D8.5 | ENABLE.EU – Written synthesis of ENABLE.EU's findings

Deliverable:	*Written synthesis of ENABLE.EU's Findings*
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Version:	*Final*
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Date:	03/07/2019
Grant Agreement N°:	727524
Starting Date:	01/11/2016
Duration:	36 months
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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 727524.

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About the ENABLE.EU project

The European Union is further shaping its energy integration pillar, in the form of the EU Energy Union. It aims at fostering a cost-efficient energy transition able to deliver secure, sustainable and affordable energy to all European consumers. The Energy Union Framework Strategy laid out on 25 February 2015 embraces a citizens-oriented energy transition. The low-carbon transformation of the energy system includes the development of sustainable energy production and energy efficiency. Resting on five pillars (Energy security, solidarity and trust; a fully integrated European energy market; energy efficiency contributing to moderation of demand; decarbonising the economy; and research, innovation and competitiveness), it aims at enabling the delivery of the EU energy-climate objectives.

The main assumption of the ENABLE.EU project is that the successful implementation of the Energy Union and the EU objectives depends on energy production and energy consumption behaviours and the changing roles of household and business consumers, as well as on the policymakers. Those behaviours are heavily shaped by past, present and future individual and collective choices, whether they are related to the economic prerequisites, value systems, gender-based preferences, the efficiency of governance and the maturity of civil society. As a consequence, the final aim of the ENABLE.EU project is to contribute to more enlightened, research-based policy decisions, to ease the finding of the right incentives for the reaching of the twin goals of successful implementation of the Energy Union and Europe's transition towards a low-carbon energy system of the future.

To achieve it, the project has focused on different themes. In the first phase, a theoretical research basis through a literature review was developed. Then, research was led thematically: first, economic and technological factors of energy choices with analysis of their effect on energy efficiency. As a next step, the research has focused on the analysis of social, cultural and behavioral factors of the energy choices and in-depth studies on mobility, prosumers, heating and cooling. Then at the governance level, the bottlenecks that hinder the transition were defined. The studies were supplemented by participatory foresight exercise in a form of workshops for stakeholders and/or for individual consumers. The results of the latter have been used in the modelling exercise, that helped to translate the microdata into the macro scenarios. Those scenarios present a possible impact that the decisions of consumers might have on the development of the EU Energy Union[1].

[1] All reports produced by the ENABLE.EU project can be found at http://www.enable-eu.com/downloads-and-deliverables/

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WPI	• Project administration
WPII	• Literature review and teoretical basis
WPIII	• Energy choices - technological and economic factors
WPIV	• Energy choices - social and cultural factors • Household survey (11 countries); Case studies: (low-carbon mobility, heating and cooling, electricity, and prosumers)
WPV	• Governance bottlenecks and their impact on collective energy choices (9 country studies; 3 governance workshops)
WPVI	• Workshops (for stakoholders, an for the users): transition visioning; tranistions practice backcasting,
WPVII	• Modelling; scenario-building of different energy consumption patterns using the EU EnergyUnion benchmarking tools
WPVIII	• Summary, recommendations • PR

Table 1. Work Packages within the ENABLE.EU project.

Project objectives

There are five specific project objectives, illustrated in Table 2 below. The first one aims to define the key determinants of individual and collective energy choices in three key consumption areas, including transportation, heating & cooling, and electricity. The second one expands the knowledge of the interactions between the individual and collective energy choices and the regulatory, technological and investment prerequisites of the Energy Union transition pillar. The third objective aims to expand the knowledge of the governance and social mobilisation practices, which can foster collective energy choices towards the completion of the Energy Union and its R&I pillars. The fourth aim of the project is to understand the social acceptability of energy transition through a participatory foresight and assessment process engaging key stakeholders and selected households. Finally, the fifth project oobjective is to provide strategic policy recommendations for overcoming the gaps in the social acceptability of the energy transition, based on Energy Union scenarios, elaborated with a global modelling framework modified to factor in energy-related behaviour assumptions.

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ENABLE.EU's overarching goal: *to feed in to the EU Energy Union creation and low-carbon transformation* *through the research on the social and economic drivers of individual and collective energy choices and changes in energy choice patterns*				
I. Determinants of individual and collective energy choices with a focus on: (1) transportation; (2) electricity; (3) heating and cooling.	II. Interactions between the individual and collective energy choices; Regulatory, technological and investment prerequisites	III. Governance and social mobilisation practices; Research and innovation	IV. Social acceptability of the transition	V. Policy recommendations, modelling
WP2; WP3; WP4; WP5; policy meetings	WP3; WP4; WP5; policy meetings	WP3; WP5; policy meetings	WP6; workshops	WP7; WP8

Table 2. Overarching goal and five specific objectives of ENABLE.EU project.

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1. Methodology of ENABLE.EU's synthesis

The synthesis of the ENABLE.EU project summarises the project outcomes and serves as a basis for the formulation of policy recommendations. It concisely presents the research methodology and the main research findings. The synthesis is based on first and foremost the project deliverables, but also its Interim Technical Report for the European Commission of June 2018, and feedback from the project partners. For an in-depth analysis, however, it is advisable to read the original publications as collected in the Bibliography at the end of this report.

The structure of the synthesis reflects the structure of the project. It begins with the Executive Summary and follows the order of research conducted within the project. First, by analysing the factors influencing consumers' energy choices, and later by highlighting the specific case studies performed within ENABLE.EU.

The *factors* influencing both individual and collective energy choices that were at the centre of analysis were: economic, technological, social, cultural, behavioral and related to governance. The findings on most of them are cross-cutting through the research in the project, although the majority of economic factors can be found in chapter III, while the results of the social, demographical, cultural and behavioral studies are summarised under the chapter IV. The governance factors, together with country assessment of the bottlenecks in national governance of the energy transition can be found under chapter V of this synthesis.

At the same time, the horizontal, in-depth analysis in the project has focused on four case studies, which included analysis of the factors mentioned above. The research on energy and electricity savings is presented within chapter III, while the research on prosumers, on low-carbon mobility, and on heating and cooling are described in detail under chapter IV. Additionally, the citizens' and practicioners' creative input on those case studies collected during the Participatory Foresight process can be found under chapter VI. Based on the latter, the modelling process towards scenarios for the energy transition is defined in chapter VII.

While many findings are similar in several countries of the project, one needs to be cautious and avoid drawing general conclusions from particular examples. Most of the research has been country- and time-specific, thus linked to the specific characteristics and conditionalities that should not be extrapolated onto the whole European Union and its neighbouring countries. Those readers searching for the specific answers on the experiments related to the specific countries only are encouraged to see the results as presented in Table 3 below, referring to full reports produced by the project and available online.

Country	Household Survey, D4.1	Country governance D5.3, D5.4	Energy efficiency, economic factors	Low-carbon mobility, D4.2	Prosumption, D4.3	Heating and cooling D4.4, D4.5	Participatory foresight, D6.1, D6.2, D6.3, D6.4
Bulgaria	✓	✓	✓ D3.4	-	-	-	✓
France	✓	✓	✓ D3.3	-	-	✓	✓
Germany	✓	✓	✓ D3.4 ✓ D3.5	-	-	✓	✓
Hungary	✓	✓	-	✓	-	✓	✓
Italy	✓	✓	-	✓	✓	-	✓

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Norway	✓	✓	-		✓	✓	-	✓
Poland	✓	✓	-		✓	-	-	✓
Serbia	✓	✓	✓	D3.4	-	✓	-	✓
Spain	✓	✓	-		✓	-	✓	✓
The UK	✓	✓	✓	D3.2	-	✓	-	✓
			✓	D3.4				
Ukraine	✓	✓	-		-	✓	✓	✓

Table 3. Research performed within the ENABLE.EU project divided by the participating countries. The reports can be found at http://www.enable-eu.com/downloads-and-deliverables/

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2. Executive summary

For the successful realisation of the EU Energy Union, it is vital to understand the bottom-up processes and factors that determine both individual and collective energy choices of the consumers. Therefore, the questions that this synthesis aims to answer are: what can we tell about consumers' energy choices and behaviours? And what meaningful policy implications can we draw from an analysis resulting from the bottom-up process?

The analysis on the drivers of energy choices confirms findings from the initial literature review, which suggests that energy choices are influenced by several factors, of economic, technical, social, cultural, and behavioral and regulatory nature. Eleven countries that were the objects of the research reflected the variety of the European states, representing both larger, and smaller countries, richer and poorer populations, the leaders of energy transformation and those lagging behind. The research included the European Union members Bulgaria, France, Germany, Hungary, Italy, Poland, Spain and the United Kingdom; European Economic Area member Norway, and Energy Community members Serbia and Ukraine.

Significant, though nuanced, the impact of economic factors

On the consumers' level, economic factors remain central aspect of the energy choices made. At the same time, the thesis that the rise in energy prices (i.e. by additional taxation) result in energy-savings has been partially disproved, at least in relation to the business customers (D3.6). Based on the example of French manufacturers, the research has shown that an increase in energy price cause different reactions among the biggest companies, and small and medium-size enterprises (SMEs; see D3.3). Whereas the first may react with employment reductions, but at the same time innovate more and fill more patents; SMEs more often substitute energy for labour or capital, by i.e. increasing output and investment in end pipe technologies for the abatement of air, water and waste pollution. Some SMEs might also compensate for the higher energy costs by increasing the scale of production.

Among business, new entrants on the market are usually more energy efficient than incumbents, as shown by the study on emissions pathways in the German manufacturing sector (D3.6). Both, firm-level energy efficiency improvements and structural changes in the economy are responsible for an overall decline in emissions but differ in importance across industries. The structural changes being especially pronounced for rather energy-intensive and export-oriented industries.

On the level of households, the impact of pricing is much more nuanced. First, households may misperceive their energy costs as shown in the research in Germany (D3.5), where present bias has influenced short-term energy consumption, but not long-term energy choices (e.g. investment in energy-efficient appliances). At the same time, neither households' the true electricity price nor households' expected electricity price can predict short-term and long-term energy choices. As a consequence, the research questions the thesis that a higher price of electricity leads to significant energy-savings.

Second, not only the consumers' values and attitudes change when confronted with extra costs of the pro-environmental actions (D4.1). Too low energy prices may limit the will to save energy, making saving instructions ineffective, as illustrated by a randomised control trial held in Serbia (D3.4). Conversely, in case of a large number of energy-poor households as in Bulgaria, information and feedback policies do not induce significant energy-savings (D3.4). Potentially, because energy-poor households already consume energy most efficiently and thus, are not able to save more with behavioral adjustments. (D3.4). The energy-poor, at the same time, might not be able to make larger scale improvements to save energy without state support schemes, or subsidies. Those long-term investments in energy-efficient durable goods and refurbishment are reckoned to be of primary importance not only in heating and cooling, where

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dwelling characteristics and insulation are the major factors influencing the energy consumption (D4.4, D4.5) but also in electricity use. Although in the short-term households can adopt behavioural electricity saving measures (such as switching lights off when leaving a room, avoiding using a dryer etc.), the impact of the latter is limited, and the information campaigns to support those actions bring limited results (D3.4).

One of the projects' experiments held among students in Germany has shown that immediate billing has the potential of bringing energy-savings (D3.4). The opposition to the installation of smart meters that could give immediate information is still visible in many countries; an experiment in the United Kingdom proves that despite considerable opposition to uptake, incentivising households to adopt may be cost-effective and result in positive net-present-value benefits (D3.4).

Thus, the interventions performed within the project framework on short term energy choices of consumers' show that the potential to give consumers a stimulus for energy-savings is limited. To cap the households' potential for energy conservation, it might be more beneficial to focus on their long-term commitments. To that end, however, support schemes are desirable, though still relatively little used mechanism of support (D4.1).

Thus, ENABLE.EU research (D3.2) analysed governmental schemes for household adoption of energy-saving technologies based on the examples from the UK. Economic factors, as well as geographical location, proved to be decisive for the uptake of these governmental schemes, though the combination of factors seemed to bring the highest savings return. Moreover, although more deprived households benefited mostly from the scheme, the energy-saving potential was greater among more well-off households. Sufficient financial appeal was also a decisive factor for the uptake of the loans for energy-saving measures.

Not least, the low cost of technology can enhance technology-based energy transformation and the bottom-up technological shifts. To this end, the role of the SET Plan in the policymaking could be strengthened, since its current visibility remains very limited (D5.4).

Social, cultural and behavioral factors

The literature review (D2.2) shows that social conventions are an important factor to explain energy choices. Especially demography, income level, and age can affect energy behaviours, though based on different motivations. At the same time, technological factors can re-shape the social conventions.

The ENABLE.EU studies have generally confirmed the role of these factors. Low-carbon mobility stands out from all case studies as the habits of the European travellers, and the choice of the vehicle remain quite similar across the countries (D4.1). On the other side of the scale are heating and cooling practices which primarily depend on the dwelling characteristics. The consumers' preferences generally play a much smaller role. The Europeans show a variety of preference towards the optimal temperature, though most of those who have such an option, adjust the temperature in their houses. Still, the research shows that the controllability of temperature is neither associated with lower temperature, nor with higher energy-savings (D4.4).

Interestingly, environmental awareness is usually not a decisive factor in pro-environmental actions (D4.1). In those cases where the energy transformation is linked to the technological shift, the energy choice might be resultant of the technological interest and knowledge, like in the case of early adopters of prosumption (D4.3).

Moreover, strategies like social comparison and the targeting of specific groups seem to positively influence energy conservation, and the usage of support schemes, though it is the combination of several strategies (e.g. information provision and social norms) that can be particularly effective. Nonetheless,

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beyond the effectiveness of a specific strategy, the design of a policy should not neglect several essential aspects, such as synergies between factors and strategies, policy cost, timing, consistency with other policies and the institutional context.

More successful than the mere provision of information can be the implementation of behavioral interventions, e.g. in a form of trial periods, that can break old habits. Prosumption can be an example here as it gives an opportunity for direct engagement with electricity generation. The same positive aspects come from electric car sharing, which offers an inexpensive way to try new, more efficient, technology.

Low carbon mobility

In terms of mobility, European consumers follow similar travel patterns, and the travel modes used vary more depending on the type of trip than across different countries. Moreover, the environmental impact of a travel mode is not a significant factor when choosing the mode of travel; contrarily, the commuters preferences play a significant role in it, together with socio-demographic and behavioral factors. At the same time, in those places where the parking infrastructure is well developed and public transport insufficient, the households will tend to prefer using private cars. The additional part of the study was devoted to carsharing, though at the stage of researching (2018), it was a phenomenon in a still early phase of development and very varied across the research countries. For carsharing to be a step towards low-carbon mobility transformation the policies need to focus on electrical vehicles and link it to the public transport offer (D4.2).

Prosumption

The research has shown that although prosuming through Household Solar Power Plants (HSPPs) is increasing, the potential for prosumption is still large. Despite a great variation in the contexts of becoming a prosumer among the samples from the different countries, the common profile of a prosumer can be identified with respect to demographic data, such as age, education, or income group. To advance with the phenomenon, financial and environmental motivations are vital, however on the top of support schemes and proper legislation. Not least, gender aspects of prosumption are important, showing that there is a potential in addressing and encouraging women to become more active in the households' shift to prosuming (D4.3).

Heating and cooling

Energy consumers differ vastly across Europe in terms of their heating habits and preferences, and the heating sources used. However, the dwelling and household attributes remain the vital factor defining the heating costs. Surprisingly, the research has shown that consumers' income status, daily routines or values affect the heating costs in a very limited way. And although the households in richer countries live in newer dwellings, the energy efficiency of the older dwellings can be improved with proper insulation. Moreover, as the heating challenges overlap in several countries, sets of measures can be defined to address them (D4.4). Those with multiple benefits are of so-called "triple dividend" (D4.5).

Governance improvements are needed

The EnabLE.EU research shows, that the consumers' energy choices are also shaped by factors associated with their home country, including its demography, geographical conditions, not least regulatory regime. The conclusions that stem out from the representative Household Survey conducted in all eleven states (see D4.1) is that the situations differ from country to country and that the situations within each country differ from household to household. No simple grouping can be made with respect to the consumers' choices based on their nationality. Even the countries considered to be in the lead of the energy transformation, such as Germany, France or Norway are not homogenous. Paradoxically, the performance of a country in one climate goal can hinder it from performing in the other, as illustrated by Norwegian

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fully-renewable electricity sector that lowers the incentive to use the resources in a more efficient manner.

However, what all the eleven researched countries have in common are many governance challenges for the energy transition (D5.2). Even the transformation leaders have a way to go to improve their management of the transformation and their policymaking. Long-term, stable, reliable and strategic energy planning, support for the bottom-up transition movements of local communities, non-selectivity in the implementation of the EU climate and energy regulations, and strengthening of resources in energy administration are just a few of the measures to enable the transformation on the national level (D5.3).

No quick fix

In general, ENABLE.EU research points to a sound conclusion - if the energy behaviours are to be changed, the combination of factors needs to be applied, and later adjusted accordingly. Though some policies (e.g. support schemes for long-term energy-saving appliances, or insulation of dwellings) have a high potential of immediate return, it is usually the combination of factors that can bring a positive "spill-over" effect. The direct communication with the citizens and practitioners, either in a form of forecasting exercises (D6.1, D6.2, D6.3 and D6.4), or the focus groups (D4.4) confirm it. The European citizens identified the variety of measures in all categories, leaving a much more nuanced picture of a successful pathway towards the energy transition.

Energy choices of the consumers' matter

In the last step of the project, based on the issues defined primarily in the participatory foresight, scenarios have been designed to quantitatively assess the role households can play in meeting the goals of the Energy Union and to analyse the wider economic implications in doing so (D7.2). The exercise of analysing possible technological and economic changes in the household sectors all the way through to their economy-wide impact has constituted an interesting way to see how modest individual contributions can shape the future.

The results show that ambitious policies to empower and incentivise consumers could produce significant benefits to speed up the EU energy transition. However, further sustainable actions from other sectors of the economy will be required in order to meet the EU climate goals. Even in the most ambitious scenarios (i.e. high prosumption, zero emissions from heating and cooling by 2050, and sustainable mobility), reductions in fossil fuel consumption and greenhouse gasses from changing household behaviour alone would not be sufficient to meet the EU 2030 energy and climate targets. The simulation does show that the transition might bring economic advantages - overall, the EU economy is expected to benefit from the changes in household spending.

