attempt to co-create their own policies. Finally, they may also be interested in the "Policy Toolkit" a separate document that explains the most important aspects to keep in mind.

Conclusion

There are several policy instruments that can be used to aide in policies' effectiveness. Achieving the desired behaviour change generally implies using more than one policy instrument at a time. Even when the appropriate mix of policy instruments are used, policies may fail due to other factors. For energy behaviour-change, these factors tend to be: a lack of theoretical ground, ineffective measures, a lack of monitoring and feedback, and a lack of integration with other policies. These failures stress the importance of a solid approach throughout the entire process, and policymakers are encouraged to pay close attention to the policy cycle framework presented in this report.

The scope of the policy work presented focuses particularly on three high-consuming energy sectors: Transport, Buildings and Local Energy Production. These can be broken down further into eight target behaviours, which were explored in-depth via the 10-step methodology developed in this deliverable. This methodology was inspired by the Design Thinking principles, as they place great importance on citizen involvement. It was then complemented with the Individual Social Material (ISM) Methodology, and expanded upon by engaging citizens in the policy-design process.

3 Understanding the Energy System

3.1 Introduction

Over the last century the energy technologies have evolved substantially fed by a proliferation of new energy sources, improved recovery of resources, enhanced energy conversion performance and progressing technology transfer processes, to name just a few (Gallagher *et al.* 2006; Bettencourt *et al.* 2013; Fri & Savitz 2014). Undoubtedly, these changes have had a profound impact on society in general, particularly in terms of servicing basic human needs such as home heating, mobility, communication, food supply and food consumption (Gallagher *et al.* 2006). Energy technologies are the backbone to the energy system and they encompass both the devices, machinery, protocols, market instruments, regulatory frameworks and policy procedures that are applied in the every-day running and development of the energy system (Gallagher *et al.* 2006).

Energy technology innovations in different forms are at the centre of substantial changes in the way energy is produced, distributed, stored and eventually consumed. These ultimately represent changing practices and relationships between a variety of stakeholders, which includes governments, end-use consumers, business corporations amongst others. Mapping these evolving systems is critical in terms of understanding the range of drivers, barriers, benefits and drawbacks that emerge and who they impact most. Given the current and immediate challenge to address climate change associated with the over-consumption of fossil fuels, it is imperative to engage with innovation and energy technologies and recognise the influence of different factors, including public attitudes to new energy systems. Indeed, while energy technology innovations are promising, the successful transition into a sustainable energy system remains beyond our grasp. In fact, this is not a new debate and globally there is a perceived struggle to make this transition a reality.

Indeed, debates about the challenges that we face concerning energy sustainability, that are over 40 years old, still appear to resonate with us, for example Lovin's in the mid 1970's alludes to the many difficulties in advancing a transition away from fossil fuels and in this work the author makes reference to a political satirist which paradoxically states that 'we are confronted by insurmountable opportunities' (Pogo, aka Walt Kelly in Lovins 1976).

Sustainability transitions lead to considerably enhanced ecological efficiency which occur by means of new socio-technological configurations (Coenen *et al.* 2012). Within a sustainability transition context, an energy transition can be defined as a shift from a socio-economic system dependent on one or a series of energy sources and technologies to an alternative model (Crabbé *et al.* 2013). From an energy perspective, it is increasingly apparent that current energy systems are unsustainable across a myriad of social, economic, and environmental criteria (Grübler 2012), so much so that an energy transition to a low-carbon model is necessary to meet the challenge of climate change and to bring human activities back within ecological boundaries (Meadowcroft 2009; Solomon & Krishna 2011). Literature pertaining to this debate shows that systems in transition are commonly represented as socio-technical regimes; defined as relatively stable configurations of institutions, techniques and artefacts, as well as rules, practices and networks that determine the 'normal' development and use of technologies (Rip & Kemp 1998; Smith *et al.* 2005). A focus on regimes recognises that organisations and technologies are embedded within wider social and economic

systems (Rip & Kemp 1998). Socio-technical systems are thus conceptualised as clusters of aligned elements, such as technical artefacts, knowledge, markets, regulation, cultural meaning, rules and infrastructure (Kern 2012).

Furthermore, a regimes theory approach takes a broad view of energy production and consumption and it highlights critical patterns defining the energy systems of a time and place. For example, the dominance of particular fuel sources from wood to coal and subsequently oil is closely aligned with the development of different technologies from the steam engine to the internal combustion engine (Fri *et al.* 2014) which in turn leads to particular patterns of energy distribution, storage and consumption. Specific energy regimes are thus characterised by specific processes and relationships which during a period of time become fixed and normalised and bear significant influence over the manner in which society is organised.

The work developed in WP2, WP3 and WP4 by the ENTRUST project, provides a mapping of Europe's current energy system and specifically we focus on the processes and technologies of transition that are vital for moving towards a more sustainable energy system. In the following pages, we provide a brief outlook of these core patterns by looking at the range of evolving energy technologies, innovation paths, the state of play regarding different technologies, their penetration in a European context, the political visions that guide them and how these changes are experienced and perceived at community level. A focus on public attitudes in this context further helps position how people in general negotiate and understand their role within a changing energy landscape.

As demonstrated by Figure 7 we hope to provide a multi-dimensional overview of technology innovation by engaging with a number of key elements integral to the energy system. We address these different elements in turn to explore how innovation in general is playing out within the energy system.

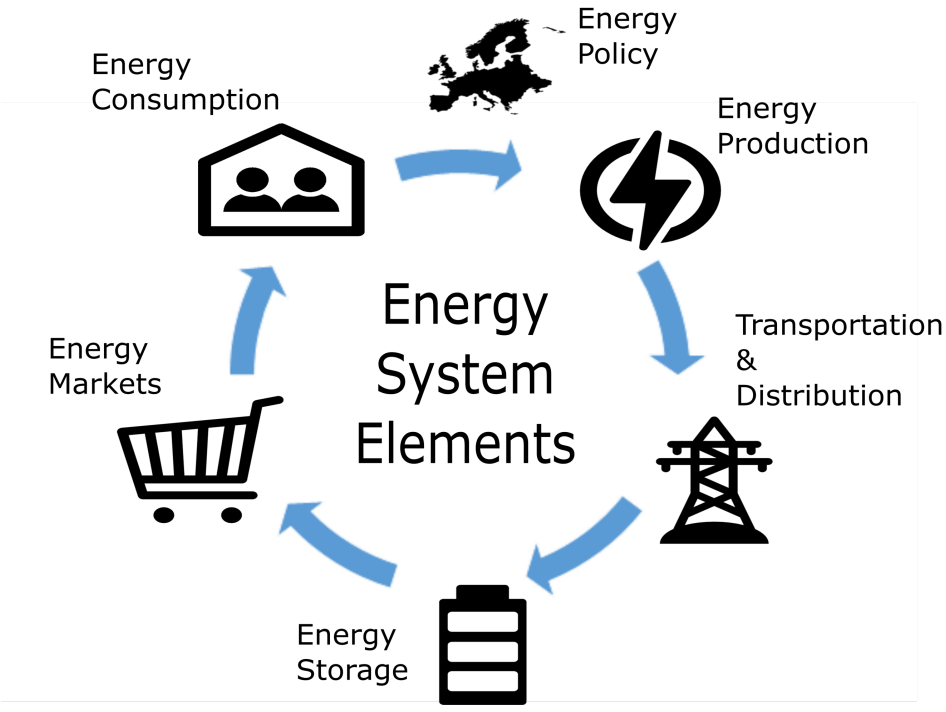


Figure 7: Elements of the energy system

3.2 Technological characterisation

A number of technologies have been analysed through the energy supply chain which consider current technological developments at a variety of levels, from energy generation to energy transmission, supply and consumption. This desk-based analysis included a review of strengths and weaknesses for different technological options and an appraisal of various driving forces. The overall indication from this characterisation of current energy system technologies strongly suggests that at least for the near future, traditional fossil fuel technologies will continue to be strongly relied on, particularly as a means towards ensuring stability and security in the energy system. While, renewable energy technologies and efficiency measures are continually being introduced and existing technologies are undergoing rapid evolution, the dominance of the centralised, high technologies fossil fuel system is still a strongly defining influence over the various national energy systems across Europe. This is evident across the energy supply chain and the following sections will expand further on the state of play regarding these different dimensions pertaining to energy technology.

Energy Production

Primary energy production in the EU-28 is reliant on a range of different energy sources. Eurostat data from 2013 indicates that the most important primary energy source, in terms of the size of its contribution, was nuclear energy (28.7 % of the total). Close to one quarter of the EU-28's total production of primary energy was accounted for by renewable energy sources (24.3 %), with a predominance of Biomass and waste among them. Overall, renewable sources experienced a fast growth over the period 2003-2013, with an increase of 88.4%.

The share for solid fuels (19.7 %, largely coal) was just below one fifth and the share for natural gas was somewhat lower (16.7 %). Crude oil (9.1 %) was the only other major source of primary energy production. With an opposite trend with respect to renewable energies, the production of other primary sources generally decreased in this period, mainly for crude oil (-54%), natural gas (-34.6%) and solid fuels (-24.9%).

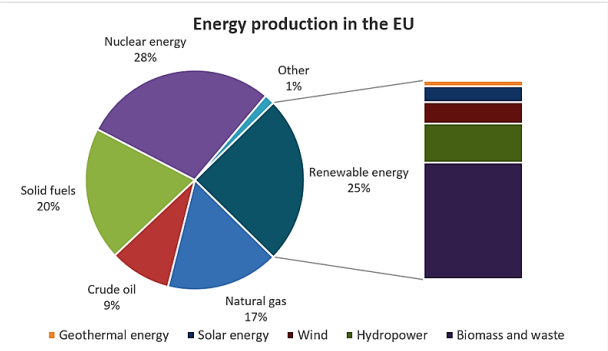


Figure 8: Production of primary energy, EU-28, 2013
(Eurostat 2016b)

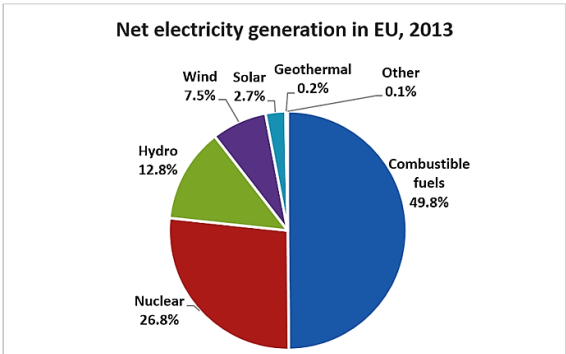


Figure 9: Net electricity generation, EU-28, 2013
(Eurostat 2016b)

A breakdown of electrical energy production further indicates that more than one quarter of the net electricity generated in the EU-28 in 2013 came from nuclear power plants (26.8 %), while almost double this share (49.8 %) came from power stations using combustible fuels such as natural gas, coal and oil (Eurostat

2016a). Large fossil fuel, nuclear and hydroelectric power plants produce electricity in specific restricted areas and subsequent transport and distribution is essential to provide electrical energy to the whole territory.

Renewable sources experienced a fast growth over the period 2003-2013, with an increase of 88.4%.

The widespread geographical span of traditional power plants in operation across Europe is an indication of the central role they play in terms of the energy production system (Hansen, 2001). Following the growing concern towards environmental problems and GHG emission in the atmosphere, renewable energy has been strongly promoted in Europe during the last decades. Among the renewable energy sources, the highest share of net electricity generation in 2013 was from hydropower plants (12.8 %), followed by wind turbines (7.5 %) and solar power (2.7 %) (Eurostat 2016a). Selected performance indicators for key energy sources[3] are illustrated in Figure 10.

	Fossil Fuel			Renewable Energies					Nuclear
	Coal	Oil	Gas	Hydro	Tide	Solar	Wind	Geo-thermal	Bio-energies	Nuclear Fission
Type of Environmental Impact	GHG Emissions			Landscape		Hazardous Waste	Visual-Noise	GHG emissions		Hazardous Waste
Level of Environmental Impact	High	Medium High		High		Low-medium	Medium	Low-medium		High
Technological Regime (Maturity)	High			High	Medium	Medium	Medium	High	High	High
Public Opinion	Low	Medium		Medium -high	Medium -high	High	High	Medium	Medium	Low

Some technologies with lower environmental impact are still in maturing stages

Figure 10: Performance indicators for energy production

Figure 10 above provides a brief multi-level comparison between non-renewable energy and renewable energy production technologies. This table offers a general consideration of each technology with regards to their relative impact on the environment, their level of maturity and public opinion. A key notable observation from this table is that most of the technologies with lower environmental impact are less mature than those with higher environmental impact. Non-renewable energies still represent nowadays the great majority of source of electrical energy in Europe. Furthermore, although all of these non-renewable technologies have a high level of environmental impact they are part of mature energy regimes with more

[3] Figure 10 provides a short selection of Key Performance Indicators (KPI's) for a full list please refer to ENTRUST Deliverable 2.2 (Landini *et al.* 2016).

clearly established protocols, practices and general understanding. These more advanced technology regimes as a result enable greater and more widespread engagement which further consolidates their competiveness and usability. In other words, using terms put forth by Straub (1994), diffusion of technologies are facilitated by increased social presence and information richness which allows a greater and more widespread understanding of its usability, impact and productivity benefits.

Energy transportation and distribution

The transportation and distribution elements of the energy system covers a more capillary network of the supply infrastructure, taking the energy source to end users (residential buildings, industries, services, *etc.*). It is very important to technically evaluate these two phases of the energy supply chain, because both transportation and distribution aspects can have huge impacts on several crucial points of the energy system. They can affect the final energy cost to the end user, furthermore impacts on the landscape often occur due to transportation and distribution infrastructures. It is problematic that these impacts trigger social changes that are not economically computable (residential value decreasing, reduction in life quality, *etc.*). Moreover, environmental impacts such as carbon emissions and other pollutants are worth evaluating, together with the risk of serious environmental accidents associated with the transportation and distribution of energy sources, for instance the risks associated with oil tanker accidents and oil spills.

Transportation and distribution technologies can act on two different segments of the energy chain:

- primary energy sources like coal, oil, gas (*i.e.,* those which have not been transformed into any other energy form yet) are carried from a place to another and then distributed to their transformation sites and plants (*i.e.,* thermal power plants, residential buildings heating, public services buildings, *etc.*)
- already transformed energy (*e.g.,* electric high voltage) is transported and distributed to end users (houses, industries, *etc.*).

Figures 11 to 14 below provide a brief overview of some key energy performance indicators as they pertain to the evaluation for electricity transmission technologies, oil, gas and coal.

Transport & Distribution – Selection of performance indicators

	3-phase overhead Transmission	3-phase underground Transmission	Bundle conductors	Transmission
Type of Environmental Impact	High landscape (visual) impact, high electromagnetic induced field	High landscape (visual) impact, high electromagnetic induced field (for overhead application)	CO_2 emissions, yard logistic impacts, noise impact.	CO_2 emissions, yard logistic impacts, noise impact (underground transmission in urban areas)
Technological Regime (Maturity)	High	Medium	High	High
Technology Flexibility	Medium	Medium	High	High
Public Opinion	Medium, Stable	High, stable	High, stable	High, stable

Figure 11: Selected KPIs for electricity transport and distribution

	Pipelines and pump stations	Tanker Ships	Tank Trucks	Rails
Type of Environmental Impact	Yard logistic and noise impact during installation, landscape impact	CO2 emissions, environmental disaster risks	CO2 emissions	Logistic issues
Technological Regime (Maturity)	High	High	High	High
Technology Flexibility	Low	Low	High	Medium
Public Opinion	Medium-decreasing	Low	Medium	Medium

While public opinion in general is low, all oil related Transport and Distribution technologies are fully matured

Figure 12: Selected KPIs for oil transport and distribution

	Pipelines	LNG on Ships	Gas Hydrate on Ships
Type of Environmental Impact	Yard logistic and noise impact during installation, landscape impact	CO2 emissions	CO2 emissions
Technological Regime (Maturity)	High	High	Low
Technology Flexibility	Low	Low	Low
Public Opinion	Medium-stable	Medium-stable	-

Figure 13: Selected KPIs for gas transport and distribution

	Coal Slurry Pipelines	Coal Log Pipelines	Railroad Trains	Barges	Trucks	Conveyor Belts
Type of Environmental Impact	Yard impact during installation, landscape impact, high water demand	Yard impact during installation, landscape impact, water demand	Logistic issues, electricity demand	GHG emissions	GHG emissions	-
Technological Regime (Maturity)	Medium-High	Medium	High	High	High	High
Technology Flexibility	Low	Low	Medium	Low	High	Low
Public Opinion	Low to medium and decreasing for all					

Figure 14: Selected KPIs for coal transport and distribution

A very large part of energy transportation and distribution that we see today is a reflection of the dominance of fossil fuel energy production which is extremely reliant on a complex system of energy transportation through pipelines, pumping stations, tanker ships, to name a few. This is therefore a dimension of the energy supply chain which is particularly influenced by the forms of energy production that dominate. Two

additional issues stand out from this general overview of performance of Energy transportation and distribution technologies. One is the fact that most of these are mature technologies that have been established over a long period of time but public opinion in general is low. The other interesting issue is that flexibility overall is generally low in terms of energy transportation and distribution which means that greater complexity and diversity is required.

Energy Storage

Energy storage involves the capture of the energy produced at one time to be used at a later moment. To make this possible, the energy captured needs to be converted from forms that might be difficult to store to more storable forms. Storage capacity is thus used at times when consumption, that cannot be deferred or delayed, exceeds production. In this way, electricity production does not need to be drastically scaled up and down to meet momentary consumption but instead, transmission from a combination of generators and storage facilities is maintained at a more constant level. Grid energy storage (also called large-scale energy storage) can be defined as a group of methods and systems used to store electrical energy within an electrical power grid. A smart grid communication infrastructure that enables Demand Response (DR), can be used, alternatively and complementary, to achieve the same effect: in fact, both these technologies shift energy usage and transmission of power on the grid from one time (in which it is not useful and it would be wasted) to another (in which it's required).

Energy storage is particularly important in an energy system dominated by renewable sources and this is a key objective in current EU energy targets. Energy produced from photovoltaic and wind sources inherently varies: the amount of electrical energy produced varies according with time, season, day of the week, and weather. Therefore, renewables present special challenges to electric utilities. Strategic wind farm development can help reduce some of this variability. Solar energy is usually reliable but there are obvious day and night time variants. Tidal power is also linked to variability in gravitational forces exerted from the moon. All of these issues represent potential challenges to energy availability on peak demand. Figures 15 to 17 below presents some of the performance indicators we have collated to provide a deeper understanding of the state of play regarding energy storage at present.

Energy Storage – Selection of performance indicators

	Pumped-storage hydroelectricity	Compressed air energy storage	Flywheel energy storage	Hydrogen storage and fuel cell
Type of Environmental Impact	Special site required. Land destruction to create reservoir.	Special site required. Some NOx emissions can occur.	None	Impacts of mining and manufacturing catalyst
Technological Regime (Maturity of Technology)	High	Medium	High	Low
Public Opinion	High	Medium	Low	-

Figure 15: Performance indicators for storage of electricity

	Sensible heat storage	Phase Change Materials	Thermo-Chemical storage
Type of Environmental Impact	Low to negligible environmental impact for all		
Technological Regime (Maturity)	Medium-High	Medium-High	Medium-High
Public Opinion	Medium	Low-Medium	Low

Figure 16: Performance indicators for heat storage

	Depleted gas reservoir	Aquifer reservoir	Salt formation	LNG storage tanks
Type of Environmental Impact	Landscape impact due to extraction equipment installation	Landscape impact due to extraction equipment installation	Disposal of saturated salt water during mining	8-10% of gas losses in LNG production 2-2.5% losses in regasification
Technological Regime (Maturity)	High	High	High	High
Public Opinion	Low	Low	Low	Medium

Public opinion of energy storage technologies in general is very low

Figure 17: Performance indicators for storage of gas

While energy storage has little impact regarding emissions, many storage technologies bear significant impact in terms of landscape degradation and destruction. As the table above shows environmental impacts are particularly relevant with regards electricity storage and gas storage. Furthermore, it is also notable that many storage technologies have a low public opinion. The other aspect which is notable is that there are a number of external impairments in terms of solar and wind energy capabilities which place greater emphasis on energy storage innovations. Night and day differentials for solar energy and weather conditions for wind energy operate as a 'utilization wall' which limits their provision as steady and stable energy sources.

Energy technology and end users

The end user dimension of the supply chain is a very wide field, which comprehends multiple aspects of the energy system. As shown in Figure 18, the three main sectors responsible for the European Union's final energy consumption are Households, Transport and Industry. For the purposes of this report we are going to focus mainly on Households and Transport. The main types of technological solutions and innovations for building comfort (lighting, heating, cooling and ventilation), building control (building management systems), individual power and heat generation, along with private transport are highlighted.

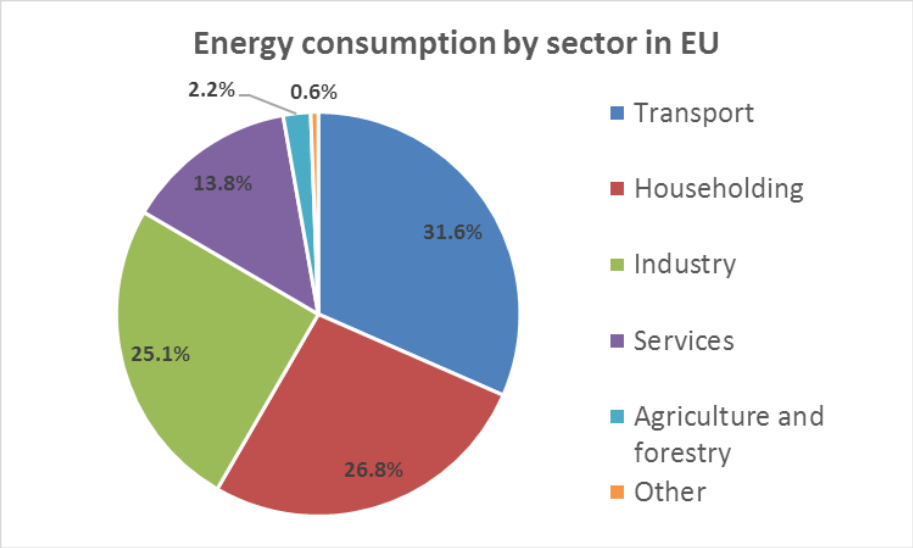


Figure 18: European final energy consumption by sector (Eurostat 2016)

Household and buildings technology

The built environment accounts for 30-40% of global energy consumption and associated greenhouse gas (GHG) emissions (Cheng et al. 2008). Due to their long-life and typical levels of energy inefficiency, buildings are seen as representing one of the largest sources of unrealised potential cost effective energy savings and GHG reductions, more perhaps any other single domain within Europe (European Commission 2011a). Even though building technologies present several differences depending on the region of Europe considered, it is possible to give a general overview of the current state of the sector based on when the building has been last retrofitted. Current situation for building without retrofitting in the last 10-15 years:

- **Lighting:** Mainly Fluorescent and Compact Fluorescent Lamps (CFL) are installed. In residential buildings, older incandescent lamps are still prevalent. Automation systems are very rare and only implemented in commercial buildings.
- **Micro CHP:** Micro CHP solutions are implemented very rarely.
- **Heating:** Building are generally heated with individual gas or oil-fired boilers. As we have already alluded to in Chapter 4, district heating would be a more efficient solution, but has been mainly implemented in the North-East regions of Europe.
- **Ventilating:** Building air quality is guaranteed almost solely by natural ventilation.
- Housing and building technologies performance indicators.

	Incandescent	Halogen	CFL	LED
Type of Environmental Impact (toxicity)	No	No	Yes	Yes
Technological Regime (Maturity)	High	High	High	Medium-high
Market Share (2011)	69.3%	4.9%	25.4%	0.4%

Figure 19: Lighting technologies performance indicators

	Simple switch	Dimmers	Day lighting	Occupancy sensors	Timers
Technological Regime (Maturity)	High	High	High	High	High
Average annual energy savings[‡‡]	-	38%	26%	50%	54%
Public Opinion	-	Medium-high	Low-medium	Medium	Medium

Figure 20: Lighting control systems performance indicators

	Depleted gas reservoir	Aquifer reservoir	Salt formation	LNG storage tanks
Type of Environmental Impact	GHG emissions	GHG emissions	Depends on heat source	GHG emissions
Technological Regime (Maturity)	High	Medium	High	Low medium
Public Opinion	Medium	Low-medium	Low-medium	Low-medium

Figure 21: Micro Combined Heat and Power performance indicators

	Boilers	Furnaces	Heat Pumps	Solar Heating	Electric Heaters
Fuel used	Gas-Oil	Gas Oil	Electricity	Sunlight	Electricity
Technological Regime (Maturity)	High	High	High	Medium- high	High
Public Opinion	High	High	High	Medium-high	Low-medium

Figure 22: Building heating technologies performance indicators

	Natural ventilation	Hybrid ventilation	Mechanical Ventilation
Type of Environmental Impact	None	Electricity consumption	Electricity consumption
Technological Regime (Maturity)	High	High	High
Public Opinion	High	Medium-high	Medium-high

Figure 23: Ventilating solutions performance indicators

	Chillers	VRF
Type of Environmental Impact	Electricity	Electricity
Technological Regime (Maturity)	High	High
Public Opinion	Medium-high	Medium

Figure 24: Air conditioning performance indicators

Overall, in terms of household and building energy technologies it can be said that market shares, and by default energy technology choices, are influenced by the maturity of a specific energy technology. For one in terms of competitiveness, emerging or maturing technologies usually have higher prices which work as a barrier to gain market shares. For instance, in terms of Micro CHP technologies, the most innovative solutions are fuels cells. However, their prices are still too high for them to occupy a large market share. Another significant influence is the 'technological fit' and context suitability of particular technologies. For instance, in terms of heating technologies, solar heating is the least diffused technology, despite it not producing GHG emissions and it being the least harmful to the environment. However, slow uptake is due to very fact that it has a weak social presence and therefore information and practical know how is poor. Furthermore, in the case of solar heating, there are also use difficulties associated with day-night use variability. Another important component in the diffusion of emerging and innovative technologies is their flexibility and adaptability to pre-existing structures. For instance, air-conditioning technologies show that growing market shares are to a degree associated with the ease with which these technologies can be adapted in the context of retrofitting old buildings. This factor, to an extent, accounts for VRVs growing potential and increased competitiveness.

Transport

Transport is a very indicating sector in an energy and environmental impact analysis, since its energy demand is near one quarter of the total energy consumption worldwide, with huge effects on our society carbon footprint, CO_2 and other GHG emissions. In particular, private transport sector (*i.e.,* the methods to move people by using their own relatively little sized vehicles like cars or motorcycles).

In this section, several different private transport methods are analysed and compared in an end-user perspective, with the main focus on the different propulsion methods like the traditional carbon-based ones (*i.e.,* gasoline and diesel cars) and the innovative solutions based on less CO_2 emitting electric propulsion (hybrid and full hybrid cars).

