Building consensus for a citizen-driven Energy Union: understanding energy choice dynamics and their impact on energy governance in the EU

Report No ECHOES 7.1 – D7.1 Knowledge Consolidation

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ABSTRACT

This Deliverable elaborates a consolidated scientific knowledge base stemming from the correlation of the main findings obtained throughout the ECHOES project with the existing literature in order to advance consensus on the key factors and relationships driving (or meaningfully influencing) specific energy choices and related behavioural patterns illustrative of particular energy lifestyles, for three different levels of decision-making (micro-, meso-, and macro-) within a specific technological domain (smart energy technology, electric mobility, or buildings) identified in the ECHOES project. This report distils the conclusions from the consensus achieved on the soundness of the results obtained, the expected influence/impact on actual (energy) behaviour, the relevance to practice and decision-making, and the required changes on energy governance at national and European levels. The resulting knowledge base distilled form this process is then embedded into the wider volume of research conducted outside the scope of the project.

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EXTENDED SUMMARY

ECHOES (Energy CHOices supporting the Energy union and the Set-plan) aims to address the knowledge gap resulting from insufficient data and the inconsistency of existing research on the individual and collective energy-related memories, cultures and lifestyles, the resulting social changes and levels of acceptance/engagement, the political feasibility, and the institutional aspects to be considered in order to facilitate and catalyse a more holistic and multidisciplinary understanding of the main driving factors influencing particular energy-related choices and behaviour, and by extension the level of acceptance and engagement of individual citizens and communities in the low-carbon energy transition in Europe.

To that end, the overarching goal of Work Package 7 (WP7) is to harness the scientifically-grounded knowledge obtained in the ECHOES project with respect to energy-related choices and behaviour; and to advance a set of policy-prescriptive recommendations and strategies tackling individuals' acceptance, engagement, and complicity with energy policy measures and instruments advancing the Energy Union and SET-Plan.

The research conducted throughout the duration of the ECHOES project has benefited from a key conceptual approach which consists on the adoption of the theoretical concepts of 1) energy culture, 2) energy memories (a new development in the ECHOES project), 3) energy lifestyle and 4) group processes and place attachment. Combined, these theoretical concepts aided in structuring the relationship between culture, social practice, social structures, and energy choices according to the historical embeddedness of energy decisions with respect to the ECHOES technological focus areas: electric mobility, smart energy technology and buildings.

From a practical standpoint, these conceptual tools have been developed in line with the progressive development of the project itself and were utilised, on the one hand side, as "conceptual resources" to aid in the design and implementation of the various different methodological tools employed for data collection and analysis throughout the execution of various different deliverables, while simultaneously better elaborate a coherent and more comprehensive interpretation of results, as well as the potential policy impacts stemming from them.

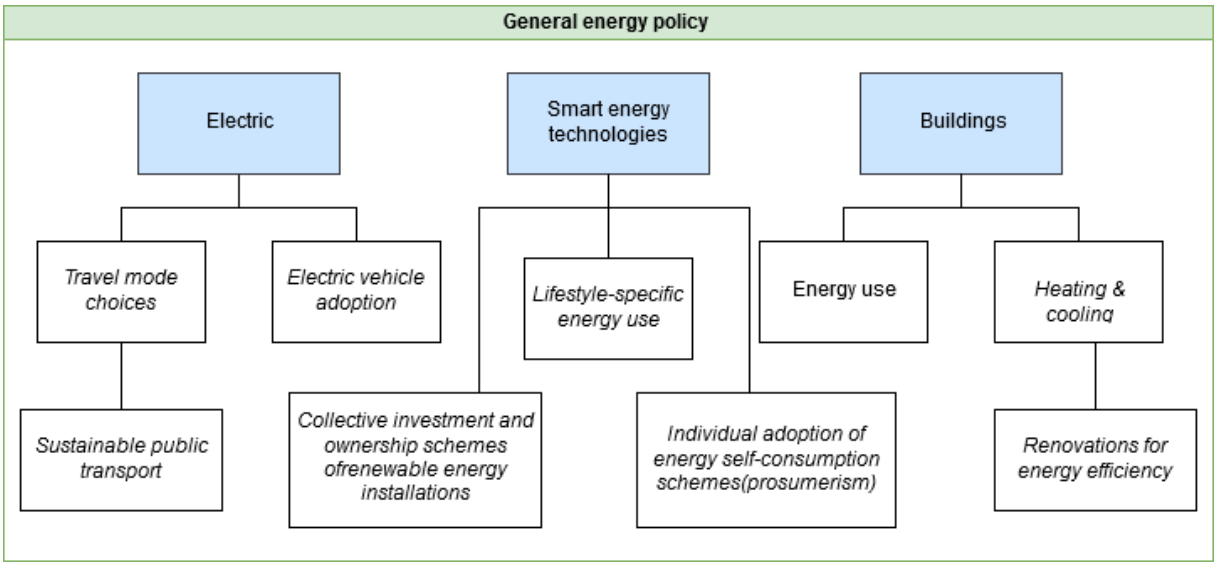
The combined use of these key concepts serves to illustrate a more dynamic, permeable, and rounded model of individual and group energy choices, uses and behaviours that differs substantially from the stricter model of techno-economic rationality derived from market dynamics largely determined by available supply and demand forcings, and price formation mechanisms. For instance, by incorporating market exogenous key determinants related to the cultural heritage and socio-spatial embeddedness of energy collectives, the project employs a more nuanced, dynamic, and representative socio-cultural approach enriching the more traditional techno-economic approach to energy choice, use and behaviour.