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3. Economic and technological factors for energy transition and study on energy efficiency

This part of the project aimed to study the economic and technical factors influencing the energy choices. The works have covered an online-business survey (D3.1) which results, despite CSD's efforts, have turned out not to be representative due to the difficulty to obtain responses to the survey from firms throughout Europe. The other research has focused on both, household's preferences (D3.2, D3,4) and companies' behaviours (D3.3, D3.6). In detail, the research has covered the analysis of the drivers of household adoption of energy-saving technologies using the English Housing Survey (D3.2), impact of energy prices and other policies on energy-saving innovation and technology adoption in the manufacturing sector based on French company data (D3.3), and analysis of the economic factors impacting energy-choices, both collective/company (D3.6) and individual; the latter either long-term energy choices (D3.5) or short-term energy choices (D3.4). It must be noted, however, that most of the research within D3.2, D3.3, D3.4, D3.5 and D3.6 was_country-specific. The question thus remains to what extent the research outcomes can be extrapolated into the whole of Europe (both EU, EEA, and non-EU members). As the Report D3.5 is a compilation of D3.2 and WWU research on energy efficiency, to avoid duplication, the synthesis of D3.5 focuses thus only on the latter. The same holds for the Report D3.6 and D3.3, where to avoid duplication, the synthesis of D3.6 focuses only on the additional WWU research.

3.1 Economic drivers of energy choices (D2.2 Literature review)

As the literature review shows, energy choices are often shaped by economic factors, though the efficiency of the economic policy interventions varies. Price-based interventions are a more appealing solution than imposed standards in encouraging consumers to reduce their energy consumption. Nonetheless, they do not necessarily stimulate high-return energy efficiency investments, as outcomes can differ depending on the manner in which households reduce their consumption and on the choice of instrument (e.g. carbon tax). Underinvestment in energy-efficient technology is often explained in the literature by market failures (e.g. asymmetric information, liquidity constraints) and behavioural anomalies (e.g. consumer inattentiveness, bounded rationality).

Context is critically important when examining consumer responses to energy prices. The wide range of demand elasticities reported in the literature reflects the numerous methodologies, geographies, fuels and sectors considered, not to mention the limitations associated with observational data. The measurement of price responses can be improved by gathering actual consumption and price data through randomised controlled trials and smart metering.

Low responsiveness to energy prices may be due to inefficiently low energy prices which do not fully take environmental externalities into account, or regulatory mechanisms resulting in prices that do not fully reflect production costs. A range of behavioural biases and management failures may also impede information processing and ultimately result in sub-optimal decision making.

3.2 Analysis of the business enterprises' survey (D3.1 Report)

The report D3.1 "Analysis of the business enterprises' survey" provides a technical overview of the results from a survey of business enterprises in the eleven project countries (Bulgaria, France, Germany, Hungary, Italy, Norway, Poland, Serbia, Spain, Ukraine, and the United Kingdom). The survey focused on SMEs and

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aimed at taking a snapshot of the experiences and future plans of the enterprises regarding social, economic, technological and governance factors, which determine their behaviour and choices regarding the use and management of energy resources. In the framework of the Energy Union initiative, SMEs have been one of the key players, which should both guide and benefit from the transition to a low-carbon economy and thus contribute to meeting 2030 energy and climate objectives cost-effectively. The survey contained 6 sections covering the following topics: energy use, energy management, energy efficiency, corporate sustainability policy, mobility and company's demographics[2]. Half of the responses have been received from manufacturing and mining and services sectors. However, the response rate has been extremely low (215 complete survey responses out of 164.000 invitations sent from Amadeus database). Thus, the results are not representative, and the below findings need to be approached with caution.

Medium-and-large companies are more prone to transform

Still, despite the limitation of the small sample number, the authors found out several major differences in the use of energy according to companies' size and main economic sectors. Medium-and-large companies and companies from the manufacturing sectors have implemented more often policies towards the introduction of RES, environmental-friendly activities and optimization of company's energy use than micro-and-small companies and companies from the other sectors (agriculture, wholesale and retail trade, services). Possible reasons are the higher investment potential, related capabilities for long-term decision making, as well as the influence of political and institutional frameworks and professional requirements, applicable for medium and large companies from the manufacturing sectors. At the same time, micro companies differentiated from the others in terms of their major characteristics that could be seen as vital for the implementation of energy transition policies - lack of structured corporate sustainability policies, lack of long-term planning and much lower investment readiness.

High-GDP countries inspire the energy transition

Moreover, the results confirm also the correlation between the level of general economic development in the country and the degree of implementation of energy transition policies. The companies from the high-GDP countries (UK, NO, DE, FR) dominated all areas of activities, related to the introduction of energy transition policies and practices as compared to the companies from the groups of low- and even medium-GDP countries. This could be seen also as a result of the favourable policy and institutional frameworks in the high-GDP countries towards the development of a low-carbon economy.

Slow transition in general; solar technology as a leader, low carbon mobility lagging behind

The results show the broad diffusion of one of the RES technologies across all type of companies and sectors, and namely – solar technologies for the production of both heat and power. This fact diminishes the differences between the companies and sectors and reveals a specific trend. On the one hand, the differences in the use of solar technologies between the companies' types and sectors are much smaller as compared to the differences in the use of all other types of RES technologies. Even when micro companies are concerned, the differences in the diffusion and the use of solar technologies as compared to the other companies could be measured in percentage points, while the respective differences regarding the application and the use of the other types of RES are in times higher (e.g. three to ten times).

On the other hand, despite the broad diffusion of solar technologies, the majority of the companies irrespective of their size or sector are still relying mostly on fossil-based energy sources (mainly on natural gas) for their major production and business processes. This is clearly visible particularly in the area of mobility and corporate sustainability policies, while companies perform much better in terms of

[2] The Report D3.1 includes the detailed information on each of them, as well as each of the countries.

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introduction of energy efficiency measures.

One particular area, where the differences between the companies from the three groups are much smaller and in some cases – not existing, is again the area of low-carbon mobility policies and practices. Having in mind that companies differentiate only slightly in their energy behaviour regarding mobility also in terms of size or sector, it could be concluded that mobility is one of the less developed areas in the companies' policies and, hence, it has a higher potential for short- and medium-term progress in achieving energy transition goals.

3.3 Drivers of household adoption of energy-saving technologies (D3.2 Report)

The research has focused on the adoption of energy-saving technologies in households. The study has examined which factors have influenced the enrolment into government-funded energy efficiency schemes in the UK (the Supplier Obligations which subsidised energy efficiency measures) and the resulting energy-savings from these measures. The methods used by GRI-LSE were statistical matching followed by binary (logistic) regression models and panel econometric estimations.

Economic and geographical factors are vital

*T*he main factors that drive household adoption of energy-saving technologies under the analysed governmental schemes were economic, but the geographic location also played a role. Although more deprived households have mostly benefited from the scheme, the energy saving potential is greater among more well-off households. The results indicate that household and dwelling characteristics significantly determine the uptake of measures and affect the returns to energy efficiency measures. The results suggest that the schemes examined have been quite successful in delivering energy efficiency measures to more deprived households in the UK.

Uncapped energy saving potential in affluent areas, and in London

The analysis demonstrates that while energy efficiency programmes have been successful in delivering measures to households from deprived areas, the energy savings are much higher for households living in more affluent areas. The analysis also revealed large regional differences in the participation in government-funded schemes. Clearly, colder winters and more heating degree-days will drive higher adoption of measures in more northern parts of the UK. Future policies will need to address the regional differences of barriers to uptakes and set incentives for households in and around London and the South of England.

Value added of a combination of measures

Of particular note is the fact that combinations of measures deliver higher savings than the combined sum of individual measures. This suggests that there may be efficiency gains in installing multiple measures simultaneously, and also that households may be installing additional measures that are not being reported. This could be the result of households making additional private investments to complement the policy support they are receiving. Unfortunately, the data do not allow to fully disentangle this result, but it does suggest that policy support should target deep renovations, rather than individual measures. While the focus of this research was on Supplier Obligations, or subsidised energy efficiency measures, the results also provide important insights for another type of policy.

Loan-schemes need to be attractive

Pay-as-you-save financing mechanisms are becoming increasingly popular for energy efficiency. For

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example, the Green Deal was a recent policy initiative in the UK (2011-2015) which provided households with loans in order to finance energy efficiency measures at interest rates of approximately eight percent. This was widely considered to have been a failure; during its lifespan, the scheme only funded one percent of energy efficient measures installed nationally and avoided negligible amounts of CO2 emissions. The main reason for that was because it did not have sufficient appeal for householders. These relate to a range of factors, including uncertainty regarding energy savings, limited financial appeal, and limited awareness of the scheme. A key factor in limiting its appeal was the high rates of interest charged on loans. In particular, low-income households would actually lose money by making these improvements unless energy prices rise significantly. Market-based interventions will only work for certain segments of the population and policy needs to take this into account. Future work will focus on examining the cost-effectiveness of various measures and how this ultimately impacts the cost-effectiveness of policies and optimal policy mix for energy efficiency.

3.4 Impact of energy prices and other policies on energy-saving innovation and technology adoption in the manufacturing sector (D3.3 Report)

The Report D3.3. has studied the effect of energy price changes on firm-level environmental and economic performance in France using combined firm-level information from a number of databases managed by the French Statistical Office (Insee). These data sets include the energy consumption and expenditure from the EACEI survey (Enquête sur les consommations d'énergie dans l'industrie), financial data from FARES (Fichier complet unifé de SUSE) and FICUS (Fichier approché des résultats Ésane), patent data from PATSTAT, and pollution abatement investment data from the Antipol survey. The study has performed two analyses, on a micro-level, and on the macro level.

Business may react differently to an energy price increase

The simple argument goes, that increase in energy price is one of the most potent factors for energy savings and energy efficiency, thus supporting i.a. carbon tax. These need not necessarily be the case. The way in which businesses respond to changes in energy prices has important policy implications. Some firms may end up altering production processes through the adoption of energy-saving technology; they can also try to lower other costs, such as wages or lay off workers. Some firms may be able to pass on the cost of price increases to consumers or firms in other sectors. Other may have to reduce their energy consumption and, consequently, output. Alternatively, firms can substitute one form of energy for another, or substitute labor for capital in some instances.

The economic losses among affected businesses may be small or even negative if the price change prompts companies to invest in unexploited high return energy efficient technologies. In contrast, the economic losses may be significantly greater if they respond by reducing their consumption of energy services and eventually output and employment. This makes analyses of business responses to policies and energy price changes very complex. However, evidence on firm-level responses to the increased cost of energy can enhance our understanding of the ultimate economic consequences of these climate change policies.

Energy intensity of sector has decreased

The first analysis of the study has estimated a firm-level econometric model using exogenous energy price variation and found that a 10% increase in energy price would reduce CO2 emission by 8%. At the aggregate level, the study finds that (i) aggregate energy intensity of the French manufacturing sector has decreased by 33% between 2001 and 2013 and (ii) the changes in manufacturing-wide energy intensity is driven by firm-level reduction (and not market share reallocation towards energy efficient firms); and (iii)

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these changes are associated with an upward trend in the energy price.

Large French manufacturers reduce employment, while SMEs substitute energy for labour and increase output

At the same time, the study has revealed different reactions to price changes between the large manufacturers (that employ 250 people or more) and small and medium enterprises (SMEs). The study suggests that, for large companies, environmental goals have negative economic consequences.

Large manufacturers react to price increase with employment, but the magnitude is signficantly smaller compared to the reduction in energy and (where 10% increase in the energy price reduces employment by 3%). In contrast, SMEs (which represent 99% of French manufacturing firms and 56% of the workforce) do not reduce employment when the energy price increases but substitute energy for labor with greater magnitude,by i.a. increasing their output and investment. One reason for that could be that SMEs may compensate the higher energy cost by increasing the scale of their production in order to decrease average production costs, or perhaps some inefficient smaller firms exit the market which may increase the market share of the incumbents. Large firms do not do that because they have already exploited economies of scale.

Large manufacturers innovate more while SMEs substitute energy for capital

Moreover, in terms of the will to innovate, the results provide some evidence that an increase in the energy price modifies the technology produced and used by the firms. Large firms react by filing more patents while SMEs clean-up by substituting energy for capital. Large firms innovate more while all firms invest more in end of pipe pollution abatement technologies presumably because firms replace their existing energy efficient equipment. Due to data limitations, future work is needed to test whether these firm-level responses to rising energy prices have resulted in lowered air, water, and waste pollution.

Limited impact of an increase in French carbon tax

The policy implications are further illustrated in the research with a simulation of the effect of the French carbon tax on CO2 emissions and employment. The study measures the size of emissions reductions and employment loss by simulating the effect of a planned increase in the French carbon tax. On average, total emissions would reduce by about 5%, while gross employment loss would be 0.12%. However, the impact of the carbon tax is limited given that EU-ETS firms are exempted. On the micro-level, the results suggest that increases in energy prices result in a decline in energy use, with an own-price elasticity equivalent to 0.5. This figure is higher than estimates from previous studies looking at short-run responses of industrial energy users to energy price changes.

Increased energy prices have, though very limited, effect on employment

As previously stated, the study finds that, for large firms only, employment declines as energy price increases, which suggests that environmental goals have negative economic consequences. However, the employment elasticity (0.15) is far smaller than that of own-price elasticity, suggesting that affected firms manage to partly reduce their energy intensity other than through reductions in the size of the workforce. In contrast to large firms, SMEs (which represent 99% of French manufacturing firms and 56% of the workforce) do not reduce employment when the energy price increases. At the aggregate level, we do not find any strong evidence to suggest that increased energy price reduce net employment, particularly when entry and exit of firms are taken into account.

Limitations to drawing policy implications

There are, however, some limitations to drawing policy implications out of the research. First, because there is no output data at the plant level, the research does not analyze the potentially important role of

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between plants reallocation of production in explaining within-firm variation in energy intensity. Even if the employment effect is small at the firm-level, reallocation of production and workers between firms is not without cost or redistributive consequences. Second, the absence of data on output quantity prevents us from analyzing the effect of the energy price on total factor productivity and output prices. Third, sufficient data on emissions of other pollutants will be necessary to understand the net effect of energy taxation on total pollution, particularly when co-benefits (or spillovers) are occurring simultaneously with changes in energy prices.

3.5 Economic factors impacting individual short-term energy choices (D3.4 Report)

The research aims at identifying the effect of different policy interventions on electricity consumed. It was led by Westfaelische Wilhelms-Universitaet Muenster (WWU). It is assumed that by understanding the drivers of electricity consumption, policies can directly target these drivers and implement corresponding strategies. The countries involved in this case study are Bulgaria, Serbia, UK and Germany. The case studies were implemented by the project partners: CSD, EI, GRI-LSE and WWU, respectively. They were conducted in the form of randomized controlled trials (RCTs), also known as A/B Testing[3]. RCTs are economic experiments, which aim at identifying the causal effect of an intervention on an outcome variable by instrumenting randomized exposure to the intervention.
Each of the countries focuses on a different intervention that has best suit its needs. In Bulgaria, the consumers were given information on the energy costs of single appliances; in Germany, the effects of immediate billing were examined; Serbian households have received instructions on how to save energy, while in the UK the goal was to maximise the smart meter adoption. In general, the research has demonstrated a limited potential for information and feedback policies in decreasing energy consumption.

Cost break-down information on appliances in Bulgaria does not decrease their utilisation

As an analysis of the ENABLE.EU households survey shows Bulgarian households provide less accurate estimates of appliances' energy costs compared to households in Germany, Serbia and the United Kingdom. By receiving an energy consumption and cost break-down by different appliances, households are able to understand and to learn about their consumption. Thus, the research question of the Bulgarian case study was: "What is the effect of energy cost break-downs by appliance on energy consumption?" To answer the question an RCT was conducted with 405 households over a duration of four months, including both heating and non-heating seasons. Results show that, although households in the treatment group received monthly energy cost break-downs by appliance, their energy consumption is not significantly different from the control group, which did not receive the information. However, a within-analysis of the treatment group for specific appliances shows that the treatment group significantly decreases utilization of both the electric water heater and the washing machine over time. Still, the lacking significance in the comparison with the control group indicates a very limited potential for detailed cost break-downs to decrease energy consumption. A possible reason might be the high share of energy-poor households in Bulgaria, who might already consume energy most efficiently. However, further research should be led to better understand whether feedback per appliance and in what form can help consumers to reduce their energy consumption.

[3] A RCT is a quantitative method that allows the identification of the causal effects of inventions by instrumenting randomization. Participants are randomly placed in either an intervention or a control group, and only the intervention group has access to the intervention (e.g. the energy-saving instructions). Because of this randomization, the participants in both groups are expected to be equal in all of their observable and unobservable characteristics, except of the intervention. By using randomization, instead of relying on before and after comparisons, also time effects, such as a change in the weather, are controlled for. This is how the causal effect of the intervention can be isolated, without the contamination of any other characteristics.

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Immediate billing may decrease the consumption

The results of the German study provide important insights into one driver of households' energy consumption: intermittent billing. For Germany, the lag between the consumption of energy and payment of the bill is particularly severe as meter readings only occur on a yearly basis. Thus, the researchers designed an RCT to focus on the discounting effects associated with such intermittent billing. The research question is, whether there is evidence of hyperbolic discounting in energy consumption. Hyperbolic discounting[4] gives rise to time-inconsistent choices, such that overconsumption of energy occurs from both a social and an individual perspective. The RCT was conducted as a lab experiment with 171 students to investigate the effect of more frequent energy billing on energy consumption, holding saliency and information effects constant. The control scenario is billing one week after consumption has taken place, the treatment scenario is billing immediately after consumption. The main result is that immediate billing decreases light consumption on average by around 10-12% compared to delayed billing. Further, these results are consistent with (quasi-) hyperbolic but not with exponential discounting. The results provide important insights to understand qualitatively the consequences of intermittent billing. From a practical perspective, holding information and saliency effects constant, more frequent billing will decrease energy consumption. From a conceptual perspective, first causal evidence of hyperbolic discounting under intermittent billing is provided.

Saving instructions do not decrease consumption where the energy is cheap

Because energy prices of households in Serbia are the lowest in Europe, information provision, rather than financial incentives, was selected as a potential policy intervention in the Serbian case study. In particular, the research aims to shed light on whether energy saving instructions are a fruitful strategy to a promote reduction in energy consumption. In cooperation with the national electricity supplier EPS Supply, a total of 330 participants were recruited to participate in an RCT, where the treatment group received a brochure of energy-saving instructions. Such intervention was used to increase consumer's awareness, and observe if the adoption of new consumption patterns has an actual impact on consumption reduction. The results show that in a country where the electricity price is very low, or where the personal incentives to save energy are generally limited, the energy-saving instructions have reduced the effect on consumer behavior. Households may be not interested to pursue the instructions, as their expected monetary savings are too low.