In particular, their technical features are investigated with main reference to a general performance evaluation of their energy demand, environmental impact and social acceptance by mean of suggested KPIs. The following table provides a brief over of some of performance indicators which relate to the four key performance indicators for private transport vehicles.

	Gasoline	Diesel	Hybrid	Electric
Polluting gas emissions gCO2/distance	150 g/km	100 g/km	82 g/km	0 g/km (65 g/km considering electricity production)
Technological Regime (Maturity of Technology)	High	High	Medium-High	Low-Medium
Market Share	45% (-5% 2009 to 2012)	Medium (+8% 2009 to 2012)	1.4% increasing	0.4% increasing

Figure 25: Private Transport Vehicles: performance indicators

Energy Technologies: final comments

A characterisation of current energy technologies demonstrates that fossil fuel based technologies and energy regimes continue to dominate across the different areas of the supply chain. In terms of technological developments fossil fuel technologies are the most mature and stable technologies. These mature regimes are largely more self-sustaining than emerging or maturing technologies as they benefit from the accumulation of larger pockets of knowledge and experience. This is a crucial element in the speedier development and diffusion of alternative energy sources. Technological efficiency requires user interaction and input. As argued by McDonald and Schrattenholzer (2001), maturing and learning with regards energy technologies is often not a function of time but a function of experience.

Furthermore, frequently very different levels of energy savings are reported in the literature for the same technologies, depending on a rich array of social parameters, including education, geographic location, income, social status, life-style, family stage and so on.

Wider practice based understanding on how people and technologies interact in sometimes complex ways are emerging from the literature. The useful depiction of technologies is enhanced by applying this knowledge to wider social, political and market based contexts which add further insights into how best to foster new bonds and forms of interaction which lead to the faster maturing of renewable energy technologies.

3.3 Business model perspectives

In Europe, the energy sector is a key component of economic growth and employment. By way of example, the renewable energy sector alone employed over one million people in Europe and created a turnover of around €143.6 billion in 2014 (EurObserv'ER 2015). Megatrends– such as energy availability and security, resource depletion, the technological revolution and urban development – affect and challenge the energy value chains in the energy system.

Indeed, Europe is positioning itself as a leader of the global energy transition after having set ambitious sustainability targets for 2020 and 2050 (European Commission 2011b). Indeed, measures and policies have been deployed to achieve these targets. In particular, the recent adoption of the Energy Union Framework Strategy (European Commission 2014), with the aim of fully integrate and the redesign the energy market, represents a major step ahead towards the transition to a low-carbon, secure and competitive economy.

Innovation in business models

Innovation has played a key role in the energy system but most of the time the term is misunderstood and confused with others like creativity, change, or invention. There are many definitions of innovation: The Oxford Dictionary of English defines the term innovate as to "make changes in something established, especially by introducing new methods, ideas, or products" (OED 2010). If we compare change and innovation, change does not need to have desirability and intentionality (Watson 1997), and the final result of a change can be positive or negative, while innovation must have a positive outcome, as it is supposed to add value to the customer.

Innovation is most commonly related to products because it is easier to think of a tangible product. However, it also appears at processes level used to develop new products or services. A parameter that allows comparing product, process, and service innovation is the degree of tangibility and the degree of interaction with the end user. Product innovation means innovating tangible products, with little interaction with customers, while service innovation normally involves intangible products with a high interaction with customers. Innovation in processes is right in the middle of products and services.

Business model innovation can support the creation of disruptive innovation that generally asks for new competitive approaches, for example, to lower prices or reduce the risks and costs of ownership for customers. In times of instability and crisis, companies generally reinvent themselves, rather than fostering incremental innovation or deploying defensive or reactive tactics in the market (Lindgardt *et al.* 2009). Emerging markets for greener products and the rise of sustainability are increasingly leading firms to integrate innovation in their decision-making process. Innovation aims to create both economic and environmental value, by replacing old practices. It allows companies to restructure their value chain and generate new relationships with the customer (Machiba 2012).

In order to provide a mapping of existing business innovation trends in the energy sector, the ENTRUST project undertook a desk-based study focused in six specific European countries (Germany, , France, Ireland Italy, Spain, and the United Kingdom), which entailed the identification and review of 145 energy companies (Boo et al. 2017). Following this initial mapping a further exploration and analysis resulted in the identification of a range and variety of business model patterns. These highlight the fact that innovation is happening across different areas of the energy system but that there particularly notable leaps in terms of business model innovation which merit further attention.

A classification of innovation

We have developed a number of key categories and sub-categories which provide us with a way to explore innovation patterns. We developed this framework based on two key pre-established frameworks. These were the “ten types of innovation” developed by Keeley *et al.* (2013). and the ‘business model innovation grid’ (Plan C vzw 2016). Figure 26 illustrates we have structure our classification (inspired by these previous models) into four overarching categories and eleven sub-categories.

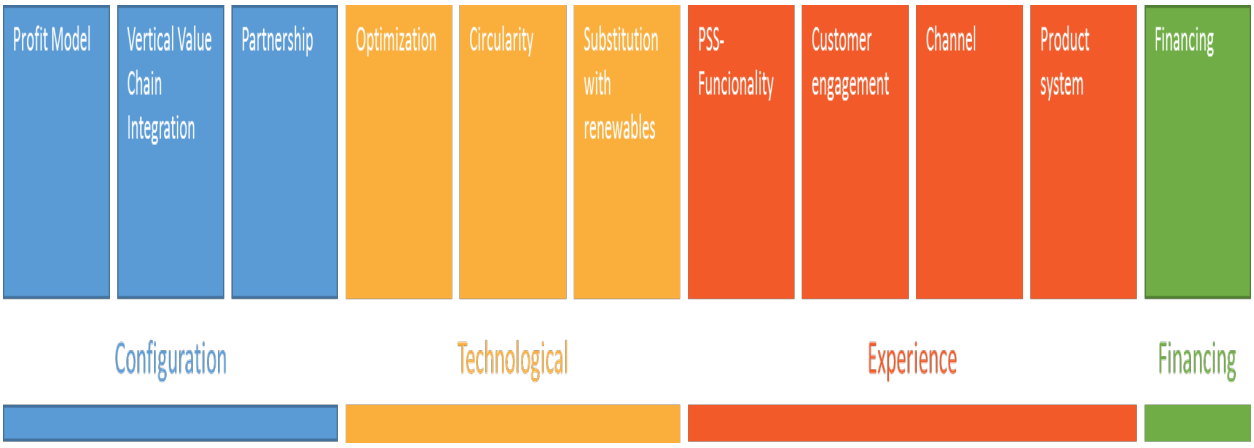


Figure 26: Classification of innovation

The schematic overview below provides a descriptive account of each category and sub-category. These categories are developed in terms of the form of innovation that it refers to as well and the schematic offers added detail in terms of how these innovations appear at different levels.

Innovation Schematic

Main category	Description	Subcategories
Configuration	Innovation in configuration deals with the innermost workings of an enterprise and its business system	**Profit Model** Finding a new way to convert a firm's offerings and other sources of value into cash. A good profit model understands what their customers cherish and where new revenues and opportunities are. **Vertical Value Chain Integration** It is an expansion strategy where a company adds business operations into different steps on the same production path. For instance, a manufacturer that acts as both supplier and distributor. This strategy helps to reduce costs, turnaround time, transportation expenses, and improve efficiencies. **Partnership** This type of innovation takes advantage of other companies' processes, technologies, offerings, and brands. The risk in developing new offers is shared between the partners. Firms can capitalise its own strengths but also exploit the capabilities of others. These collaborations can be formed between competitors or close allies.
Technological	Innovation may also come from the introduction of new technologies in an enterprise. In this case, there are three subcategories	**Optimisation** The aim is to do more with fewer resources while generating less waste, emissions, and pollution. Enhancing efficiency and improving resource use. **Circularity** The key idea is to turn waste streams into useful and valuable input to other production cycles and making better use of capacity. This innovation includes reduction of waste, creation of new business lines, and revenue streams **Substitution with Renewables** This innovation comes from the reduction of environmental impacts and increase business resilience by addressing resource constraints associated with non-renewable resources. Also, it implies the support on long-term energy supply with renewables and contribution to "green economy".
Experience	These four types of innovation are focused on more customer-facing elements of an enterprise and its business system.	**PSS- Functionality** Provide services instead of products that satisfy users' needs. It encourages right behaviours with manufacturers and users and potentially reduces the need for physical goods. **Customer engagement** Refers to understanding the needs of customers and users, and using inputs to develop meaningful relationships between them and companies. Customer engagement innovations improve customers' life, making them more conscious about the current problems of the energy system. **Channel innovations** used to gather all the connections between company's offerings and customers. *I.e.,* E-commerce has gained force in recent years. It also compromises all the new ways to bring products and services to customers. **Product system (integration)** focused on how products and services are bundled together to create a strong and scalable system. The aim is to integrate other ways of creating valuable connections between different offerings. Moreover, it fosters the creation of ecosystems that defend customers against competitors.
Financing	Refers to advances in the financial instruments and payment schemes used in the development of projects.	*No additional subcategories were developed*

Based on this categorization of innovation and on our identification of different innovation initiatives occurring across Europe a number of patterns have emerged. For instance, looking at energy supply and production, we observed that innovation is occurring at the new stages of the value chain such as storage and electric devices and appliances. Technological and configuration changes are the main trends that are shaping the current business models, in which interconnection and customer engagement are key.

The main barriers that the sector has to confront are related to the intermittency of renewables, balance of supply and demand, and the necessity of energy storage. In terms of deployment, the UK would appear to be leading in terms of development of novel business models. Business innovation on the building sector is occurring all along the industry value chain, starting with the re-design of project delivery models, energy performance solutions, and leading to deep renovation. The built environment paradigm shift is pulling building users at the centre of the ecosystem and therefore, service oriented business models are leading the way towards a greener building industry, in which cross sectoral collaboration is considerable.

In the industry sector, innovation is focusing on re-designing energy and resource efficient production systems and leading to extended producer responsibility in the form of remanufacturing, and recycling. In addition, circularity and optimisation are the main innovation sources. For instance, transport or urban mobility, the aim is at developing new mobility alternatives and digital infrastructure that enables their integration. Improving customer experience and creating new configurations are playing a fundamental role to achieve an affordable and sustainable urban mobility system, in which partnerships and customer engagement are also significant. From an urban mobility perspective, car-sharing services and real-time mobility are the main trends in all countries reviewed. Overall, several new forms of innovation are identified. These findings help situate the areas where most forms of innovation are occurring, whether they are tangible or intangible forms of innovation and the degree to which they challenge more traditional practices and processes in the energy system. This analysis highlights that emerging business models are innovating within the four archetypes proposed – configuration, technology, experience, and financing. Three subtypes stand out over others *viz.,* partnerships, PSS-functionality and customer engagement.

Partnerships between companies are enabling the developing of new offerings for customers. In addition, firms provide more and more services instead of products, encouraging right behaviours and satisfaction of users' needs. The last trend is customer engagement. Innovative business models foster the commitment of customers, making them more conscious about energy usage and consumption. While these have a social impact in terms of quality of service and perhaps reducing use. There are obvious limitations in terms of the development of new products and new visions which promote a shift away from current fossil fuel based energy system technologies. Financing of innovation also appears as relatively weaker than other innovation initiatives. Customer engagement can also foster more dynamic interactions which the energy system which makes a range of elements in the energy system more visible and more accessible to end-users. These by default further encourage learning and experience which as noted in terms of energy technology are an essential component in terms of a needed maturing process in renewable energy regimes. On this point, it is also positive that many innovation markets appear to be focused on looking at energy storage capabilities which is a vital component in promoting more widely renewable energy as a stable energy source.

However, end-users and consumers of energy are not always pro-active and neither are these interactions even or unfettered by external social and policies context. There are therefore potential limitations in the form of interaction that is promoted which seems to allow a greater control over energy consumption but nonetheless does not address these potentially problematic areas which can lead to growing incidence of energy poverty, greater responsabilisation for consuming patterns amongst others.

Conclusion

Despite all the technological advances, the deployment of green technological solutions is not increasing fast enough to meet Europe's ambitious goals to decarbonise the energy system. New market players are emerging from other sectors and the way in which energy services are generated, delivered and paid will be very different. In essence creating new energy landscapes and regimes. To do this global value chains need to respond and reconfigure existing structures to accommodate all new entrants.

Within this rapidly evolving scenario, **new business models** are often seen to be the **key enabler** for the adoption of any new technology, product or service. Business model innovations and in particular the creation of disruptive innovations, which overcome potential limitations by advancing new competitive approaches that re-shape existing energy system relationships and structures. By playing a performative role, business models frame and encourage the innovative behaviour of businesses and markets as well as their development and growth (Doganova & Eyquem-Renault 2009). As it will be seen in the following section, these ideas are supported and interpreted in various ways, depending on a range of social and political factors, at policy level which has resulted in a set of policies looking to strengthen the ability of the energy market to promote innovation.

3.4 Energy Policy

Another challenge to the energy transition is the acccepted complexity found at the intersections of energy-orientated governance structures and innovation (Lockwood 2014). While there are significant elements within any given governing architecture which impact on energy transitions there is no one model to ensure a faster and more reliable transition to a sustainable, secure and affordable energy system in Europe. In order to better understand these links and to identify crucial institutional forms in the promotion of innovation it was found that there was a clear need to has carry out an evaluation of the policy landscape in Europe, along with an assessment of the degree of Europeanisation in the national programmes of Member States towards fostering innovation and energy transition. Work carried out by Boo *et al.* (2016), Aze *et al.* (2016) offer detailed reviews of these themes. These can be read in conjunction with Morrissey *et al.*'s (2016) assessment of current innovations in energy policy, which has tended to focus on energy-related, behaviour-change initiatives; a key theme in numerous energy debates across Europe. Morrissey *et al.*'s approach was to focus on two core elements of the debate. The first explored evidence of political commitment towards reducing the costs of newer, more sustainable technologies, and to encourage innovative industrial processes that favour sustainability. The second identified particular initiatives and actions that support drivers of change and the subsequent shifts in governance. This work also included a review of key literature pertaining to energy transition and innovation (among other policy related themes), along with a desk-based mapping of

national polices, the regulation landscapes in France, Germany, Ireland, Italy, Spain and the United Kingdom, and the degree of Europeanisation in each of these six countries.

The European Commission's efforts to foster greater cooperation and a convergence of national support schemes, leading to more integrated approaches taken by Member States has been largely driven by a suite directives, regulations and state aid guidelines for environmental protection and energy. With regards to research and innovation, the Energy Union promotes the improvement of smart grid, smart home technology, smart transport networks, safe nuclear generation, clean carbon capture, reliable storage and carbon capture and smart use of technologies. At a strategic level, the EU recognises that current research and innovation systems are a long way from being fully coordinated or effective in combining EU and Member State programmes around common goals and deliverables. Elements within its strategy call for an integrated approach to funding and a greater exploration of how public procurement can exploit its potential to act as a catalyst for industrial and business innovation both within the EU and beyond its borders. To try and achieve a fuller implementation of these key objectives, most notably the EU's 2030 energy and climate targets, the Commission proposed an Energy Union governance regulation 2016 , which involves annual reporting to the European Parliament and the European Council on the state of the Energy Union to address the key issues and steer policy debates.

The most significant development in EU energy policy has been the Energy Union Package. Launched in 2015, it affirms and completes the liberalisation process begun decades earlier, and is based on five key dimensions:

1. Energy security, solidarity and trust;
2. A fully integrated European energy market;
3. Energy efficiency contributing to moderation of demand;
4. Decarbonising the economy;
5. Research, Innovation and Competitiveness

In responding to these dimension the Energy Union Package incorportes the European Union's Energy Security Strategy (2014); the creation of a resilient and integrated energy market across the EU (with new pipelines and power lines for gas and electricity) referred to as the Internal Energy Market; 2020 and 2030 energy strategies and a roadmap for 2050 (European Commission 2015a; European Commission 2011b). In November 2015, the first "State of the Energy Union" report demonstrated that there has been considerable progress made since the adoption of the Energy Union Framework Strategy. According to the European Commission, the Energy Union Framework Strategy has helped create the conditions needed to bring about the transition to a low-carbon, secure and competitive economy, which supports Member States in driving the transition to a low-carbon economy (European Commission 2015b).

According to Deloitte (2015), the 20-20-20 energy and climate package attracted much criticism in its early years for failing to bring into effect the expected results it had projected and for having numerous unexpected, or unintended, impacts on energy markets and the industry. At the beginning of the 2010s, many countries were more or less on track to meet their 20-20 targets and the EU as whole had made

considerable progress towards realising these objectives. However, the question remains whether this is due to dedicated policies or to external factors. In particular, the economic crisis of 2008 led to a steep decline in energy demand, making achievements towards energy policy goals look better than they otherwise might have been (Deloitte 2015). Improvements in EU business activity will no doubt rapidly push up CO_2 emissions and reverse the relatively positive trajectory that most countries have been on up to now *(Ibid.)*.

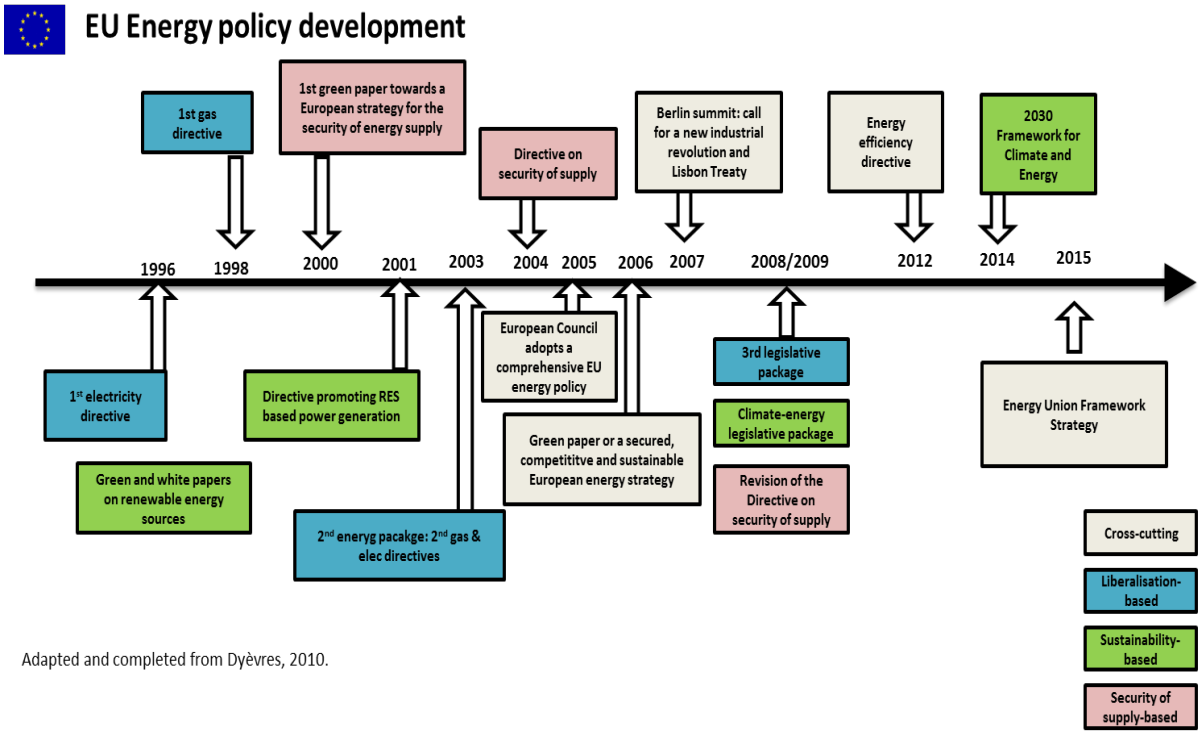


Figure 27: A timeline of EU energy policy development, from 1996 to present (adapted from Dyevre 2010)

The neoliberal model

Research by Kuzemko (2013a; 2013b) suggest that the current policy paradigms and institutional formations taskedwith driving the low-carbon energy transition have moved energy systems – in their current configurations – towards broadly neoliberal economic models. This has proven true across the European Union. In the latest development in the EU's common energy policy, the Energy Union package affirms and completes the energy market liberalisation process begun in the 1990s. According to Ranci (2003), liberalising the energy sector across the whole of the EU was the only realistic way to achieve an integrated market. This strategy has been central to the EU's energy-orientated policy making since at least as far back as the 1990s. However, tensions with the European Parliament and individual Member States has resulted in this liberalisation process taking a considerable length of time to complete. This liberal stance was not always compatible with Member States' national interests and during the first decades of European integration, the European institutions' ability to act was proven to be somewhat limited. Jegen (2014) shows how the liberalising of EU energy policy was achieved rather circuitously with the Commission managing to achieve its goals by referring to areas of key competences outside those directly linked to energy, and in the process inscribed its power by way of new directives and treaties, encapsulating its objectives under the "Competitive, Sustainable and Secure (CSS)" energy market framework. Jegen and others estimate that the

CSS framework has been so successful because it was taken over and incorporated into the everyday discourses of national policy makers (Jacquot & Woll 2008; Jegen 2014).

A notable component of this strategy has been its relative ambiguity, which has allowed national actors to emphasise the specific elements that were congruent to their own national interests (Chester 2010). This has resulted in different degrees of institutionalisation of the CSS framework being adopted by the various member states. An example of this incongruity can be seen in Ireland's policy strategy, which adapted its energy policy strategy to very closely match the goals of the CSS framework, stating that "the three key pillars of Ireland's energy policy are security, sustainability and competitiveness". France, Italy, Spain and the UK have not made such an explicit reference to the CSS framework. However, their national plans on energy more or less emphasise the link between energy and competitiveness and also comply with EU directives.

This emphasis on adopting (neo)liberal economic approaches as being the most efficient interpretative framework for energy transitioning has proven controversal and, in many ways, it has proved somewhat counterproductive. While proponents of neoliberal economic instruments including Deloitte (2015), have praised the third EU energy and climate package – referring to it as being based on strong liberal principles that produced unexpected and unintended outputs – other commentators are not so sure. Kuzemko (2013a; 2013b) contends that neoliberal economics has resulted in conflicting relationships between policy-makers and companies, which have proven to be counterproductive to attempts to establish an efficient energy transition (Boo *et al.* 2016).

The "models of capitalism" approach (Crouch 2005; Bresser-Pereira 2012) proposes a differentiated view on how institutions are subject to neoliberal economic paradigms with regard to the energy topic, with relationships existing between different energy governance institutions and the wider economic governance structures (Schmidt 2002). For Lockwood (2014) models of capitalism are deeply embedded in institutions, while (Hall & Soskice 2001) differentiate two models of capitalism into Liberal Market Economies (LMEs) such as the UK and Ireland that rely on market competition and an emphasise individual action or Coordinated Market Economies (CMEs) such as Germany where the State plays a greater role in shaping the economy with an emphasis on collective over individual goals, and non-market modes of coordination are important, including more extensive collaborative relationships. Institutions shaped by these two capitalism models have different approaches to governing low-carbon energy transitions (Lockwood 2014) with the following consequences:

- CMEs are better at incremental innovation while LMEs are better at radical innovation. Following this, it comes that CMEs are better at strengthening niche innovation, and therefore are better able to support innovative low-carbon technologies *(Ibid.)*; while
- CMEs are better than LMEs at innovation aimed at sustainability because industry and government are able to reach consensus on goals through deliberation while LMEs have to rely on arms-length regulation that industry will seek to game and erode (Mikler & Harrison 2012).

Such assessments are interesting they are consistent with the findings from Boo *et al*. (2016) who suggest that Germany leads the way, by a good margin, towards realising a sustainable energy transition. In addition, Germany's current *Energiewende* programme is less related to the EU's CSS framework than say that either

the UK's or Ireland's current energy strategies. This suggests that Germany has a differing interpretation of wider neoliberal policy frameworks, in this terms of energy policy at least, than those found in countries like the UK and Ireland.

Europeanisation as a tool for measuring energy transition policies

An approach taken by Aze *et al*. (2016) has been to look at the degree of Europeanisation in the national policy dialogues of Ireland, France, Spain, Italy and the UK to see what might be learned from studying the continued alignment of each countries' political frameworks towards what appear to be converging neoliberal economic models in relation to energy. The authors also assess the role greater Europeanisation has had in strengthening or weakening the energy transition pathways of these Member States, by way of the market driven approaches taken by each. Potential inconguences, in terms of each country's Europeanisation approach, include: differences in political orientations, institutional structures and models of capitalism in place. These all have an impact in terms of the replication of successful national policies. Despite the differences in macroeconomic approaches taken in the different Member States Aze *et al*. (2016) go on to identify a number of key success factors in each of the member states they studied, which are outlined in Table 6 below.

	Key success factors leading to potential for replicability
The sustainable Development Tax Credit – France	- Wide area of application: households, businesses and industrial sector - Wide variety of renovations - Smooth coordination - Regular updates on technical developments - Unique interest rate - Communication among stakeholders
Special fund for energy efficiency in SMEs – Germany	- Two programmes addressing lack of expertise/awareness and financing - Low threshold access - Support from regional partners - High quality of the audits - Transparent financing structure - Selection of applicants – prioritizing those with low expertise on energy efficiency - Interest rate adapted to ease private sector investment
The Renewable energy feed in tariff – Ireland	- Ensuring sufficient profitability for the investment - Inherent versatility: in terms of application and design - It reduces the economic risks to RES-E producers - Long-term and stable policy environments - Take into account varying electricity costs of different RES-E technologies to avoid rent seeking by producers - Transparency of the instrument - Avoid complicated pricing structures and administrative burden
White Certificates – Italy	- Avoid overlapping with other incentives - Adapt the instrument to EU changes at international level and to the evolving energy objectives - Target new technologies that cannot be supported other ways - Monitor the value of the certificate in the market

	Key success factors leading to potential for replicability
	- Complementarity with other instruments as tax deduction schemes, guarantee funds or incentives for interest
Urgent measures to face emergency in housing and energy poverty – Spain	- Context of deep economic crisis, large unemployment rates, social exclusion and increasing fuel poverty - Strong commitment at regional level of all actors involved: government, local authorities, citizens and suppliers - Good communication among stakeholders - Active participation of citizens
The Climate Change Act 2008 - UK	- Outline a comprehensive national strategy to address climate change - Establish long-term, achievable targets for GHG reductions - Ensure the adapted carbon budgets to support the ambitious targets - Independent body to support UK government on the Act deployment with technical expertise - Periodic reporting on mitigation and adaptation programme – duty on the Secretary of State for Energy and Climate Change - Empower administrations with flexibility to set their ETS systems through secondary legislation (replicability with similar structure – union of nation states) – reviewed by the independent body - Large scope including wider industries and its related sectors, to have a comprehensive approach - Coherent and stable policy on climate change for many years

Table 6: Key success factors of national policy documents

All the highlighted policies have been successfully implemented in their national contexts and, given their adherence to good practice models, could be rolled out in the other jurisdictions with little friction, therefore offering a strong potential for replicabilty. Advances in technologies and communication between the European legislative machine and its national counterparts suggest that it should be easy to transpose EU legislation and the foster replicability of successful and innovative initiatives through the provision of integrated guidelines, targeted supervision and applying best practice in line with local considerations. For instance, access to information about the barriers other member states may have encountered and how they overcame those barriers could be beneficial to the whole process. Overall, even if the Member States' energy systems are to some extent integrated, they are not sufficiently so in order to effectively tackle global challenges such as energy security, climate change, and the transition toward a low carbon economy. Overcoming these obstacles requires a meaningful, coherent and comprehensive EU energy policy that is shaped through Europeanisation (Aze et al. 2016).