These concepts place the individual and collectives decision-making units tackled by ECHOES into a cultural and historical context and tap into explanations of energy use behaviour that go unnoticed by the individual or societal approaches. But most importantly, understanding the relational ties between these theoretical concepts serves to obtain a broader and systemic, yet more refined and structured understanding, of the influence that past/historical (and inherited) socio-cultural dynamics, geographical location (and distribution), material and economic paradigms, and technological developments have on our manifested energy-related decisions, choices, consumption patterns and habits, and lifestyles. Understanding the causal relationships that these inherited societal traits have with every-day individual and collective energy behaviours results in the agency necessary to advance a better tailored, more targeted, purposeful, predictable and timely sustainable energy transition.

The multidisciplinary of the scientific teams conforming the ECHOES project consortium has provided the space necessary to incorporate a set of different – yet complementary – data collection methodologies involving both qualitative and quantitate tools which have included, but are not limited to: literature and policy reviews, meta-analyses, case studies, interviews and focus groups, psychological studies (experiments and correlational surveys), a netnography study, and an international survey and choice experiment conducted across 31 European countries.

In fact, the elaboration of the international survey has been a major data collection endeavour for ECHOES, and has proven a key element for conducting a pan-European analysis on individuals' energy related behaviours, attitudes and choices covering six main areas of life: Housing, Mobility, Diet, Consumption, Leisure, and Acquisition of Information. Importantly, one key element of the international survey was the design of a choice experiment utilised to identify respondents' levels of interest in participating in a collective investment scheme to finance different kinds of community-based renewable energy (CRE) installations. Responses were scrutinised and utilised to then investigate what specific set of investment attributes and related operational conditions, as well as governance models of CRE initiatives, drive citizen participation in collective investment schemes to finance localised forms of RE generation.

As a starting point to operationalise WP7, this report summarises the critical knowledge gaps identified from earlier scientific work. It then provides a synthesis of the main findings and results obtained throughout the ECHOES project lifetime that either fully or partly address the knowledge gaps summarised previously. These have been organised following the three main technological foci of the ECHOES project, that is: smart energy technologies, electric mobility, and energy-efficient buildings. Specific sub-themes under each encompassing technological focus have been further developed in order to advance a more specific and refined analysis, and categorised as follows:



Such a categorisation has in turn facilitated a more schematically-structured overview of the critical elements that the project has (fully or partially) addressed in order to advance a more multidisciplinary understanding of the main knowledge-related challenges limiting our understanding of the various different socio-political intricacies either preventing or advancing Europe's transition towards a carbon-neutral energy paradigm.

ECHOES addresses the challenges related to each focal area by employing the innovative theoretical concept of "energy collectives" which covers determinants of energy choices from the perspective of (1) individual decision-making as part of collectives (micro), (2) collectives constituting energy cultures and life-styles (meso), and (3) formal social units (macro). As a general conclusive remark, the existing knowledge reveals the existence of

fragmented and disciplinary-isolated analyses of particular factors influencing energy related decision-making within a specific level (micro-, meso- *or* macro-) with a specific technological domain (smart energy technology, electric mobility, *or* buildings). Consequently, it remains unclear if differences between, for instance, individual barriers/levers are substantial and common to all technological foci or rather circumstantial due, for instance, to studies that advocate for a particular effect/influence selecting only one of the three technology foci. It is for example likely that a certain emotional reaction resulting from a mismatch between an individual's own behaviour and his/her social norms (e.g. a feeling of guilt or shame, or pride) is not specific to the building focus, but will instead play a significant role in the other two technological foci.

The abovementioned example serves to illustrate a major shortcoming of the existing literature and current state of scientific knowledge, from the absence of disciplinarily-comprehensive and integrated analyses employing a multilevel perspective whereby the different social units/energy collectives are collectively addressed to identify both the unit-specific and common/shared overarching factors influencing energy-related choices, along with the decision-making processes underpinning such choices, for each technological focus included in ECHOES. As such, the relevant research identified is not conducive to confidently predict decisions in a satisfactory way, nor does it allow to derive integrated policy or market recommendations. This is an important conclusive insight that has opened up an opportunity gap for ECHOES to advance a more holistic and comprehensive multilevel approach for uncovering the relational ties between unit-specific factors and energy related-choices and behaviours in relation with the focal areas of smart energy technology, eco-mobility, and buildings.

Furthermore, there are generalised tendencies – common to all technology domains – shaping the way through which European citizens are positioned and integrated into a transitionary period of transformation of national energy systems. Such tendencies are common to all technology domains analysed under ECHOES, and point towards a change in the view and understanding of the renewed role ascribed to European citizens acting as *energy consumers* co-driving and co-shaping a gradual transition towards an energy paradigm based on net carbon emissions.