Compensation for installation of the smart meter may reduce households' oposition

The single most important domestic energy policy initiative ongoing in the UK is the Smart Meter Implementation Programme (SMIP). This programme provides the legal framework to install smart electricity and gas meters in every household in the UK by 2020. Smart metering may allow consumers to save energy and money, but of greater social benefit is their potential to pave a path toward a more flexible energy system, allowing optimisation of generation and storage. Indeed, smart meters can be considered a key enabling technology of a sustainable energy system. However, consumer resistance has severely inhibited rollout thus far. This research provides new evidence on this important topic. Information treatments are provided to households to assess the impact of anchoring in willingness-to-accept elicitation for this unusual but important context, where subjects are essentially asked to place a value on the compensation necessary to provide a public good. From these responses, the study infers the optimal subsidy level of approx. 100 euro that policymakers may need to provide to incentivise households to adopt smart meters and comment on the sensitivity of that inference to the methodology deployed.

[4] If individuals discount future costs (quasi-)hyperbolically, they overvalue present benefits compared to an ex ante valuation, i.e. they are biased towards the present. This inconsistency in valuation induces a reversal of choices. The consequence is an overconsumption of the respective good.

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Main conclusions on the impact of information provision on energy consumption

The information provision alone encounters many limitations in bringing energy savings. This is particularly the case when the countries either exhibit a high share of energy poverty, as seen in Bulgaria, or have a very low energy price, as seen in Serbia. Households living in energy poverty might not demand information as they already gathered knowledge themselves on how to save as much as possible. Households facing low energy costs may simply value the effort costs of following through energy saving behaviours higher than expected savings.

Once taking information as given, the German case study points to the role of discounting in recurring billing cycles. Because consumption and payment of energy are separated in time, the payment will be (quasi-) hyperbolically discounted leading to an overconsumption of energy. A change in the billing system, such as more frequent billing or prepaid metering, would decrease this overconsumption. The UK case study complements the three other case studies by focusing on the adoption of a potentially energy-saving technology. The results suggest that, in contrast to the previous RCTs focusing on consumption, information treatments, combined with subsidies has a saving potential.

3.6 Economic factors impacting individual long-term energy choices (D3.5 Report)

This Report is built on two sub-researches. The one on governmental schemes for household adoption of energy-saving technologies in the UK has been described in point 3.3 above, Therefore, to avoid duplication, only the research on misperceptions regarding energy costs held in Germany is elaborated on below.

Uncertainty of energy costs, and benefits of energy efficient investments

Despite the policy goals to reduce energy consumption, the potential for energy-savings by households has remained largely uncapped. One reason for this energy efficiency gap might be the opaqueness of energy, which contributes both to information asymmetries and various behavioural anomalies. The consumption of energy services is associated with two sources of uncertainty. First, in the productivity with which energy is turned into energy service, and second, in the cost of using one kilowatt-hour due to complex energy pricing structures. Further, energy consumption is just intermittently billed, leading to dynamic tradeoffs between consumption and payment as well as inattention towards consumption expenditures. The dynamic trade-off can cause discounting mistakes, such as hyperbolic discounting and naiveté towards such biased discounting. Similar concerns hold for energy efficiency investments. Costs are immediate for these investments, but the benefits lie in the future and are subject to uncertainty. As a result, households may optimize their long- and short-term energy decisions under various misperceptions. With respect to energy consumption, the future energy bill may be misperceived. Regarding energy efficiency investments, future investment benefits may be misperceived.

Opaqueness of energy costs

The report pays attention to the opaqueness of energy costs. The opaqueness manifests in two sorts of misperceptions: first, uncertainty in energy prices and second, present biased discounting of future energy costs. Holding everything else constant, present bias can induce a reversal of preferences. Ex ante dominated decisions, such as smoking or eating fast food, become the optimal choice once its benefits are immediate. The consequence is overconsumption of energy from households' ex ante perspective. Additional uncertainty in energy costs interacts with present bias. Literature demonstrated that households know neither their energy price nor how kilowatt-hour consumption maps into energy services. Regardless of present bias, if the expected energy price deviates from the true energy price, households can invest too much or too few in energy efficiency as well as consume too much or too few, depending on the direction

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of deviation.

Methodology

The research was based on a survey (the extension of a household survey in a form of the additional section was added in Germany only), designed as an artefactual field experiment with a representative sample of 711 individuals. In the experiment, each participant was asked to take multiple decisions, with each decision having a certain probability to be paid. By each participant making a series of decisions between earlier and later payments, some of them involving the present, individual present bias parameters were elicited. By asking for the probability with which each participant's electricity price lies in certain price intervals, individual price expectations were elicited. From this incentivized within-subjects design, it was possible to elicit each participant's revealed time preferences and energy price beliefs. Further, because the experiment was operated through face-to-face interviews, it was possible to observe participants' revealed electricity consumption: each participant was asked to show their last electricity bill to the interviewer. This measurement of revealed preferences and consumption has enabled trustworthy, robust estimates. The measures of present biased discounting and price expectations are correlated with either electricity consumption, as a measure of short-term energy choices, or the share of energy efficient lighting and the age of electric appliances, as measures of low-cost and mid-cost long-term energy choices.

Present bias influence short-term energy consumption, but not long-term energy choices

The main result is the significant correlation between present bias and electricity consumption, which stays robust upon including covariates and across specifications. Participants with present bias are predicted to consume on average 8-9% more electricity than participants with time-consistent discounting. In absolute amounts, this is 22kWh per month. These results suggest to support policy in introducing commitment technologies, such as energy-saving goals or particular contracts which help individuals to stick to their ex ante electricity consumption plans. Further, a policy should test alternative billing schemes, such as more frequent billing or pre-paid billing, to target the dynamic nature of consuming and paying for electricity as being the source for such present bias.

In contrast, the researchers have not identified a significant relationship between present bias and long-term energy choices. This could be because the assumption of immediate investments costs compared to delayed investment benefits is in practice often violated. At the time of deciding whether to buy an energy efficient appliance, investments costs occur as well in the future. Partly because credit card payments are more common and partly because payment by instalments is becoming more popular. As a consequence, decisions on energy efficiency investments might involve only future states: future costs and future benefits.

Electricity price cannot predict energy choices, a higher price may not result in energy-savings

The results further suggest, that neither the true electricity price nor the expected electricity price can predict short-term and long-term energy choices. Thus, classical price based interventions, such as increasing electricity prices by taxes, may not be effective given the correlational results of the research. At the same time, as the analysis is correlational and restricted to a German sample, the authors are careful with deriving general policy recommendations. An important avenue for future research is in the relation between present bias and electricity consumption. In particular, experimental research identifying causal relations is needed. More research is also needed to identify whether households have a nearly zero price elasticity or whether another price construct influences short-term and long-term energy choices.

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3.7 Economic factors impacting collective/company energy choices (D3.6 Report)

This Report builds on two pieces of research. One of them - on price rise effects on French manufacturers – has already been described under point 3.4 above. Thus, to avoid repetition, only the part of the Report on emissions pathways in the German manufacturing sector made by WWU is analysed below.

The study on emissions pathways in the German manufacturing sector is using disaggregated data. In particular, the study decomposes the changes in industrial CO2 emissions from energy usage in Germany between 2006 and 2014. It applies the Logarithmic Mean Divisia Index to production census data on the firm level, which allows a highly detailed separation of firm-level energy efficiency improvements from structural changes in the economy.

Emissions decline due to firm-level improvements and structural changes in the economy, especially for energy-intensive industries

First, the analysis shows that both, firm-level energy efficiency improvements and structural changes in the economy are responsible for an overall decline in emissions, but differ in importance across industries. The German manufacturing sector has managed to reduce emissions between 2006 and 2014, despite major changes in the energy market and a stabilization of output after the financial crisis. In a regression of the decomposition effects, the researchers have found that the contribution of the within-industry structure effect can be explained by different firm characteristics. As such, the contribution of structural change of economy to emissions reductions is especially large in rather energy-intensive and export-oriented industries.

In the decomposition of aggregate emissions, the median contribution of the activity effect and the fuel mix effect are close to zero. At the same time, structural effects are dominantly contributing to reductions of emissions. On the one hand, changes in the output shares between industries are a major contributor. On the other hand, changes in the output shares of firms within industries also drive a reduction of industries' emissions.

Energy cost does not influence a reduction in emissions

Interestingly, the average price of energy as well as the share of energy costs does not show a significant influence. At the same time, firms with larger energy prices clearly improve their energy and CO2 intensity, irrespective of the cost share of energy.

Energy-intensity of production in firms seems to rather increase total emissions

Paradoxically, despite the efficiency policies, the energy-intensity of production in firms (remaining in the sample over time) seems to rather increase total emissions, which questions the effectiveness of efficiency policies to some extent. Further, this result contradicts the results of most existing decomposition analyses for Germany. One explanation might be that surviving firms are becoming more energy intensive due to increasingly specialized and capital-intensive production.

New entrants are more energy efficient, SMEs are not

In a final regression analysis on the firm level, the research further explores the driving forces of the within-industry effect. The regression results show that firms newly entering the market are significantly less emissions-intensive than incumbents (i.e. up to 6% less emissions per output).
Another key result is that small-and-medium enterprises show much lower energy efficiency of production than large firms. Hence, future energy efficiency policies could also be directed more towards SMEs in

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order to exploit yet untapped potential for cost-efficient improvements.

All in all, although analysis sheds light on the main channels of energy usage and emissions development, any projection of future trends will require more updated data available for analysis. Energy efficiency policies could be further directed towards firms where the technology choice is still flexible and potentially yield substantial energy-savings.

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4. Social and cultural factors for energy transition and case studies on low carbon mobility, prosumption, heating and cooling

The research within this part of the project has focused on the drivers of energy choices. First, a representative survey has been conducted in all eleven countries to elicit consumers' energy preferences, attitudes, values, habits, and demographic data. Its results have been presented in the technical Report D4.1.

Second, parts of the survey has been conducted in groupings of the countries and supplemented by additional research (i.e. desk research, in-depth interviews, and econometric analysis to quantify and estimate the relative importance of the main drivers of mobility choices and heating costs) to gain in-depth knowledge on namely electricity consumption, mobility, heating and cooling, and prosumers (in the project called "case studies"). They are detailed in Deliverables D4.2, D4.3, D4.4, D4.5.

Third, the "Final report on social and cultural factors impacting energy choices and behaviour" (Deliverable 4.6) has collected and summarised the abovementioned case studies, with additional analysis of data on mobility and heating and cooling from the initial Household Survey (D4.1).

For the sake of the clarity, this part of the synthesis presents a literature review on the topic; brief general results of the Household survey with highlights on attitudes, and consequently all the information on the three case studies, that come across the project deliverables.

4.1 Socio-cultural, demographic and behavioural factors influencing energy choices (D2.2 Literature review)

The literature review shows that besides the economic factors, the energy choices are also shaped by social, cultural, demographic and behavioural aspects. This approach can be useful in attempts to predict people's behaviour in particular situations and to identify specific groups that might be more responsive to certain policies.

Social dynamics and the risk of non-compliance

Culturally determined social dynamics can affect not only people's response to specific policies but also their daily routines and practices. The social risks of not complying with the established norm can often be more important than new technology in shaping behaviour. New technology can, however, redefine social conventions. Such drivers played a decisive role in the diffusion of cars and air conditioning, which moved from desired novelties to normal objects of mass consumption.

Diverse effect of demographic variables on energy behaviours

Demographic variables like income and age affect energy behaviours differently, depending on the energy service and the empirical setting. Income, considered a determinant of social status, strongly shapes households' energy behaviours, but based on different motivations – e.g. improving one's comfort, affording basic energy needs or producing one's own energy. It appears that early adopters of new

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technologies come mainly from higher income groups. Last but not least, the research shows that the motivations for and barriers to taking up energy-saving technologies can be gendered.

Direct experience can be a successful way to break with old habits

Behavioural aspects tend to be neglected in the study of energy choices. Yet, the routinized nature of many energy behaviours might make them difficult to change. Successful habit-breaking strategies can use policies that involve direct experience, such as trial periods. Furthermore, consumers' engagement with electricity generation might also lead to the increased visibility of this consumption, and this could positively affect household energy practices. Finally, environmental awareness and values have an uncertain impact on behaviour as there are often discrepancies between people's attitudes and their actual energy behaviour.

4.2 Household survey results (D4.1 Report) and social and cultural factors impacting energy choices and behavior (D4.6 Report)

The Survey has been conducted in eleven countries: France, Germany, Hungary, Italy, Norway, Poland, Serbia, Spain, Ukraine and the UK. The general questions and those on the governance framework have been asked in all of them, while those referring to case studies have been asked only in the countries of a particular case study: mobility in Hungary, Italy, Norway, Poland, and Spain; shift to prosuming in Italy, Norway, Serbia, the UK, and Ukraine, and heating and cooling in France, Germany, Hungary, Spain, and Ukraine. The detailed sectorial and country-specific analysis is available in the Report D4.1.

Extreme differences between European countries

The survey results confirm the existence of vast differences among the studied eleven countries, which are results of the different combination of socio-cultural, economic and technological factors that influence both the experience and the attitudes of the people. In general, the survey results pointed out the extreme diversity of the countries regarding the experience and the attitudes that drive the energy choices on both individual and collective level. If according to some aspects, the countries could be grouped into specific sub-groups, corresponding to their common social, economic and political development (e.g. Central and Eastern European vs Western European or high- vs low-GDP countries), the diversity regarding other aspects of the situation makes this grouping not relevant.

The section below includes more detailed results on attitudes towards the environment and energy policies. The information on dwelling characteristics and electricity use, relevant in the interpretation of the case studies, are recalled under the specific topics.

No common patterns in the countries that lead the transition

The more advanced transformation towards a low-carbon energy system in Norway, Germany, and the UK and partially in France, has been confirmed by the survey findings. Even this could be challenged if the shift towards prosuming is considered – with the exception of Norway, where nearly half of the population produces its own energy, other countries in this group lag far behind, while Italy has decreased the gap and has similar results to the UK or Germany. At the same time, the performance of a country in one climate goal can hinder it from performing in the other, as illustrated by Norwegian fully-renewable electricity sector that lowers the incentive to use the resources in a more efficient manner.

While some of the survey findings could be confirmed directly or indirectly by the official statistics and data, there are many results that give valuable insight on certain trends in the development of low-carbon

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future in Europe. For instance, the use of additional insulation as an energy efficiency measure divides the countries into three sub-groups. In the same way, the information collected on the average temperature in the dwellings and the preferred source of heating, could support the choice of the policy measures that reflect those changes.

Electricity usage differ vastly across Europe

The survey has also shown that households have different habits and preferences when it comes to electricity usage (D4.6). The use of electrical appliances varies considerably from country to country. Differences could be explained to some extent by factors related to climate, cultural and economic reasons. Due to the large cross-country difference in owning different electrical appliance, it is very difficult to compare the average age of appliances in different countries.

The households in the richer countries usually have newer and more energy efficient appliances, but cultural aspects and information campaigns also play a role

The three most widespread and with the highest energy consumption electrical appliance types are compared across countries in terms of age of the units owned by the households: TV, air conditioning, cooker, fridge, and washing machine. Apart from Spain, richer countries have a higher share of newer appliances. The countries where households have the smallest share of older appliances (more than 10 years) are the UK, Norway, France and Germany. Households in Spain (1st), Serbia (2nd), Hungary (3rd) and Italy (4th) have the largest share of older appliances. Given the GDP of countries in the list, one possible explanation for Spain's households using the oldest electrical appliances could be some cultural reasons. Energy efficient bulbs are also widespread, especially across France, Spain, the UK, Italy and Poland.

While there are certainly economic drivers behind the choice of more energy efficient appliances in the household, there are cultural differences too. While Germany is the leader in percentage of the newest appliances, it tends to fall behind in terms of energy saving light bulbs. While Spain has the oldest electrical appliances (cooker, fridge, washing machine), households tend to invest in energy efficient light bulbs more often than in most of the other countries. These results suggest that the behaviour of energy users could be potentially influenced by information campaigns, which could convince a household to make the small extra step.

Smart meter adoption varies

Electricity and gas smart meters are generally more common in Spain (69% of households), the UK and France but as a whole are not widespread yet with the exception of electricity smart meters in Spain. The reasons for not having a smart metering system at home vary from country to country with the cost being mentioned as too high by 56% of the Ukrainian respondents who do not have smart meters and by one-fourth of those in Bulgaria, Hungary, and Spain. Another reason (particularly widespread in Hungary, Serbia, and Spain) is that utility companies have not yet adopted smart meters. A large share of respondents in most countries (more than a quarter in all countries but Hungary and the UK) are not aware of whether they can use smart meters at home. When it comes to the negative perception of smart meters, data misuse and privacy violation are mainly a concern in Germany, the UK, followed by France and Bulgaria. Mentions of fear for health remain rather limited, with French respondents being the most reluctant (11.9%). In several countries, significant percentages of the population do not know whether they have smart meters or not.

Individual attitudes towards the environment and energy policies

Interestingly, the closer scrutiny of the findings on consumers attitudes towards the environment and energy policies shows a very diverse picture of consumers preferences and choices.

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Pro-environmental awareness in Norway and Germany while "skepticism" observed in Spain, Ukraine, Serbia, Italy, Poland and France

General attitudes towards environmental issues are positive with the exception of Spain, where 73% of the population think that environmental problems are usually exaggerated. More than half of the respondents in Ukraine, Serbia, Italy, and Poland agree with the optimistic statement that environmental issues will be resolved through future technological progress. Respondents in Germany and Norway are much more skeptical about it (less than 23% agree).

Most people tend to demonstrate attitudes towards personal involvement in dealing with environmental issues. Among respondents less willing to do anything about the environment if others do not do the same, the largest shares are in Poland, Italy, Serbia and France (between 26% and 39% of the respondents). The percentage of respondents agreeing with this statement in the other seven countries is between 12% and 18%. Those who would not make any compromise in their lifestyle for the benefit of the environment are less than 20% in most of the countries, and only in Poland do they represent 24% of the population.

Answers change dramatically when practical policy measures that could cost the citizens extra money are discussed. The vast majority of the citizens agree that such policies should not cost them extra money. The highest shares are in Spain and Italy (85%-86%), while the lowest is in Norway (57%).