What Aze *et al*. (2016) also found was that the main contribution of Europeanisation to the energy transition, and innovation more generally, has been in the framing of the space in which Members States have driven the transition of their respective energy models – integrating components of the Competitive, Secure and Sustainable (CSS) and Energy Union frameworks into their Policy and Legal Systems (PLS), for instance. Nonetheless, the dynamics of the Europeanisation process should not be regarded as unique for driving the energy positioning of member states. National factors and international events can appear as significant game changers, impacting directly on the national energy strategy of individual member-states. Although the current European energy strategy seems to offer solutions to the these challenges, Aze *et al*. (2016) suggest

that it may be too early to formulate any conclusion about its effectiveness. Nonetheless their study has identified a number of potentially useful policies that may easily be replicated elsewhere.

Morrissey *et al.* (2016) identify and characterise behaviour change initiatives by referring to the factors that contribute to their (relative) success in influencing energy actions. They indicate what has worked in practice, and highlight the common enablers and barriers attributed to a range of behaviour change initiatives implemented across five European countries (France, Ireland, Italy, Spain and the UK). Behaviour, practices and culture are increasingly recognised in the literature as constituting a powerful human dimension in the energy system that can no lonegr be ignored, most notably the interactions between technologies, practices and norms that lock individuals into certain patterns of (often inefficient) energy use Morrissey *et al.* (2016). Moreover, with over one-third of many developed nations' carbon emissions attributed to domestic energy use and private travel, both individuals and communities are seen as having a key role to play in the transition to a low-carbon future (Whitmarsh *et al.* 2013). As a result, there has been an increasing focus on behaviour change research, particularly on the social contexts in which people live, the routines which shape behaviours, and the extent to which people feel empowered to change their own and their households' behaviours.

Morrissey *et al.* (2016) looked at a range of case-studies across the five European countries mentioned above in an effort to identify and appraise the range of behaviour initiatives being developed in each, and the role these initiatives plasy in promoting and sustaining innovation on the energy system. A total of fifteen case study explorations were carried out and from these six broader types of interventions were identified, *viz.,*

- Community-based peer-to-peer interventions;
- Information & advice based interventions;
- Eco-district area based interventions;
- Open home show-case events;
- Collective energy switching;
- Smart-technology focused interventions.

Innovation in relation to behaviour change initiatives can be looked at at different levels. For example, the development and ongoing maturing of smart-technologies is seen as valuable to the ongoing promotion of innovative services such as personalised customer feedback and information sharing Morrissey *et al.* (2016). Regional differences in terms of geography, topography, grid infrastructure, seasonal issues and human factors are seen as potentially easier to reconcile using smart grid technologies. Energy service enhancement, addressing some of these differences, are now an emerging component of behaviour change interventions. The focus on enhanced and innovative consumer services is consistent with the findings of Boo *et al.* (2017) which showed that emerging business models and innovation ideas are largely focused on the development of services which enhance consumer experience and promote behaviour change. Morrissey *et al.* (2016) also found that peer-to-peer learning initiatives can potentially offer innovative ways of educating and persuading consumers to change their behaviour through the promotion and normalising of alternative energy practices.

Morrissey *et al.* (2016) approach to select a large proportion of the intervention case studies on the basis of how they engaged with individuals (typically households) on energy consumption behaviour change is notable here. Other cirteria included selecting those that engaged in promoting behaviour change on their own, to others that fostered engagement by encouraging both behaviour change and energy efficient retrofitting (technology adoption), or indeed to those that were technology and/or building focused in order to deliver energy conservation goals. Consequently, a large proportion of Morrissey *et al.'s* (2016) case studies sought to target the individual context of behaviour change. A conclusion the authors note as significant is what most do have in common, which is that any given intervention – despite having individual core approaches – cannot rely on a single tool but very often may need to supplement with multiple tools; that again, typically may include some form of technology adoption and user behaviour change. This is a well-known approach to encourage behaviour change, by blending interventions and initiatives to sustain meaningful pro-environmental actions (Abrahamse et al. 2005). Also, one should also note the complexity found in energy consumption, for example, has resulted in interventions having to respond to multiple factors influencing everyday energy consumption.

Another interesting energy-orientated policy development has been the growing number of market-orientated, price-based and quantity-based instruments currently being rolled out to incentivise potentially more sustainable, customer practices and behaviours. Work from Salel *et al.* (2016) suggest that policy instruments have an important role to play in driving change, with recent instruments such as national certificate trading schemes (e.g. Green and White certificates), GHG emissions allowances and feed-in tariffs all designed to address specific environmental issues around energy use. While policy makers have had a much longer experience implementing price-based instruments to drive behavioural change Salel *et al.* (2016) suggest that quantity-based instruments also have significant potential for driving change. The authors demonstrate that price-based and quantity-based instruments can be applied in parallel to address global issues such as GHG reduction. For example, the EU Emissions Trading System (EU ETS) – a cornerstone of European climate change strategy – is defined at the EU level and, along with carbon taxes managed at the national level can do a better job of impacting on "out-of-the-scope" sectors than if they were to operate on their own. Such approaches do need to be coordinated quite closely in order to short-circuit unforseen inefficiencies from emerging. Again, returning to Salel *et al.* (2016), they offer the example where an increase in carbon tax may convince stakeholders to switch to more energy-efficient technologies, in turn leading to an overall redcution in GHG emissions. However, the subsequent increased availablilty in GHG allowances – as a result of this switch – may lead to a drop in the market value of GHG allowances with investors seeing greater value in trading the GHG allowances over investing in more energy-efficient techologies. Consequently, both insturments become inefficient or even counterproductvie. Such a scenario is quite possible if there is an absence of close monitoring and control by those in charge of such policy instruments.

3.5 Energy and the citizenry

3.5.1 Introduction

The energy system is the most important socio-technical system that exists in the industrialised West – so important that society as it is could not exist without it. The entire development of the modern Western Society: industrialization and the mass production of both goods and food; mega-urbanization; technology;

modern infrastructure and transport, education, and the modern medical system; mass media, and so on. In fact, the totality of society itself and how it has evolved, would not, and could not, have happened without the energy system. Undoubtedly the energy system is a technological system – it is laden with energy infrastructure such as electric power stations and powerlines, solar and wind farms, and pipelines carrying oil and gas across continents and countries to towns and cities, and into people's homes. Both outside and inside the home, the energy system literally powers the way that way that people live their everyday lives. Without the energy system, modern lifestyles – for people in all socio-demographic groups – would simply not be possible. The development of the energy system, its infrastructure, and the rest of Western society has been built on the use of fossil fuels. While the consumption of fossil fuels has provided us with the means to live as we do, it has also had a calamitous effect on the Earth's climate. We all rely on the energy system, yet for something so necessarily intertwined with people's entire lives – literally from cradle to grave (or, perhaps more appropriately, crematorium) – it is in many respects, invisible. The energy system is so entrenched in people's lives, that it seems simply unimaginable that life could continue on without it. And it is a fact that people really don't imagine life without it.

The energy system is also a human system. Not only is it designed by humans, built by humans, and used by humans; the energy system is now part and parcel of what it is to be human – energy practices subtend almost every aspect of people's everyday lives, and they make modern lifestyles not only comfortable but possible. The evolution of the energy system has happened in tandem with the evolution of modern societies. Since the 1800s, Western society has developed entirely in conjunction with the development of the energy system, and Western society is clearly inextricably intertwined with the current configuration of that system. Every aspect of people's lives intersects with the energy system – from the alarm that starts the day to the phone it goes off on, the morning shower, breakfast, transport to work or college or school, the food people eat, the television that is watched in the evening, the heating that warms people's homes, and the light to read by, *etc. etc*. In fact, from birth to death, it is hard to think of any area of life that is entirely separate from the energy system. Yet despite its ubiquity, and despite the fact that modern life cannot proceed without it, or maybe even because of its ubiquity, people have a very complicated relationship with that energy system – it is ever present, yet almost invisible.

3.5.2 Energy and the Making of Place

While it is clear that the energy system is inextricably interwoven with human society in the industrialised West, and that no aspect of modern life proceeds without energy – whether in people's homes, in their workplaces, in their travels, or in any aspect of their daily lives, yet, in many respects, the infrastructures of energy production and transportation are usually largely invisible to the majority of the population. For the most part, people are happy to travel to work by energy-driven transport, and to come home to turn on the lights, to turn on the oven, open the fridge, turn on the television, and to use any of the material goods that provide their homes with comfort. Moreover, the energy we require is constantly available – literally at the flick of a switch, or the turn of a knob. The apparently seamless existence of energy – electricity in particular – in the lives of people, and in homes, renders it almost not just invisible, but almost imperceptible. In fact, energy infrastructure is often made "present" in people's lives by its absence – during an electricity blackout caused by storm-damaged power lines, for example, or the "oil crisis" of the 1970s, sometimes even a nuclear

disaster; it is only as a result of these type of events that the existence of energy infrastructure enters people's consciousness in a significant way. This invisibility of energy has consequences for the change to renewables. People do live with and beside energy structures – energy structures are our neighbours. However, just as with human neighbours, there are good and bad neighbours, and some people have happier relationships with their neighbours than others. And neighbourly relationships between people and the energy system have come under a range of pressures – depending on where it is people live, and what type of energy-neighbours are moving into the neighbourhood. The required shift from intensive electricity production to dispersed production has a significant impact on some communities in particular. With the roll-out of renewable energy, the 'energy-neighbours' have often become much visible that they were.

Renewable sources of energy production are highly visible on the landscape, in a way that the older fossil-fuel and nuclear power stations are not. Not only are wind turbines and solar farms highly visible, the installation of new grid connections linking the renewable sources to transmission points are also new visible intrusions on the landscape, however the social costs are largely born by those who do not benefit from the installation of this infrastructure, mainly in rural communities.

Attitudes towards renewable energy sources (RES) varies both within, and across communities. Overall, there is overwhelming support for the development of RES, solar and wind in particular, however, the uneven impact of installing RES infrastructure was implicated in the attitudes that people expressed. Despite overwhelming support for the development of RES across all communities, it was clear that for those for whom RES was a contentious issue, the problem primarily lay with their disenfranchisement from decision-making processes. Communities feel disempowered: they are not consulted when it comes to the installation of RES infrastructure, and decision-making is taken at a remove from the community.

Across all communities, there was a clearly expressed desire to take fossil fuels out of the energy system, and people clearly want to be more energy independent, to produce their own hot water for example, where possible. While there was very strong support for the installation of RES at both commercial and domestic levels, there was less support for the installation of RES energy infrastructure and the resulting changes in the landscape in communities where they are placed as a result of the lack of both consultation, and the lack of any benefit accruing to the communities upon which RES infrastructure is imposed. But for most people carrying out their everyday lives, the energy system is simply there. People tend not to think about where their energy comes from, or how it is produced – unless some specific issue bring it to their attention.

One energy concern was constant across the communities – concern for the price of energy, and electricity in particular. As with an electricity blackout, the arrival of utility bills effectively makes energy "visible" in people's lives. Although, it was clear from our community engagements that people seem generally unaware that they are paying towards the moving costs for the new RES 'neighbours' – as was evidenced by the general lack of awareness people have that they are paying added tariffs in their energy bills for the development and roll-out of RES. Although it was the case that some people – who had the choice – were happy to opt for a more expensive RES electricity supply, where it was available, for ethical reasons.

3.5.3 Energy and the Making of Home

Energy is an integral part of how people create home. Home, for many people is their haven, and it is a haven that is heated and lit, and made comfortable with all the material goods that the energy system provides – both the power to operate the machinery of home, as well as the machinery itself. There is little desire evidenced by people to change how they live with energy system in their everyday lives. People also demonstrate little awareness of the connection between the infrastructure and supply elements of the energy system and the energy people consume to live their everyday lives – unless it is made manifest by its absence in the case of a power failure, for example.

To a great extent, for many people, their energy practices are about the making of home. Home is the space where we live our private lives, whether alone, with family, or with friends, and it is everyday practices that produce home. Home is where we carry on the intimacies of living, and perform the domestic tasks that are needed to support living our everyday lives, both inside and outside the home, where we care for the self, and for others through the performance of everyday energy practices – cooking, cleaning, washing, heating, and so on; as well as entertaining and being entertained. Everyday energy practices, and domestic practices in particular, deeply enmesh people within the energy system. That notwithstanding, many people do not seem to connect what happens in the home with the energy system outside it. There is no indication that people are aware of the potential for the transition to an energy system based on RES to impact on either on the energy system itself and on how they consume energy. That notwithstanding, there are significant limits to the potential to reduce the consumption connected to the performance of everyday domestic practices in the home, as is explained below.

In the context of domestic practices, it should be recognised that while material objects or technologies are highly relevant to the evolution of practices, they are not sufficient to explain the evolution and ubiquity of a specific practice. It is the case that some domestic practices are not only highly symbolic, but are, of necessity, deeply entrenched human behaviours which may explain their perceived resistance to substantial change, while clearly there have been changes in these practices over time (Douglas 1966).

Cooking, cleaning, and personal hygiene/grooming practices are ubiquitous across all cultures. This is unsurprising, given that all are necessary for human health and survival. While the details and elements, including the material resources, involved in these practices clearly differ from one era to another, one society to another, and within societies, from one social group to another; and the practices involve a variety of cultural norms and customs, nonetheless the practices themselves, whatever their norms, are present in every society. With regard to food preparation and cooking, people cook in every society – human beings require cooked food in order to provide the high calorific requirements for human survival, as cooked food provides more calories that raw foods, when the calorific 'spend' digesting food is taken into account (Wrangham et al. 1999). Cleaning is required for any domestic setting in order to produce and maintain its habitability, and while what is considered 'clean' is culturally, and historically, variable, nonetheless norms of cleanliness are a cultural constant (Douglas 1966). Maintaining personal hygiene and grooming is necessary for bodily health, although, again, there are considerable cultural and historical variations of what is considered optimum with regard to the social norms governing these (Lupton 2003).

However, what should be recognised in the analyses of practices, particularly within the energy research domain, is their symbolic aspect. It is necessary to understand that there is a deeper significance to everyday practices as it is this aspect that is particularly relevant when it comes to the issue of changing practices. The performance of everyday practices are particularly relevant for our sense of identity, and our sense of 'moral' worth, that is in being a 'good' person, a good woman, a good man, a good mother, a good father *etc.* The norms and values that people hold are not formed in a vacuum, but reflect those norms and values that are held in one's culture and society, and by one's peers. Practices are bound up in these norms and values also: practices "logically and historically precede individuals" (Røpke 2009, p.2493). The gendering of specific domestic practices logically and historically precedes individuals too, although, as is shown below, just as practices evolve over time, so too does the gendering of specific practices also.

It is important to recognise that practices are not the subject of great reflection by those who carry them out, they are so embedded in our everyday lives that they are not something that people think about most of the time. They are seamlessly woven into the living of everyday life where they in effect subtend to the accomplishment of successfully living those lives. Household energy practices, in particular, are performed in order to provide for our bodily needs and in so doing they also provide the basis for our personal and social lives, and all other aspects of everyday living. Many aspects of practice, how laundry is done, how homes are lit, the pattern of switching on lights and televisions *etc.* for the evening, and switching off, become somewhat routine and automatic procedures for most people. While practices are often categorised in terms of the activity itself – doing laundry, showering, travelling, home-heating, as well as in terms of what they provide – comfort, cleanliness, and warmth, clearly, they are serving another service too – in performing these practices, people are *creating* home. Home is not simply a house or apartment as such, it is more than a physical space – it is connected to relationships, emotions, and identity (Mallett 2004).

3.5.4 Living with the neighbours – large-scale energy technologies

Institutional, structural, market and political factors are forging specific interactions with energy production and energy sources. Debates focused on energy innovation social acceptance models introduced by Wüstenhagen, Wolsink, & Burer have sought to develop a greater understanding of energy diffusion practices by expanding on largely techno-centric approaches to energy innovation and public acceptance of same (Wüstenhagen et al. 2007). They suggest that social acceptance of energy innovation is linked to three key dimensions: (i) socio-political acceptance; (ii) market acceptance; and (iii) community acceptance (Dunphy, Revez, Gaffney & Lennon 2017). The findings indicate that RES has entered the public consciousness, and receives a high level of support across all demographics and across all communities, however, the infrastructure of the energy system and the potential difficulties associated with intermittent energy production that can be associated with RES, remains largely outside of people's awareness. What does bring the energy system infrastructure to people's notice are the changes to the landscape that result from the development of RES, however, the imposition of large infrastructure without community engagement and participation leaves communities feeling disenfranchised and powerless (Dunphy, Revez, Gaffney & Lennon 2017).

Increased distributed generation requires the installation of additional wind and solar farms, with stronger interconnections between big power and heat plants and building individual solutions, to avail of the

potential for a two-way flow of energy based on the energy demand variations during the day and on the peak-load periods associated with renewable energies (Landini et al. 2016). The electrical grid needs to be amplified and upgraded to sustain frequent changes in electricity direction and power levels. Natural gas pipelines will also see a similar process of development to allow for changes in gas flow direction during particularly cold winters (Landini et al. 2016). These infrastructural changes will have an uneven, but significant impact on some communities. In order to avoid the unhappy past experiences of communities living with the imposition of energy infrastructure, policy and consultation issues will need to be addressed through improved community engagement in order to avoid community resentment and the consequent delays. With regard to other infrastructural elements, it is also clear that while the necessity for energy storage facilities have become increasingly important due to the intermittent nature of the renewable energies such as wind and solar (Landini et al. 2016), there is little awareness of the increasing necessity for the installation of such infrastructural elements (Dunphy, Revez, Gaffney & Lennon 2017).

Previous research demonstrates that public attitudes and acceptance of energy technologies are heterogeneous and often confined to smaller groups of people with distinct socio-demographic characteristics (Devine-Wright 2007; Rijnsoever et al. 2015). However, while analysis suggests that social aspects such as gender, socio-economic privilege and age may have a role to play in attitudes, there are no explicit patterns linked to any socio-demographic group outside of the attitude towards nuclear energy where a clear gender bias against nuclear energy from women was apparent – notwithstanding the fact that nuclear energy was highly unpopular across all socio-demographic groups, even in France. There are considerable gender differences on the question of government investment in nuclear energy, where men are five times more likely than women to give priority to nuclear energy, albeit that the total numbers in favour of state investment in nuclear energy were small – accounting for a very modest 6% of the respondents concentrated in two of the six case-study communities: Le Trapèze in Paris and the cohort of students in Ireland. However, overall support levels for nuclear were extremely modest. It should also be noted that nuclear was not favoured over other energy technologies in any community, and was accorded the highest number of lowest preferences by both females and males alike, although women disliked it most (Dunphy, Revez, Gaffney & Lennon 2017).

The analysis of the data suggests that public attitudes towards renewable energy are often constrained by market dynamics which are seen to discourage the uptake of new technologies. Equally the lack of innovative governance models which would guide a transition and offer stable and equitable models for the production and consumption of renewables is a factor which respondents have highlighted as negatively affecting their views of alternative energy sources. For instance, the problematic imposition of the 'sun tax' in Spain (Aze et al. 2016) was highlighted by many of our respondents in Vila de Gràcia, and it was articulated as a problematic obstacle to the development of RES due to a lack of political coherence around the promotion of cleaner energy sources. Within every community some members are aware of the potential value of renewable energy as a potential resource for the local area, however, they identify political, structural, and financial barriers to developing it at a local level (Dunphy, Revez, Gaffney & Lennon 2017).

The prominence of the themes of (in)visibility and control over the energy system demonstrate that public participation and inclusion can have a substantial effect on how people perceive emerging technologies. In

the first instance these findings remind us that transitions from one source of energy to another need to be carefully managed. Fossil fuel energy production, distribution and consumption has become largely normalised in our societies and this accounts for the (in)visibility that is often associated with the way people consume energy and relate to the energy system. This (in)visibility has a range of socio-political implications as it strongly suggests that individuals and communities currently have a minimal role to play as citizens in the development of the energy system – which is reflected in citizens' sense of disenfranchisement. Regulations, policies and the deployment of energy technologies have largely been restricted and reliant on expert based inputs and in the process have reinforced and even promoted a more passive attitude toward energy production and consumption. The decoupled manner in which energy issues are often portrayed in policy, in terms of separating technical and social factors, reinforces the misconceived notion that these are indeed independent entities. This is a problematic approach which routinely marginalises social factors in favour of technical based approaches (Whitehead 2014; Luque-Ayala & Silver 2016). However, emerging research has provided compelling arguments that demonstrate that energy grids are not apolitical structures, and further that the social experience of energy is indeed shaped by material energy (Luque-Ayala & Silver 2016).

This range of experiences demonstrates how the energy landscape can be structured by social factors such as divides on the basis of socio-economic privilege. Notably, the UK community in Stockbridge where a Biomass heating system was imposed on social housing residents. Our engagement with the community strongly suggests that this new source of energy thus becomes of new form of exclusion, disempowering and subordinating people's wellbeing to ill-conceived and socially blind policies. This is in keeping with our survey results, which show Stockbridge as the community which has the lowest ranking in terms of confidence in renewable energies (Dunphy, Revez, Gaffney & Lennon 2017). This is interesting if we compare the attitudes of respondents from Stockbridge with those of the community in Le Trapèze (eco-neighbourhood) which also has considerable experience of recent implementation of new energy technologies. Both neighbourhoods have expressed concerns and un-met expectations with regards these technologies however the shortcomings identified in Le Trapèze were not articulated in terms of hardship and privation whereas in Stockbridge this was a key concern for households. The key characteristic which distinguishes these two communities is the level of socio-economic privilege. Le Trapèze is an affluent community where the majority of the residents are relatively wealthy and well educated. Stockbridge on the other hand is a neighbourhood with a very high welfare-dependency rate where a large proportion of the residents are dependent on state subsidies for their livelihood. Therefore there is a much greater degree of financial resilience and adaptability in Le Trapèze, features that are much lower in Stockbridge. This affects how transitions are perceived by each community and how shortfalls in terms of performance can be reconciled with existing social and financial circumstances. Conversely, solar energy while it is positively perceived as a clean technology and favoured as a potential alternative to fossil fuels across all communities, it is also largely seen as unattainable for many participants, and its installation and use is largely associated with more privileged households and communities. This issue was further aggravated in the Vila de Gràcia community in Spain where controversial energy strategies have tilted from policies which encouraged the private installation of solar panels through grants to a sizeable shift in approach which now looks to tax the households for the use of this form of energy. This lack of coherence has proved detrimental with regard to attitudes to renewable energies.

In the energy justice literature, distributional unfairness is frequently linked to problems with decision-making processes that, for instance, are seen as excluding certain parties or lacking transparency (Liljenfeldt & Pettersson 2017). For example, in the Irish rural community, wind energy was a contentious issue with regard to planning. While there was a high level of support in this community for wind energy, as such – what was lacking was meaningful community consultation, and the need for community empowerment with regard to the planning process. In Spain, the troubled policy history on energy pricing surrounding the development of the solar energy industry there was the subject of much discontent. Again, people felt disenfranchised from decision-making, and felt powerless to exercise their will against the power of both State and energy companies. There is a strong perception in communities that people are rendered powerless by policy-makers, planners, and the energy industry, yet, there remains a strong desire amongst some participants to be able to attain some level of energy self-sufficiency, and, at the very least, to be able to have a degree of choice over their energy supply.

3.5.5 Living at home – locating domestic energy practices

Exploring the positions and complex intersections of the energy system actors, it is clear that while communities and domestic energy consumers are obviously part of the system, they are 'located' in a largely peripheral position vis a vis the energy system as a whole (Dallamaggiore et al. 2016). Moreover, with regard to the energy actor discourses that have a significant influence on the system, its evolution, and its transition that here too the discourses of communities and domestic end-users barely feature, with the result that communities and domestic consumers have little influence or effect on the macro energy system – apart, that is, from the large share of overall energy consumption that households are responsible for. The relatively peripheral positionality of communities and individuals has a significant bearing on the potential for a successful transition to sustainability. Participants across all the communities expressed that sense of detachment from 'power' and decision-making on the macro scale in the energy system (Dunphy, Revez, Gaffney & Lennon 2017). They expressed discontent with the limited, if any, control they have over the energy system, particularly with regard to the perceived dominance of powerful energy interests and lobbies on how the energy system is structured, regulated and operated, with their interests taking precedence over the interests of the domestic consumer.

Yet, a key factor for the successful transition to a sustainable energy system will be the actions of ordinary domestic energy consumers, and their willingness, capacity, and ability to make changes at both the domestic and community level to their consumption of energy. There is a clear case for the argument that in order to progress the successful energy transition to sustainability, the inherent contradictions at play regarding the status of the domestic consumer will have to be resolved. The position and relative lack of power of the effectively disenfranchised domestic consumer with regard to the broader energy landscape contrasts strongly with the desired evolution of the active consumer into the putative proactive member of the smart grid of the future envisaged by policy makers and energy providers. In this 'techno-epistemic network' the management of domestic energy practices are regarded as an integral factor for optimising the smart grid of the future, yet the putative benefits for the end-user are contested (Ballo 2015). This issue is discussed further in the section on Smart Meters below.

With specific regard to the policy domain, at both the EU level, as well as in national policy-making the thrust of the policies that have been directed at reducing domestic consumption have focussed on lighting, heating, and cooling incorporating technological regulations and energy-rating labelling systems for domestic appliances, heating, and lighting, as well as introducing building standards for new builds, retro-fitting existing buildings, policies on installing district heating, as well as the roll-out of smart meters across Member States. Focussing on the domestic energy sphere it is clear that some techno-political innovations have been widely accepted and have proven effective – for example, the technological evolution of low-energy lighting combined with the policy-driven regulations on the phasing out of high-energy luminescent bulbs and replacing them with low-energy options instead. Across all the communities, participants listed replacing the traditional tungsten bulbs with CFLs as an energy saving change they had made, some were interested in the most efficient LED lighting, but found the costs prohibitive – a barrier that should weaken as the financial costs of technologies follow the typical trajectory and become more affordable with up-take as is the case with solar PV.

The energy labelling system has also proved effective. Participants considered the energy-rating of domestic appliances to be an important factor to be taken into consideration alongside price, when they were purchasing them. Socio-demographics were a factor in participant's ability to exercise choice in these, as well as other energy related matters – energy poverty is a significant issue that cuts across all aspects of living in the energy system, and it is of particular significance in this regard. For those already living in energy poverty, making the choice between the immediate purchase cost of the appliance and the impact of the level of energy efficiency on their energy costs was a difficult one, no matter what their housing arrangements were. For those participants who were tenants of private landlords, as with their lack of choice regarding their energy provider, they had little choice with regard to the energy-rating of domestic appliances, or their replacements either. As a result, they can find themselves paying energy costs at the highest tariff with the least energy-efficient appliances. The absence of control for tenants over such significant factors that impact directly on their energy consumption costs severely limits their agency for reducing both consumption and cost, and significantly exacerbates their potential for experiencing energy poverty (Dunphy, Revez, Gaffney, Lennon, et al. 2017; Dunphy, Revez, Gaffney & Lennon 2017).