Regulation of energy prices is highly valued

When policy priorities are discussed, energy prices and their regulation are very important for large shares of the population in most of the ten countries (over half of respondents, with more than 80% of Bulgarians and Germans). The development of clean energy sources is considered a priority by more than half of the population in France, Germany, Ukraine and the UK and by 44% of the Hungarians and 40% of the Serbians and less than 30% of Bulgarian respondents. The energy efficiency of private and public buildings is mentioned less often as a major policy priority for the country. This answer was given by 26% to 56% of the people, with the highest share being in the UK and the lowest in Hungary. Finally, full liberalization of power markets and phasing-out of nuclear power plants are seldom mentioned: in most of the countries, less than 20% of the respondents mentioned these answers with the exception of 23% of the Serbian supporting market liberalization and 29% of the French considering that nuclear phase-out should be a policy priority for their country.

Limited uptake of pro-environmental public support schemes

When it comes to publicly funded programs, subsidies or financial incentives for introducing or implementing environmental measures, less than 20% of the population in the ten covered countries report participating in (using) such programs. This share is highest in France, followed by the UK, Norway and Germany. The lowest shares are reported in Serbia and Hungary, with less than 2% of the population using public funding or financial incentives for any of these environmental measures. On the other hand, more than 10% of respondents in France, the UK, Ukraine, Norway and Bulgaria benefitted from programmes or subsidies aiming at improving energy efficiency.

Predominantly negative assessment of the efficiency of national policies

When assessing the effectiveness of different national policies related to energy, respondents in the nine countries tend to give average or below average scores, especially people in Ukraine, Germany and Serbia tend to be rather dissatisfied with the effectiveness of these policies, while in Norway, Poland and the UK, they give slightly higher scores for effectiveness. The policies that are assessed by respondents as most effective on average are "increasing the share of energy generated by renewable energy source" and "improving the energy efficiency of the residential sector", while "mitigating the effects of climate change"

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receives generally the lowest scores.

Richer consumers focus more on energy efficiency unless the electricity price is too low, like in Norway

With regard to the purchase of equipment, energy efficiency was reported as being a primary factor for choosing a particular item by 80% of the respondents in Germany. Interestingly, while Norwegians seem very concerned with the environment, in this question they are second to last with 41% who considered the energy efficiency of their new household appliances. The reason could be rather economic in the case of high-consumption appliances or cultural in other cases, than environmental concerns. Long-term decrease in electricity bills might be less important for Norway than for other countries. Still, the trend clearly shows that respondents from richer countries tend to focus more on the energy efficiency of their appliances. In Germany, in particular, this is also clearly visible in the highest share of households with new appliances, less than 3 years old.

Support for public transport in Hungary, Italy, Norway, Poland and Spain

Respondents in Hungary, Italy, Norway, Poland and Spain are generally supportive of government actions related to the improvement of the transportation system. The most supported actions with highest scores involve reducing fares and improving quality of public transportation, regulating standards of manufacturing, reducing emissions through enforcing new standards for manufacturers and expanding the existing road infrastructure. Naturally, measures affecting people's lifestyles and higher taxes are by far the least supported action. In terms of country differences, Spanish citizens are generally the most supportive while Hungarians tend to be the least supportive of governmental actions in the transportation system, with the exception of building new roads, which might be supported for other reasons than concern for the environment.

4.3 Low carbon mobility case study (D4.2 Report)

The main aims of the study conducted in Hungary, Italy, Norway, Poland and Spain were to better understand citizen's choices, identify key drivers and barriers, and explore potential solutions for low carbon mobility and shift away from private conventionally-fuelled car dependence while reducing the negative impacts of transport on citizen's health and well-being, the climate and the environment. Additionally, an in-depth study focused on the development of car sharing in those countries.

The research is based on the results of the Household Survey (D4.1), desk research, interviews on car-sharing (summarised in D4.2), and the quantitative analysis of mobility to understand households' travel behaviour, and in particular citizens' choices (part of D4.6). It focused on three travel modes: private vehicle, public transport and active modes, and factors such as households' preferences and characteristics, trip characteristics, and the specific country where the household lives. Through a multinomial logistic regression, the impact of these factors on the probability of choosing one mode or another has been quantified (D4.6).

Countries show similar travel patterns

The results show many similarities across the countries, in i.e. the weekly routine trips and that travel mode varies with destination. The Household survey has shown that the choice of the transportation mode within the same destinations was similar across countries are quite similar across countries. Trip to grocery/shopping is the one performed by the greatest share of the population, while the trip to work is the most recurrent. These trips and the trips related to children school and activities, follow similar patterns across countries. Leisure trips, on the other hand, seem to show greater variability both in terms

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of population shares having recurrent activities and number of days per week. The travel modes used tend to vary more depending on the type of trip rather than across different countries. In particular, public transport seems to be used less for activities related to shopping and involving children. A possible reason for this, mentioned in the carsharing interviews, is the inconvenience when carrying shopping bags or other equipment.

Environmental impact of travel mode is not an important factor; consumers actions reflect their preferences

Factors considered important and very important when deciding the travel mode are mainly safety, availability and reliability, while environmental impacts and reputation are the least valued. At the same time, the results of the quantitative analysis show that people tend to act consistently with their preferences. Seekers of comfort, flexibility, privacy and reliability seem to prefer the private vehicle to other modes, while those households concerned about the environment prefer active modes or public transport. Infrastructure, and in particular how its quality is perceived, is also an important factor explaining the use of a mode or the other, particularly for workplace destinations. Moreover, socio-economic factors highlight groups for which targeted policies could increase the propensity to reduce private car use in favour of more sustainable transport modes. Families with children and fulltime workers, for instance, might be targets of interest. Finally, the policies to promote this transition should account for the presence of the country-specific context, since this is also a significant determinant of households' travel behaviour.

Factors influencing the choice of travel mode. Socio-demographic and behavioral factors play a role

The closer analysis of the factors affecting the probability of using different modes for two specific recurrent destinations: the trip to the workplace or university and the trip to grocery shopping shows that several socio-demographic and behavioural factors affect the decision of mobility.
Overall, the impact of these factors on the two destinations is quite different. For the trip to the workplace, they mainly describe significantly only the choice between public transport and private vehicles, while for the trip to shopping they impact also the active mode. The factors have been grouped under 5 main categories.

Country effects

The first one is represented by specific country effects and has been useful to isolate the effects of being living in a specific country. These effects are significant for some of the countries and also, in this case, it changes significantly from one destination or the other. For instance, Norway which is the country with the lowest probability of going to work by car is the country with the highest in the case of the trip to grocery shopping. Also, while for work destination Hungary and Poland are not significantly different from Norway, it is more likely that people use fewer private cars for shopping trips. In Italy, it is more likely to find people using private car for work trips and in Spain, it is more likely than in Norway to find people using active mode for shopping and less private car but also more private car for work trips.

Trip characteristics

Leaving from home in both cases reduces the probability of going by private vehicles. This suggests that people who instead connect these trips to other previous destinations have a higher probability of deciding to move by car. The more frequently people go shopping the more likely they are to go on foot, while the same does not stand for the workplace destination. This might represent household preferring neighbourhood shops since it has been found that distance has a negative impact on active mode choices.

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Distance

It is the only variable that assumes statistically significant values for all the estimations. While on the way to work a longer trip increases the probability of choosing public transport, in the trip to grocery it heightens the probability of going by motorised transport modes, mainly private ones.

Attributes of the trip

Households who consider the cost of the trip as a very important factor tend to use less the private vehicle and have a higher probability of going by public transport to work or by active modes to the grocery. On the contrary, those households seeking the comfort of the travel mode tend to prefer their private vehicle for both destinations. The same stands for those valuing importantly the flexibility and the privacy guaranteed by the travel mode, although this is significant only for the workplace destination. In addition, people seeking a reliable travel mode have a 5% higher probability of choosing the private vehicle for their trip to the grocery. Interestingly, people's concerns towards the environment also translate into a lower propensity of using private vehicles in favour of public transport and active modes. In particular, for both destinations, households stating to have a high concern towards transport-related CO2 emissions have a lower probability of using private vehicles. Concerns on the impacts on air quality have also been found to be significantly affecting this propensity for grocery shopping.

Satisfaction with the infrastructure

Those households that are satisfied with the availability of parking are more inclined towards using their private vehicles, and those satisfied with the condition of public transport tend to use more this mode. Even though, for grocery shopping, this last satisfaction impacts even more on the use of active modes. Moreover, several socio-economic factors are found to affect the probability of choosing a specific transport mode. Although, surprisingly, being highly educated is found to have almost no effect, being older and working fulltime increases the probability of using the private car instead of other modes. Women tend to use less the car with respect to men for going to work, although no effect was found for the trip to the grocery. Having children is a significant factor for the trip to the grocery shopping, where it increases the probability of using a private car, while to some extent it also affects the trip to work for those households having more than 1 child. Finally, households living in cities have a higher probability of moving by public transport to both destinations, while those living more comfortably with their current income have a higher probability of using their private car.

5.3.1 Sub-case study: insights on carsharing

In terms of carsharing, it was identified in most countries as a practical solution, although this service as of 2018, was developing differently from country to country. The barriers to its development, as well as the potential for its added value to the low carbon mobility is presented in detail below.

Carsharing is urban-based, in an early phase of development

The study has shown differences in diffusion of carsharing between the countries, with a higher number of users in Norway and Spain. Still, the results of the representative survey among the households conducted in 2018 in all the countries (D4.1) have shown that by that time, the number of carsharing users was limited. The service was available almost exclusively in medium/big cities. Since then, however, the carsharing has been increasing in terms of both number of users and companies/vehicles available. Levels of satisfaction with the carsharing infrastructure were low in each country, while a relevant share of people stated that they were in favour of enforcing the speeding up of public transport and shared mobility through specific fast lanes.

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Various carsharing modes have a different purpose

In each country, carsharing is increasing in terms of both number of users and companies/vehicles available. However, the way in which this service is being developed differs from country to country, especially in the prevailing business model. Free-floating carsharing (i.e. the vehicles are normally freely parked on the street of an urban area, where they can be booked) is dominant in Hungary, Poland and Italy, while station-based carsharing (i.e. the vehicles occupy a specific parking lot reserved for it) is dominant in Norway. In Spain, free-floating is dominating in Madrid while it is absent in other cities. These two models seem to both have advantages and constraints:

- Station-based carsharing mainly target trips outside of the urban area and is hence less in competition with urban public transport, meaning they are more complementary. From an environmental perspective, the main advantage of station-based carsharing is its complementarity with public transport, which helps households to avoid using or, in some cases, having their own vehicle. However, some stakeholders in Norway and Spain were skeptical about the use of electric vehicle technology for the station-based system.

- Free-floating carsharing based on both conventional and electric vehicles (this have already proven to be successful in Spain, Italy and Hungary) targets urban travel and, although they might complement public transport, they might also compete as both operate within the urban area. Free-floating carsharing helps the environment especially when it relies on a fleet of electric vehicles, by increasing their presence in the urban area and by allowing people to discover this technology. However, some stakeholders expressed concerns about the number of vehicles and the distribution efforts required to ensure they are available everywhere in the area. This might lower the scheme's efficiency and its environmental impact, particularly when the service is not provided by electric vehicles.

The sector has so far been mainly driven by private initiatives with some cases of public services, public-private partnerships and member-owned companies. Carsharing is mainly developed in medium-large cities, although certain stakeholders pointed out the potential of shared cars in rural areas where they could bring benefits by substituting public transit with low demand.

Carsharing – prospects for electrification of fleet

The potential usage of electric vehicles in carsharing services is seen as a foreseeable future development by business stakeholders and is highly rated by policymakers who consider electro-mobility an important asset in order to meet emissions limits. Involvement of electric vehicles is seen by users as a value added as it gives them the feeling of using an environmentally friendly service.

Early adopters and a possibility to experience driving electric vehicles

The service seems to be more popular among the medium-highly educated between 25 and 45 years old, although older users are also becoming common. In most of the countries, users seem to choose carsharing mainly for its flexibility and comfort aspects. However, the costs of the service also seem to be an important factor for users. Environmental concerns related to air quality and global warming tend to be of secondary importance. The experience was positively evaluated by the vast majority of people who were able to try electric vehicles through this service. Many interviewees preferred electric to conventional vehicles and some of them declared they would also be ready to accept a higher price for the technology.

Linkage to the "traditional" public transport is needed

A system in which carsharing and public transport are connected and complement each other would benefit a model shift towards sustainable transport. Local authorities seem to mainly rely on the public transit offer to reduce private vehicle use and consider the complementary aspect of carsharing positively. On the other hand, business stakeholders would benefit from visibility and gain new users from an

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integrated offer with public transport. This could be done for instance by developing instruments such as mobile applications mapping the different services available.

Private car to carsharing switch is needed, and policy incentives

A sustainable model shift must support the switch from private car to carsharing use, but not all the trips that are now made by shared cars have replaced journeys by private car (e.g. it also replaced public transport use in some cases). Defining specific measures and incentives to prevent this can make sure this service is correctly developed.

The diffusion of carsharing service might benefit from a series of policies, including parking facilitation, private car access restrictions, integration with other modes, incentives for adopting electric vehicles and investing in charging infrastructures. The future of carsharing will be linked to technological development. The urban environment can be improved through the implementation of electric vehicles both with respect to local air quality and CO2 emissions levels. Furthermore, carsharing could reduce inequalities with respect to access to electric vehicles. It might also help users to live without a private vehicle and this could help reduce the number of vehicles per household.

4.4 From consumer to prosumer case study (D4.3 Report)

The case study on prosuming was conducted in Italy, Norway, Serbia, the UK and Ukraine. It has provided a mapping of the prosuming as a phenomenon; including regulations, media-analysis and what drives people's choice to become prosumers. Prosumers produce electricity for their own consumption (in this case with household solar power plants) and sell excess produced electricity to the central grid supply. In doing so, they can both reduce their energy consumption from central grid supply, but also add to the stock of renewable energy nationally. The study has put the focus on gender ideologies, to understand how the relations between gender, energy practices and choices may differ within and across households, as well as societies, and the implications this may have.
The study has emphasized the importance of producing knowledge that highlights social and cultural factors needed to advance people/gender sensitive policymaking, which can facilitate people's choice of investing in environmentally friendly energy solutions and practices. It points to relevant aspects such as feed-in tariffs, legislation and right to sell excess electricity, bureaucracy to become a prosumer that should be considered when designing energy policies and direct energy investments for prosuming in ways that are gender-sensitive, as well as socially, economically and environmentally sustainable.

Uncapped potential of prosumption

The research has shown that prosuming through HSPPs is increasing, but there is still a significant underutilised potential. Italy and the UK are leading countries, while the market in Ukraine and Norway is emerging. In Serbia, few households have installed HSPP because regulations on prosuming are not in place yet.

Common profile of a prosumer, despite country differences

There is great variation in the contexts of becoming a prosumer among the samples from different countries. The UK and Italy have a long history of incentive tariff schemes (feed-in tariffs), which has resulted in high uptake of PV systems in private homes. In Ukraine and Norway, on the other hand, the number of prosumers, although on increase, is still relatively low - between 1000-8850[5] - and subsidies and

[5] Data after State Agency on Energy Efficiency and Energy Saving of Ukraine, as of 1. April 2019. The number of prosumers in Ukraie has increased almost threefold since 2018.

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incentive tariffs are more recent and/or lower. In Serbia, the regulations regarding prosumers have not yet been harmonized, and no households and persons fit the definition of prosumers (selling excess produced electricity back to the main grid). Estimates indicate that about 385 households in Serbia are producing electricity for their own needs from PV systems.

Still, the average prosumers identified generally have middle- to high income and higher education. In the UK, Norway and Italy, the majority of prosumers are above 50, while in Ukraine and Serbia the majority are between 30-50. Most also own their own house and live in suburban or rural areas, meaning they have the financial means to invest in their own solar PV systems. In Norway, Italy and Ukraine, the sample shows that prosumers often have a higher level of education and work in the energy sector or a similar area. Another thing that all countries have in common is that prosumers, have had positive experiences of technical and financial nature, and related to skills and knowledge of becoming prosumers. At the same time, the problems they experienced have mainly been related to cumbersome bureaucracy or lack of reliable information.

Prosumption may lead to changing of energy use, and monitoring

Generally, many of the prosumers interviewed are very energy-conscious and use energy carefully, making it difficult to achieve additional savings. The main adjustment in energy use for many of the informants is connected to shifts in loads according to when electricity is produced from the solar PVs. To be able to adjust their energy use towards daytime they also now monitor their production and consumption more closely. However, not all prosumers have the possibility to adjust their energy use according to their production profiles because they are away most of the day.

Financial and environmental motivations are vital; support schemes and proper legislation needs to be in place

The motivations that drive individuals and household's decision to invest in HSPPs and become prosumers differ according to national contexts, but centre around financial and environmental reasons. Not surprisingly, in Italy, UK and Ukraine where incentive tariffs have been put in place, financial motives were ranked higher than in Norway and Serbia. Additionally, several of the prosumers interviewed were motivated because of professional or technological interests. Norway is illustrative, where 6 men and 2 women (constituting one person in half the interviewed households) worked in the energy sector.

The study confirms the importance of support schemes such as feed-in tariffs for the growth in the number of prosumers. In addition, it shows the importance of establishing prosuming in legislation. Further, it highlights the need for consumers to receive adequate support in the decision-making process and in the transition to becoming prosumers. Gender should also be a concern for policy-makers seeking to design and implement sustainable energy policies.

Gender aspects of presumption

Gender aspects are important for understanding how and why energy practices and behaviour may differ within and across households and societies and what social, economic and environmental implications this may have. Energy policies are often formulated in a gender-neutral way (the underlying assumption is that men and women will respond to and benefit equally from such policies), but research shows that the motivations for and barriers to taking up energy-saving technologies are gendered.

The decision-making on investments was done by the couples together, but it was men who in general took initiative for HSPPs and drove the process of becoming prosumers. In Norway and the UK, several women expressed disinterest or even reluctance towards the HSPP technology. They referred to it as 'his thing'. In

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many households, there is also a gendered division of labour and engagement with the HSPP. An essential aspect of prosuming is also related to any changes that occur in individuals and households' energy practices after becoming a prosumer. Here also, gender roles and gender relations matter as the gendered division of labour in the households mean that women and men do not engage with energy consumption in the same way, and they have different experiences and needs.

The study revealed that women perform the majority of several of the energy-related everyday domestic tasks such as cooking and laundry. Women then bear a higher cost of shifting their household's energy practices (such as doing domestic work in the daytime when the sun is shining). This information reveals the importance of a gender focus in understanding energy practices on the household level to inform policies.

To maximize the use of solar systems (without battery solutions), it is necessary to shift the main load of consumption from evenings to daytime when the sun is shining as this often concerns work that befalls women. Men and women's engagement with solar technology and prosuming is also embedded in how HSPP and prosuming are presented in the public eye. Re-producing the gender roles and gendered divisions of labour concerning energy, which excludes women from the technical sphere, has implications for women and men's ability to adopt new technology and change their energy consumption practices towards more environmentally friendly lifestyles.

Financial support and variations in policy design could increase the number of prosumers

The results also show that the motivations for becoming prosumers are quite varied: financial benefits, environmental aspects, technological interest, security etc. This urges the importance of a varied policy that considers all these motivations. There is also a challenge in making HSPP affordable to lower-income groups. Subsidies, tax reductions or feed-in tariffs are important measures to decrease up-front costs for lower-income households. In addition, reducing transaction costs are important to make technology more accessible. Providing opportunities for low-income households to become prosumers can also be a measure to reduce energy poverty. Learning from the above, governments can combine different policy tools to enable consumer access to prosuming.

4.5 Heating and cooling case study (D4.4 Report)

The aim of the research on heating and cooling was to obtain a better understanding of the factors that influence household behaviour related to heating and cooling, and possible measures to enhance energy saving. At the same time, most of the research has been devoted to heating, as cooling accounts for only a small proportion of energy consumption at present. The research was based on the results of the Household Survey (D4.1), desk research, and a focus group methodology, combined with participatory systems mapping, and secondary database. The information thus obtained were compared. The analysis of the Household Survey helped to understand dwelling characteristics, and heating practices, followed by in-depth case study and focus groups in France, Germany, Hungary, Spain, and Ukraine. Their aim was to define and point to the most beneficial policy interventions for energy savings (D4.4, D4.5).

As the last step, the information has been supplemented by a quantitative analysis of the factors influencing heating costs to understand households' behaviour and preferences. The aim of this analysis was to identify relationships between heating expenses (as a proxy for energy consumption) and variables related to the energy choices of households. It draws on data from the Heating and Cooling section of the ENABLE.EU household survey. Regressions for the five countries involved were performed using

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standardized monthly heating cost of households as dependent variable, while the explanatory variables were grouped into five categories: 1) variables related to household income, 2) external influencing factors, 3) knowledge and availability of information, 4) environmental awareness and 5) energy using behaviour, controlling also for the most important dwelling and household characteristics, summarised in deliverable D4.6.

Energy consumers differ vastly from country to country

The survey (D4.1) conducted among eleven countries has shown vast disparities among housing characteristics and heating practices between the countries. It was further confirmed during the case study that European consumers are diverse in terms of behavioural habits and heating requirements; financial resources that can be allocated towards low-carbon investment; housing conditions including insulation, home size, ownership; their preferences, willingness and motivation to change their habitual behaviour; their motivation for making changes; their beliefs and misunderstandings about low-carbon options. Still, most factors previously identified overlap in several countries and could be tackled with similar policy options. On the grounds of the present research, however, generalization to all European countries cannot be made, without further research.

Dwelling and household attributes are vital for the cost of heating

Both the survey and further case study analysis has shown that the main factor that influences heating costs remains dwelling and household attributes. Other factors can influence heating costs to some extent, but the magnitude of their effects seems to be much smaller, and the impacts are very diverse in different countries. Here, Spain stands out in many aspects as explained below. The survey results have shown that the disparity between individual energy choices begins as early as the type, age and size of the dwelling is considered, which is among other factors also driven by cultural, urban and architectural differences. There is a strong link between the type and size of dwelling and the household energy consumption, and the corresponding heating costs. The vast differences between the survey countries become evident as soon as the type of dwelling is considered. Some traces are seen in the Central and Eastern European countries (Serbia, Ukraine, Poland, Hungary and Bulgaria), like similar age of dwellings, while the Western European countries exhibit diverging patterns in terms of dwelling characteristics.

Dwelling types and sizes vary in the studied countries. The household survey D4.1 shows that living in single-family houses (both detached and attached to other houses) range from nearly 75% in Hungary and 79% in the UK to only 27% in Spain and 36% in Italy. More than half of the British respondents (57%) live in the single-family house attached to other houses, while a large part of Spanish respondents (47%) live in buildings with 2 to 5 flats. Living in the largest category of dwelling (more than 120 m2) ranges from 41% of the population in Norway to only 4% of the population in Ukraine, where 58% of the population live in dwellings smaller than 65 m2.

Consumers' income status, daily routines or values affect the heating costs in a very limited way

The case study held in five countries has shown that in all countries but Spain, neither objective nor subjective income status (i.e. whether one finds it difficult to live with their income) plays an important role as a determinant of heating bills. In Spain, where rich people tend to spend significantly more on heating, and subjective well-being also influences heating consumption even among people having similar income level.

Nor do the daily routines influence significantly energy consumption (only a slight effect could be detected in Spain, showing that bad routines can have a negative effect on energy cost savings). In Spain, access to information plays an important role, while having a smaller effect in Hungary and Germany.

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Moreover, in Germany, France, and to some extent Ukraine, the assumption that people who care more for the environment tend to reduce their energy consumption resulting in lower heating bills was partly validated. Still, no such relationship was identified in Spain and Hungary.

Households in richer countries live in newer dwellings

When it comes to the average age of the dwellings, cross-country comparison of the survey results clearly distinguishes between different sub-groups of countries. Germany, France and Norway have more than 30% of people living in dwellings built after 1990, while in Bulgaria and Hungary the respective shares account for 9.8% and 12.5% of the population, respectively. The UK has the biggest share of the oldest dwellings (46.4% built before the 1970s), Spain is in the middle and Italy has a pattern very similar to the East European countries' group. In the Central and Eastern European (CEE) countries (Serbia, Ukraine, Poland, Hungary and Bulgaria) the dwellings built during the socialist period prevail (i.e., before the 1990s), while the Western European countries exhibit diverging patterns.

Insulation matters

The household survey D4.1 has shown that the age of the dwelling could be considered as one of the important indicators of its energy efficiency, but it is by no means the only factor determining the energy bills. Renovated old houses are more energy efficient in terms of heating and cooling. Insulation is very common in Norway, the UK, Germany and France, where the majority of the population lives in dwellings having at least one sort of additional insulation. In the CEE countries like Ukraine, Hungary, Serbia and Bulgaria, 50% to 68% of the population reports having no additional insulation in their dwellings (Poland is an outlier since, despite being part of the CEE countries, external wall insulation is very common). Countries with a warmer climate such as Spain and Italy have similar shares of the population without any insulation.

Diverse heating sources: mostly natural gas and electricity but also wood and coal

Furthermore, the household survey D4.1 has shown that in most of the countries, more than half of the households predominantly rely on a single type of energy source for heating. Only in Norway and in the UK, the majority of households rely on two or more types of energy sources for heating. Among the countries with a single energy source type, district heating is more common in most of Central Eastern Europe (CEE) countries (Serbia, Poland, Ukraine, and Bulgaria). Natural gas from a central source is a very common source of heating in Germany, Italy and Hungary (over 45%), and arrives as the second source in Spain, Ukraine, France (over 20%) and Poland (11%). It is also the most common choice (19%) for UK households who use a single energy type for heating. Electricity is largely used as a single source for heating in Spain (39%), Bulgaria (28%), France (25%) and Norway (25%). Finally, 33% of Serbian households rely on wood for their entire heating (this explains why a large share of Serbian households do not have precise control over the temperature in their homes), followed by smaller shares in Bulgaria (17%) and Hungary (16%). Poland is the only country where coal is used as a preferred single energy source by a considerable share of households (i.e. 10%). At the same time, the country has high share of households using district heating.

The majority adjust the temperature when possible

On the top of the above, the results of the household survey D4.1 indicate that when adjustment of the temperature is possible, most of the households tend to use this option and prefer adjusting the temperature either manually or automatically. The latter is most common in the UK with 44% and in Germany with 40% of people adjusting the temperature automatically, followed by France with 27%. Generally, less than 1/3 of households prefer to set a constant temperature in the heated parts of the dwelling without dynamically adjusting it. Norway is an exception with as much as 39% of households following the same strategy. This could be explained by the lower and more constant average external temperature during the heating season, which makes the adjustments less necessary. The country, where

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the adjustment of the temperature at home is most widespread in the UK.

The heating challenges overlap

As the focus groups conducted in the framework of the case study D4.4 have shown, despite the differences between the countries, most challenges overlap in several countries and could be tackled with similar policy actions.

The challenges related to decreasing the heating bills raised by focus group participants overlap in the 5 countries covered by the case study: technical status and age of the heating system; characteristics of the dwelling in terms of age, condition, orientation, location; issues of insulation: poor or no insulation decreases the efficiency of heating; fuel types used for heating/use of renewable resources for heating; fuel price and fuel price differences; difference between inside and outside temperature; individual heating behaviour; sharing bills between blocks of apartments; conflicts and difficult dialogue between tenants and landlords connected to issues regarding investment into more efficient heating systems or into insulation; differing interests within multi-apartment houses related to investing into renovation that may block investments into house or heating system renovation.

Policy measures to address problems

In many cases, those problems can be addressed with common policy measures. The focus groups helped to elicit the ideas directly from the consumers and define the variety of policy measures. . Those measures can be categorised in five groups of actions: information-sharing and communication, raising awareness, technology-related strategies, financial measures and fighting energy poverty.

- Information-sharing and communication measures include: (1) provision of easily understandable practical information about energy-saving solutions, metering and behavioural patterns, (2) multichannel communication for reaching various target groups with appropriate messages, and (3) use of independent, trustworthy parties for successfully influencing the energy-related behaviour of the society.

- Awareness raising measures concerning: (1) energy-efficient behaviour, (2) the interrelationship between energy consumption and its impacts on the environment, on our health, and on the costs of the household, and (3) good examples and benefits of behaviour change.

- Technology-related strategies include: (1) supporting the availability, the cost efficiency and the affordability of new, more sustainable technological solutions for heating. In addition (2) promoting the modernisation of buildings for better insulation, thermal conditions and ventilation, (3) promoting individual metering and the use of thermostats, and (4) making use of community-based solutions.

- Financial measures stressed both: (1) the need to provide more financial incentives for using more renewable energy, switching to more energy-efficient solutions, solving conflict situations (e.g. between landlords and tenants), (2) the need to penalise the overconsumption of energy and polluting ways of heating. (3) The examples from Ukraine have shown that governmental schemes are more efficient when they can be monetized directly to the consumers, rather than in the form of compensation of energy providers. This form of support stimulates consumers to energy saving, as they can save received money through reduction of energy consumption and invest them in energy efficiency measures.

- Fighting energy poverty, policy recommendations commonly focused on: (1) the need for social support for higher-scale investment into improving the energy efficiency of the houses of vulnerable families, and (2) the need for strengthened social schemes.

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Actions resulting in "triple dividend"

Measures that create "triple dividend" create positive effects in minimum three of the following categories: environment, economy, society, health, and community. Among those, providing information through different communication channels about the required temperature should be mentioned. It results in less energy consumption, creating less environmental load, savings on energy costs, and a healthier lifestyle. Trusted communication channels are important here, as different target groups have to be approached in different ways.

A properly designed insulation programme also appears to be a triple-dividend solution: less energy is consumed, resulting in significant savings for households, along with less emissions and a healthier lifestyle.

Moreover, community-based projects can generate the economic benefits of saving energy costs and the environmental benefits of less pollution, but also result in better community life and inclusion. Shared practices can have a reinforcing impact on members of the community, encouraging them to find energy-saving measures reasonable and to better recognize their benefits. Fair individual billing may also contribute to the triple dividend by reducing suspicion and finger-pointing among neighbours, while creating a common interest in making energy-saving investments.

Furthermore, managing the challenge of heating with waste will also result in a health-related, social and environmental dividend. Informing people about how dangerous and detrimental this practice is to their own health may change this behaviour, resulting in better individual and settlement-level health conditions, less social tension and a cleaner environment.

Helping low-income households through financial support to invest into the refurbishment of more efficient-energy heating systems empowers those households economically. They will be able to pay back loans from the savings they make because of more efficient resource use and hence, fewer energy costs while lessening energy consumption is beneficial to the environment as well. Thus, social investment at the EU level should be considered as a form of economic investment - for example, for thermal renovation which creates a triple dividend benefit – reducing the energy consumption of dwellings, lowering energy expenses, and perhaps even lifting households out of energy poverty and making the dwelling an asset that is more environmentally friendly.

European energy policy may involve diverse approaches that fit the circumstances of various social groups. Identifying affordable and low-carbon options for vulnerable groups may create a triple-dividend in terms of reducing carbon footprint, energy costs, and energy dependence.

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5. Governance barriers for an energy transition

The research aimed at assessing the quality and trust in governance in the nine studied countries (Bulgaria, France, Germany, Hungary Norway, Poland, Serbia, Ukraine, and the UK), using the literature review (D2.2, D5.1), desk research and interviews (D5.2, D5.3). Additionally, the survey with stakeholders and desk research helped to elicit the implementation of low-carbon energy technology, summarised in the Report D5.4.

5.1 Governance literature review (D5.1 Report)

Governance as a factor of energy-related choices

As the literature review (D2.2) shows, in addition to economic and social factors affecting the energy choices, several drivers and bottlenecks exist at the governance level. A low carbon energy transition requires disrupting the current energy system. This raises the challenge of consistent policy-making based on a long-term strategy that cannot be easily overturned in the future and that takes into account obstacles to the liberalisation of markets, path dependency, regulatory barriers to technological diffusion, support for R&D, the active engagement of stakeholders and consumer acceptance.

Differences between member states

This is further confirmed in the review of the literature on governance barriers for the social acceptability of energy transition technologies and policies in Europe (D5.1). It shows that although the EU Energy Union is developing a coherent plan for a sustainable energy transition[6], there are large differences between countries regarding their ability to design and implement such a transition.

Need for consistent, stable, long-term policy-making

A low-carbon energy transition requires disrupting the current energy system based on fossil-fuels, centralised generation, supply-side orientation, and all the practices, policies, technological development, business models, norms and attitudes linked to this system, while at the same time developing and introducing sustainable alternatives. This raises the challenge of good governance and of consistent policy-making that is predictable and based on a long-term strategy that cannot be easily overturned in the future.

Diverse theoretical frameworks on the governance of the energy transition

Moreover, the existing studies on energy transition governance apply a variety of theoretical frameworks aiming at understanding the practical planned and unplanned implications of the transition processes. In many of the cases, researchers have applied multi- or inter-disciplinary approaches, combining concepts and methods, borrowed from different disciplines and sciences. The literature review D5.1 has identified four predominant groups of theoretical frameworks: innovation systems, incl. science technology studies, multi-level perspective, evolutionary approach and social practice theory. These frameworks use specific key concepts and apply respective methods to the study of the governance of energy transition. Still, the boundaries between approaches are not very sharp and research concepts often overlap. Thus, the Report D5.1 offers a detailed, though non-conclusive analysis of those theories. The authors underline, that reviewing the literature on energy transition governance clearly reveals how diverse both the research field and its analyses are. There are (still) no widely recognised key concepts and definitions nor a clearly delineated respective set of theoretical frameworks. Moreover, the diversity and complexity of the

[6] In a form of a comprehensive set of legislative proposals, including Energy Union Governance Regulation adopted in December 2018, that is one component of the European Commission's 'Clean Energy for All Europeans' package.

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research object suggest that a comprehensive theory could hardly be elaborated.

5.2 National governance barriers (D5.2 Nine country reports), and their synthesis (D5.3 Report)

The nine, detailed country reports on governance bottlenecks in the energy transition, include both the EU members and non-EU countries (Bulgaria, France, Germany, Hungary, Norway, Poland, Serbia, the United Kingdom and Ukraine). They are available on the ENABLE>EU project website. Only their Synthesis Report 5.3 is presented below.

Different pace of energy transition

The research has revealed that the group of the countries can be categorised into transformation leaders, the countries in between, and those lagging behind. The analysis of governance bottlenecks and constraints, faced during the design, monitoring and implementation of energy transition policies in European countries show that these processes are naturally mostly country-dependent and have their own specifics in each of the nine countries studied. In addition to that, the sector-specific research and recommendations have focused on: wind and solar energy and smart grid power networks; biomass and biofuels, energy efficiency and electrification of vehicles.

Achievement of one transformation goal can hinder the realisation of the other

Despite the differences, some similarities can be traced across the countries, also when comparing EU and non-EU or leaders, and laggards. It is also a paradox, however, that in some cases, when a particular country has achieved some of the targets in its progress towards low-carbon economy (e.g. generation of energy almost fully based on renewables in Norway), this could be assessed as a factor limiting the progress toward another targets (e.g. improving energy efficiency) in the absence of the comprehensive policy.

Similar structural governance problems

Interestingly, the major structural governance problems seem to be common. The respective recommendations for future policy actions both at EU and national level, aim at improving the design and implementation of energy transition policies in Europe.

More commitment is needed

First, secure long-term political, financial and social commitments and synergy across the various policy areas to shift away from fossil fuels towards decentralized energy production from renewable energy sources. This shift should be managed in accordance with common EU priorities and consistent with national specifics but without compromising the former at the expense of the latter. Policies and legislation related to energy transition are generally framed at the EU level and regulatory rules are mostly elaborated in response to EU requirements. This is extremely valid for the "policy-takers" countries (e.g. Bulgaria, Ukraine, Serbia) but at the same time it is often relevant also for the countries, leading the energy transition (Germany, the UK, Norway, France), as well as for the group in the middle, e.g. Hungary and Poland. As demonstrated above, this common feature of the energy transition policies applies to both EU and non-EU countries. It produces or at least reinforces two spill-over effects at the level of national policy-making and implementation – the "stop-and-go" problem and the discrepancy between the top-down approach of the general policy-making and the bottom-up characteristic of the energy transition, seen as intrinsic and vital for its success by many of the experts.

Selective implementation of the EU energy and climate regulations

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Second, the problem of selective implementation of climate regulations is clearly visible and results in the lack of or inefficient synergy among the various policy areas of the energy transition in all of the countries. For instance, in Hungary special attention is given to the uptake of e-vehicles, while the government faced an infringement procedure for a delay in adopting the EU's Energy Efficiency Directive. Similarly, in Bulgaria, the RES development has boomed for three years with the following freezing period due to mismanagement and governance deficits, while at the same time other transition policies, e.g. toward e-vehicles, have been considerably lagging behind.