Another widely accepted and supported technological development is the retrofitting of buildings, especially installing insulation, and improving heating systems. Initially driven at EU level, and incentivised with financial supports in some member-states to support the retrofitting of existing housing stock, this policy development and implementation has reduced domestic energy consumption for heating in the member-states, as well as improving the quality of life, and health, for domestic residents. Retrofitting makes financial, environmental, and social sense and remains the number one most cost-effective means of reducing carbon emissions per euro of investment. In particular, installing insulation is a key intervention that could significantly reduce CO_2 emissions in the residential sector and represents a highly effective use of technology to reduce energy demand. While the roll-out of building insulation installation the EU has been somewhat successful, its take-up has been patchy across member-states. At issue is the fact that current policy instruments are characterised by a predominantly 'soft law, voluntarist and incentivising approach' (Boardman 2007; Murphy et al. 2012).

The link between energy poverty and poorly insulated and poorly heated homes is established, as is the fact that while those living in the most severe energy poverty would benefit most from retrofitting, that even where available they are often either ineligible, or otherwise unable to avail of the existing grants and supports to retrofit their homes (Walker et al. 2014). There are also a number of barriers to private landlords improving the energy efficiency of their properties including lack of knowledge and misinformation, the principal–agent problem (split-incentive), and the prioritisation of cosmetic improvements amongst others (Ambrose 2015).

Despite the requirement under Directives 2009/72/EC and 2009/73/EC for EU member-states to take action on energy poverty, it is estimated that less than one third of Member States officially recognise energy poverty, and only four member-states – Cyprus, France, Ireland, and the UK – have a legislative definition (Pye & Dobbins 2015). Energy poverty is growing across member-states, and is becoming a significant risk for increasing numbers of EU citizens in an uncertain international energy landscape. People on low incomes are most likely to experience fuel poverty, especially if they live in homes which have poor quality insulation and heating (Dallamaggiore et al. 2016). However, when energy prices are high, fuel poverty can become widespread throughout a region (Liddell et al. 2011). It is an ironic, if very unfortunate, fact that those who are most vulnerable to energy poverty are often those least empowered to economise on energy costs and consumption by means of retrofitting their homes, choosing their energy provider(s), and purchasing energy-efficient domestic appliances.

Comfort, including thermal standards are highly important to people in general, to parents, and to mothers in particular. Participants who are mothers placed especially high importance on having a warm home for their children, if at all possible. Parents, and grandparents, are not averse to dressing more warmly in the home themselves in order to economise on heating, however, they were not willing to allow their children and grandchildren, or their own elderly parents, to go cold (Dunphy, Revez, Gaffney, Lennon, et al. 2017). This is in keeping with other research that demonstrates that maintaining thermal comfort is a key aspect of heating practices that is resistant to change (Smale et al. 2017).

The sustainability interventions outlined above share an important feature that makes a significant contribution to their success – they required very little, if any, adjustment to people's everyday energy practices. Replacing energy inefficient bulbs with low-energy bulbs and taking the energy rating of domestic appliances into consideration as part of purchasing decisions requires no change in the pattern of use. The pattern of living in a retrofitted home will entail either using the same amount of energy for a much warmer home, or setting the thermostat or timer differently so the thermal comfort is maintained using less energy (granted that some people did struggle with knowing how to adjust their heating practices effectively). But to reduce consumption in other domains that would require changing everyday practices that are much harder to accomplish.

While the interventions to reduce the energy consumption associated with everyday domestic practices have primarily been technical solutions driven by policy, such as energy efficiency ratings on domestic appliances, what has not been addressed has been the practices themselves. In ways, this is very understandable. People's everyday practices are complex in origin, evolution, and process; and they are completely interwoven with how people live their lives, how they parent, how they partner, and how they care for

friends, family, and community (Dunphy, Revez, Gaffney, Lennon, et al. 2017). Practices are also interwoven with how people present themselves to the world, and so, their identities. Practices are also shared with other people, they are socially sanctioned and there are social norms guiding the appropriate ways in which to present ourselves, including how we "keep house". Ultimately, the "goods" of cleanliness and comfort are about creating "home" (Aune 2007). It is the creation of "home" aspect of practices which makes them particularly resistant to change, as well as politically fraught with regard to policy-making.

Domestic practices by their very nature are, to a great extent, *necessarily* entrenched – given that their purpose is to support people, communities, and ultimately societies to function in their everyday existence – their *raison d'être* is to provide the wherewithal for human existence, food, shelter, warmth and hygiene. The close connection between everyday behaviours and practices and an individual's sense of identity, and the function that practices have of creating home, particularly for parents, and mothers especially, means that they are deeply embedded in people's lives. For those living in energy poverty, literally going without the 'goods' that energy provides – light, heating, cooking, showering – is the only way that these people can consume less, given their often powerlessness to avail of the means to reduce their energy requirements by, for example, retrofitting their homes or buying the most energy-efficient domestic appliances. Making energy more expensive will have limited effects on consumption, and will disproportionately affect those already in energy poverty, and will undoubtedly push ever more people into energy poverty.

However, that notwithstanding, some practices have more scope for adjustment than others; Smale, van Vliet, and Spaargaren remark that "Cleaning practices were found to be most suitable for demand-side response, whereas practices implied in ambiance regulation, leisure, cooking and eating, align only with some flexibility instruments" (2017, p.132). Three 'cleaning' practices – laundry, dishwashing (with a dishwasher) and showering – offer some potential for change, and there is evidence that the timing of laundry is one of the most amenable to adjustment (Smale et al. 2017). This argument was supported by some of the narratives from the community in Secondigliano – a number of the women there mentioned putting on their washing machines late at night to avail of the cheaper electricity tariff.

There is obviously a significant 'class' and gender element to this issue. Laundry is a strongly gendered activity – it is a household practice primarily carried out by women (Dunphy, Revez, Gaffney, Lennon, et al. 2017). Therefore, it is clear that elongating the domestic working day in order to make energy consumption more affordable will tend to impact less financially privileged mothers, in particular, disproportionately – notwithstanding the fact that it will impact on parents, and dual-role working mothers, more generally. It is clear from both the qualitative engagements and quantitative time-use surveys that we conducted that women have the primary responsibility for doing the laundry, so shifting the timing of laundry to late evening, or night-time means that the time women spent working in the home is hugely extended, exacerbating the existing experience for many working mothers of being "time-poor". It is arguably profoundly unfair to expect some of those already most burdened with both time and energy poverty to pay the price for reducing peak electricity demand when they are amongst the most already carful and minimal energy consumers already. Moreover, while the most economically deprived consumers may be persuaded to shift the timing of some energy consuming practices, as is the case in Secondigliano, the minimal financial gains from doing so may strongly limit the take up of such time-shifts for more relatively affluent consumers.

Because domestic practices provide the necessary elements people need to live their everyday lives, there is obviously little scope for the elimination of those practices or of implementing wholescale change, however, even small alterations to practices could have immediate yet considerable – taken in the aggregate – impact on energy consumption, and related environmental effects. Taking a more holistic approach that 'views" everyday practices in their complexity cannot not offer a 'quick-fix', because no such quick-fix is possible. Instead, positioning practices as complex entities that serve vital human purposes and recognising that while they are, in a sense, biologically and psychologically determined, they are social determined too. Recognising their complexity makes it apparent that reducing consumption will require a suite of complimentary endeavours that 'speak to' that complexity – not just technical and policy fixes, but also 'social' fixes too.

3.5.6 The affordable home – power and energy poverty

Unique patterns of deprivation, disempowerment, impoverishment and hardship associated with access and use of energy continue to unfold and bring heightened significance to the concept of energy poverty (Bouzarovski 2014). While in the past, these ideas were largely applied to third world regions and developing countries, evidence continues to grow which makes it necessary to look at energy poverty in a European context. A recent study found that approximately 11% of the EU population may be affected by Energy Poverty (Pye & Dobbins 2015). Furthermore, if left untackled, it is likely that these issues may be aggravated due to expected rises in energy costs and rapidly shifting energy landscapes (Thomson et al. 2017; Bouzarovski 2014).

A range of processes demonstrate that in particular circumstances the energy system limits individual and community capacities and life course prospects, and diminishes community resilience (Dunphy, Revez, Gaffney, Lennon, et al. 2017; Dunphy, Revez, Gaffney & Lennon 2017). These processes of oppression are felt at many levels, for instance, in terms of ability and resources to actively participate in ongoing energy transitions, in relation to opportunities for employment for young people, and in terms of independence and quality of life for older people and people with disabilities. The negative health related effects of fuel poverty can also be exacerbated by the 'Heat or Eat' factor where people may forgo healthy eating in order to pay for heating, and then suffer from the effects of low calorie intake and/or poor diet instead of low temperatures (Walker & Day 2012). Sadly, there was evidence of this phenomenon in the community of Stockbridge.

Access to abundant, reliable, and cheap energy is necessary for the unprecedented standard of living experienced by those residing in the developed world. Energy is therefore a key social justice issue, as well as an environmental one. Healy and Barry (2017) stress the need to consider whether, where and how policies aimed at decarbonizing the economy can address the range of injustices and impacts of such a socio-energy transition. Hiteva and Sovacool (2017) argue that social sustainability in energy terms should incorporate equitable distribution of costs and benefits, affordability, due process and greater participation in decision-making. These constitute key elements of an energy justice perspective. Sovacool *et al.,* (2017) define 'energy justice' as a global energy system that fairly distributes both the benefits and burdens of energy services, and one that contributes to more representative and inclusive energy decision-making. Healy and Barry (2017) advocate for a 'just transition' highlighting, amongst other aspects, the need for

supports for communities that have been marginalised or negatively impacted by low carbon energy transition processes.

A case in point is the Stockbridge experience. While energy poverty is a theme that has emerged strongly in our qualitative findings, it was a particularly pressing issue there, and a clear example of how energy can reinforce and reproduce patterns of poverty and deprivation. Albeit there is a substantial contrast between our six communities, the evidence indicates that emerging trends and shifts in energy production and consumption can be problematic for communities already in poverty. Furthermore, these can heighten existing patterns of marginalization, disempowerment and displacement.

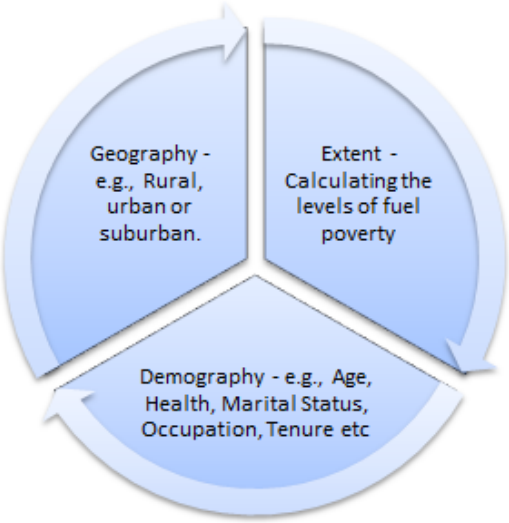


Figure 28: Information requirements for estimating fuel poverty

Indeed, we have seen that socio-economic practices diverge considerably between those that benefit from a high level of socio-economic privilege and those that experience poverty. Among the six communities where we conducted in-depth qualitative research, Le Trapèze in Paris stands out as one of the wealthiest communities while the community in Stockbridge in Liverpool stands out as one of the most deprived. There are also noteworthy issues pertaining to energy poverty in both Secondigliano and Vila de Gràcia. The physical and social context in each community frames most socio-economic relations as it can either constrain or enable individual attitudes and behaviours.

Socio-economic privilege, emerges in different ways as a critical dimension for understanding community interactions with energy. The table below highlights a number of socio-economic characteristics in each community and helps contextualise and position our communities in reference to a range of qualitative indicators, which illustrate a diverse context. This process of comparison and analysis supports the identification and examination of the multiplicity of different factors which either enable or inhibit the ability to make choices, have influence over and adapt to a changing energy system.

A number of processes from disempowerment to displacement and inequality permeate many of the narratives of our participants living in more deprived areas, notably in Stockbridge, Secondigliano and Gracia. The connection between wealth and community cohesion suggests that social capital derived from networks

of support and the ability to collectively articulate common needs is uneven across communities and is a barrier towards voicing and gaining influence with respect to the energy system. There are potentially a range of community supports and initiatives which may help to mitigate against experiences of poverty and social inequality. This was particularly evident in in Gràcia, so while Spain seems to have a higher percentage of energy poverty than the other communities, well-being there is higher in comparison to other countries such as the UK which suggests that community support structures have a role in mitigating the impacts of energy poverty. In contrast, the socio-privileged community in Le Trapèze has displayed a greater assertiveness and ability to interact with energy in terms of knowledge of energy technologies, energy policies and energy markets.

The ill-effects of energy poverty can manifest in different ways, in Stockbridge, energy poverty in old age is seen to be leading to loss of home and independence, whereas In Secondigliano the immediate impact of energy poverty for younger cohorts included limitations in terms of access to education and employment opportunities. Across all communities, less socio-economically privileged participants who lived in rented accommodation expressed more limitations and lack of choice in terms of the energy supplier they use, use of appliance and retrofitting homes for improved energy efficiency.

Contrasting heavily with issues of energy poverty, identified in Stockbridge, Secondigliano and Gràcia, the community in Le Trapèze in Paris, shows that interactions with energy can be very different when arising from wealthy, well-resourced neighbourhoods. For instance, while many of our participants in the other communities reported a range of energy reducing strategies in the home, such as changing to energy efficient light bulbs, installing smart meters, placing timers on showers and other appliances to name a few, the same measures did not follow to reducing energy use in the workplace. Our participants in Le Trapèze in comparison with other communities held jobs at a managerial or higher level which allowed or prompted them to extend their influence over their immediate household environment and into the workplace. Many of these participants also reported having leadership roles at local level in terms of overseeing the deployment of new technologies in Le Trapèze which, as an eco-neighbourhood, has seen a large range on new energy system put in place recently.

Access to a healthy environment, spacious surrounding and good quality sources of food was a key priority for many of the residents in the making of their home and in choosing how and where they live. This narrative was particularly strong among parents with young children. Crucially, many participants expressed the fact that the ability to choose what was important for them and to live in a manner which best reflects these values was a very significant factor for their well-being.

Another interesting contrasting position between participants in this wealthy neighbourhood and the more deprived neighbourhoods was the ease with which many of the participants engaging with the technicalities associated with the implementation of new technologies, their merits in terms of efficiencies and the political context in which these can be best implemented. While both in Secondigliano and Gràcia many of the participants were less comfortable expanding on their understanding of different dimensions of the energy system, in contrast the community in Le Trapèze were more assertive and confident in their knowledge. While there were various levels of knowledge and assertiveness from participants across the six communities, in Le Trapèze it was manifestly higher than in all the other neighbourhoods.

3.6 Summation

The preceding sections clearly indicate that ensuring the creation of a sustainable energy path necessarily entails the development and mobilization of a number of elements of the energy system which are themselves complex and have multiple socio-environmental implications. Plans to decarbonise the energy system in a European context require extensive development and growth of alternative energy sources, ascertaining what has been achieved to date in this context is critical to future developments.

The EU as an influential international player to an extent has mediated visions for the future of the energy system. However, large discrepancies remain with regards the way member states envision their path to sustainability. For instance, nuclear energy in some member states such as France and the UK are very much part of long term plans to move away from a dependence on fossil fuels while for Italy and Germany current long term visions reject this energy source as an alternative.

Greater consensus exits in terms of the use of renewable energy as a means to achieve sustainability. However, there are a number of obstacles which have prevented these alternatives from becoming a reality. Some of these challenges pertain to technological issues. Renewable energy sources and in particular those with least environmental impacts such as solar, tidal and wind energy are still maturing technologies. This means that there are a number of shortfalls in terms of efficiencies, logistics and social presence which has prevented a speedier diffusion of renewable energies in Europe.

Substantial shifts are projected to achieve Europe's 2050 targets of 80% reduction in CO_2 emissions. To achieve these targets changes across all dimensions of the energy system need to occur, from shifts in energy production practices, energy transportation, distribution, storage and end use consumption. In terms of end use building and transport systems there is a great focus in reducing current emissions by shifting the way energy is consumed. Technological innovations play a role here in terms of decarbonizing buildings and transport systems and making them more efficient. Substantial policy focus in this instance is also given to the patterns of energy consumption and behaviour change. A range of market based initiatives focused on enhanced consumer engagement and information sharing looks to tap into this area by promoting change through active consumer practices. Smart-meters are some of the technological instruments which look to enable the development of these practices.

By all accounts, evidence suggests that progress relative to decarbonisation of the energy system in Europe has not proceeded according to desired targets and expectations. For one, there are large differences in the way energy sustainability is understood and interpreted at national level. For instance, the liberalisation model, which is largely supported at EU level in the belief that it leads to greater competitiveness and innovation in the energy system, is often not compatible with national agendas and this has created dissonances in the approaches taken across different member states. Equally important are the resources, political competency and commitment to make these aspirational sustainability targets a reality.

Public engagement with these shifting energy landscapes is telling on a number of ways. For instance, public attitudes to energy technologies are mediated by a number of socio-demographic and place based issues. Gender, age, socio-economic and community context are important variables to consider when looking at

public perceptions of different energy sources. For instance, variations in attitudes towards nuclear energy based on gender and community setting were evident in the research we conducted.

These differences, often operate in an interlinked manner and are also apparent in the way people engage with energy in their everyday lives. The making of spaces, in particular the making of home is strongly determined by the roles individuals assume within their life course such as mothers, fathers, careers, guardians, independent elders which carry different conceptions of the energy system, how it is used and the impact it has for them and others.

These insights are valuable for understanding the potential impacts that an energy transition can have on different segments of the population. Technological, market and policy changes have different effects at local level for different cohorts and there is therefore the potential for creating new forms of social exclusion or new social issues by emerging energy systems which fail to recognise the differentiated way in which the energy system affects and is used by different cohorts.

4 Conclusion

Promoting transition towards a sustainable energy system: current regimes, opportunities and practices.

The eleven deliverables outlined and summarised in this synthesis report cover a wide range of themes concerning the energy system from a variety of different perspectives. These eleven deliverables emerge from work produced by the ENTRUST project on three distinct work packages. These are WP2, WP3 and WP4.

Work produced for WP2 was mainly focused on developing an extensive characterization of the energy system and the key actors involved. It produced a comparative overview of several energy system profiles linked to diverse energy technologies. By contrast WP3 looked to develop a deeper understanding of energy practices and human behaviour in relation to energy. The intersectional approach used in this work package allowed for an exploration of socio-demographic interlinks with energy. Finally, WP4 was largely concerned with providing a mapping of current policies and regulations concerning the energy system and energy transitions in a European context. This analysis included an identification and evaluation of the key processes shaping key national and European policy.

The work produced for these deliverables aimed to provide a detailed view the energy system by offering an analysis of different elements in the system which included socio-demographic, technical, market and policy dimensions. Some of the deliverables therefore offered a detailed mapping and evaluation of existing energy stakeholders (D2.1 and D4.1) energy technologies (D2.2) energy markets and business models (D2.3 and D4.3), energy policies and institutions (D4.1, D4.2, D4.3 and D4.5) and socio-demographic factors pertaining to energy practices, attitudes and behaviours (D.3.1, D3.2, D3.3 and D4.4).

The European focus employed is apparent throughout the eleven deliverables on which this synthesis report is based. However, the focus and methodological directions of each deliverable further determine the level of detail and the scope that each deliverable offers. For instance, some of these deliverables are grounded on empirical, field based materials at community level which pay particular attention to local context and socio-demographic variables (D3.2 and D3.3). Other deliverables have a broader outlook in terms of scope. For example, deliverables D2.1, D4.4 and D4.5 make use of workshops with different stakeholders to develop

their materials and merge these with extensive desk-based research. Finally, some deliverables are largely desk-based studies which look to aggregate data from a range of academic, statutory and other secondary sources to map out the current state of play in relation to market, policy and technological elements in the energy system (D2.2; D2.3; D3.1; D4.1; D4.2; D4.3).

The work from these eleven deliverables brings together a very large number of constitutive components which are an integral part of the energy system. These encompass both a broad overview of macro as well and micro views of the energy system. This work involves broader perspectives and exploration of large scale energy sources and production (D2.2), European governance regimes (D4.1; 4.2; and D4.5) market models (D4.3 and D2.3) and to much smaller scale grassroots engagement with local attitudes to energy production (D3.3) and local energy practices and behaviour (D2.3). Furthermore, paying particular attention to the human-factor in the energy system we consider both current policies and approaches focused on end-user behaviour change initiatives (D4.4) and from a more critical stance we expand and contrast these insights using practice theory and intersectionality which places practices in the context of other intersecting elements from identity to social organizing structures and re-traces everyday activities not as an accumulation of choices to either consume more or less energy but activities bound by a variety of social, cultural and environmental factors which have to be considered when seeking or envisioning substantial shifts in the way energy system is organised.

Upcoming insights derived from work produced within ENTRUST prpject Work Package 6 will expand on these ideas by looking specifically at feasible energy transition pathways. The work produced uses community (bottom-up) and top-down approached to develop a portfolio of scenarios which include technological, business model innovation as well as practice-based innovation options. These insights in turn will complement work produced in Work Package 5 which will culminate in the development of a report focused on 'Energy Management Approaches for Sustainable Communities'.

The ENTRUST project has maintained ongoing engagement with the six case-study communities on which empirical evidence from WP3 is based. These engagements have led to continued learning and reflection on issues pertaining to our intersectional analysis of energy practices and attitudes towards energy technologies. New iterations of D3.2 and D3.3 are therefore anticipated to include the materials that we have continued to collect. These deliverables are an essential component of this synthesis report and for that reason we would anticipate an update of this version of the synthesis report to include these insights from D3.2 and D3.3.

5 Bibliography

Abrahamse, W. et al., 2005. A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology*, 25(3), pp.273–291.

Allio, L., 2014. *Design thinking for public service excellence*, Singapore: UNDP Global Centre for Public Service Excellence.

Ambrose, A.R., 2015. Improving energy efficiency in private rented housing: Why don't landlords act? *Indoor and Built Environment*, 24(7), pp.913–924.

Aune, M., 2007. Energy comes home. *Energy Policy*, 35(11), pp.5457–5465.

Aze, F. et al., 2016. *Europeanisation of national policy dialogues on energy pathways. Deliverable 4.2 of the ENTRUST H2020 Project*, Cork: University College Cork.

Aze, F. et al., 2017. *Policy toolkit typology. Deliverable 4.5 of the ENTRUST H2020 project*, Cork: University College Cork.

Ballo, I.F., 2015. Imagining energy futures: Sociotechnical imaginaries of the future Smart Grid in Norway. *Energy Research and Social Science*, 9, pp.9–20.

Barnett-Page, E. & Thomas, J., 2009. Methods for the synthesis of qualitative research: a critical review. *BMC Medical Research Methodology*, 9(1), p.59.

Bettencourt, M.A., Trancik, J.E. & Kaur, J., 2013. Determinants of the Pace of Global Innovation in Energy Technologies. *PLoS ONE*, 8(10), pp.1–6.

Boardman, B., 2007. *Home Truths: A Low Carbon Strategy to reduce UK Housing Emissions by 80% by 2050*, Oxford, UK.

Boo, E. et al., 2017. *Report on novel business models and main barriers in the EU energy system. Deliverable 2.3 of the ENTRUST H2020 Project*, Cork: University College Cork.

Boo, E. et al., 2016. *Report on policy & regulation landscape. Deliverable 4.1 of the ENTRUST H2020 Project*, Cork: University College Cork.

Bouzarovski, S., 2014. Energy Poverty in the European Union: landscapes of vulnerability. *WIREs Energy and Environment*, 3, pp.276–289.

Bresser-Pereira, L.C., 2012. Five models of capitalism. *Revista de Economia Política*, 32(1), pp.21–32.

Capros, P. et al., 2011. Analysis of the EU policy package on climate change and renewables. *Energy Policy*, 39(3), pp.1476–1485.

Cheng, C. et al., 2008. *The Kyoto Protocol, the Clean Development Mechanism, and the Building and Construction Sector*, Paris, France: United Nations Environment Programme.

Chester, L., 2010. Conceptualising energy security and making explicit its polysemic nature. *Energy Policy*, 38, pp.887–895.

Coenen, L., Benneworth, P. & Truffer, B., 2012. Toward a spatial perspective on sustainability transitions. *Research Policy*, 41(6), pp.968–979.

Cohen, J.J., Reichl, J. & Schmidthaler, M., 2014. Re-focussing research efforts on the public acceptance of energy infrastructure: A critical review. *Energy*, 76, pp.4–9.

Crabbé, A. et al., 2013. Transition towards sustainable material innovation: evidence and evaluation of the Flemish case. *Journal of Cleaner Production*, 56, pp.63–72.

Creswell, J.W., 2014. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* 4th ed., Thousand Oaks: Sage Publications.

Creutzig, F. et al., 2014. Catching two European birds with one renewable stone: Mitigating climate change and Eurozone crisis by an energy transition. *Renewable and Sustainable Energy Reviews*, 38, pp.1015–1028.

Crotty, M., 1998. The Foundations of Social Research: Meaning and Perspective in the Research Process. , p.256.

Crouch, C., 2005. Models of capitalism. *New Political Economy*, 10(4), pp.439–456.

D'Agostino, N. et al., 2001. Interactions between mantle upwelling, drainage evolution and active normal faulting: An example from the Central Appennines (Italy). *Geophysical Journal International*, 147(2), pp.475–497.

Dallamaggiore, E. et al., 2016. *Energy System Stakeholder Characterisation. Deliverable 2.1 of the ENTRUST H2020 Project*, Cork: University College Cork.

Deloitte, C., 2015. *Energy market reform in Europe. European energy and climate policies: achievements and challenges to 2020 and beyond*, Neuilly-sur-Seine, France.

Devine-Wright, P., 2007. *Reconsidering public attitudes and public acceptance of renewable energy technologies: a critical review*,

Doganova, L. & Eyquem-Renault, M., 2009. What do business models do?. Innovation devices in technology entrepreneurship. *Research Policy*, 38(10), pp.1559–1570.

Douglas, M., 1966. *Purity and Danger: An Analysis of Concepts of Pollution and Taboo*, London: Routledge.

Doyle, L.H., 2003. Synthesis through meta-ethnography: paradoxes, enhancements, and possibilities. *Qualitative Research*, 3(3), pp.321–344.

Dunphy, N.P., Revez, A., Gaffney, C., Lennon, B., et al., 2017. *Intersectional Analysis of Energy Practices. Deliverable 3.2 of the ENTRUST H2020 Project*, Cork: University College Cork.

Dunphy, N.P., Revez, A., Gaffney, C. & Lennon, B., 2017. *Intersectional Analysis of Perceptions and Attitudes Towards Energy Technologies. Deliverable 3.3 of the ENTRUST H2020 project.*, Cork: University College Cork.

Dyevre, A., 2010. Unifying the field of comparative judicial politics: towards a general theory of judicial behaviour. *European Political Science Review*, 2(2), pp.297–327.

Enevoldsen, P. & Sovacool, B.K., 2016. Examining the social acceptance of wind energy: Practical guidelines for onshore wind project development in France. *Renewable and Sustainable Energy Reviews*, 53, pp.178–184.

EurObserv'ER, 2015. *The State of Renewable Energies in Europe*, Paris: EurObserv'ER.

European Commission, 2011a. COM(2011) 109 Final. Energy Efficiency Plan 2011. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.

European Commission, 2014. COM(2014) 15 Final. A policy framework for climate and energy in the period from 2020 to 2030. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.

European Commission, 2015a. COM(2015) 80 Final. Energy Union Package A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee,.

European Commission, 2011b. Energy Roadmap 2050 COM(2011) 885/2. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.

European Commission, 2015b. State of the Energy Union 2015. COM(2015) 572 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Invesment Bank.

Eurostat, 2016a. Consumption of Energy. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Consumption_of_energy [Accessed November 1, 2011].

Eurostat, 2016b. Energy production and imports. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_production_and_imports [Accessed January 20, 2011].

Falagas, M.E. et al., 2008. Comparison of PubMed, Scopus, Web of Science, and Google Scholar: strengths and weaknesses. *FASEB Journal - Official Publication of the Federation of American Societies for*

Experimental Biology, 22(2), pp.338–342.

Fraune, C., 2015. Gender matters: Women, renewable energy, and citizen participation in Germany. *Energy Research & Social Science*, 7, pp.55–65.

Frederiks, E.R. et al., 2016. Evaluating energy behavior change programs using randomized controlled trials: Best practice guidelines for policymakers. *Energy Research & Social Science*, 22, pp.147–164.

Fri, R.W. & Savitz, M.L., 2014. Energy Research & Social Science Rethinking energy innovation and social science. *Energy Research & Social Science*, 1, pp.183–187.

Gaffney, C. et al., 2015. *Survey of socio-demographic data on energy practices. Deliverable 3.1 of the ENTRUST H2020 project*, Cork: University College Cork.

Gallagher, K.S., Holdren, J.P. & Sagar, A.D., 2006. Energy-Technology Innovation. *Annual Review of Environment and Resources*, 31, pp.193–237.

Goetz, K. & Dyson, K., 2003. Living with Europe: Power, Constraint and Contestation. In K. Goetz & K. Dyson, eds. *Germany, Europe, and the Politics of Constraint*. Oxford: Oxford University Press, pp. 3–36.

Grübler, A., 2012. Energy transitions research: Insights and cautionary tales. *Energy Policy*, 50, pp.8–16.

Hall, P. & Soskice, D., 2001. Introduction. In P. A. Hall & D. Soskice, eds. *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage.* Oxford: Oxford University Press.

Hancock, A.-M., 2013. Empirical Intersectionality: A Tale of Two Approaches. *UC Irvine L. Rev.*, 3, pp.259–296.

Hancock, A.-M., 2007. Intersectionality as a Normative and Empirical Paradigm. *Politics & Gender*, 3(2), pp.248–254.

Healy, N. & Barry, J., 2017. Politicizing energy justice and energy system transitions: Fossil fuel divestment and a 'just transition'. *Energy Policy*, 108, pp.451–459.

Hiteva, R. & Sovacool, B., 2017. Harnessing social innovation for energy justice : A business model. *Energy Policy*, 107(April), pp.631–639.

Howell, K., 2004. *Europeanization, European Integration and Financial Services: Developing Theoretical Frameworks and Methodological Perspectives*, London: Palgrave Macmillan UK.

Jackson, T., 2005. *Motivating Sustainable Consumption - A review of evidence on consumer behaviour and behavioural change*, Guildford.

Jacquot, S. & Woll, C., 2008. Action publique européenne : les acteurs stratégiques face à l'Europe. *Politique européenne*, 2(25), p.161–192.

Jacsó, P., 2010. Metadata mega mess in Google Scholar. *Online Information Review*, 34(1), pp.175–191.

Jegen, M., 2014. *Energy policy in the European Union: The power and limits of discourse*,

Kaplan, S., 2000. New ways to promote proenvironmental behavior: Human nature and environmentally responsible behaviour. *Journal of Social Issues*, 56(3), pp.491–508.

Keeley, L. et al., 2013. *Ten Types of Innovation: The Discipline of Building Breakthroughs*, Hobeken: John Wiley & Sons.

Kern, F., 2012. Technological Forecasting & Social Change Using the multi-level perspective on socio-technical transitions to assess innovation policy. *Technological Forecasting & Social Change*, 79(2), pp.298–310.

Kitchenham, B. & Charters, S., 2007. Guidelines for performing Systematic Literature Reviews in Software Engineering. *Engineering*, 2, p.1051.

Kuhn, T.S., 1996. *The Structure of Scientific Revolutions* 3rd ed., Chicago: University of Chicago Press.

Kuzemko, C., 2013a. Exploring the Politics of Low Carbon Energy Transition. In Science Po, ed. *7th ECPR General Conference, Science Po. Innovation, technology and regulation – Exploring new modes of energy governance*. Bordeaux: 7th ECPR General Conference.

Kuzemko, C., 2013b. *Understandings the politics of low carbon transition: contexts, paradigms and power*, Exeter: University of Exeter.

Landini, A. et al., 2016. *Energy Technological Review. Deliverable 2.2 of the ENTRUST H2020 Project*, Cork:

University College Cork.

Liddell, C. et al., 2011. *Defining Fuel Poverty in Northern Ireland, A Preliminary Review*, Coleraine.

Liljenfeldt, J. & Pettersson, Ö., 2017. Distributional justice in Swedish wind power development – An odds ratio analysis of windmill localization and local residents ' socio-economic characteristics. *Energy Policy*, 105, pp.648–657.

Lindgardt, Z. et al., 2009. Business model innovation. When the game is tough, change the game. Available at: http://www.bcg.com/documents/file36456.pdf.

Lockwood, M., 2014. *The political dynamics of green transformations : The roles of policy feedback and institutional context*, Exeter, UK.

Lovins, A., 1976. Energy Strategy: the road not taken? *Foreign Affairs*, 55(96), pp.65–96.

Lupton, D., 2003. *Medicine as Culture: Illness, Disease and the Body in Western Societies* 2nd ed., London: Sage Publications.

Luque-Ayala, A. & Silver, J., 2016. *Energy, power and protest on the urban grid : geographies of the electric city*, Oxon: Routledge.

Machiba, T., 2012. OECD Background Paper. In *OECD/European Commission/Nordic Innovation Joint Workshop. The Future of Eco-Innovation: The Role of Business Models in Green Transformation*.

Mallett, S., 2004. Understanding home: a critical review of the literature. *The Sociological Review*, 52(1), pp.62–89.

McDonald, A. & Schrattenholzer, L., 2001. Learning rates for energy technologies. *Energy Policy*, 29(4), pp.255–261.

Meadowcroft, J., 2009. What about the politics ? Sustainable development , transition management , and long term energy transitions. *Policy Sciences*, 42(4), pp.323–340.

Meho, L.I., 2006. The Rise and Rise of Citation Analysis. *Physics World*, 114, p.15.

Michie, S., van Stralen, M.M. & West, R., 2011. The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science*, 6(1), p.42.

Mikler, J. & Harrison, N., 2012. Varieties of Capitalism and Technological Innovation for Climate Change Mitigation. *New Political Economy.*, 17(2), pp.179–208.

Moloney, S., Horne, R.E. & Fien, J., 2010. Transitioning to low carbon communities—from behaviour change to systemic change: Lessons from Australia. *Energy Policy*, 38(12), pp.7614–7623.

Morgan, G. & Smircich, L., 1980. The case for qualitative research. *Academy of Management Review*, 5(4), pp.491–500.

Morrissey, J.E. et al., 2016. *Identification and Characterisation of Energy Behaviour Change Initiatives. Deliverable 4.4 of the ENTRUST H2020 project*, Cork: University College Cork.

Moses, J. & Knutsen, T., 2012. *Ways of Knowing: Competing Methodologies in Social and Political Research*, Palgrave.

Murphy, L., Meijer, F. & Visscher, H., 2012. A qualitative evaluation of policy instruments used to improve energy performance of existing private dwellings in the Netherlands. *Energy Policy*, 45, pp.459–468.

OED, 2010. *Oxford Dictionary of English* A. Stevenson, ed., New York: Oxford University Press.

Osterwalder, A. & Pigneur, Y., 2010. *Business Model Generation* T. Clark, ed., Hobeken: John Wiley & Sons.

Plan C vzw, 2016. The business model innovation grid. Available at: http://www.plan-c.eu/bmix/.

Pye, S. & Dobbins, A., 2015. Energy poverty and vulnerable consumers in the energy sector across the EU : analysis of policies and measures. , (May).

Radaelli, C., 2003. The Europeanization of Public Policy. In K. Featherstone & C. Radaelli, eds. *The Politics of Europeanization*. Oxford: Oxford University Press, pp. 27–56.

Ranci, P., 2003. *Liberalisation of the European energy markets: the role of regulation and regulators*, Athens, Greece.

Rijnsoever, F.J. Van, Mossel, A. Van & Broecks, K.P.F., 2015. Public acceptance of energy technologies : The effects of labeling , time , and heterogeneity in a discrete choice experiment. *Renewable and Sustainable Energy Reviews*, 45, pp.817–829.

Rip, A. & Kemp, R., 1998. Technological change. In S. Rayner & E. L. Malone, eds. *Human choice and climate change. Vol. II, Resources and Technology*. Columbus: Battelle Press, pp. 327–399.

Røpke, I., 2009. Theories of practice — New inspiration for ecological economic studies on consumption. *Ecological Economics*, 68(10), pp.2490–2497.

Salel, M. et al., 2016. *Review of market-driven approaches in sustainable energy policies. Deliverable 4.3 of the ENTRUST H2020 project*, Cork: University College Cork.

Schmidt, V., 2002. *The Futures of European Capitalism.*, Oxford, UK.: Oxford University Press.

Shahin, A. & Mahbod, M.A., 2007. Prioritization of key performance indicators. *International Journal of Productivity and Performance Management*, 56(3), pp.226–240.

Smale, R., van Vliet, B. & Spaargaren, G., 2017. When social practices meet smart grids: Flexibility, grid management, and domestic consumption in The Netherlands. *Energy Research and Social Science*, 34(February), pp.132–140.

Smith, A., Stirling, A. & Berkhout, F., 2005. The governance of sustainable socio-technical transitions. *Research Policy*, 34(10), pp.1491–1510.

Solomon, B.D. & Krishna, K., 2011. The coming sustainable energy transition: History, strategies, and outlook. *Energy Policy*, 39(11), pp.7422–7431.

Sovacool, B.K. et al., 2017. New frontiers and conceptual frameworks for energy justice. *Energy Policy*, 105(March), pp.677–691.

Sovacool, B.K., 2014. What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda. *Energy Research and Social Science*, 1, pp.1–29.

Straub, D.W., 1994. The Effect of Culture on IT Diffusion : E-Mail and FAX in Japan and the U.S. *INFORMS*, 5(1), pp.23–47.

Thomas, J. & Harden, A., 2008. Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology*, 8(1), p.45.

Thomson, H., Snell, C. & Bouzarovski, S., 2017. Health, Well-Being and Energy Poverty in Europe: A Comparative Study of 32 European Countries. *International Journal of Environmental Research and Public Health*, 14(6), p.584.

Verbong, G. & Geels, F., 2010. Exploring sustainability transitions in the electricity sector with socio- technical pathways. *Technological Forecasting and Social Change*, 77(8), pp.1214–1221.

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

Walker, R. et al., 2014. Fuel poverty in Northern Ireland: Humanizing the plight of vulnerable households. *Energy Research and Social Science*, 4(C), pp.89–99.

Watson, J., 1997. The technology that drove the 'dash for gas'. *Power Engineering Journal*, 11(1), pp.11–19.

Webster, J. & Watson, R.T., 2002. Analizing the Past to Prepare for the Future: Writing a Review. *MIS Quarterly*, 26(2), pp.xiii–xxiii.

Whitehead, M., 2014. *Environmental transformations : a geography of the anthropocene*, Oxon: Routledge.

Whitmarsh, L., O'Neill, S. & Lorenzoni, I., 2013. Public engagement with climate change: What do we know and where do we go from here? *International Journal of Media & Cultural Politics*, 9(1), pp.7–25.

Wicker, P. & Becken, S., 2013. Conscientious vs. ambivalent consumers: Do concerns about energy availability and climate change influence consumer behaviour? *Ecological Economics*, 88, pp.41–48.

Wrangham, R.W. et al., 1999. The Raw and the Stolen. *Current Anthropology*, 40(5), pp.567–577.

Wüstenhagen, R., Wolsink, M. & Burer, M., 2007. Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, 35, pp.2683–269.

Appendix 1: Intersectionality

Intersectionality, appreciating the mutually constitutive relations among social identities

What is Intersectionality?

Intersectionality is a concept that recognises the dynamics, relationships, and connections between different categories of identity, including but not limited to the categories of race, socioeconomic privilege, gender, sexuality and (dis)ability. It is an approach to understanding the complexities of social positioning, that recognises the power of identity categories and the work that they do in reifying hegemonic positions of privilege, as well as the material impact those categories have on lived experience.

The concept of intersectionality emerged from Black feminist critiques of conceptualising categories of identity – such as 'woman' and 'black' narrowly along a totalising 'single-axis'. At its core rationale, the concept is intended to produce a better conceptual framework that captures what it is to be human in a social world where the human being is demarcated along axes of identity such as gender, 'race', socio-economic privilege, ability, sexuality, culture, etc., while understanding that each person is positioned at the intersection of these markers of identity, simultaneously. Intersectionality as a concept captures the complexity of identity, of social positioning, and the dynamics of power at the macro-, meso-, and micro-level. This bears significance on the conduct of research, including 'scientific' research, as explored below. In bringing this analysis intersectionality offers a conceptual approach to research that overcomes the lacunae that results from approaches that utilise overtly narrow concept of the universal 'human subject', and so is better placed to incorporate otherwise unrecognised or unacknowledged perspectives into key social issues such as energy justice.

Intersectionality gives recognition to the fact that every person's identity is multiple-aspected, and that these different aspects entail that the individual cannot be defined along a single axis, such as gender or race, as mentioned. Moreover, intersectionality captures the ways that multiple identities combine and amplify each other rather than being merely additive, recognizing that no person is simply a woman, or a man, or white, or black, or or socio-economically privileged or socio-economically deprived, or young or old. A female person is, for example, not simply a woman, nor is a black person simply black – being black and being a woman are not ontologically separate aspects of existence, nor is one aspect ontologically prior to the other, they are experienced simultaneously. Both are significant aspects of her existence, as are other aspects of identity, none of these bodily specificities are not-trivial for her life experience and life chances. Significantly, intersectionality gives particular recognition to the fact that individuals can be multiply oppressed, as well as multiply privileged.

While an individual's unique, personal, circumstances clearly has a significant impact on their life experience, intersectionality gives recognition to the fact that certain social categories of identity — such as those listed above — as well as the larger social forces and structures that reinforce exclusion and social stratification — such as the gender system, the immigration system, the class system, the education system, colonisation *etc.* — can, and does, have a profound effect on an individual's life experience, and their life chances. These aspects can also significantly impact on behaviours, practices, and interactions with the social system at large, as well as with the energy system in particular.

While the recognition that the concept of intersectionality gives to the fact that people are located at multiple social positions of identity may seem obvious, in many ways, from a conceptual perspective within the research paradigm generally, and in energy research in particular, it is still relatively novel.

Feminist foundations

This sketch of feminism is of necessity very brief, and is intended simply as an overview to historically position the concept of intersectionality, and its theoretical sisters, feminist epistemology and standpoint theory. It should be noted here that the focus is on the temporal and conceptual evolution of "Western" feminism, rather than feminism as it has developed in other parts of the world.

The history of feminism is often divided into three "waves", which I shall draw on here. However, it should be noted that while the designation of "waves" to the range of different foci that concern feminism is a convenient means of temporal demarcation, it should be noted that there are many overlaps between the waves, and on many issues, including the sharing of positions that are critical of hegemonic discourses which are common to all three.

There is a significant history of feminist critique of the social, political and intellectual ordering of people and society. There are 'feminist' analyses and theoretical specialities that range across all disciplinary, political and social interests. It can be demonstrated that in challenging the ontological and epistemological tenets that have been held in society, in academia, and across the research process, feminism (along with other critical approaches) has enhanced our knowledge and understanding of the world, its structures, its societies, and human experience (Richardson 2010). It should also be noted that there are some significant early examples of feminist writing about the rights of women that predate the advent of 'first-wave' feminism. For example, Mary Wollstonecraft wrote *A Vindication of the Rights of Women* in 1792 arguing that women were not inferior to men, but only seemed to be so because of a lack of education; and an earlier writer, Marie de Gournay, who also advocated education for women, wrote *The Equality of Men and Women,* in 1622.

What is described as "First wave" feminism emerged in the late 19th and early 20th century, and while it is largely associated with campaigns for suffrage – votes for women – there were other significant aspects to the movement. Employment rights, property rights, rights of married women, access to contraception and abortion were also significant personal and political issues for women at that time, as they remain 'live' issues for many women today, over one century later, albeit that the situation regarding these women's rights shows considerable variation across the EU, and even more so across the rest of the world.

'Second-wave feminism' broadly covers the span of the second-half of the 20th century, and its emergence is often linked to the publication of Simone de Beauviour's *Second Sex* (1949), later translated into English (1950), and more recently re-translated (de Beauvoir n.d.). Second-wave feminism broadened out the concerns of women beyond rights-based campaigns for 'equality' in the specific fields noted above (although these were, and too often remain, goals yet to be attained for many women), to a deeper critical analysis of how society is structured and organized, revealing the various mechanisms of how women are 'constructed' as intrinsically inferior to men, and as existing to serve men's needs. De Beauvoir's analysis of women's 'situation' is materially based, and she recognised that abstract freedoms, such as the right to vote, are of little use to women who are deprived of education and financial wherewithal to avail of any such rights. De

Beauvoir drew on a vast range of philosophical, historical, scientific, medical, and literary texts to demonstrate her thesis that 'one is not born, but becomes, a woman'. Her analysis differentiates between biological 'sex' and the socially constructed 'gender', although she does not use the term 'gender' (the English language facilitates defining the social roles that are attached to particularly sexed bodies as 'gender', however, the French language does not). Nevertheless, without naming it 'gender', de Beauvoir undoubtedly defines the 'content' of the conceptual differentiation between biological sex and the gendered attributes associated with each sex. She demonstrates that gendered attributes are socially constructed along asymmetrical binaries, and arguing against assigning the stereotypical attributes of gender to innate biological and psychological dispositions, or 'essences'. She demonstrates through reference to canonical texts how 'woman' has been constructed and imposed philosophically, legally, medically, scientifically, and socially on those born female. Although her primary focus in The Second Sex is on the situation of women, de Beauvior also recognized that racial, class, and religious stereotypes are also social productions that limit people's ability to exercise agency over their own lives.

Feminist activism both inside and outside the academy grew exponentially during the latter half of the Twentieth Century, and feminist thought was incorporated into every political persuasion – radical, liberal, cultural, centrist, and socialist. Within the academy feminists challenged hegemonic discourses across all disciplines both looking for 'forgotten' women in the fields of science, literature, medicine, art, and history, as well as challenging the theoretical and conceptual paradigms within which research and academic pursuits are conducted. Some of the feminist resources that offer analytical support to the conceptual development of intersectionality are explored in more detail below.

The term "third wave" feminism was coined by Rebecca Walker in an article in Ms. magazine in 1992 (Snyder 2008) as part of a discussion contesting 'post-feminists' characterisation of second-wave feminism as elitist and ideologically rigid, however the term refers more broadly to a wider movement within feminism to embrace an intersectional analysis of gender and social issues. Snyder describes third-wave feminism as rejecting 'grand narratives for a feminism that operates as a hermeneutics of critique within a wide array of discursive locations, and replaces attempts at unity with a dynamic and welcoming politics of coalition' (Snyder 2008). Walker argued that feminism imposed narrow identities of personhood that "doesn't allow for individuality, complexity, or less than perfect personal histories" forcing people into oppositional relationships of "female against male, black against white, oppressed against oppressor, good against bad" (Walker 2006 p.22 cited in Snyder 2008).

While the concept of intersectionality emerged, and evolved in temporal conjunction with third-wave feminism, in many respects one of the core aspects of intersectionality – the relationship between race and gender, as well as 'class' – was articulated many years prior either wave, during the earlier era of 'first-wave' feminism by former slave, Sojourner Truth in 1851. Truth campaigned for both the abolition of slavery as well as for equal rights for women. "Ain't I a woman" was first delivered as an extemporaneous speech by her at Women's Rights Convention in Akron, Ohio, in the USA, and was later (1863) published with the above title. In her speech, she pointed out how as a black woman she was excluded from the category of 'woman', while also demonstrating that the supposed helplessness of women was a fiction as demonstrated by poor black [and white] women who have always toiled in physical labour.

> All [this] talking about rights--the white men will be in a fix pretty soon. But what's all this talking about? That man over there says that women need to be helped into carriages, and lifted over ditches, and to have the best place everywhere. Nobody helps me any best place. And ain't I a woman? Look at me! Look at my arm. I have plowed (sic), I have planted and I have gathered into barns. And no man could head me. And ain't I a woman? I could work as much, and eat as much as any man—when I could get it—and bear the lash as well! And ain't I a woman? I have borne children and seen most of them sold into slavery, and when I cried out with a mother's grief, none but Jesus heard me. And ain't I a woman? (cited in Brah & Phoenix 2004)

Sojourner Truth's powerful words resonate with what can be described as intersectional insights, yet the dominance of conceptualizing people, or issues of social justice along narrow categories of identity along a single axis remained, and all too often remains, a significant issue yet to be recognised even amongst those who struggled for social justice. The great American civil rights leader, Martin Luther King had to recognize the gaps in his vision and embrace an intersectional analysis by recognizing the significance of gender and class for "defining a comprehensive political agenda for the entire Black community"; and the worker's rights campaigner Emma Goldman also incorporated a gender analysis into her work to change the economic system – and in so doing had to contest with those both inside and outside the class-based movement to foreground the position of women within those movements. (Hancock 2007b)

As shown, the idea of analysing race, gender, and class identities together has existed for over a century. As explored in more detail below, the term "intersectionality refers to *both* a normative theoretical argument *and* an approach to conducting empirical research that emphasizes the interaction of categories of difference" (Hancock 2007b). While the concept of intersectionality is applied on the micro-level of the situated individual and the particularity their location at the node of intersecting axes; intersectionality has also emerged over the past thirty years as an interdisciplinary approach to analysing the interactions of the organizing structures of society on a macro level, including gender, race and socio-economic privilege "recognizing that these key components influence political access, equality, and the potential for any form of justice." (Hancock 2007b).

The concept of intersectionality

Although, as outlined above, intersectional analyses of gender, race, and class had been produced without being identified as intersectionality, the term 'intersectionality' was initially coined by Kimberly Crenshaw (1989) primarily to demonstrate that the categories of race and gender are not "mutually exclusive categories of experience and analysis". As Patricia Hill Collins puts it: "rather than examining gender, race, class, and nation as distinctive social hierarchies, intersectionality examines how they mutually construct one another" (Collins 1998). Although the ideas that inform the content and context of intersectionality have been around for well over a century, the term "intersectionality" was specifically coined by Crenshaw in relationship to the exercise of legal rights. This was a significant development in the realm of delivering on "equal" rights for people who suffer from discrimination, because equality legislation is usually defined along single axes – on the basis of sex, or on the basis of race, for example. Crenshaw demonstrated the unfortunate paradox that

what is not captured in these single-axis legal understanding of discrimination, is discrimination on the basis of multiple, intersecting axes – with the result that those that may experience multiple, or exacerbated discrimination, for example, as being both female, and black may not have recourse to legal remedy on either axis, as Crenshaw (1989) demonstrated. Treating these "axes of oppression" as singular, as they tend to be in social and legal rights discourses, has had the result of denying access to justice to those who are multiply oppressed, or experience discrimination as a result of being positioned at multiple axes of discrimination. As Crenshaw remarks, the "multidimensionality of Black women's experience" is distorted by the "single-axis analysis" that is foundational to equality and anti-discrimination policies and legislation (Crenshaw 1989).

Intersectionality captures the ways that multiple identities combine and amplify each other rather than being merely additive. By elaborating on the multiple, overlapping, intersection of social positions that marginalize people and demonstrating that oppressions are not additive, but rather multipliers, Crenshaw drew attention to the failure of the 'women's movement' to incorporate a class and race, as well as other axes of oppression, analysis into feminism. The level of attention directed at the confinement of women to the domestic sphere in early 'second-wave' feminism, and the focus on bringing women into the workplace, for example – overlooked the fact that some groups of women have always worked outside the home – because poor women, and women of colour often did work outside their own home out of necessity. In the current era of neoliberalism, it appears that the focus of feminist organizations in the public sphere is on issues such as the 'glass ceiling' and primarily concerns efforts to open up the professions and upper-management positions to women as well as the relative pay-gap between (white) women and (white) men, however, there are strong critiques of this narrow focus on what are, often unfairly, characterised as the concerns of 'privileged white women'. It is argued that feminism should re-embrace the originating structural critique of social organization, bringing an intersectional analysis to social structures of inequality and addressing issues of social justice such as the precariousness of labour, zero-hour contracts, the setting of minimum wages below the standard of a living, as well as endeavouring to give practical application to ideals such as gender equality now widely socially accepted, but not yet existing in social practice (Fraser 2009).

Intersectionality's recognition of the complexity of social positions (that is categories of gender, socio-economic privilege, "race" *etc*.) as multiple, interdependent, and overlapping offers an antidote to the narrow conceptualisation of issues of social justice outlined above. One of the significant benefits of utilising an intersectional approach to research is that it attends to 'causal complexity' and the social operation of 'discourses of power' (Haraway 1991). The concept incorporates the recognition that every person has multiple intersecting attributes which are personally internalised and experienced, and that they are also socially constructions formed through social norms, social institutions, and social structures. The experience of living at the node of multiple intersecting axes of identity all impact on a person's life expectations and experiences – both positively and negatively. Intersectional research captures both the complexity of the individual as well as the complexity of institutional structures that directly impact on the individual and the complex interplay between both. More recently, the use of intersectionality has expanded beyond its initial focus on those who are oppressed by the intersections of identity, and it is now being constructed in a way that is "applicable to any group of people, advantaged as well as disadvantaged" (Yuval-Davis 2006).

MacKinnon (2013) points out the strengths of using intersectionality as a method of analysis as intersectionality "does not simply add variables. It adopts a distinctive stance, emanates from a specific angle of vision, and, most crucially, embodies a particular dynamic approach to the underlying laws of motion of the reality it traces and traps while remaining grounded in the experiences of classes and people within hierarchical relations … criticising a rigidly top-down social and political order from the perspective of the bottom up". Also, expanding on the politically oriented benefits of utilising intersectionality as methodological tool, Hancock argues that "intersectionality can also more comprehensively answer questions of distributive justice, power, and government function … This capability is not limited to the inclusion-oriented content specialization for which intersectional scholarship is well known" (Hancock 2007a). Hancock suggests that intersectionality operates as a research paradigm, a topic we return to below.