Local-level involvement needs to be strengthened

Third, should the energy transition to take place, many French experts believe the potential for it would rather be in a bottom-up approach where regions, local authorities and even citizens act at their level to develop renewable energy production locally and reduce energy consumption. In this sense, the change in personal behaviour and attitudes are seen as fundamental for the success of the energy transition. The bottom-up approach requires more active and better dialogue in planning the synergies at the national, regional and local level, while the lack of or inefficient coordination results in nonaligned ineffective plans and failing implementation of the respective policies. If the regional, local and community levels are seen as key in driving the energy transition, they require more resources to contribute effectively than they can afford recently (partially with the exception of Germany and Norway, where this problem has not been raised in the country analyses). However, as the Hungarian case reveals, the top-down approach of the general policy-making in the field of energy transition policy has negatively influenced the national policy and led to strong centralization and a top-down attitude also at the level of local administration. As a result, several municipalities functions were transferred to the central government leaving only a limited role and budget for local governments to participate in policies related to the energy transition.

Long-term commitment is necessary

Fourth, the research has confirmed the findings of the literature review. In all of the nine countries, the need to ensure long-term political, financial and social commitments was defined. Additionally, it should be in line with priorities and actions that are realistic and concretely feasible, so that policy remains credible in the eyes of the citizens. If policies often fail to be implemented according to the timeline, long-term strategies lose their meaning and worsen the conditions for active and widespread social commitment.

Need to invest in human resources

Fifth, there is urgent need to ensure continuous and permanent development and improvement of human resources in the public administration at all levels and in all policy areas, particularly avoiding political interest groups' influence over the independent legislative, executive and regulatory bodies through staff turnover and "revolving door" mechanisms. With no exception, all countries have been vulnerable – to a different degree, to these problems, varying from an insufficient number of professional staff, often overburdened with high workload and non-adequate remuneration, to politically motivated enrolments of key middle- and top-management or influence over decision-making in private interests through "revolving door" practices. In addition to the public administration, the same should apply for the state-owned energy enterprises, especially taking into consideration that in most of the studied countries, the energy sectors are still heavily dominated by large state-controlled businesses.

Clear division of competence

Moreover, a better division of jurisdictions, responsibilities and tasks is required to avoid overlapping of functions (particularly important in monitoring and implementation of policies) and conflicting priorities or activities. In many cases, it is not only a question of formal legal framework but also depends on the real division of power among different jurisdictions and governance levels, controlled or influenced by different political parties with their own priorities and ideologies. Finding the "golden mean" between over

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centralization and federalization is not an easy task as shown for instance by the Hungarian and German examples.

Need for independent expertise

Last but not least, all the countries examined are moving closer and faster towards global information society. The shift towards low-carbon economy and society raises extremely high requirements regarding the communication of information, knowledge development and stakeholders' involvement in the whole life-cycle of policy-making in three important aspects. On the one hand, to increase public acceptability of sometimes socially- and economically-sensitive issues (e.g. restructuring of the coal industry or addressing energy poverty), energy transition policies should be accompanied by clear evidence-based independent assessment of their economic, social and environmental benefits and disadvantages. Politically-driven misleading communication is the greatest threat here. On the other hand, energy transition policies need highly qualified expertise on all governance levels and from all involved stakeholders. It requires the development of (new) mechanisms for more effective dissemination of information, knowledge transfer and deliberative decision-making, involving particularly local authorities, civil society organisations, community' and business' representatives. Last but not least, enhanced understanding at the end-user level of highly-specialized technological and economic realms, accompanying the introduction of new energy technologies and policies, requires changes not only in the field of the political system but also in the other social spheres, incl. education system.

5.3 National policies, strategies, practices and non-technical bottlenecks in low-carbon energy technology implementation (D5.4 Report)

The Report builds on the research from the whole WP5 as well as case studies within WP4, together with the surveys on SET plan conducted among the national stakeholders.

Lack of in-depth knowledge on technology-driven policy aspects

The analysis has shown that beside some country specific features, there are many similarities across the European countries studied, and often these similarities are based on the more general knowledge and understanding of technology-driven aspects of the respective policies instead of going deeper into the complex technical matter.

Social and demographic factors influence energy transition attitudes

Particular focus on non-economic and non-technical factors that could affect the individual and collective energy choices, tested with the socio-demographic characteristics as predictors for specific attitudes or opinions, demonstrates also that there are more similarities than differences across the countries and that especially socio-demographic characteristics strongly predict the anti- or pro- energy transition goals' attitudes and opinions.

Inefficiency of the SET Plan...

In general, the stakeholders' assessment of the SET Plan implementation progress in the countries has not been positive and the Plan is not seen as enhancing the policy coordination and support for R&I related issues in the national policies. Among the main reasons about this is the low level of knowledge about SET Plan and involvement of wider stakeholders' community in the decision making and implementation processes. Moreover, the lack of active engagement on country (e.g. governmental) level with the SET Plan of some member states, e.g. Central and Eastern European ones is also a limiting factor. In addition, even the coordination of the SET Plan on EU level, including the creation of specific monitoring mechanisms to

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track its progress, is seen as ineffective mostly due to the non-binding targets and requirements related with it.

The alignment of the EU framework programme for research and innovations Horizon 2020 with the SET Plan priorities, which is intended to channel substantive part of the available funding to topics related to the Plan, is seen as inadequate as the access to this funding is locked in by established players and not suitable for important groups, such as SMEs.

... could be tackled with monitoring mechanisms, financing links, capacity building and wider inclusion.

To improve the situation, the following actions could be considered: to set up a monitoring tool or initiative on EU level, which requires every country to report the implementation of the SET Plan priorities on policy level according to pre-defined set of criteria. The monitoring process should prioritize the provision of information by national representatives instead of a collection of information from a centralized point (e.g. current JRC-based monitoring). Moreover, the additional requirement could be introduced to align SET Plan targets and priorities more directly with the planning and implementation of ESIF funded programmes on national level.

Additionally, the European Commission could support capacity building initiatives for SET Plan working groups' members. Not least, the inclusion of member states' representatives into the group of people, who received information on or are consulted for the SET Plan implementation could be widened and include, e.g. members of the relevant H2020 Program Committees and National Contact Points.

Low public awareness about the SET Plan...

The stakeholders also assess as insufficient the public awareness and knowledge about the SET Plan, including among specific target groups, e.g. enterprises in relevant economic sectors. One of the possible reasons is the fact that the Plan is not recognized by various stakeholders' groups as a "funding stream", which lowers the interest into it. It should be noted, that most of the experts belonging to both public administration and academia, do not recognize civil society organisations (CSOs) as a relevant target group, which should be also involved into planning and implementation of the Plan-related policy measures.

... could be changed by explicit links in the climate, energy, and innovation documents and policies.

Enhance the process of raising public awareness and knowledge about the SET Plan among different target groups and general public, including relevant CSOs, through incorporating explicit links to SET Plan and its priorities and targets in all related climate and energy strategic documents and initiatives on EU level, as well as encourage the national policy-makers to do the same for national and regional/local ones. These could be not only documents and initiatives, directly related to climate and energy policy but also more general ones, related to innovation policy, e.g. national Smart Specialisation Strategies and Regional Innovation Strategies (RIS3 in lagging regions), or cross-country initiatives and funding programmes, e.g. the EU Strategy for Danube Region, Interreg Europe, etc.

Governance bottlenecks of technical issues of energy transition...

Even though technology-driven aspects of specific national policies usually attract less attention from stakeholders, most of the respective policies include technology-related issues as a substantial part of them. As demonstrated with the example of two policy areas – low-carbon mobility and heating and cooling, the major governance bottlenecks regarding technical issues of the energy transition policies are similar to the constraints met by these policies due to economic (market and financial) constraints. In the case of low carbon mobility (and electrification of car-sharing services as a particular example), such a

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bottleneck is the lack of long-term political commitment and insufficient policy coordination, as well as the "stop-and-go" approach in the design and implementation of the respective national policies. In the case of heating and cooling policies, the technical aspects, highlighted by the stakeholders, are much more, but major governance bottlenecks are seen also in the lack of or inefficient coordination and harmonisation of national policies across various sectors and policy areas (e.g. construction sector, energy, production of electrical devices, etc.), as well as affordability and poverty issues that are seen vital for the shift towards more sustainable H&C.

... could be tackled with more efficient policy coordination and harmonisation, support for RES and R&D, and behavioral shift supporting affordable heating and cooling options.

Further and deeper harmonization of national policies across sectors and policy areas is highly needed. In addition to that diversification and decentralization of RES is deemed fundamental and governments must pay higher attention not only to electricity generation but also to other sectors and services (heating, use of alternative fuels), which has to go hand in hand with the development of new materials and community-based services. Additionally, the low-carbon R&D and technological development in universities as well as to tech companies should be improved and supported.

Another important aspect is that both the EU and Member States should secure long-term political, financial and social commitments and synergy across the various policy areas: overcoming the EU-centered design of energy policies; overcoming the "stop-and-go" approach in national policies; and overcoming the discrepancy between the top-down approach of the general policy-making and the bottom-up characteristic of the energy transition, seen as intrinsic and vital for its success.

Moreover, incentives and drivers for shift in individual behaviors regarding H&C are largely missing. The value of community-based solutions should be promoted as they offer sustainable multiplier effect. Particularly in H&C, affordability of energy transition policies should be ensured to be in the focus of decision-making, avoiding that the energy transition is seen as increasing social inequalities.

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6. Participatory foresight

The foresight part of the ENABLE.EU project focused on understanding how to encourage people to make better and more sustainable energy choices. Its three transition workshops have brought together experts and citizens to create a roadmap for the future. To begin with, 60 experts were asked to envision future energy scenarios during the Transition Visioning Workshop in Sofia, Bulgaria in June 2018. Then, 60 citizens refined these scenarios based on their experiences, offering their feedback on enablers and barriers to adopting sustainable energy behaviours during Transition Backcasting Workshop in Rome, Italy in November 2018. Finally, the third Transition Roadmapping Workshop brought those experts and citizens together to create a roadmap for the future, in Brussels in February 2019. The workshops were elaborated on in the three subsequent Reports (D6.1, D6.2, and D6.3 and evaluated and summarised in the Report D6.4.

6.1 Transition visioning workshop (D6.1 Report)

The Report D6.1 summarises the Workshop with the participation of expert and practitioners from 11 countries. Taking into consideration the targets set by Europe 2020 and the Energy Union Initiative, the workshop addressed the questions on actions and practices shaping energy behaviours.

Prevalence of economic, technological and governance factors

First, the participants defined the trends and events that influence the energy transition, based on the analysis of political, economic, social and technical factors (PEST). They highlighted the economic and technological trends that have influenced our energy consumption the most over the last few decades. Participants also noted the role of the EU in setting regulations and targets for sustainable energy production and consumption. The national level was acknowledged for its role in governing energy prices and incentives. Only a few social trends were proposed by the participants, possibly because social trends are considered to have only a relative impact on energy decisions in comparison with other trends, or because social trends are less known and investigated compared to other factors. In addition, looking at the experts' background, fewer participants with social science expertise attended the workshop and thus there was less knowledge shared about these aspects.

Three horizons methodology

In the next step, the Three Horizons methodology was used to frame future thinking together, in a group of participants convened in workshops to discuss future scenarios for a given area
Participants were asked to answer the following questions:

First, what evidence do you see around you that suggests the current energy system is under strain, and which individual and collective energy behaviours are showing a decreasing fit to emerging conditions, knowledge, and societal requirements? Second, what might a future energy system look like and which individual and collective energy behaviours would support it? Third, what emerging new practices, actions, and solutions do you know about and/or do you propose to shape new energy behaviours in the future?

Three future energy systems

As a result, the participants have defined future energy systems. Those included the Community-led, Technology-led and Behavioural shift coupled with technology-led future energy systems. Based on those, new actions have been proposed, clustered in seven themes, namely: 1.New energy business models,

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simplification; 2. Prosumers/ Renewable energy production; 3. Mobility as a service (MAAS), electric/smart mobility; 4. Energy affordability; 5. Energy education and awareness; research & innovation; 6. Active houses and energy efficiency measures at home; and 7. Reduction of energy consumption, dematerialization/virtualization.

6.2 Transition practice backcasting workshop (D6.2 Report)

The underlying idea behind the second workshop with citizen involvement was that the face to face discussions with the others enables to understand better the drivers of the individual energy choices, as well as influences to make changes in energy consumption. The ENABLE.EU Transition Practice Workshop aimed to elicit the opinions of 60 households invited from 11 countries to canvass their experiences on what drives their energy choices and how their energy needs might be satisfied in a more sustainable way.

Citizens' insight on prosumers, low carbon mobility, heating and cooling and energy efficiency

In the first day of the Transition Practice workshop, the participants were informing about their daily energy practices to understand what might facilitate or hinder these changes. The topics focused on prosumers, low carbon mobility, heating and cooling and energy efficiency. The day after, the participants were asked to imagine what kind of social, technological and organisational practices could promote more sustainable energy consumption in the next 20- 30 years, based on the revised transition storyline that emerged in the first ENABLE.EU workshop. Three topics were analysed: energy production, energy consumption and mobility.

Actions defined by consumers

Participants highlighted many opportunities available today to reduce energy consumption and to use it in more sustainable ways. From the use of advanced technologies to the (re)-discovery of frugal innovations and the adoption of sustainable behaviours and solutions, small changes in our everyday practices can make a difference in reaching the long-term goal of decarbonising our economy and lifestyles. Workshop participants pointed out how the adoption of sustainable energy practices needs to be promoted and supported by policies acting in four fields influencing energy choices. The actions, in general, can be categories under four aspects: skills and knowledge, material conditions, attitudes and norms, and beliefs, values and identities. The aspects highlighted by the participants as important within the categories of the four case studies are presented in the Table 4 below.

The framework adopted by the ENABLE.EU project highlights also the importance of taking into consideration and including measures on beliefs, values, identities, attitudes and norms for fostering and shaping a real energy transition. The ENABLE.EU households pointed out the need of a paradigm shift toward circular economy should be coupled with mentality shift of citizens who should become more aware of their consumption consequences and proactively engaged in the search and implementation of sustainable actions and solutions. To make this shift possible, participants identified several actions that should be taken by decision-makers that the last workshop (held in Brussels) has built upon.

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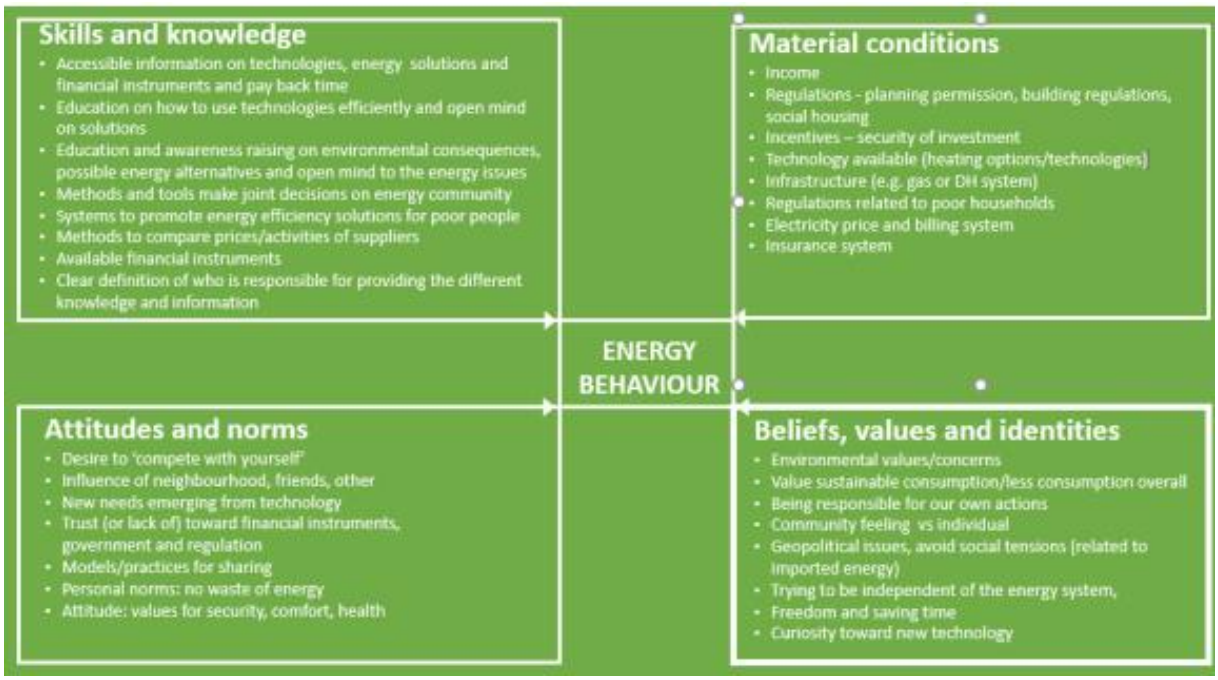

Table 4. Aspects influencing energy behaviour as defined by the citizens during the Enable.EU Transition Practice Backcasting Workshop.

6.3 Transition practice framework workshop (Report D6.3)

During the third workshop, held in March 2019 in Brussels, the citizens met the practitioners. The detailed Report from it is described in ENABLE.EU Deliverable D6.3. Analogically to the second workshop, the discussion has focused on the four energy transformation fields: energy efficiency in electricity consumption, low-carbon mobility, heating and cooling and prosumption, to develop the recommendations further, as well as to verify whether the actions and practices defined at the second workshop match the scenarios of the first one. Additionally, the online survey was conducted beforehand among the participants to get input on what actions they consider to be of an utmost importance.

Although the definite, realistic Roadmap has not been defined, the workshops helped to identify the factors that influence energy choices in the four categories that have been closer scrutinised within ENABLE.EU project. Their results are presented in the tables below.

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Environmental awareness: • knowledge of energy costs, prices and efficiency ratings; • knowledge of environmental cosequences; • education on energy literacy and available technology	Efficient energy consumption	**Economic factors:** • Technology labelling; • Heating with electricity; • Household size; • Electricity pricing and billing by utilities; • Subsidies / incentives for poor households to improve energy efficiency of their homes; • Pricing negative externalities
Attitudes and norms: • Personal norms - no waste of energy and money; • Attitude: care for environment	**Beliefs, values, identities:** • cultural values; • pro-environmental behaviour is valuable; • advanced technology and comfort are valuable; • community feeling.	**Governance aspects:** • enhanced role of the communities to facilitate exchange of information and shared investments; • incremental regulation to enhance reduction of energy consumption in buildings, • Subsidies to stimulate Researc and Development.