Feminist epistemologies and the critique of science

Sandra Harding's critical work in the philosophy of science and epistemology are foundational texts for feminist critical analysis in the fields of science and epistemology, and for the development of standpoint theory. (Harding 1986a; 2015; 2004a). The concept of "feminist standpoint theory", explored in more detail below, has shared concerns with intersectionality, and in particular with the representation of oppressed or silenced groups. The two approaches to developing the range of critical analyses – intersectionality and feminist standpoint theory – are complimentary, and developing both offers a strong epistemological grounding for the intersectional analysis of any area of investigation that is centred on the human subject. The two approaches address different, yet interconnected aspects of analysis. Intersectionality is a method for analysing complexity – of persons, groups, and institutions, of axes of difference and their multiple intersections within and between the person, group and institutions. On the other hand, feminist standpoint theory strongly focuses on the knowledge produced by those whose lives, in a sense, occupy those axes — those whose voices are rarely, if ever, heard in the public discourse, and whose opinions do not figure in policy and planning decisions.

Turning to 'knowledge' claims, Harding situates the origin of feminist epistemological theory in the attempt by feminists to 'include women' by reinterpreting and extending theoretical categories of analysis to represent women's activities and interpersonal relationships in order to render them visible within the range of theoretical discourses. (Harding 1986a) However, these attempts at inclusion revealed that the discourses cannot fully accommodate women – "liberal political theory and its empiricist epistemology, Marxism, critical theory, psychoanalysis, functionalism, structuralism, deconstructionism, hermeneutics, and the other theoretical frameworks we have explored both do and do not apply to women and to gender relations." (Harding 1986a) While elements of these can be used to fruitfully theorize and explore some aspects of women's lives, the theories must be significantly stretched to do so, with the result that feminist theorists spend much of their endeavours defending their use against those theorists who advocate more traditional usages of concepts.

Harding notes that just as feminist critiques had revealed the "destructively mythical character of the essential and universal 'man' which was the subject and paradigmatic object of nonfeminist theories", the recognition developed that the "essential, universal woman" is also a partial representation of women, and therefore that any theory with such a narrow conception of "woman" as its subject cannot be extended to

the experiences of all women (Harding 1986a). The connection in conceptual dispositions between feminist epistemology, standpoint theory, and intersectionality are obvious. "We have come to understand that whatever we have found useful from the perspective of the social experience of Western, bourgeois, heterosexual, white women is especially suspect when we begin our analyses with the social experiences of any other women. The patriarchal theories we try to extend and reinterpret were created to explain not men's experience but only the experience of those men who are Western, bourgeois, white, and heterosexual." (Harding 1986a) It is clear that feminist critiques of the androcentrism of theoretical discourses revealed not only how women had been excluded as the subject of theory, but in so doing revealed how the majority of men had been excluded also. "Feminism has played an important role in showing that there are not now and never have been any generic 'men' at all – only gendered men and women. Once essential and universal man dissolves, so does his hidden companion, woman. We have, instead, myriads of women living in elaborate historical complexes of class, race, and culture." (Harding 1986a)

Feminist analyses uncovered the inherent androcentrism across the research milieu that extended beyond the 'subject' of research to the research paradigm itself. "Feminists such as Harding, Haraway, Longino, Wylie, and many others have laboured to build a philosophical understanding of science as a social practice with institutional, rhetorical, ideological and social-structural dimensions … feminist philosophers of science carried the leading edge of this work, recasting traditional philosophical questions about the nature of concepts such as objectivity, value-neutrality, theory-ladenness, underdetermination, and pluralism, and crafting newer concepts for understanding science such as contextualism, epistemic communities, and background assumptions." (Richardson 2010) "Our ability to detect androcentrism in traditional analyses has escalated from finding it in the content of knowledge claims to locating it in the forms and goals of traditional knowledge seeking" (Harding 1986a).

However, while feminist critical analyses can reveal the androcentric biases in theoretical discourses, the problem remains of how to theorise without replicating biases, or of replicating inherently fictitiously stable monolithic categories. Instead, it is argued, the inherent "fuzziness" of categories should be embraced as an analytical tool, particularly given the, relatively, rapid changes underway across societies: "Feminist analytical categories should be unstable – consistent and coherent theories in an unstable and incoherent world are obstacles to both our understanding and our social practice" (Harding 1986a). Harding makes the acute observation that "the destabilization of thought often has advanced understanding more effectively than restabilisations, and the feminist criticisms of science point to a particularly fruitful arena in which the categories of Western thought need destabilization" (Harding 1986a).

Feminist standpoint theory

Emerging out of feminist epistemological theory, standpoint theories have been developed over the course of four decades. Standpoint theory is both an epistemology and a philosophy of science, as well as a research practice (2009; Harding 2004a). In the context of the western 'crisis of representation' that emerged from postmodernism and poststructuralism, standpoint theory is viewed as offering a 'third way' against absolute relativism. Standpoint theory refined by intersectional analysis "reinforces the insight that context-specific analysis is required to understand exactly how our 'cognitive styles' and epistemic resources are affected by

the material and social conditions of life that function, to varying degrees, as structural features of the social contexts in which we operate" (Wylie 2012).

Feminist standpoint theory was developed as an alternative to both "neopositivist objectivism, on the one hand, and to relativism, on the other". (Jaggar 2015) Feminist standpoint theory holds that marginalised groups, because of their social position of social outsiders are better placed to observe and critique social norms and knowledge claims, and to recognise the 'partiality' of apparently 'objective' views. Their social positioning offers them a vantage point of 'otherness'. The cumulative effect of multiple perspectives serves to make apparent the fact that the 'objective view', while hegemonic, is as socially positioned, and therefore as partial, as any other.

While there are different 'origin stories', feminist standpoint theory is often dated back to sociologist Dorothy Smith's (1974) germinal article "Women's Perspective as a Radical Critique of Sociology". Evolving out of feminist epistemology, the later 'explicit formulation' of feminist standpoint theory was first articulated by Nancy Hartsock (Hartsock 1983) in *Money, Sex, and Power: Toward a Feminist Historical Materialism,* however, the theorist most closely associated with the concept and who has developed the most comprehensive application of the theory is Sandra Harding (1986b; 2004b; 1986a). While standpoint theory is widely used across a range of research disciplines, particularly in the social sciences, as well as a framework for research projects, it is still a controversial theory in many quarters (Harding 2009). While the use of standpoint theory as a "logic of inquiry", that is, as "a trans-disciplinary, regulative ideal", is often unremarked, nonetheless it is utilised in research that is focussed on "race, class, sexuality, and studies in postcolonial research". (Harding 2009)

However, it should be understood that standpoint theory "is not an empirical perspective"; it is not a "bundle of beliefs actually held by an individual or group of individuals." (Jaggar 2015) And in any case, no viewpoint is "innocent". While arguing that the "vision is better from below", Haraway qualifies that, "the standpoints of the subjugated are not 'innocent' positions" (Haraway 1988). On the contrary, they are preferred because in principle they are least likely to allow denial of the critical and interpretive core of all knowledge. … 'Subjugated' standpoints are preferred because they seem to promise more adequate, sustained, objective, transforming accounts of the world." (Haraway 1988) Feminist standpoint theorists believe that the perceptions of most people in male-dominated societies, including most women, are distorted both by dominant systems of knowledge and by the structure of everyday life" (Jaggar 2015). "Standpoint theory offers an approach to assessing the epistemic reliability of knowledge claims by taking into account the circumstances in which these claims were produced" (Jaggar 2015).

It is important to recognise that a "standpoint" is not like a "perspective": a standpoint "is a theoretical system of beliefs that incorporates some of the views held by members of a particular group but rejects other views … [the system] presents issues of concern to [the group] in ways that allow their objective interests to be revealed" (Jaggar 2015). Standpoint theory takes as its premise that membership of subordinated groups can facilitate insight into aspects of social systems that remain obscure to those located in privileged positions of gender, race, and class, for example, thus producing knowledge that would be otherwise unavailable to those in more hegemonic positions of privilege. However, while standpoint theory recognises that it is "the occupation of marginal social locations that facilitates recognition of certain insights", it also

acknowledges that the "epistemic privilege" of those living at the margins is limited. Their position can provide insight into everyday life "under oppression", but it is "neither automatic nor all-encompassing" (Jaggar 2015). Central to both standpoint theory, and intersectionality is the recognition of both the instability of categories, as well as the range of social locations that occur within categories. Both standpoint theorists, and theorists of intersectionality resist conceptualising "woman", or any other group, as a unified category. Clarifying the remit and range of standpoint theory, Harding emphasises that "standpoint work must always be 'intersectional'" (Harding 2009).

Challenging homo economicus

In order to appreciate the significance of bringing an intersectional analysis to research generally, it is illustrative to examine an example of the proto-neutral 'subject' of research demonstrating the partiality of its representation of actual embodied persons. Reductive representations such as that of *homo economicus* [the rational self-maximiser] and other such similarly reductive conceptualisations of persons have produced less that optimal results across the fields of research (Schiebinger & Schraudner 2011). As feminist (and other critical) researchers, such as Harding above, have demonstrated, the genderless, classless, colourless "human" of theory when interrogated turned out to be male, socioeconomically privileged, and white. The actual human beings who are the focus of research, and who comprise the majority of the cohort of research subjects, across all disciplines, and in health research in particular, have primarily been male (Schiebinger & Schraudner 2011). This has had the unfortunate result of skewing research processes, and results, and in effect has led to "bad science" (Rees 2011). *Homo economicus* is a recent example of 'universal man'. Universal man is the gender neutral, classless, colourless, disembodied, subject of inquiry, who was subsequently revealed through feminist analysis to be, in fact, a white, able-bodied, socially privileged, heterosexual, Western male that he had always been. The dominance of this version of 'human' is ubiquitous across all the sciences since the Enlightenment – to the detriment of science, society, and knowledge production. "As intersectional work has shown since its inception, social hierarchy creates the experiences that product the categories that intersect. Substantively, white males dominate" (MacKinnon 2013).

Henrich *et al*. (2001) demonstrate that not only is *homo economicus* an inadequate conceptualisation of "human", and human behaviour in Western society, it is also untenable as a "working model" of human behaviour in any society. Henrich and his international cohort of fellow researchers carried out cross cultural field work in 15 small scale communities, in twelve countries across three continents. Three experimental games used in economic modelling of human behaviour were conducted in the communities – "ultimatum", "public goods", and "dictator". The researchers found that not only did the "canonical model" of *homo economicus* fail to hold in any of the societies, it "fails in a wider variety of ways than in previous experiments" (Henrich et al. 2001). The working assumptions of many economists – that human beings are self-interested maximisers – demonstrates a narrow world-view that may well reflect the partiality of their own particular perspective, but it is clearly not a universal trait shared amongst humanity at large. The authors suggest that major revisions to the "rational-actor framework" model are required in order to account for the failures in predicated behaviours, behavioural change, and the connection between economic choices and the "economic and social interactions of everyday life" (Henrich et al. 2001).

The reward of intersectional analysis

Putting intersectionality at the core of the research process has a significant impact on how research is done, as well as for foregrounding what is often invisible in science and technology studies [STS] in particular – the lived experience of human beings and their complex interactions with as technologies and technology systems, as well as the with social, economic, and political institutions that impact on and intersect with those interactions. The history of research on the energy system shows that it has been dominated by technocratic and technologically focused approaches to assessing initiatives aimed at reducing energy consumption with an over-concentration on technical remedies to reduce energy consumption (D'Agostino et al. 2001). Conversely, the majority of the limited research that has inquired into the human factor in the energy system is further limited in the range of analyses. Primarily, this research has drawn on reductive models of human behaviour that tend to predominate in economics and related disciplines (Sovacool 2014) – such as the problematic *homo economicus*, described above. In addition, most of the research on the human factor in the energy system has been largely quantitative in nature (*ibid*.). Further to these limitations there has been a significant lack of focus on women in the energy system, and on a gender analysis more generally, with some notable exceptions (Fraune 2015). These limitations are also found in analyses that incorporate other socio-demographic factors such as socio-economic privilege and age.

However, the concept of intersectionality has started to make the briefest of appearances in energy research. The call has been made for energy research to bring particular focus to the issue of energy justice, and with that, for the necessity for applying intersectionality as a key element of a conceptual framework for addressing issues of energy justice on a global scale (Sovacool et al. 2017). While there are clear advantages to using intersectionality, as paradigm, and as conceptual tool, to contribute to producing informed policies and mapping potential pathways for social change at the global level, it also provides clear advantages for research taking place at the micro- and meso- levels too.

For ENTRUST, developing our analysis on the human factor in the energy system has its primary focus on the individual, and on communities in order to deliver the bottom-up analysis which is required for understanding that human factor. An intersectional approach to the research process, and analysis has been vital for delivering that analysis. Sovacool *et al.* (2017), for example expressly advocate an intersectional approach as one of their ten principles for developing conceptual frameworks for energy justice. Recognising the intersecting multi-layered nature of energy poverty, that includes structural, economic, cultural and political factors, the authors acknowledge that the concept of intersectionality has "rendered itself as a useful theoretical tool for understanding the multiple identities that individuals and communities carry and its consequent implications in the form of disparate resource distribution and social outcomes" (ibid).

Intersectionality can be seen to have expanded beyond "inclusion-oriented content specialisation" and offers a new research paradigm, as well as a methodological approach to research more generally (Cho et al. 2013; MacKinnon 2013; Hancock 2007a).

Intersectionality as a research paradigm

Morgan and Smircich (Morgan & Smircich 1980) posit that research is inherently based upon three assumptions, namely: ontological assumptions, on the nature of reality; epistemological assumptions, on the

nature of knowledge; and methodological assumptions, that inform the framing and approach to gaining knowledge on a subject. The set of assumptions adopted by a researcher – whether explicitly or by default – establish a paradigm (Kuhn 1996, pp.10–11) or world view (Creswell 2014, pp.5–6), under which the research will be conducted. All researchers operate within an implicit paradigm based on the ontological, epistemological, and methodological assumptions that underpin their world-view. All human beings, including researchers, whether or not it is recognised, have ontological and epistemological biases that are brought to the understanding of human existence, to knowledge claims, and to the status of knowledge itself—and these have an impact on the work that researchers do. It is incumbent upon researchers to bring a reflexive stance toward these concepts and to assess their implications for the research project as a whole, as well as their significance for the conduct of the project, and the analysis of the data (Ryan et al. 2014).

The concept of intersectionality is a valuable tool that can assist in providing an expanded research paradigm which can produce better research grounded in a more complex understanding of human experience. Hancock suggests that intersectionality can operate as a research paradigm (Hancock 2013; Hancock 2007a; Hancock 2007b). She argues that intersectionality brings a new approach to the way that problems are identified, how they are conceptualised, researched, interpreted, and analysed (Hancock 2007b). Describing intersectionality as "a body of normative theory and empirical research", Hancock offers an accessible guide to conducting intersectional research (Hancock 2007a). She outlines the six key assumptions that are foundational to an intersectional analysis of a particular research issue:

(1) Examining complex social and political problems involves analyses along more than one axis of difference such as gender, race, or class.

(2) However, while all relevant social categories should be included, no presumption should be made as to the nature of the relationship between any particular category – "the relationship among the categories is an open empirical question" (Hancock 2007a, p.251). While, for example, class and gender may be analysed together, it should not be assumed either that they are independent of each other, nor that analysing both will fully capture all aspects of an issue.

(3) It is understood that categories of difference are not fixed, but rather are "dynamic productions of individual and institutional factors." (*ibid.*). The categories of difference are maintained, and challenged in complex interchanges between individuals and society.

(4) There is significant diversity within each socio-demographic group which has an impact on policy development, its reception, and its impacts.

(5) Intersectional research integrates multiple levels of analyses of individuals, their interactions within communities as well as with society and social institutions, including the energy system.

(6) Intersectional research requires theoretically informed empirical research that integrates multiple methods applying an intersectional approach across all aspects of the conduct of the research project. (Hancock 2007a)

As further explication of the suitability of utilizing intersectionality as a research method, Hancock outlines the "multiple paths" concept (Charles Ragin, 2000) to explore how socio-structural and political institutions

impose "solutions" on social issues that are predicated on the experiences of narrow demographic groups resulting in unintended negative consequences that can impact disproportionately on some social groups. She argues that what is required for the successful outcome to any policy initiative or goal is paying attention to causal complexity, analysing institutional restrictions, and identifying multiple pathways to successful outcomes. (Hancock 2007a)

Intersectionality provides a conceptual approach to research that allows an investigation of the simultaneous effects of "categories of difference", and their intersections, and in so doing overcomes the limitations of other approaches to research, as demonstrated in **Error! Reference source not found.**. The concept takes into account the complexity of social locations, as well as the impact of social location on health, well-being, and life chances. In the table below, Hancock (2013) summarises three different forms of approach to researching the organising structures of society such as gender, race, class and other categories of difference, and demonstrate the benefits of an intersectional analysis in comparison to other, more restricted approaches.

Three Empirical Approaches to Conceptualising Categories of Difference (Hancock, 2013, p. 268).

	Unitary Approach	**Multiple Approach**	**Intersectional Approach**
Number of Relevant Categories/Processes	One	More than one	More than one
Posited Relationship Between Categories/Processes	None	Predetermined and conceptually distinguishable relationships	Relationships are open empirical questions to be determined
Conceptualization of Each Category	Static at individual or institutional level	Static at individual or institutional level	Dynamic interaction between individual and institutional factors
Case Makeup of Category/Class	Uniform	Uniform	Diverse; members often differ in politically significant ways
Approach to Intersectionality	Lip service or dismissal	Intersectionality as testable explanation	Intersectionality as paradigm/ research design

As explored above, intersectionality, draws attention to the fact that identities have multiple aspects – that there is no woman or man who does not also have an ethnic identity, or different levels of socioeconomic privilege, as well as a range of other identity attributes – all of which are highly significant for the individual, and their life experience. Contesting the critiques of intersectionality as being disconnected from the material impact of embodying particular identities, Hancock remarks that "intersectionality theory has been incorrectly reduced to identity politics". (Hancock 2013). Whereas on the contrary, as argued above, intersectionality avoids the overt relativism that is associated with some schools of "identity politics", and offers a pragmatic, materially based, theoretical "middle-way" between absolutism and relativism regarding the epistemological and ontological status of categories of identity. Crenshaw writes: "Recognizing that

identity politics takes place at the site of where categories intersect thus seems more fruitful than challenging the possibility of talking about categories at all" (Crenshaw 1991).

Intersectionality and the Research Process

As further explication of the suitability of utilising intersectionality as a research method, as well as research paradigm, Hancock outlines the "multiple paths" concept (Ragin 2000) to explore how socio-structural and political institutions impose "solutions" to social issues that are predicated on the experiences of narrow demographic groups. She argues that what is required for the successful outcome to any policy initiative or goal is paying attention to causal complexity, analysing institutional restrictions, and identifying multiple pathways to successful outcomes (Hancock 2007a). As Hancock remarks "intersectionality theory has been incorrectly reduced to identity politics" (Hancock 2013). On the contrary, intersectionality avoids the overt relativism that is associated with some schools of "identity politics", and offers a pragmatic, materially based, theoretical "middle-way" between absolutism and relativism regarding the epistemological and ontological status of categories of identity. Crenshaw writes: "Recognizing that identity politics takes place at the site of where categories intersect thus seems more fruitful than challenging the possibility of talking about categories at all". (Crenshaw 1991, p.377)

Putting intersectionality at the core of the research process has a significant impact on how research is done, and further, for foregrounding what is often invisible in science and technology studies – the lived experience of human beings and their complex interactions with as technologies and technology systems, as well as the with social, economic, and political institutions that impact on and intersect with those interactions. Extending the intersectional analyses beyond the individual "consumer" and their situation, to encompass the institutions they interact with, as well as to those who are leading the technological, economic, and political pathways towards sustainability reveals the complexity of both the overarching "energy system" – inextricably bound up with industrialised society itself, and consequently people's identities – and can also reveal the relevance of the social positions of all actors – including those with the power to direct change at an institutional level.

It is clear from engagements with the communities that energy poverty is both a reality, and potentially a growing concern across most communities into the future. It is inevitable then that it has emerged as a theme – energy poverty is experienced by people across a wide demographic, and can be an outcome of number of different social circumstances. It is here too that intersectionality can offer a methodology to understand the multiple factors and pathways that are responsible for its incidence in order to avoid the pitfalls of a "one size fits all" approach to prevention strategies and solutions that will have to be incorporated into the transition pathways.

Our analyses and analytical frameworks are grounded in an intersectional ontology and epistemology, and critical theory, and draws from a range of disciplines including human geography, philosophy, and sociology amongst others. If as Wallenborn and Wilhite (2014) observe:

> The co-evolution of bodies and the material world thus affects the ontology of energy consumption as well as providing an interesting approach to conceptualizing changing consumption practices

Then it is clear that the particularity of those bodies – their gender, ethnicity, socio-economic privilege, age, bodily ability, sexuality, *etc.* is implicated in their relationship with energy and the wider energy system. An analysis that does not attempt to capture some of that complex particularity cannot hope to offer a rich analysis of the 'human factor' in the energy system.

Three socio-demographic elements

As described above, adopting intersectionality as a research paradigm provides a conceptual approach that overcomes the limitations of other empirical approaches to research. Bringing an intersectional approach to analysis entails developing a more complex conceptualisation of the particularity of the effect of the intersections of social identities and social locations on the embodied person which strongly contrasts with the limitations of narrow representations of human beings figured as disembodied rationalists. Below, we are expanding on the socio-demographic attributes of gender, socio-economic privilege and age in order to elaborate on their significance for life-experience, and so the 'performance' of energy practices – this elaboration notwithstanding, it should be understood that these socio-demographic attributes never exist in isolation in any person, but are always lived in combination with other attributes and factors which can all operate along multiply experienced axes of oppression or privilege or both.

For community based research, where applicable, the concept of intersectionality should guide the selection of communities, the selection of participants within those communities, as well as the analysis of the data that is generated from the community engagement. As outlined above, ENTRUST is giving particular consideration to the effects that gender, age, and socioeconomic privilege have for transitioning to low carbon energy system as its has been demonstrated that these attributes have a significant impact on energy use, as demonstrated by, for example, (Clancy & Roehr, 2003) [Gender]; (Yang *et al.,* 2015) [Age and Gender]; (Kennedy *et al.,* 2014) [Socioeconomic].

Incorporating an intersectional approach to participant recruitment, both women and men from a range of ages and from a diversity of socio-economic backgrounds should be interviewed by the research team, and the focus group participants should also be diverse in their demographic range. At all stages of the research process recognition should be given to the fact that each individual lives a diversity of social positions, and so at all times researchers should be consciously resistant to stereotyping individuals on the basis of any particular attribute. Adopting an intersectional approach throughout all stages of the research process should enable the development of fresh insights into the human factor in the energy system, or indeed the 'human factor' in any research project.

Intersectionality captures the ways that multiple identities combine and amplify each other rather than being merely additive, and offers a materially based and theoretically rich approach to analysis that incorporates a recognition of the complex ways that the social identities and social positions that we inhabit can affect our everyday energy practices. Using intersectionality as a research tool allows the examination of complex social and political problems involving analyses along more than one axis of difference such as gender, race, or class. What is key to the intersectional approach is recognising that no presumption should be made as to the nature of the relationship between any particular category, not that the categories themselves cannot be analysed. So, for example, class and gender may be analysed together, but it should not be assumed either

that they are independent of each other, nor that analysing both will fully capture all aspects of an issue. It is also understood that categories of difference themselves are not fixed, but rather are "dynamic productions of individual and institutional factors" (Hancock 2007b). Yet, while attributes of identity are not static, and can never be entirely disaggregated from the others personal and socially significant attributes, still each "category of difference" has an impact on those who share it, granted that impacts are variable, and are differentially experienced – what is necessary for the research process and analysis is retaining a reflexive approach alert to these complexities. The three key demographic factors under exploration are: gender, socio-economic privilege, and age; these are expanded upon here.

Age

Definitions of age and aging are varied and research from the social sciences field including psychology have contributed substantially to widening this understanding through a focus on more subjective constructions of age. This represents a break away from dominant concepts of aging predominantly linked to life-cycle and biological processes. Subjective definitions of age include a greater understanding of how people identify themselves in age terms and how institutions operationalize the concept in relation to the services they offer and the policies that are implemented.

Innovative insights from developmental psychology have linked age with individual reflections on personal development (Stinson, 1999). Research in this areas has shown that calendar age is not accurately representative of how individuals perceive their development, and that there is a large degree of subjectivity in individual experiences of age (Stinson, 1999). For example, adolescents typically feel older than their calendar age, while adults when they reach midlife typically report feeling younger than their calendar age. These perceptions in turn can have a real impact on health and wellbeing, with further studies in the field showing that negative perceptions of aging and age stereotypes influence cognitive functioning and may lead to maladaptive behaviour, especially in older age (Stinson, 1999).

Further insights from a Social Gerontology perspective seek to destabilize mainstream representations of age based on biological processes by demonstrating that experiences of ageing are strongly related to life course processes (*i.e.,* early life influences, access to education and employment, health status) which can lead, for example, to instances of accumulated advantage or disadvantage in life that often become conflated with age (Burton & Bromell, 2010).

Finally, the steady trend towards global demographic ageing is leading to extensive social transformations which demand new, and innovative, policies to address these changes. Old age is linked to increased levels of functional disabilities and chronic morbidity ,but new trends suggest that older adults are living longer, healthier lives, and they are able to live independently for longer too (Lecovich, 2014). This ability however is tied in with the capacity to make choices in shaping one's life, and in some instances in shaping the way institutional care is provided (Walsh *et al.,* 2016). Literature on ageing-in-place shows the significance of home in promoting independent living. Furthermore, social gerontologists argue that increased place attachment is a significant factor in older age and this is linked to increased sensitivity to the immediate social and physical environment (Lecovich, 2014).

From an energy research perspective age trends have been shown to have a significant impact in the context of transitions into alternative energy sources. For example, an ageing population will lead to large increases in energy demand and energy use in the home, and as these households are dependent on pensions new energy sources need to be provided at affordable prices (Willis *et al.,* 2011). Research in this field has also shown that there are potential differences in adaptability and acceptance of new energy system regarding different age groups (Stigka *et al.,* 2014; Willis *et al.,* 2011).

Gender

Investigating the role of gender as a key human factor in the energy system is a core concern of ENTRUST as well as STEM projects more generally. Within the social sciences, and in feminist theory, a distinction is often drawn between sex and gender where sex is understood to refer to the biological differences between women and men; and gender is understood to refer to the social differences between women and men. Gender is the primary categorical division in society and it operates as the primary means of social organisation across all societies. The most significant biological difference between women and men concerns their reproductive capacities, however while gender is based on the fact of the biological differences between women and men, these differences, while significant in some aspects, are amplified, and often exaggerated to make unsubstantiated claims about women's and men's capacities and abilities. The concept of gender encompasses the far more wide-reaching social inscriptions of expected and acceptable behaviours that are attached to having a particularly "sexed" body. In brief, gender refers to the social differences between women and men, while people are born with a particular biological sex, gender is a social and cultural construction, with rules of behaviour incorporating acceptable ways of presenting oneself to others. From birth, gender is internalised as a key element of the dynamic developmental process of growing up into childhood. (Fausto-Sterling *et al.,* 2012a; Fausto-Sterling *et al.,* 2012b) While biology clearly plays its part, essentially, gender is learned. Continuing into adulthood, the individual develops their gender, along with their gendered identity, through social and personal interactions (Oakley, 1972). The fact that gender is socially learned, rather than determined by biology, is demonstrated by the huge variation in gender roles assigned to individuals across different cultures, and across time (Eagly & Wood, 2013; Wood & Eagly 2002). Gender roles also vary within societies, where they intersect with age and socio-economic status as well as other sociocultural factors such as culture, ethnicity, and religion. We can understand gender in terms of the personal attributes people are expected to have (aptitudes and characteristics) as well as the social roles (behaviours and responsibilities) to which people are expected to conform. Men are expected to display the traits conventionally attributed to masculinity; while women are expected to display the appropriate traits often associated with femininity. But the content of those traits of masculinity and femininity, and how those traits are assigned vary across cultures, as well as across time within particular cultures. Some aspects of gender roles have undergone significant changes in recent decades, particularly in the context of broader societal developments. For example, while women still have primary responsibility for parenting, fathers have become increasingly more involved in active parenting, as is evidenced in the research findings reported below. This social shift in parenting responsibilities is increasingly being recognised as an accepted social norm across the EU. Maternity leave is already mandatory in the EU, and an

increasing number of European countries are now introducing paternity leave, albeit along less generous terms, with more countries expected to follow.

Gender, its negotiation and interpretation, plays a significant role in everyone's lives. Gendering is present from birth, and continues for the duration of one's lifespan (Fausto-Sterling, 2005). Gender is both a social process and a personal experience; it can be understood as a dynamic interplay between self and social system, a complex intersection between biology and society. People develop their gender identities [as women and men] over the course of their lifetimes. Each person is born into a social world that already has a gendered set of norms and expectations to which they are expected to conform, based on their biological sex. From the moment of birth, each individual's experiences being gendered as either a boy or as a girl. Infants are described in gendered terms, treated differently, and encouraged to display the appropriate gender attributes associated with the biological body that they happen to be born with (Fine, 2010). Considerable social pressure—from family, peers, and wider society – is brought to bear upon children as they grow up to conform to their socially sanctioned gender roles. These normative expectations translate into the energy-related behaviours and practices people engage in in their day to day lives, but for many they remain largely unexamined and are accepted as immutable constructs.

Unexamined ontological and epistemological assumptions about gender also pervade social and scientific research, including energy-related research. Ontological assumptions of, and binary distinctions between, categories of persons and their attributes are often unreflexively accepted across the sciences, such as "man/woman" and "masculinity/femininity", and these distinctions are often reified as essential (determined) aspects of the person. Further, they are reified as essentialist (innate) dichotomies. Of course, recognising the, effectively, constructed nature of gender is not to deny its undoubted effects. Understanding the role that gender plays in a person's self-concept offers a way of understanding the significance that an everyday practice may have for that person – and as is shown in the findings, some practices, such as laundry, remain highly gendered despite the signs of change in responsibility for other practices such as childcare, and cooking. However, that notwithstanding, understanding the socially constructed nature of gender, and how this impacts on energy related practices indicates the potential for social change to practices that while individually performed, are always, to some degree, socially mandated.

Gender analyses should utilise the concept of intersectionality as a key component to understanding whatever aspect of human behaviour is under exploration, in this case, people's everyday energy practices, in order to ensure that gender was not viewed in isolation from other relevant socio-demographic attributes.

Socioeconomic privilege

In this section, we have situated the analysis of socioeconomic privilege in the energy system, and addressed it through the lens of energy justice. Access to abundant, reliable, and cheap energy is necessary for the unprecedented standard of living experienced by those residing in the developed world. Many in the developing world do not enjoy the same access to energy services that exists in high-income countries (Bridge *et al.,* 2016). Energy is therefore a key social justice issue, as well as an environmental one. Healy and Barry (2017) stress the need to consider whether, where and how policies aimed at decarbonizing the economy can address the range of injustices and impacts of such a socio-energy transition, for instance. Hiteva and

Sovacool (2017) argue that social sustainability in energy terms should incorporate equitable distribution of costs and benefits, affordability, due process and greater participation in decision-making. These constitute key elements of an energy justice perspective. Sovacool *et al.,* (2017) define "energy justice" as a global energy system that fairly distributes both the benefits and burdens of energy services, and one that contributes to more representative and inclusive energy decision-making. Healy and Barry (2017) advocate for a 'just transition' highlighting, amongst other aspects, the need for supports for communities that have been marginalized or negatively impacted by low carbon energy transition processes.

Lennon (2017 p27) argues for evidence of an emerging 'just transition' whereby "renewable energy technologies and intersectional ideologies have collectively enabled marginalized groups to participate in and shape the technocratic energy sector, reconfiguring dominant understandings of energy and generating new political imaginaries from the grassroots to the corporate boardroom". In the same paper 'Decolonising energy', Lennon (2017) applies a Black Lives Matters framework to develop an intersectional understanding of energy. This framework suggests that pervasive understandings of energy reify colonial hierarchies. Lennon proceeds to emphasise the need for intersectional work that reconceptualises energy in terms of vital relationality. Socio-economic privilege and income levels are key socio-demographic elements in this regard, to be considered along with a wide range of other socio-demographic parameters.

At the macro level, energy consumption increases with income in emerging market and developing economies, while in advanced economies energy consumption increases with income beyond a point at which the economy achieves a threshold level of income (Chang, 2015). Azam & Khan (2016) report that energy has statistically significant positive relationship with trade openness and CO_2 emissions in Tanzania, the USA, Guatemala and China and significant negative relationship with economic growth in all of these countries. According to Change (2015), energy use per capita continues to grow in the advanced economies, especially in high income countries, as incomes increase. The explanation appears to be that energy-saving technical innovations tend to allow a greater number of energy-using appliances to be introduced into households and industries (causing more energy consumption), as the money saved is spent on other goods and services (Chang 2015). On the consumption side, ''direct'' rebound effects arise because energy efficiency improvements look much to the consumer like reductions in energy price, spurring increased energy consumption directly (Saunders, 2013). ''Indirect'' rebound effects arise on the consumption side because, to the extent households reduce their energy bills owing to more efficient use of energy, their disposable incomes will rise, which will be spent on goods and services that themselves have taken energy to produce and transport, thus increasing energy use (Saunders, 2013).

In a study of the relationship between energy consumption and economic growth for high, middle and low income countries Ahmed & Azam (2016) find causal, reverse casual, bidirectional causal and no-causal relationship between energy consumption and economic growth across different groupings of countries. In other words, the picture is very complex and clear macro-scale trends are not easily discernible. Results reported in Pablo-Romero & Sanchez-Braza (2017) do show that the Environmental Kuznets Curve[1] hypothesis is confirmed for the residential sector in the EU-28 countries. Moreover, the results also show

[1] Whereby environmental impacts increase to a peak, and then decrease with increase in income, in an inverted U-shaped curve.

that a turning point has been reached in Denmark, Luxembourg, Finland, The Netherlands, and Sweden; that is, as income increases in these countries, residential energy consumption has now started to decrease (Pablo-Romero & Sanchez-Braza, 2017).

At the household level (and notwithstanding the emerging evidence presented by Pablo-Romero & Sanchez-Braza), households with higher annual incomes were more likely to be high electrical energy users (Jones & Lomas, 2015). Druckman and Jackson (2008) found that there was a positive correlation between disposable income and energy consumption in a UK study. In the same study, Druckman and Jackson (2008) report that the amount of household energy consumption by the poorest 10% of households was only 43% of the energy consumed by the richest 10% of households in the UK. However, evidence from the literature suggests that care needs to be taken when drawing conclusions on the relationship between energy and income levels in particular. Socio-economic and socio-demographic characteristics can interact in complex and sometimes unexpected ways. While analysis in the paper by Yun & Steemers (2011) shows that socio-economic factors of households performed a vital role in determining space cooling energy consumption, indirect, rather than the direct effects of socio-economic factors were important[2]. While a weak and almost negligible relationship between household annual income and energy use is reported by Yun & Steemers for direct effects, when indirect effects were taken into account, income had a strong, positive relationship with energy consumption (Yun & Steemers, 2011).

Households with higher incomes may purchase new and high-end appliances for instance. Larger 'power hungry' appliances also tend to be higher-end devices with higher price tags, which are consequently more likely to be purchased by households with a high income (Jones & Lomas, 2015). As a result of such consumption patterns, high income earners consume a considerably higher proportion of embedded/embodied energy than direct energy. This suggests that as incomes rise, so will the relative significance of embedded/embodied energy use (Saunders, 2013). Income levels are also influential determinants of the physical characteristics of housing units and for example AC equipment, which in turn influence user control behaviour and thus cooling energy consumption patterns (Yun & Steemers, 2011). Santamouris *et al.,* (2007) support this, reporting that household income was an important determinant of the size, age, type, envelope quality of dwelling and type of equipment. It follows that through greater scope to control and design their home environment, households on higher incomes have more agency (whether they exercise this or not) over the type and nature of their domestic energy use practices.

Higher-income households also have great capacity to respond to externally imposed costs, such as changes in taxation rates or tariffs of various kinds. The financial burden of specific energy taxes may be incurred disproportionately by low-income households for instance. These households tend to spend a larger share of their disposable income on goods and services, such as heating and electricity (Oueslati *et al.,* 2017). This point is also argued by Schulte & Heindl (2017), who present evidence that real increases in energy prices show a regressive pattern of incidence. Simply put, the welfare consequences of direct energy taxation are larger for low income households. A given change in energy prices has a significantly different impact on

[2] Physical energy insecurity is defined as deficiencies in the physical infrastructure of the home environment that impact thermal comfort, induce harmful exposures and increase energy cost (Hernandez 2016).

households' welfare as a result of the price change. Welfare losses tend to be large for low-income households and changes in energy prices will impose unequal burdens on different households (Schulte & Heindl, 2017).

In the energy justice literature, distributional unfairness is frequently linked to problems with decision-making processes that, for instance, are seen as excluding certain parties or lacking transparency (Liljenfeldt & Pettersson, 2017). Investigating the extent to which the decisions to approve or reject windmill proposals in Sweden can be explained by factors related to the socio-economic characteristics of people living in the areas surrounding windmill sites, results reported by Liljenfeldt & Pettersson (2017) show skewness in the distribution of windmills. In this study, findings show a higher likelihood of rejection of projects in areas with more highly educated people and people working in the private sector, compared to a higher likelihood of approval in areas with more unemployed people.

Hernandez (2016) uses the concept of energy insecurity to capture the full range of these challenges for low-income households. "Energy insecurity is a multi-dimensional construct that describes the interplay between physical conditions of housing, household energy expenditures and energy-related coping strategies" (Hernandez, 2016 p1). In this framing, energy insecurity is predicated on markers of social disadvantage such as low socioeconomic privilege, race, ethnicity, family composition and housing tenure; all considered key social determinants of health. In addition, energy insecurity acts as a mediator in the poor housing to poor health continuum (Hernandez, 2016).

In Conclusion

As stated above, intersectionality captures the ways that multiple identities combine and amplify each other rather than being merely additive, and offers a materially based and theoretically rich approach to analysis that incorporates a recognition of the complex ways that the social identities and social positions that people inhabit can affect everyday energy practices. Although the three socio-demographic categories have been disaggregated here, throughout the research process, we have taken an intersectional approach and remained attendant both to the disparities within "groups", and to the effect that multiple overlapping and intersecting positions can have on an individual's experience and their 'lifeworld'.

Gender has been foregrounded as a key locus of analysis across this project, as well as in research more generally, and STEM research in particular (Schiebinger & Schraudner 2011). However, the attention to gender must be attenuated by the application of an intersectional positioning of gender within a range of socio-demographic attributes. A range of socio-demographic attributes have a significant impact on the gender roles that people are expected to enact within societies – different social groups can have varied gender role expectations, for example, even within the same culture. These gender roles can differ where they intersect with age, as well as other sociocultural factors such as socioeconomic privilege, ethnicity, and religion. An intersectional analysis goes further to capture the complexity of identity that other approaches and as such can provide a more grounded and 'rich' conceptualisation of social research topics, and so produce better, and more effective research.

Bibliography

Ahmed, M. & Azam, M., 2016. Causal nexus between energy consumption and economic growth for high, middle and low income countries using frequency domain analysis. *Renewable and Sustainable Energy Reviews*, 60, pp.653–678.

Azam, M. & Khan, A.Q., 2016. Testing the Environmental Kuznets Curve hypothesis : A comparative empirical study for low, lower middle, upper middle and high income countries. *Renewable and Sustainable Energy Reviews*, 63, pp.556–567.

de Beauvoir, S., *The Second Sex*, New York: Vintage Press.

Brah, A. & Phoenix, A., 2004. Ain't I A Woman? Revisiting Intersectionality By Avtar Brah and Ann Phoenix. *Journal of International Women's Studies*, 5(May), pp.75–86.

Bridge, B.A., Adhikari, D. & Fontenla, M., 2016. Household-level effects of electricity on income. *Energy Economics*, 58, pp.222–228.

Burton, L.M. & Bromell, L., 2010. Childhood Illness, Family Comorbidity, and Cumulative Disadvantage An Ethnographic Treatise on Low-Income Mothers' Health in Later Life. *Annual Review of Gerontology and Geriatrics*, 30(1), pp.233–265.

Chang, S., 2015. Effects of financial developments and income on energy consumption. *International Review of Economics and Finance*, 35, pp.28–44.

Cho, S., Crenshaw, K.W. & Mccall, L., 2013. Toward a Field of Intersectionality Studies: Theory, Applications, and Praxis. *Signs: Journal of Women in Culture and Society*, 38(4), pp.785–810.

Clancy, J. & Roehr, U., 2003. Gender and energy: is there a Northern perspective? *Energy for Sustainable Development*, 7(3), pp.44–49.

Collins, P.H., 1998. It's All In the Family : Intersections of Gender, Race, and Nation. *Hypatia*, 13(3), pp.62–82.

Crenshaw, K., 1989. Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. *University of Chicago Legal Forum*, pp.139–167.

Crenshaw, K., 1991. Mapping the Margins : Intersectionality , Identity Politics , and Violence against Women of Color. *Stanford Law Review*, 43(6), pp.1241–1299.

Creswell, J.W., 2014. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* 4th ed., Thousand Oaks: Sage Publications.

D'Agostino, N. et al., 2001. Interactions between mantle upwelling, drainage evolution and active normal faulting: An example from the Central Appennines (Italy). *Geophysical Journal International*, 147(2), pp.475–497.

Druckman, A. & Jackson, T., 2008. Household energy consumption in the UK: A highly geographically and socio-economically disaggregated model. *Energy Policy*, 36(8), pp.3167–3182.

Eagly, A.H. & Wood, W., 2013. The Nature-Nurture Debates: 25 Years of Challenges in Understanding the Psychology of Gender. *Perspectives on Psychological Science*, 8(3), pp.340–357.

Fausto-Sterling, A., 2005. The Bare Bones of Sex. Part I: Sex and Gender. *Signs: Journal of Women in Culture and Society*, 30(2), p.1491–1527.

Fausto-Sterling, A., Coll, C.G. & M., L., 2012a. Sexing the Baby: Part 1—What Do We Really Know About Sex Differentiation in the First Three Years of Life? *Social Science & Medicine*, 74, pp.1684–1692.

Fausto-Sterling, A., Coll, C.G. & M., L., 2012b. Sexing the Baby: Part 2—Applying Dynamic Systems Theory to the Emergences of Sex-Related Differences in Infants and Toddlers. *Social Science & Medicine*, 74,

pp.1693–1702.

Fine, C., 2010. *Delusions of Gender: The Real Science Behind Sex Differences*, London: Icon Books.

Fraser, N., 2009. Feminism, Capitalism and the Cunning of History. *New Left Review*, 56(2), pp.97–117.

Fraune, C., 2015. Gender matters: Women, renewable energy, and citizen participation in Germany. *Energy Research & Social Science*, 7, pp.55–65.

Hancock, A.-M., 2013. Empirical Intersectionality: A Tale of Two Approaches. *UC Irvine L. Rev.*, 3, pp.259–296.

Hancock, A.-M., 2007a. Intersectionality as a Normative and Empirical Paradigm. *Politics & Gender*, 3(2), pp.248–254.

Hancock, A.-M., 2007b. When Multiplication Doesn't Equal Quick Addition: Examining Intersectionality as a Research Paradigm. *Perspectives on Politics*, 5(1), pp.63–79.

Haraway, D.J., 1991. *Simians, Cyborgs, and Women: The Reinvention of Nature*, New York: Routledge.

Haraway, D.J., 1988. Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. *Feminist Studies*, 14(3), pp.575–599.

Harding, S., 2004a. A Socially Relevant Philosophy of Science? Resources from Standpoint Theory's Controversiality. *Hypatia*, 19(1), pp.25–47.

Harding, S., 2015. Borderlands Epistemologies. In A. M. Jaggar, ed. *Just Methods: An Interdisciplinary Feminist Reader*. Boulder CO: Paradigm Publishers, pp. 331–341.

Harding, S., 2009. Standpoint Theories: Productively Controversial. *Hypatia*, 24(4), pp.192–200.

Harding, S., 2004b. *The Feminist Standpoint Reader: Intellectual and Political Controversies*, New York: Routledge.

Harding, S., 1986a. The Instability of the Analytical Categories of Feminist Theory. *Signs: Journal of Women in Culture and Society*, 11(4), pp.645–664.

Harding, S., 1986b. *The Science Question in Feminism*, London and Ithaca: Cornell University Press.

Hartsock, N.C.M., 1983. *Money, Sex, and Power: Towards a Feminist Historical Materialism.*, New York: Longman.

Healy, N. & Barry, J., 2017. Politicizing energy justice and energy system transitions: Fossil fuel divestment and a 'just transition'. *Energy Policy*, 108, pp.451–459.

Henrich, J. et al., 2001. Cooperation, reciprocity and punishment in fifteen small-scale societies. *American Economic Review*, 91, pp.73–78.

Hernandez, D., 2016. Social Science & Medicine Understanding 'energy insecurity' and why it matters to health. *Social Science & Medicine journal*, 167, pp.1–10.

Hiteva, R. & Sovacool, B., 2017. Harnessing social innovation for energy justice : A business model. *Energy Policy*, 107(April), pp.631–639.

Iecovich, E., 2014. Aging in Place: From Theory to Practice H. Morphy & A. Young, eds. *Anthropological Notebooks*, 20(1), pp.21–34.

Jaggar, A.M., 2015. *Just Methods: An Interdisciplinary Feminist Reader* 2nd ed. A. M. Jaggar, ed., Boulder CO: Paradigm Publishers.

Jones, R. V & Lomas, K.J., 2015. Determinants of high electrical energy demand in UK homes: Socio-economic and dwelling characteristics. *Energy & Buildings*, 101, pp.24–34.

Kennedy, E.H., Krahn, H. & Krogman, N.T., 2014. Egregious Emitters: Disproportionality in Household Carbon Footprints . *Environment and Behavior* , 46(5), pp.535–555.

Kuhn, T.S., 1996. *The Structure of Scientific Revolutions* 3rd ed., Chicago: University of Chicago Press.

Lennon, M., 2017. Decolonizing energy: Black Lives Matter and technoscientific expertise amid solar transitions. *Energy Research & Social Science*, 30, pp.18–27.

Liljenfeldt, J. & Pettersson, Ö., 2017. Distributional justice in Swedish wind power development – An odds ratio analysis of windmill localization and local residents ' socio-economic characteristics. *Energy Policy*, 105, pp.648–657.

MacKinnon, C.A., 2013. Intersectionality as Method: A Note. *Signs: Journal of Women in Culture and Society*, 38(4), pp.1019–1030.

Morgan, G. & Smircich, L., 1980. The case for qualitative research. *Academy of Management Review*, 5(4), pp.491–500.

Oakley, A., 1972. *Sex, gender, and society*, New York: Harper Colophon.

Oueslati, W. et al., 2017. Energy taxes , reforms and income inequality : An empirical cross- country analysis. *International Economics*, 150(January), pp.80–95.

Pablo-Romero, M.P. & Sanchez-Braza, A., 2017. Residential energy environmental Kuznets curve in the EU-28. *Energy*, 125, pp.44–54.

Ragin, C., 2000. *Fuzzy-Set Social Science*, Chicago: University of Chicago Press.

Rees, T., 2011. The Gendered Construction of Scientific Excellence. *Interdisciplinary Science Reviews*, 36(2), pp.133–145.

Richardson, S.S., 2010. Feminist philosophy of science: history, contributions, and challenges. *Synthese*, 177(3 Making Philosophy of Science More Socially Relevant), pp.337–362.

Ryan, S.E., Hebdon, C. & Dafoe, J., 2014. Energy research and the contributions of the social sciences: a contemporary examination. *Energy Research & Social Science*, 3(3), pp.186–187.

Santamouris, M. et al., 2007. On the relation between the energy and social characteristics of the residential sector. *Energy and Buildings*, 39, pp.893–905.

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

Schiebinger, L. & Schraudner, M., 2011. Interdisciplinary Approaches to Achieving Gendered Innovations in Science, Medicine, and Engineering. *Interdisciplinary Science Reviews*, 36(2), pp.154–167.

Schulte, I. & Heindl, P., 2017. Price and income elasticities of residential energy demand in Germany. *Energy Policy*, 102, pp.512–528.

Smith, D.E., 1974. Women's Perspective as a Radical Critique of Sociology. *Sociological Inquiry*, 44(1), pp.7–13.

Snyder, R.C., 2008. What Is Third-Wave Feminism? A New Directions Essay. *Signs: Journal of Women in Culture and Society*, 34(1), pp.175–196.

Sovacool, B.K. et al., 2017. New frontiers and conceptual frameworks for energy justice. *Energy Policy*, 105(March), pp.677–691.

Sovacool, B.K., 2014. What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda. *Energy Research and Social Science*, 1, pp.1–29.

Stigka, E.K., Paravantis, J.A. & Mihalakakou, G.K., 2014. Social acceptance of renewable energy sources : A review of contingent valuation applications. *Renewable and Sustainable Energy Reviews*, 32, pp.100–106.

Stinson, L.L., 1999. Measuring How People Spend Their Time Bureau of Labor Statistics , Paper prepared for the Joint Statistical Meetings in Baltimore , Maryland Any opinions expressed in this paper are those of

the author and do not constitute policy of the Bureau of Labor S.

Wallenborn, G. & Wilhite, H., 2014. Rethinking embodied knowledge and household consumption. *Energy Research and Social Science*, 1, pp.56–64.

Walsh, K., Scharf, T. & Keating, N., 2016. Social exclusion of older persons : a scoping review and conceptual framework. *European Journal of Ageing*.

Willis, K. et al., 2011. Renewable energy adoption in an ageing population : Heterogeneity in preferences for micro-generation technology adoption. *Energy Policy*, 39(10), pp.6021–6029.

Wood, W. & Eagly, A.H., 2002. A cross-cultural analysis of the behavior of women and men: implications for the origins of sex differences. *Psychological Bulletin*, 128(5), pp.699–727.

Wylie, A., 2012. Feminist philosophy of science: standpoint matters. *Proceedings and Addresses of the American Philosophical Association*, 86(2), pp.47–76.

Yang, S., Shipworth, M. & Huebner, G., 2015. His, hers or both's? The role of male and female's attitudes in explaining their home energy use behaviours. *Energy and Buildings*, 96, pp.140–148.

Yun, G.Y. & Steemers, K., 2011. Behavioural , physical and socio-economic factors in household cooling energy consumption. *Applied Energy*, 88(6), pp.2191–2200.

Yuval-Davis, N., 2006. Intersectionality and Feminist Politics. *European Journal of Women's Studies*, 13(3), pp.193–209.

Appendix 2: Practice Theory

'Nexuses of activity': A primer on practice theory

> A practice, on my understanding, is an open-ended, spatially-temporally dispersed nexus of doings and sayings.
>
> (Schatzki 2012, p.14)

Grounding research in philosophy and theory allows social scientists to provide solid contextual frameworks from which one can engage in empirical work in an informed and considered way. In turn, it enables further elaborations of the bodies of knowledge around which research disciplines grow and flourish and provides researchers with the opportunity to engage with key ideas that legitimate social and political activism (Aitken & Valentine 2016). This conceptual and practical approach also allows one to develop deeper understandings of the complexities and contradictions of the spatial world we collectively negotiate and occupy.

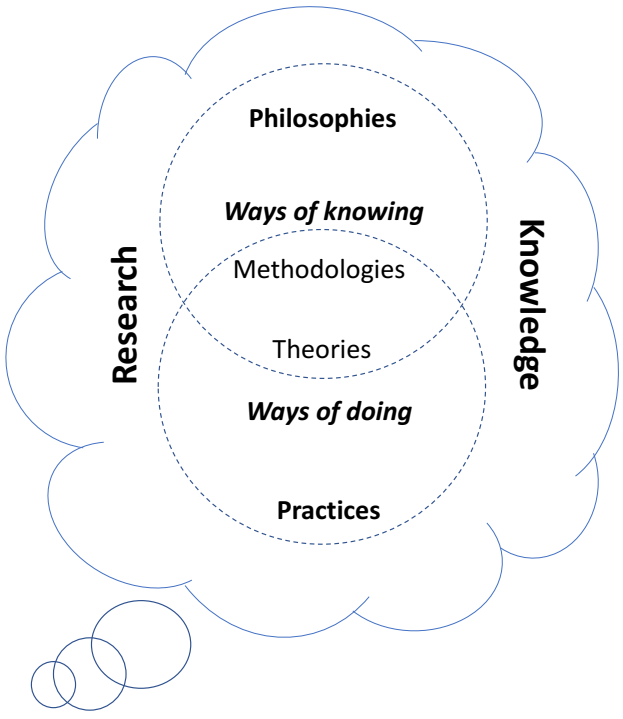


Figure 1: W*ays of knowing* and *ways of doing*, when doing research. Adapted from Aitken and Valentine (2016)

Writing on how one should approach academic research Aitken and Valentine (2016) divide the processes involved into two representative terms that help to demonstrate the complexities associated with engaging in this type of activity: ways of knowing and ways of doing. Both speak to each other in dynamic, non-linear, and often unstable ways where one's understanding is shaped by an amalgam of intersecting knowledges and experiences. As such, one's understanding, or knowledge (built up through active learning and from previous learned experiences), can have a deep influence on how one perceives a "new" experience. In turn, any new experience can either question or reinforce one's original sense of knowing. This process can equally be understood in terms of how individuals shape and are shaped by they collected knowledges and experiences. An adaptation of Aitken and Valentine's representation can be seen in Figure 1. Understood in this way, one can begin to see dominating paradigms or ways of seeing change or shift over time, with practices occupying an integral role in this process.