Table 5. Aspects influencing energy efficiency and electricity consumption as defined by the citizens during the ENABLE.EU Transition Practice Backcasting Workshop and citizens and practitioners during Transition Practice Framework Report.

Environmental awarenes, knowledge: • education; • open mind; • awareness of the alternatives; • change of a mindset.	Low -carbon mobility	**Economic factors:** • fast, save time; • availability, economy; • distance; • flexibility.
Attitudes and norms: • comfort; • safety and health; • individualism	**Beliefs, values, identities:** • environment, • tine to relax, • freedom.	**Governance aspects:** • provision and enforcement of alternatives to private vehicles; • sustainable mobility planning of the cities.

Table 6. Aspects influencing low-carbon mobility as defined by the citizens during the ENABLE.EU Transition Practice Backcasting Workshop and citizens and practitioners during Transition Practice Framework Report.

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Environmental awarenes, knowledge: • Education to make it easy to install; • Find and understand the information; • Providing free or low-cost energy advisors for the citizens; • Communication campaigns targeting the general population; • Digital platforms and databases for energy advice and knowledge exchange	Prosuming	**Economic factors:** • Income; • Support schemes: feed-in tariffs, subsidies, and flexible feed-in tariffs; • Grants to energy communities; • Taxes to dis-incentivise "business as usual"; • Economic incentives targeting those who have less financial agency.
Attitudes and norms: • Want to compeet with oneself; • Neighbourhood, friends, other; • Comfort and technology drive your energy use, create new habits	**Beliefs, values, identities:** • environmental values, • geopolitical issues.	**Governance aspects:** • Regulations - possible to feed in, install yourseld; • Planning permission, building regulations.

Table 7. Aspects influencing prosumption as defined by the citizens during the ENABLE.EU Transition Practice Backcasting Workshop and citizens and practitioners during Transition Practice Framework Report.

Environmental awareness / knowledge: • On pricing and activities of suppliers; • On saving practices and efficient solutions for the poor; • On available financial instruments.	Heating and cooling	**Economic factors:** • Cheap and easily accesible technology; • Type of dwelling; • Available heating options and techologies; • Available infrastructure (e.g. gas og DH); • Energy efficient solutions for the poor;
Attitudes and norms: • How to make joint decisions;	**Beliefs, values, identities:** • reduce energy use because of the care for environment; • Avoid social tensions (related to imported energy); • Trying to be independent ofin the energy system; • Value sustainable / less consumption; • Responsibility of ones own actions.	**Governance aspects:** • Regulation related to landlords; • Regulation related to poor households.

Table 8. Aspects influencing heating and cooling practice as defined by the citizens during the ENABLE.EU Transition Practice Backcasting Workshop and citizens and practitioners during Transition Practice Framework Report.

6.4 Evaluation of the participatory foresight (D6.4 Report)

At the last stage of the foresight exercise the process itself was evaluated, as well as ideas defined by the workshops' participants, based on their potential contribution to the policy making. The most concrete measures have been scrutinised to identify policy recommendations relevant for energy and climate policy-

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making. To do so, they were confronted with the elements about the current policy context (i.e. whether some measures are already implemented) and included comments on the level (i.e. EU, national and local) at which such measures could be adopted. The Detailed analysis can be found in part 4 of the Report D6.4.

Advantages of the foresight process

The sole process of the ENABLE.EU participatory foresight was assessed as bringing a valuable contribution to the project findings and to the formulation of policy recommendations for future energy policy-making in Europe. Having insights and opinions of numerous experts and citizens on the energy future and ways to achieve it helps to frame the possible measures that policy-makers can adopt to accelerate the energy transition.

The methodology of participatory foresight has the advantage of bringing together different perspectives to exchange opinions and to build on each other's ideas. Additionally, the diversity of nationalities and profiles led to fruitful exchanges where most participants could learn about practices from other countries but also notice similarities across countries. Based on surveys carried out after each workshop, we gathered numerous feedbacks from participants and the project team. Most participants expressed satisfaction with the way the workshops were organised and enjoyed being part of the participatory process.

The shortcomings to improve in the future

However, some lessons can be drawn from the shortcomings of the process, due, among other things, to the limited length of the workshops, complex methodology and a broad range of topics covered. For these reasons, it was difficult for participants to develop a clear roadmap towards a clean energy future in all the energy areas investigated (i.e. energy consumption at home, heating and cooling, prosuming and mobility). Some participants thus expressed reservations about whether the outcomes of the workshop could be used. It is thus key in future applications to precisely frame the topic and the expected outcome.

Externalities defined as the major obstacles to the energy transition

In the last workshop, participants formulated a list of measures that could be undertaken at different levels of governance. When asked about the sustainable behaviours and practices, they envisage adopting to contribute to the energy transition, most participants seemed enthusiastic and willing to make such changes. But they considered that the main limits to adopting more sustainable behaviours are external conditions such as the lack of infrastructure and services, communication, economic incentives and regulations that are either needed to change (e.g. availability of public transport) or would encourage the shift (e.g. subsidies for solar panels and electric cars). The measures they proposed thus reflected the areas where they think public policy at different levels (i.e. cities, countries, EU) should devote more attention to allow a further change in individual energy practices.

It should be reminded, however, that the participants were not representative of the European population as they were generally more aware of energy and climate issues than average and they all spoke English. This bias needs to be considered when assessing the potential impact of the measures they proposed because not all citizens are likely to change their behaviours to the same extent as the workshop participants think they would. This might also be one of the reasons why a share of participants was mixed about whether the outcomes are realistic in the current policy framework. Last but not least, some participants underlined the added value of the participatory foresight tool for increasing the involvement of citizens in policy-making. Future participatory applications can build on the ENABLE.EU experience.

Assessment of the cross-cutting measures for more sustainable energy behaviour

The participants of the foresight workshops have listed a number of measures towards more sustainable energy behaviours. The feasibility and impact of those actions have been analysed and presented in detail

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in Deliverable D6.4. They are synthetically recalled below, under the following categories: education, communication, taxation, prosumption, energy efficiency at home and mobility.

Education

Sustainability could be built into University curriculums, such as economics and engineering studies. Although the EU cannot impose curricula constraints in universities, the initiatives to integrate a sustainability dimension in university programmes exist locally. Energy learning could also be built into existing curricula of younger students, in junior high school and high school education.

Moreover, homework exercises could be designed for children to share learning about energy with their parents. Finally, the EU citizens could be provided with free or low-cost energy advisors, Citizens benefit from being informed by trusted parties, as illustrated by the heating and cooling case study, and examples from the local energy programmes in France or in Barcelona.

Communication

Communication campaigns targeting the general population, need to be more user-friendly and better adjusted to the target group. This could be done with the involvement of the digital platforms and databases for energy advice and knowledge exchange.

Taxation

Although the participants of the workshops suggested that revenue from taxation (e.g. carbon tax) and other levies on companies and on household fuel bills could be directed towards financing energy education, the actual impact of this measure in terms of energy-savings, additional revenue and most importantly social impacts should be thoroughly assessed before its implementation.

Prosumption

Marketing, advertising and information campaigns could make energy production trendier and appealing to all (also via social media e.g. prosumers who become promoters to disseminate experiences on energy production at home). It could be a way to increase the number of prosumers, and more specifically women, non-engineers and later adopters. Moreover, 'hands-on workshops' for children and adults on how to use technologies to produce energy at home could be created to engage them.

In the countries where prosumers market is yet not developed, the national authorities could certify companies who guarantee a high-quality job for energy systems installation.
Furthermore, participants suggested the creation of an EU "toolkit" of regulations that national and regional level could use. This could take the form of a web portal, on the model of the EU Energy Poverty Observatory which categorises policies and measures by country, type of measure, target groups, financing method and energy carrier.

Participants also stressed the need for economic incentives to encourage prosuming – especially targeted towards vulnerable consumers. As highlighted by participants, these can include subsidies and 'flexible' feed-in tariffs; grants to energy communities; financial mechanisms to finance upfront costs for the installation of PV systems or heat pumps; incentives for tenants to install solar panels (e.g. by regulating the sharing of investment costs with the owners or by means of tax reductions for the owners renting apartments equipped with solar panels); more adequate regulation and incentives for multi-apartment settings where the decision is shared.

Energy efficiency at home

Smart metering implementation in all homes, to help better understand one's energy usage. At the same time, the introduction of smart meters could have been more user-friendly with better communication and

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information display to make them more popular and effective. To this end, the participants added an idea of introducing smart technics, smart meters and smart home devices used by households in their dwellings and in entire buildings (e.g. apps to check if appliances are on/off from a distance) and measures to monitor more closely energy consumption (e.g. Apps with a visual display or Web apps; online calculators for energy similar to FX converters):

Reducing consumption could also be triggered by change of behaviour*:* participants raised several possible practices related to heating, such as turning on the heating a week later than the beginning of the heating season, setting lower night temperature or an hour earlier than usual, setting different temperatures in different rooms and turning off/ lowering the heating when not at home. Thermostats also give the possibility to control and programme energy use.

What is essential, is the knowledge of the prices and products offered by energy suppliers. It could incentivise the customers to use off-peak tariffs, the new electricity market design currently finalised aims at making electricity billing user-friendly and easier to understand (e.g. by displaying the most important information for consumers to be able to adapt their consumption and compare suppliers' offers). It will also give consumers the right to request a smart meter and a dynamic price contract that allows them to be rewarded for shifting consumption to times when energy is widely available and cheap.

Another measure concerned new labelling for home appliances, to provide consumers with better information on energy efficiency. Also, as a longer lifetime for products in Europe can have a positive impact on the economy, on society and on the environment, the planned obsolescence could be eliminated by legislating longer warranties.

Some of the actions suggested by the workshop participants, such as setting very high standards, and requiring the implementation of all the technologies that are available on the market, have already been implemented by the EU in a form of labelling mentioned above, or in the Energy Performance of Buildings Directive that requires all new buildings to be nearly zero-energy by the end of 2020.

Some measures provide for the involvement of the children, such as energy efficiency refurbs for schools, gamification to make care for the environment more fun by developing games for children [and adults] to play.

Other measures require engagement and cooperation of the owners of the dwellings. The owners in larger apartment buildings could create unions to foster collective decision and investments to promote energy-savings. Also, the landlord/tenant relationship needs to be regulated.

Mobility

The participants of the workshops believe that introducing higher taxes on more polluting fuels (including on flights) can trigger more sustainable energy behaviours. As mentioned above, those measures need to be introduced with caution and based on thorough analysis.

Another measure is to improve public transport and trains (in terms of quality, reliability -also thanks to real-time information- and comfort; in particular night trains), which is a key improvement that is needed to leave the car behind. At the same time, subsidies for electric cars (including extended recharging infrastructure) and alternative fuels vehicles, and having a charging station every 150 km in all Europe by 2030 would support the shift towards electric mobility. Moreover, to support the development of electro-mobility that is both more sustainable and comparable in performance to current internal combustion engine cars, the production of batteries needs to become cleaner and provide sufficient autonomy for a competitive price. This could be done by funding for R&I for batteries performance improvement.

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Many measures highlighted by participants should be undertaken at the city level, where the EU can encourage their adoption through networks like the Covenant of Mayors. This includes:
- measures encouraging the use of shared and public transport such as the implementation of free public transport days; Subsidies for the use of public transport; Developing affordable or free park and drive for people living in more remote area to then take public transport; Earmark parking space for carpooling; measures encouraging the use of soft modes, i.e. improving conditions for bikes, such as better bike lanes, slower car speed in cities for security, subsidies for e-bikes and developing shared bikes services in smaller cities; and measures restricting car use, such as higher parking rates and car free zones.

Several actions recommended by participants should be undertaken at the level of companies: e.g. teleworking and reward system for bicycle users, with a premium system in case of difficult conditions (e.g., taxi cheques in case of hard rain). The participants have also underlined that car efficiency labelling system is not sufficiently visible in car showrooms. Also, car marketing could be limited.

Finally, some measures highlighted by participants can seem rather restrictive to individual freedom but are useful to put in perspective how far we are ready as citizens to change our habits and accept constrain in our future energy use, e.g. whether it would be feasible to implement a carbon quota per person or to limit car ownership (e.g., one per family).

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7. Modelling and scenarios

ENABLE.EU approaches the question of what drives energy choices through the lens of several energy services and activities, namely electricity consumption, mobility, heating & cooling, and prosumers. For each of these areas, other chapters provide new and useful insights on drivers and trends in energy consumption. One of the key expected outcomes of ENABLE.EU are the policy scenarios, based primarily on contributions from the participatory foresight, and assessed using quantitative modelling, to compare the outcomes with the current long-term energy targets as part of the Energy Union. The scenarios should be seen as projections (what could happen under certain conditions), rather than forecasts (what one thinks will happen).
To meet this objective, the challenge for Cambridge Econometrics (CE) and REKK was threefold. First, to the extent possible, develop their models to better reflect the heterogeneity and complexity of decision-making processes, based on the research findings of the ENABLE.EU case studies. Second, to harmonise and link the models into a unique, comprehensive and dynamic modelling framework for the European Union, in order to be able to answer the main research questions of the project. Third, to translate the transition scenarios of participatory foresight into quantifiable policy scenarios and assess these policy scenarios using the modelling framework.

7.1 Developing a modelling framework for ENABLE.EU (D7.1 Working Paper)

Working paper D7.1 presents the suite of models that are being applied in the modelling framework and the planned developments to them as part of ENABLE.EU. In total, 6 different models are linked together for ENABLE.EU to cover the different energy services and activities being investigated in the project.

To model the impact of changing household decisions regarding energy services and activities on energy demand and its composition, the approach focuses in the first instance on modelling the take up of specific technologies in the various household sectors: mobility, heating & cooling, and prosumership (i.e. solar PV). The FTT: Transport model projects forward the deployment of electric vehicles (including hydrogen) versus conventional ICE vehicles, depending on government policies. The FTT: Heat model projects forward the deployment of renewable heating technologies versus heating technologies based on fossil fuels, depending on government policies. The Residential Prosumer Model projects forward the deployment of installed capacity on buildings in the EU, restricted by its technical potential and influenced by government policy.

The take up of solar PV, renewable heating technologies and electric vehicles by households leads to changes in energy demand, a reduction in greenhouse gas emissions and changes in consumer spending. The impacts from these changes on the wider economy are analysed for all EU Member States by linking the results from the technology diffusion models with Cambridge Econometrics' macroeconomic model E3ME. E3ME is a global, macro-econometric model with a high level of disaggregation, enabling detailed analysis of sectoral and country-level effects from a wide range of scenarios. E3ME is defined at Member State level and extends the economic analysis to include physical environmental impacts (energy consumption, emissions and material consumption).

The changes in energy consumption resulting from the diffusion of advanced technologies and their associated economic impacts also affect the energy system and the power sector in particular. The impact on the EU's electricity and gas markets are modelled using REKK's dispatch models - the European

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Electricity Market Model (EEMM) and European Gas Market Model (EEGM), covering the impact on prices, quantities, and emissions. Not only the change in the quantity of consumption but the pattern of consumption can have significant impacts on system operation and performance. Changes can take place in many directions: while energy-savings would reduce the overall energy consumption, electric mobility on the other hand would increase electricity consumption, with the possibility of even higher volatility in hourly consumption patterns.

In total, the modelling framework that has been developed for ENABLE.EU includes four technology diffusion models, one macroeconomic model and two dispatch models. When linked together, these models provide a unique modelling framework to assess many of the impacts changing household behaviour can have on the EU's economy and the environment in the future.

7.2 Designing and assessing the impact of changing household behaviour (D7.2 Report)

In total, 4 different scenarios were designed and assessed for the ENABLE.EU project. This includes a Prosumption Scenario, an Energy Consumption and Saving Scenario, a Sustainable Mobility Scenario and a combined ENABLE.EU – Sustainable Citizens Practice Scenario.

Analysis of the impacts in the scenarios requires comparison against what the outcomes would have been in the absence of intervention. This information is found in the **Baseline**, which describes a 'business as usual' situation and reflects conservative projections for key indicators (demographic indicators, labour productivity and GDP growth, energy consumption and emissions, trade, etc.) from which change and impacts can be assessed. The other scenarios reflect alternative futures for the EU towards 2050 if ambitious policies are implemented by all EU Member States. The **Prosumption Scenario** simulates an ambitious democratisation of electricity production for household consumption, driven by an ambitious deployment of rooftop solar PV across the EU. Solar PV is deployed across the EU close to its full technical potential. The **Energy Consumption and Saving Scenario** simulate a future in which there are zero local emissions from heating and cooling by 2050. The **Sustainable Mobility Scenario** simulates a future in which there is a reduced use of passenger vehicles and a transition towards e-Mobility, enough to reduce Greenhouse Gas emissions from the road transport sector by 80%. Where technically feasible, the policy packages for the scenarios were informed by the recommendations from THE Participatory Foresight.

The **ENABLE.EU – Sustainable Citizens Practice Scenario (SCP)** combines the Prosumption Scenario, Energy Consumption and Savings Scenario and the Sustainable Mobility Scenario into one overarching scenario that reflects a realistic contribution that households can make to the goals of the Energy Union. By combining the various sector-specific scenarios, the SCP Scenario brings together reinforcing and contrasting effects that may exist between the sector-specific scenarios and offers a fuller picture of impacts on the EU's economy from a transition within the household sectors. It should be noted that the transition in the household sectors was modelled in isolation; no assumptions were made around decarbonisation or energy efficiency in other sectors.