The primary focus of the research team has been on understanding the reciprocal relationships involved in people's practices – relationships that involve people, their social world, and the energy system. Understanding practice, both in terms of its philosophical underpinnings and the practical applications of those underpinnings, is an important component of this research focus. Ultimately, understanding practice

theory speaks to our social and collective ways of knowing how people interact with the energy system, usually along multiple nexuses of intersecting, situated perspectives that they continually (re)construct, (re)negotiate, and (re)contest around identity and experience. This appendix should be read as primer on practice theory. It provides an outline of what we understand practices to be, their meaning, and how we see them being applied by people in the respective communities of practice.

Understanding practice theory

As a collected body of knowledge, practice theory's founding exponents have been Pierre Bourdieu (1977; 1990; 1993) and Anthony Giddens (1979; 1984), two key early contributors to discussions on the subject, and has been widely informed by the philosophies of Ludwig Wittgenstein and Martin Heidegger (Schatzki 2012). While there are significant differences between the two philosophers, both in terms of the traditions they inherited and their respective stylistic approaches, they do share some quite strong commonalities, though these may not always be apparent at first (Egan *et al.* 2013). Both philosophers, for example, insist on accepting the radical finitude of what it is to be human, and therefore that reason – as definitive means for understanding the world – cannot *be* accepted as the definitive means of understanding, since human beings exist in a world that existed long before such ideas arose (Braver 2012). First coined by Sherry Ortner (1984), the concept of practice theory has been developed over the intervening years with contributions from a diverse range of thinkers from across the disciplines, including more recently Andreas Reckwitz (Reckwitz 2002b), Theodore Schatzki (2002; 1996), Elizabeth Shove (Shove & Walker 2010; Blue *et al.* 2016; Shove *et al.* 2012), Tom Hargreaves (2011), Jill Sweeney *et al.* (2013), and Cecily Maller (2015). Such diversity, some would argue, may go some way towards diminishing the usefulness of the concept, but as Schatzki (2012) points out there are a number of key commonalities that are shared amongst this diverse group when understanding what a *practice* actually means. Accepted by most practitioners more or less across the board, he suggests a practice is often understood to signify:

- An organised "constellation" of different people's activities;
- Important features of human life must be understood as being inherently rooted in human activity; and
- As a counter to traditional philosophical thought, which divides subject and object into separate parts, where essentially much of human activity remains explained and is tied up with their organised activities.

These broad, somewhat loosely defined descriptions of what practices are – there is still no absolute clearly defined definition of what a practice is – has seen the, often inappropriate, use of terms such as "practice" and "practice-based research", as it has become increasingly popular across a broad spectrum of researchers to describe their work as such merely on the basis that it involves people in some way. This has further obscured some researchers' understanding of what exactly practice theory pertains to, and limited their ability to address the concept in a comprehensive or concrete way.

At its most basic, we can understand practice theory to be primarily concerned with practices themselves, and a practice is, as Theodore Schatzki puts it:

> A practice is an organised constellation of different people's activities. A practice is a social phenomenon in the sense that it embraces multiple people. The activities that compose it, moreover, are organised.
>
> (Schatzki 2012, p.13)

By this definition, a practice is composed of number of coordinated activities, that are performed by many people, that are assembled and located at interstitial nodes of space and time. In essence, they are organised as interacting, and reactive relationships that can have multi-directional causal, intentional, and material elements associated with them (Schatzki 2012). The example given here is the phenomena of commuting to work. The practice of commuting to work is an amalgam of activities that occur across space and time. There is a constellation of activities associated with this practice, from preparing to, and engaging in the commute itself, to the underlying reasons for doing the commute in the first place – the need to travel to work from one's home *etc.* And in this case, the practice of commuting, the practice incorporates the particular means of transport also. However, not all practices are as clearly identifiable as the commute to work, with its rather linear demarcation in space, travelling from *A* (one's home) to *B* (one's place of work), and time, the start and end of the working day. For example, if describing a team winning a sports competition, the practice of "winning" can be located at the conclusion of the final game, over the entire competition itself, or when the final result has been ratified by the adjudicating officials overseeing the competition. Any one, or all, of these points in time can be used to describe the team winning the competition. The main point is that this can be described as a spatial and temporally dispersed amalgam of activities that comprise its own "nexus of doings and sayings" (Schatzki 2012). There is an acknowledged hierarchy here with sayings being subordinate to that of doings, since doing is usually a combination of the former. Also, it should be noted that all practices comprise basic activities that actor can perform as discrete activities, without having to do anything else. They are, more often than not, bodily actions that a person, or actor, can do without any specific additional input being needed. If we are to use our commuting to work example again, in the instance where one commutes to work via a car, the act of driving the car can be considered to be a basic activity. When engaging in basic activities actors can still engage in other activities (though in this instance, one would recommend limiting the types of activities one does while driving) such as listening to the radio or composing one's thoughts about the day's work schedule *etc.* The "mental" actions, or higher-level activities in themselves engage in further activities that are of a higher order again. For example, thinking about the day's work schedule can have far-reaching consequences for both the thinker and her work colleagues. Indeed, the very act of commuting to work is itself a result of the commuter's need to remain in employment in order to support her or himself, and/or their family. These hierarchies are referred to by Schatzki (1996; 2012) as "teleological hierarchies", which top off with some activity that ends the chain of activities that comprise the practice. For example, the practice of commuting ends once the commuter enters her/his location of work; they are no longer commuting, they are now "at work".

This open-ended, spatially-temporally dispersal of activities (Schatzki 2012) is interesting, since a practice by this definition is dynamic and subject to change, yet at the same time it adheres to, or is constrained by, fairly rigid organisational structures and hierarchies. For Bourdieu, his use of the term *habitus* is important for describing the embodied, learned knowledges that appear second-nature to people as they negotiate social

life. Essentially, habitus describes the relationships between objective social structures and individual action, and how these shape individual agent's character and patterns of behaviour which, in turn, influence the individual to behave and act in certain ways. This enables the individual to respond to social situations in specific ways that do not require concentrated effort or deep, critical analysis, thus appearing to them to be many ways "natural" or "normal". Habitus is both the outcome and instigator of social groupings and divisions in society. Consequently, it is an important concept for developing our understanding of how identities and behaviours, which can determine practices, are constructed by learned and habituated processes that themselves are open to modification and transformation. These transformations occur "through reflexive agency, educational practices and the acquisition of intercultural capital" (Pollmann 2009, p.537). Habitus, therefore, is subject to endless transformations given it is a product of social conditioning. Lillian Farrell (2010) provides the example of the school as a site for social conditioning with education acting as the *field*[1] (Bourdieu 1990) where generations of individuals are habituated to all manner of officially sanctioned identities and social norms.

Charles Lemert (2016) presents Bourdieu's work on structures, habitus, practices in Figure 2 below, which succinctly demonstrates the complex and dynamic relationships they share with each other. Habitus is further complicated, and complicating, by the range of durable dispositions an agent possesses by way of her/his life experiences. As Appelrouth and Edles (2011, p.450) points out, for Bourdieu "a central unintended consequence of this circular process is the legitimation and reproduction of a stratified social order that advantages some groups while disadvantaging others". The authors provide the example of two people, one whose parents are "successful, college-educated professionals" *(Ibid.)* and the other whose "family has worked as manual laborers for generations" *(Ibid.)*. The person whose parents are successful professionals, Appelrouth and Edles suggest, will most likely grow up to expect to work in a similar work environment and attain similar educational qualifications. While the person whose parents are manual labourers may see the same professional career path as being unattainable to her/him. This internalised, estimation of what is achievable for both individuals will result in very different outcomes for both, which at the same time reinforces the unequal, objective structures that they both negotiate. As such, the habitus of both families locks them in to their respective (dis)advantaged fields – along with their unequal opportunities – down through the generations with respective successive individuals contributing to this through their expectations and behaviours (Appelrouth & Edles 2011).

[1] Another core concept of Bourdieu's is that of the *field*, which he uses to describe the setting (either geographically or in thought) where agents and their respective social positions are situated (Liu 2012). The location of each agent in the field is subject to a myriad of intersecting influences including the specific rules of the field, the agent's own habitus and her/her social, economic and cultural capital (Bourdieu, 1993). In addition, these fields can interact with one another via strong hierarchical power relations that delineate the range of accepted and prohibited behaviours and social norms for agents operating within each field. Therefore, fields can be understood as sites of competition, struggle and confrontation as to the definition of the field itself and the what agents consider to be legitimate and valued behaviours (Liu 2012).

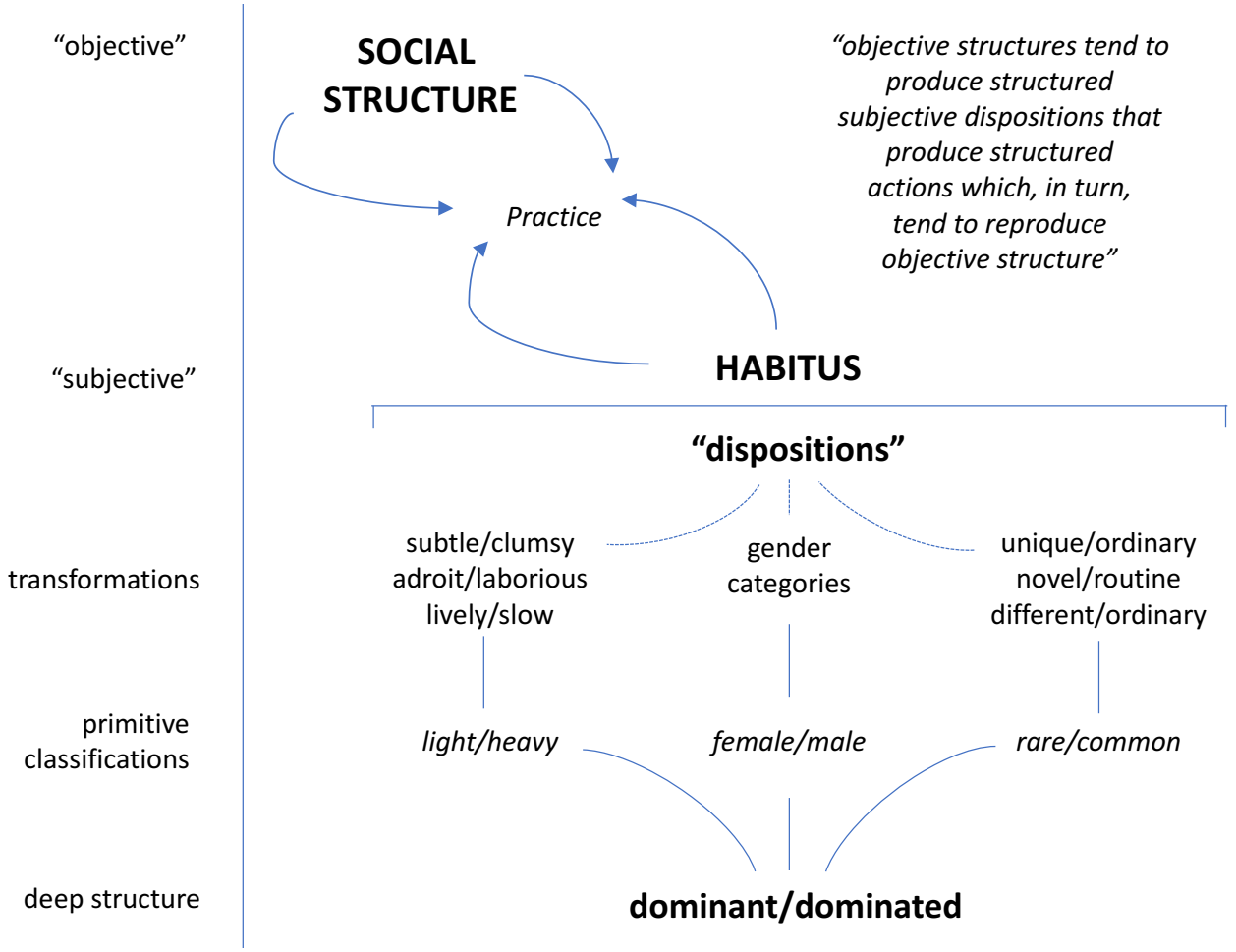


Figure 2: A representation of Pierre Bourdieu's structure-habitus-practice relationship (Lemert 2016)

Another key thinker who has heavily influenced the canon of practice theory is Anthony Giddens (1979; 1984), whose theory of structuration offers an alternative perspective to that of Bourdieu's in how we analyse the way social systems are created and reproduced. Like Bourdieu, Giddens does not see human life happening as a series of random individual acts, but rather indicates that there are very real structures and agents at work, with one not necessarily having a more dominant effect over the other. In *The Constitution of Society* (1984)

Giddens suggests that human agency and the social structures within which one must negotiate operate within rather bounded relationships with each other. Therefore, while it can be taken as given that individuals adhere to specific social structures (*i.e.* long-established institutions, traditions, codes and ways of doing) these social structures adhere to changes in people's attitude towards them (*i.e.* by reproducing them differently, replacing them or ignoring them completely). Applying phenomenological and hermeneutic discourses in his analysis of social practices at the multiple intersections experienced between structures and agents, Giddens suggests:

> To be a human being is to be a purposive agent, who both has reasons for his or her activities and is able, if asked, to elaborate discursively upon those reasons

> (including lying about them) … Human action occurs as a *durée*[2], a continuous flow of conduct, as does cognition. Purposive action is composed of an aggregate or series of separate intentions, reasons and motives.
>
> (Giddens 1984, p.3)

Both Giddens and Bourdieu accept that there is a clear relationship between human agency and social structures, and that social structures comprise of systems of classification and meaning that organise specific patterns of distribution; usually in terms of material resources. Therefore, they are both very much concerned with the real world, corporeal manifestations of human practices (Bourdieu) and actions (Giddens).

Consequently, both acknowledge that social structures cannot be considered to be real without considering human practices/actions since it is the aggregation of these practices/actions that contribute to the formation of social structures in the first place. Where they both diverge is in terms of the importance they each give to whether the reproduction of social structures is as a result of purposeful, conscious human agency. We have already seen how Bourdieu sees this relationship in terms of *habitus* and the conditioning of agents to consider the social structure as "natural", which by extension reinforces the interests of the powerful within that social structure. For Giddens actors behave reflexively, with the capacity to reflect on and change their behaviours, and actions, in response to their experiences; whereas Bourdieu less optimistically sees actors as having much less agency due to the inbuilt restrictions of the social structures they inhabit.

What is most interesting for this research is that both thinkers actively challenge the false dichotomies that drive much of traditional thinking in social theory, often along rather misleading, binary divisions such as structure-agency and society-individual *etc*., and their contributions offer us a considerably more complete and holistic assessment of what social reality in fact is. Bourdieu's writing on the concept of habitus, in conjunction with his understanding of field and cultural capital, is seen by some to offer a useful, or operationalizable, toolkit for carrying out empirical research especially given its preoccupation with analysing the power dynamics of dominant groups over subordinate groups within society (Reay 2004). As such, this understanding of power can be just as productively applied to the study of gender, ethnicity, age and socio-economic disadvantage (McClelland 1990).

> People do not live in fragmented, unconnected lives; they still construct narratives about their selves, but they do so in "post-traditional" conditions which make such narratives much more problematic than in the past.
>
> (Tucker 1999, p.143)

[2] Giddens distinguishes between two different interpretations of the French term: *durée*, which directly translates and is understood in English as "term". The first refers to the duration in everyday life experiences (the repetitive, time-substantiated routines one engages in day-to-day); and *longue durée*, which is more directly concerned with "long-term" institutional time (Leccardi 2016).

The transformations that are required of the energy system extend into every aspect of daily life, and across all sectors of society. By applying these understandings of how practices inherently shape people's engagements with, and reactions to, the energy system only then can we really begin to reconceptualise how such relationships can be better adapted to foster the just and meaningful change that is required. In applying a practice based approach, we shift away from the emphasis on the individual as (a usually passive) consumer with little agency to a situation where the individual becomes an agent who practices real agency in her/his interactions with the energy system. By conceptualising patterns of consumption within a practice theory framework, one can more easily recognise that consumption practices are not simply the idiosyncratic habits of individuals and families (and therefore easily adjusted), but rather are social phenomena deeply embedded in cultural understandings that are generated and evolve as a dialectic between technologies and societies. Further, practices are implicated in personal and social understandings of self, other, and community.

Practices often become sedimented into everyday consumption patterns that are socially validated, socially valorised, and internalised; and are shaped by a whole range of factors including technical infrastructures, institutional arrangements, systems of governance, as well as the norms and values of social groups. As such, it is clear that everyday practices of consumption must change not only in tandem with technological advances, but crucially, with social, and cultural developments as well. Envisioning the future of the energy system requires that the meanings practices hold for individuals, communities, and society will have to be recognised and incorporated into the transition to sustainability. Therefore, adopting a practice-based approach to the research allows for a more holistic analysis of the human factor in the energy system, that contextualises energy use, through practices, as central to the act of living and how people "perform" their lives. In their everyday lives, people do not actively consider their energy use. Instead, more often it is abstracted from the goals that are achieved from the use of energy. Energy is viewed – if "viewed" at all – as a means to an end, a facilitator of sorts that enables a task to be completed: *e.g.,* cooking a meal, heating a home, commuting to work. However, energy is neither solely "commodity" nor solely a "means"; rather, energy is – and always has been – intimately interwoven with all aspects of living.

As we have alluded to earlier, practice theory conceptualises the relationship between agency and structure – a relationship that has been, and remains, the topic of considerable scholarly debate – thus providing the theoretical means for investigating the social aspects of the energy system. Halkier *et al.* (2011) refer to the "problematic" dimension of agency and structure as being clearly relevant to researching the intersecting relationships between the individual and the energy system – in particular – but also between wider social groups, including communities, and the energy system. This "problematic relationship" is strongly implicated in how the energy user is conceptualised and presented in wider discourses on the subject of energy, for example, with portrayals such as "rational chooser", or "passive consumer" reflecting the somewhat narrow theoretical perspectives and paradigms in which people are pigeonholed into adopting. As discussed earlier, the conceptual background to practice theory resists any notion of there being a stasis of any kind; recognising that there is an often-dialectical relationship between both those who use energy and the energy system itself. This perspective also allows space for us to consider how both agents can evolve, foregrounding what energy is used for and the circumstances in which it is used, and offers the potential to move beyond

the paradigm of energy as a commodity and the user as a passive consumer. Adopting such an approach also allows for other conversations to come to the fore, such as concept of the "energy citizen", which has the potential to present people as transformative agents, processing real agency, within the energy system that can and does have a very real, transformative effect on people's practices.

Practice theories have been described as "a set of cultural and philosophical accounts that focus on the conditions surrounding the practical carrying out of social life" (Halkier *et al.* 2011). The "turn to practice" developed across a range of disciplines has come about in order to transcend the problematic of the structure-agency dualism in social theory and philosophy (Bryman & Bell 2011). In his investigation, *The status of the 'material' in theories of culture: From 'social structure' to 'artefacts'*, the cultural sociologist Reckwitz (2002a) takes the position that Schatzki's contribution to social practice theory has helped clarify the relationship between the material and the cultural, and that he [Schatzki] "integrates" Latour's understanding of material objects as "actors" [with some caveats] into the literature, arguing that the "post-Wittgensteinian theory of social practices has good reason to regard artefacts as necessary and influential components of social practices, while wishing to retain an "asymmetric" relation between them and the "human agents" (Reckwitz 2002a).

Alan Warde's (2005) work also has particular relevance for theorising the relationship between [energy] consumption and practice theory. His germinal article on the issue outlines the relevance of practice theory to the sociology of consumption, and he elaborates on Schatzki's exposition of the two central concepts of practice – practice as an entity; and practice as performance. Warde describes consumption is "a moment in almost every practice" (Warde 2005). Another key figure in the field of energy research is Elizabeth Shove, who is credited with applying practice theory to everyday practices such as laundry, and she has had, and continues to have, a significant impact on the social scientific contribution to energy research. Significantly, from the perspective of imagining the potential for change in energy practices, Shove *et al.* (2012, pp.7–8) noting the tendency in the literature to "take practices to be enduring entities reproduced through recurrent performance", want to account for the reconfiguration of practices – as both entity and performance *(Ibid.)*. They draw on Reckwitz's (2002b) definition of "practice" as consisting of "interdependencies between diverse elements", cited above; however in order 'to better account for change' they argue for a broader emphasis that can describe and analyse the processes that reconfigure practices as both entity and as performance (Reckwitz 2002b). At the same time, they maintain the analytical distinction between practices as "entities" and "performance" as a useful means of showing "how novel combinations of competence, material and meaning are enacted and reproduced" (Shove *et al.* 2012).

Sarah Pink offers a further development of practice theory with her innovative "applied anthropological" approach to empirical research, and her rich interdisciplinary analysis of everyday practices (Pink 2004; 2005; 2012). Bringing together three "turns" – "the practice turn", "the sensory turn" and "the spatial turn" – Pink (2012) develops her analysis of how energy is used in the home by "follow[ing] the routes that domestic practices forge in their moving through and creating environments" (Pink 2012). Her analysis conceptualises "home" as a "place-event" (Pink 2012). Through her ethnographic research and her interdisclipinary analyses Pink embeds practices, not in the home, but as an aspect of home. Laundry practices, for example, "are

integral to the constitution of the sensory home" (Pink 2012). Pink demonstrates how "when people do consider questions about energy use, they may weigh this up against other factors … in terms of existing structures, relationships and other practices and to ways that they can ensure that an appropriate aesthetic balance is maintained" (Pink 2012). For example, she describes how "movement, materiality, the senses, sociality, technology, and the weather are implicated in the way that the everyday practice of doing laundry is performed. … [And] are implicated … in the contingencies of how energy is consumed" (Pink 2012).

Practice theory's importance to ethnographic research is evident in its growing use in energy-focused research where the human dimension of the energy system is given particular importance. Further research in this field will only enhance this expanding body of literature.

Key terms
teleological hierarchies (end-project-activity combinations), doings, sayings, practical rules, understandings, organisations, causal relations, prefiguration, constitution, intentionality, intelligibility.

Bibliography

Aitken, S. & Valentine, G., 2016. Ways of Knowing and Ways of Doing Geographic Research. In S. Aitken & G. Valentine, eds. *Approaches to Human Geography*. London: Sage Publications, pp. 1–13.

Appelrouth, S. & Edles, L.D., 2011. *Sociological Theory in the Contemporary Era: Text and Readings* 2nd ed., Los Angles: Sage Publications.

Blue, S. et al., 2016. Theories of practice and public health: understanding (un)healthy practices. *Critical Public Health*, 26(1), pp.36–50.

Bourdieu, P., 1977. *Outline of a Theory of Practice*, Cambridge: Cambridge University Press.

Bourdieu, P., 1993. *The Field of Cultural Production* R. Johnson & L. D. Kritzman, eds., Columbia University Press.

Bourdieu, P., 1990. *The Logic of Practice*, Palo Alto: Stanford University Press.

Braver, L., 2012. *Groundless Grounds: A Study of Wittgenstein and Heidegger*, Cambridge, Massachusetts: MIT Press.

Bryman, A. & Bell, E., 2011. *Business Research Methods* 3rd ed., Oxford: Oxford University Press.

Egan, D., Reynolds, S. & Wendland, A.J., 2013. *Wittgenstein and Heidegger* D. Egan, S. Reynolds, & A. J. Wendland, eds., London: Routledge.

Farrell, L., 2010. Pierre Bourdieu on European identity: Theories of habitus & cultural capital. *Social and Political Review*, 20, pp.107–115.

Giddens, A., 1979. *Central Problems in Social Theory: Action, Structure, and Contradiction in Social Analysis*, Berkeley: University of California Press.

Giddens, A., 1984. *The Constitution of Society: Outline of the Theory of Structuration*, Cambridge, UK: Polity Press.

Halkier, B., Katz-Gerro, T. & Martens, L., 2011. Applying practice theory to the study of consumption: Theoretical and methodological considerations. *Journal of Consumer Culture*, 11(1), pp.3–13.

Hargreaves, T., 2011. Practice-ing behaviour change: Applying social practice theory to pro-environmental behaviour change. *Journal of Consumer Culture*, 11(1), pp.79–99.

Leccardi, C., 2016. Memory, time and responsibility. In A. L. Tota & T. Hagen, eds. *Routledge International Handbook of Memory Studies*. Abingdon: Routledge, p. 546.

Lemert, C., 2016. Bourdieu Pierre: Structures, Habitus, Practices. In C. Lemert, ed. *Social Theory: The Multicultural, Global, and Classic Readings*. Westview Press, pp. 336–340.

Liu, J., 2012. Habitus of Translators as Socialized Individuals: Bourdieu " s Account. *Theory and Practice in Language Studies*, 2(6), pp.1168–1173.

Maller, C.J., 2015. Understanding health through social practices: performance and materiality in everyday life. *Sociology of Health & Illness*, 37(1), pp.52–66.

McClelland, K., 1990. Cumulative disadvantage among the highly ambitious. *Sociology of Education*, 63(2), pp.102–121.

Ortner, S., 1984. Theory in anthropology since the sixties. *Comparative Study of Society and History*, 16, pp.126–166.

Pink, S., 2005. Dirty laundry: everyday practice, sensory engagement and the constitution of identity. *Social Anthropology*, 13(3), pp.275–90.

Pink, S., 2004. *Home Truths: Gender, Domestice Objects and Everyday Life*, Oxford: Berg Publishers.

Pink, S., 2012. *Situating Everyday Life: Practices and Places*, London: Sage Publications.

Pollmann, A., 2009. Formal education and intercultural capital: Towards attachment beyond narrow ethno-national boundaries? *Educational Studies*, 35(5), pp.537–545.

Reay, D., 2004. 'It's all becoming a habitus': Beyond the habitual use of habitus in educational research. *British Journal of Sociology of Education*, 25(4), pp.431–444.

Reckwitz, A., 2002a. The status of the 'material' in theories of culture: From 'social structure' to 'artefacts'. *Journal for the Theory of Social Behaviour*, 32(2), p.195–127+ii.

Reckwitz, A., 2002b. Toward a theory of social practices: A development in culturalist theorizing. *European Journal of Social Theory*, 5(2), pp.243–263.

Schatzki, T., 2012. A Primer on Practices: Theory and Research. In J. Higgs et al., eds. *Practice-based education: perspectives and strategies*. Rotterdam / Boston / Taipei: Sense Publishers, pp. 13–27.

Schatzki, T., 2002. *The site of the social: A philosophical exploration of the constitution of social life and change*, University Park, PA: Penn State Press.

Schatzki, T.R., 1996. *Social Practices: A Wittgensteinian Approach to Human Activity and the Social*, Cambridge: Cambridge University Press.

Shove, E., Pantzar, M. & Watson, M., 2012. *The dynamics of social practices: Everyday life and how it changes*, Thousand Oaks, CA: Sage.

Shove, E. & Walker, G., 2010. Governing transitions in the sustainability of everyday life. *Research Policy*, 39(4), pp.471–476.

Sweeney, J.C. et al., 2013. Energy saving behaviours: Development of a practice-based model. *Energy Policy*, 61, pp.371–381.

Tucker, K., 1999. *Anthony Giddens and Modern Social Theory*, Thousand Oaks: Sage Publications.

Warde, A., 2005. Consumption and Theories of Practice. *Journal of Consumer Culture*, 5(2), pp.131–153.