The contribution from households to the goals of the EU Energy Union

The 2030 Energy Union targets are to reduce greenhouse gas emissions by at least 40% (compared to 1990), increase the share of renewable energy to at least 32%, and achieve an energy efficiency improvement of at least 32.5% (compared to EU Reference Scenario 2007 baseline projections).
The results for the SCP Scenario show that while considerable reductions in GHG emissions can be made in the household sectors in case ambitious policy packages are implemented, these reductions by themselves

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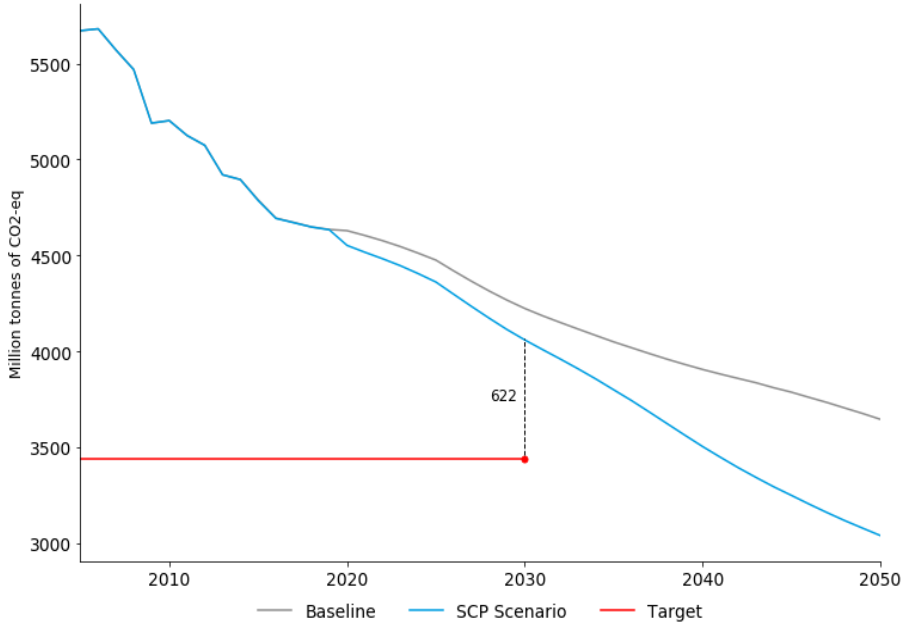
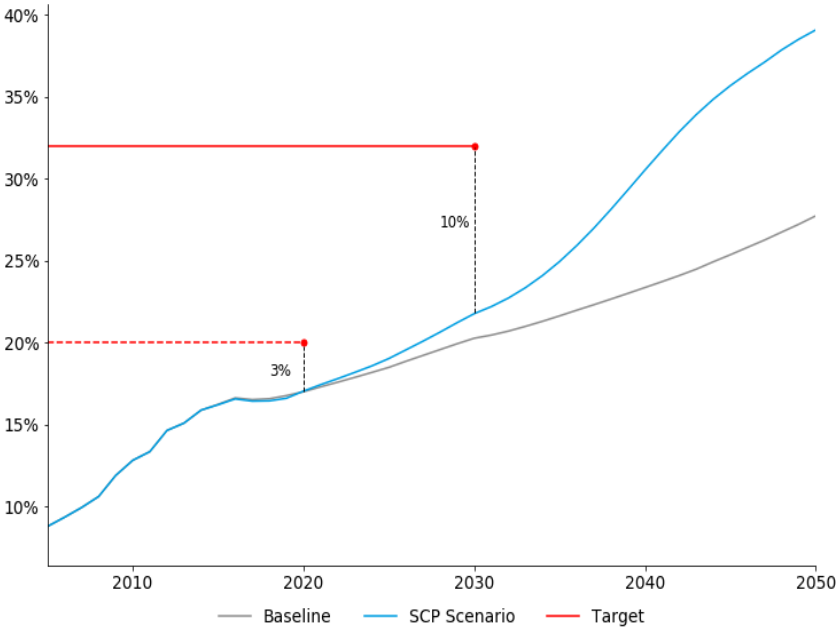
would not be sufficient to meet the EU 2030 target. Further action to reduce emission from the power sector, as well as other sectors of the economy, will be required in order to reduce greenhouse gas emissions to the desired level by 2030.

Figure 1: GHG emissions – EU28



The conclusions are similar for the household contribution to the EU 2030 target for the share of renewables in final energy consumption. The shift to more solar PV for household consumption plus increased electrification of the heating and road transport would lead to a higher share of RES in final energy consumption (compared to baseline). However, the scenario does not include any decarbonisation policies applied to the non-household sectors, which is where the largest contribution will need to come from.

Figure 2: Share of renewable energy in final energy consumption – EU28



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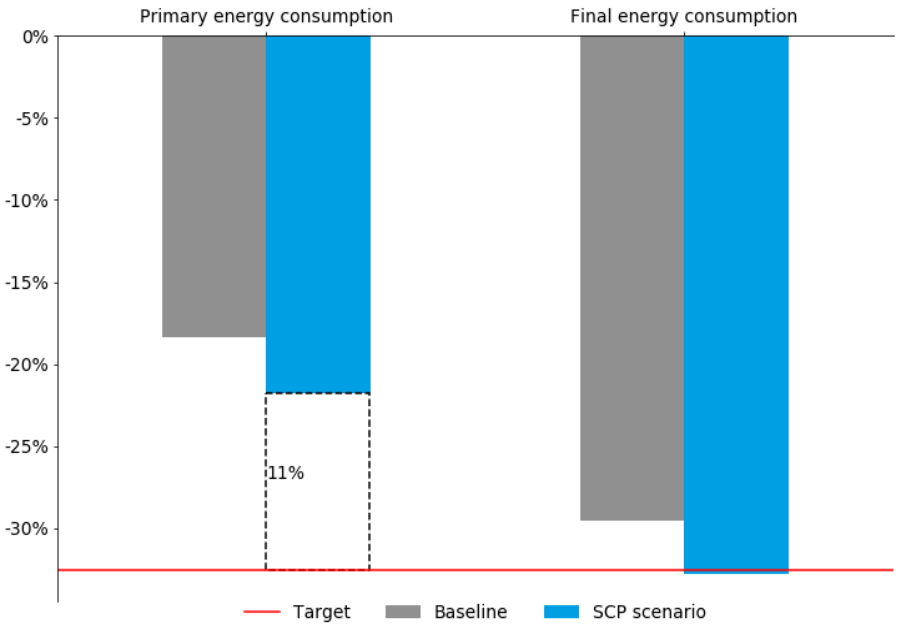
When assessed against primary energy consumption, the household's contribution fails to meet the target for energy efficiency due to the shortfall in efficiency improvement of primary energy consumption - a reduction of 22% in the SCP scenario. This is in line with expectations as the scenario does not include any efficiency measures or decarbonisation strategy which would reduce primary energy demand in the power sector.

However, when assessed against final energy consumption, household contributions narrowly exceed the target, reaching 33% energy efficiency compared to the EU Reference Scenario (2007) projections for 2030. This achievement is the result of taking up of e-mobility, more efficient heating technologies and ambitious energy efficiency measures at the level of households.

Figure 3: 2030 primary and final energy consumption – EU28



The economic impact of changing household energy choices

Overall, the EU economy is expected to benefit from the changes in household spending. The policy packages included in the SCP are designed to encourage purchases of renewable and fuel-efficient technologies while reducing consumption of fossil fuels, which are largely imported from outside the EU. The associated savings can be spent on domestic goods and services by households, generating a multiplier effect and employment along supply chains in the European economy. Assuming there is no change in government balances in the scenario as compared to the baseline, there is a net positive effect to GDP in the EU28 over the projected period due to the changes in household spending.

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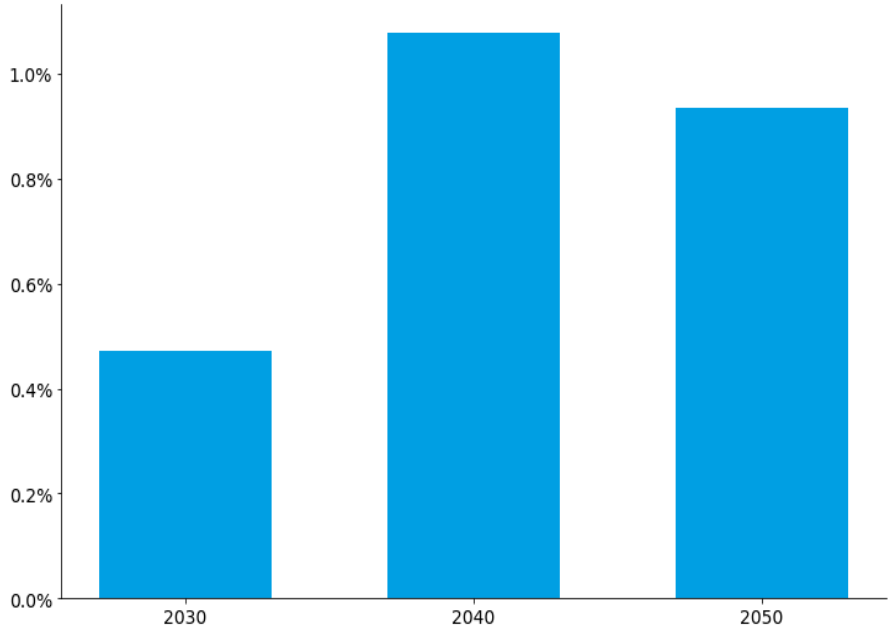
Figure 4: GDP relative to baseline – EU28



The impact of changing household energy choices on the power and natural gas sectors

In most of the analysed scenarios the introduced policies and measures lead to accelerated electrification. Consequently, total demand for electricity from the grid increases compared to baseline in all but one (Prosumer scenario) of the analysed scenarios. This means that significant emission reductions could only be achieved through the introduction of additional measures targeting the power sector. Nonetheless, changing household spending can still generate a reduction of around 10% in the CO_2 intensity of power generation in the SCP Scenario.

Wholesale electricity prices (on average in the EU) can also be decreased through the applied measures, but only slightly, by around 3% in the SCP scenario. Sizeable price differences can be observed among regions, with wholesale electricity prices in the Nordic region being the cheapest, and wholesale electricity prices in the Mediterranean countries being the most expensive.

Most household savings on gas expenditure can be achieved through the restriction of natural gas use in the heating sector. In the SCP scenario, almost 30% less is spent on natural gas by households. This is due to lower overall consumed levels of natural gas and resulting reductions in wholesale prices. This effect is most significant in countries with higher heat demand and larger present share of natural gas in the heating sector. The highest reduction is observable in the Central Eastern European region. However, this reduction in the procurement cost of natural gas is accompanied by the one-off installation of alternative technologies (e.g., heat pumps) and the increased electricity consumption for heating.

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Appendix 1. Bibliography of the deliverables

D2.1 Bibliography of relevant scientific articles and books on energy choices organised by relevance for each WP, available at: *http://www.enable-eu.com/wp-content/uploads/2017/03/ENABLE.EU_D2.1.pdf*

D2.2 Final comprehensive literature review setting the scene for the entire study, available at: *http://www.enable-eu.com/wp-content/uploads/2017/08/ENABLE.EU_D2.2.pdf*

D3.1 Final report on comparative sociological analysis of the business enterprises' survey results, available at: *http://www.enable-eu.com/wp-content/uploads/2018/10/ENABLE.EU_D3.1.pdf*

D3.2 *Report on the drivers of household adoption of energy-saving technologies using the English Housing Survey*, available at: *http://www.enable-eu.com/wp-content/uploads/2018/12/ENABLE.EU_D3.2.pdf*

D3.3 *Report on the impact of energy prices and other policies on energy-saving innovation and technology adoption in the manufacturing sector based on French company data*, available at: *http://www.enable-eu.com/wp-content/uploads/2018/12/ENABLE.EU_D3.3.pdf*

D3.4 *Report on economic factors impacting individual shortterm energy choices*, available at: *http://www.enable-eu.com/wp-content/uploads/2018/02/ENABLE.EU_D3.4.pdf*

D3.5 *Report on economic factors impacting individual long-term energy choices*, available at: *http://www.enable-eu.com/wp-content/uploads/2019/03/ENABLE.EU_D3.5.pdf*

D3.6 *Report on economic factors impacting collective/company energy choices*, available at: *http://www.enable-eu.com/wp-content/uploads/2019/03/ENABLE.EU_D3.6.pdf*

D4.1 Final report on comparative sociological analysis of the household survey results, available at: *http://www.enable-eu.com/wp-content/uploads/2018/02/ENABLE.EU-D4.1.pdf*

D4.2 Synthesis report on the "low carbon mobility" case study, available at: *http://www.enable-eu.com/wp-content/uploads/2018/10/ENABLE.EU-D4.2.pdf*

D4.3 Synthesis report on the "from consumer to prosumer" case study, available at: *http://www.enable-eu.com/wp-content/uploads/2018/10/ENABLE.EU-D4.3.pdf*

D4.4 Synthesis report on the "heating & cooling" case study, available at: *http://www.enable-eu.com/wp-content/uploads/2018/10/ENABLE.EU-D4.4.pdf*

D4.5 Policy paper with recommendations for "triple dividend" low carbon options in the field of heating and cooling, available at: *http://www.enable-eu.com/wp-content/uploads/2018/11/ENABLE.EU_D4.5.pdf*

D4.6 *Final report on social and cultural factors impacting energy choices and behaviour*, available at:

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http://www.enable-eu.com/wp-content/uploads/2019/03/ENABLE.EU_D4.6.pdf

D5.1 Report on governance barriers for the social acceptability of energy transition technologies and policies, available at: *http://www.enable-eu.com/wp-content/uploads/2018/02/ENABLE.EU_D5.1.pdf*

D5.2 Nine national case study reports on governance barriers to the energy transition, available at: http://www.enable-eu.com/wp-content/uploads/2018/10/ENABLE.EU-D5.2.zip

D5.3 Synthesis case study report with policy recommendations, available at: *http://www.enable-eu.com/wp-content/uploads/2018/11/ENABLE.EU_D5.3.pdf*

D5.4 *Report on national policies, strategies, practices and non-technical bottlenecks in low-carbon energy technology implementation, available at: http://www.enable-eu.com/wp-content/uploads/2018/12/ENABLE.EU_D5.4.pdf*

D6.1 Transition visioning workshop report, available at: *http://www.enable-eu.com/wp-content/uploads/2018/10/ENABLE.EU-D6.1.pdf*

D6.2 Transition Practice Backcasting Workshop Report, available at: *http://www.enable-eu.com/wp-content/uploads/2018/02/ENABLE.EU_D6.2.pdf*

D6.3 Transition Practice Framework Workshop Report, available at: *http://www.enable-eu.com/wp-content/uploads/2019/05/ENABLE.EU_D6.3.pdf*

D6.4 Participatory foresight evaluation report, available at: *http://www.enable-eu.com/wp-content/uploads/2019/06/ENABLE.EU_D6.4.pdf*

D7.1 A working paper detailing the model development, available at: *http://www.enable-eu.com/wp-content/uploads/2018/12/ENABLE.EU_D7.1.pdf*

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Appendix 2. List of deliverables

Appendix 2.1 Submitted deliverables

The deliverables have a written form of reports and policy papers. As of 27 June 2019, they cover over 1.700 pages, and are presented in the Table 9 below. All deliverables are available at the project website: http://www.enable-eu.com/downloads-and-deliverables/ and listed in Annex 2 at the end of this Synthesis Report.

WP N°	Del. N°	Deliverable name	Month of completion	N° of pages
1	*D1.1*	*Internal project management tool: software tool for sharing with partners and archiving documents and reports online*	*February 2017*	-
	D1.2	*Data management Plan*	*November 2017*	-
	D1.3	*Project Management Plan*	*January 2017*	-
2	*D2.1*	*Comprehensive bibliography of relevant scientific articles and books on energy choices organised by relevance for each WP*	*February 2017*	*62*
	D2.2	*Final comprehensive literature review setting the scene for the entire study*	*July 2017*	*125*
3	*D3.1*	*Final report on comparative sociological analysis of the business enterprises' survey results*	*July 2018*	*93*
	D3.2	*Report on the drivers of household adoption of energy-saving technologies using the English Housing Survey*	*December 2018*	*24*
	D3.3	*Report on the impact of energy prices and other policies on energy-saving innovation and technology adoption in the manufacturing sector based on French company data*	*December 2018*	*53*
	D3.4	*Report on economic factors impacting individual short-term energy choices*	*April 2019*	*90*
	D3.5	*Report on economic factors impacting individual long-term energy choices*	*February 2019*	*45*

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	D3.6	*Report on economic factors impacting collective/company energy choices*	*February 2019*	*89*
4	*D4.1*	*Final report on comparative sociological analysis of the household survey results*	*March 2018*	*71*
	D4.2	*Synthesis report on the "low carbon mobility" case study*	*September 2018*	*106*
	D4.3	*Synthesis report on the "from consumer to prosumer" case study*	*September 2018*	*66*
	D4.4	*Synthesis report on the "heating & cooling" case study*	*September 2018*	*81*
	D4.5	*Policy paper with recommendations for "triple dividend" low carbon options in the field of heating and cooling*	*October 2018*	*26*
	D4.6	*Final report on social and cultural factors impacting energy choices and behaviour*	*February 2019*	*76*
5	*D5.1*	*Report on governance barriers for the social acceptability of energy transition technologies and policies*	*April 2017*	*37*
	D5.2	*Nine national case study reports on governance barriers to the energy transition*	*September 2018*	*FR (38); BLG (31); GER (29); HUN (51); NO (48); PL (26); SER (34); UK (37); UKR (52).*
	D5.3	*Synthesis case study report with policy recommendations*	*October 2018*	*52*
	D5.4	*Report on national policies, strategies, practices and non-technical bottlenecks in low carbon energy technology implementation*	*December 2018*	*32*
6	*D6.1*	*Transition visioning workshop report*	*August 2018*	*64*
	D6.2	*Transitions practice backcasting workshops' reports*	*December 2018*	*38*
	D6.3	*Transition practice framework workshop report*	*March 2019*	*40*

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	D6.4	*Participatory foresight evaluation report*	*May 2019*	*35*
7	*D7.1*	*A working paper detailing the model development*	*October 2018*	*52*
8	*D8.1*	*Dissemination and Communication Plan*	*February 2017*	*-*
	D8.2	*Communication material produced (corporate identity, leaflet, poster)*	*March 2017*	*-*
	D8.3	*ENABLE.EU website*	*March 2017*	*-*
	D8.4	*ENABLE.EU e-bulletin*	*May 2017*	*-*
	D9.2	*H - Requirement No. 1*	*November 2017*	*-*

Table 9. Project deliverables as of 27 June 2019.

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Appendix 2.2 Expected deliverables

The three unpublished deliverables of ENABLE.EU project as of 27 June 2019 are presented below:

WP N°	***Del. N°***	***Deliverable name***	***Month of planned completion***	***Leader***
7	*D7.2*	*Working paper describing the scenarios and the implications of the scenarios for the Energy Union*	*June 2019*	*CE*
8	*D8.5*	*Written synthesis of ENABLE.EU's findings*	*June 2019*	*PISM*
	D8.6	*Written formulation of policy proposals*	*August 2019*	*JDI*

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