For the three main technological foci included in ECHOES, some of the main findings obtained throughout the project's lifetime include:

Electric mobility

Sustainable public transport & Travel mode choices

- Public transport is the preferred mobility option for work-related travelling for people with access to it. In such cases, private transport alternatives are rarely used, except for high energy consumers (they prefer private transport options). There is a heavier use of individual cars leisure mobility regardless of energy consumption profiles.
- Time, convenience and comfort, and health-related considerations play a more prominent role than energy savings in influencing individuals' travel mode choices.
- Irrespective of payment vehicle increasing the price per trips/tickets or taxes both decrease the willingness to accept upgrading the public transport system towards a more environmentally-friendly one.
- Higher satisfaction with the current transport system lead to increased willingness to pay for more expensive ticket/trip or higher taxes to upgrade public transport system.
- Perceptions of the sustainability of the public transport system decrease the willingness to pay for environmental upgrades.
- The higher the use, the higher the willingness to pay for a more expensive ticket/trip but the lower the willingness to pay higher taxes as a means to upgrade the current transport system to a more environmentally friendly version.

Electric vehicle adoption

- Costs are the most influencing factor for EV adoption, followed by income, financial incentives, convenience and maintenance, household size, and bus lane access; environmental considerations are a weak influencing factor. Lack of technology awareness, misperceptions on high EV prices, and insufficient charging points are significant deterrents.

- EV owners are very active in networking: sharing experiences, building a peer-community, and maintaining dialogue with companies, municipalities, and authorities.
- Individual environmental & place-related identities directly predict the intention to use an electric bicycle mediated via personal and social norms.
- Municipalities incorporating EV sharing pilot services view it as a success and an important tool to meet climate targets.
- Small businesses have important reservations about the effectiveness of municipalities' pilots and are not overly enthusiastic to transition to e-mobility.
- EVs may substantially alter lifestyles due to changes in commuting and preferred choice patterns. They may also eventually alter the existing infrastructure due to different energy needs and how these need to be met.
- There are identified risks challenging the introduction of EVs into urban transportation hubs due to public rejection and lack of public trust.

Buildings

Renovations for energy efficiency (i.e. retrofits); heating & cooling

- Collective action for building retrofits can be an effective solution for housing communities due to acknowledged impact of measures, available national/EU financing schemes, the commitment of public authorities in training, information distribution, and mediation.
- In countries with high energy poverty, adequacy of energy assistance programs is questioned along with lack of transparency and citizen control over the energy system.
- The 'preferred temperatures' concept is an important factor influencing heating/cooling-related decisions. There are significant differences across countries, regions, and income groups. Facets of the heating and cooling temperature choices include cultural, economic, demographic, and environmental factors.

Energy use

- Situational influences on energy consumption include weather conditions, square footage and construction year of one's home, household size, energy prices, income, and automatization.
- Situational influences on energy-related investment intentions and behaviors include income, monetary costs, household size, square footage of one's home, and policy interventions such as subsidies and regulation.
- Situational influences on preferences for green electricity include income, monetary costs, and household size.
- When properly employed, analyses utilising the 'energy memories' conceptual resource can aid in the understanding of how the temporal evolution of resource-efficient and resilient settlements can unfold due to the historical evolution of past energy consumption patterns, cultures, habits, behaviours and attitudes.

Smart energy technologies

Data availability for smart energy technology

- The lack of a commonly used understanding of 'smart energy technology' could be partly overcome with the development of an up-to-date multidisciplinary & multifocal public database.
- Data privacy is a critical factor influencing energy choices. Ease of use and access to technology is also as decisive a factor in driving energy related choices within all three decision-making levels.

Information provision on energy demand behaviour

- The smart meter rollout strategy in Europe has not had the expected success due to low acceptance at the household (micro) level. Few efforts exist to provide end-use energy consumers with consistent and reliable information on their energy use behaviours and consumption patterns.

- Prolonged education-provision policies and awareness-raising campaigns will be needed in order to expedite the technology learning curves of end-users – particularly in younger generations and first-time users.
- Addressing the element of awareness on consequences related to climate change must complement economic motivations for driving user changes.
- A smooth and fast rollout of smart meter technology requires a) more attention to personal norms/habits and social identification, b) a customer segmentation to identify and develop policies targeting energy lifestyles/cultures/memories; and c) identifying impact factors that inform "decision making" frameworks.

Lifestyle-specific energy use

- Factors such as attitudes or values came out as not always relevant predictors of general energy behaviour patterns under some conditions. Therefore, in addition to these general factors, other psychological variables (e.g., identity processes, emotions), or structural factors should be taken into account as proxy variables for predicting behaviour.
- Mobility is the main behavioural factor for distinguishing between high- and low-energy lifestyles. It is the most energy intensive behavioural domain in 6 different countries.

Choice & awareness of low-carbon electricity purchase options

- There is high heterogeneity between countries regarding different low-carbon electricity purchase options, and availability of information about the source of electricity available for purchase.
- Choices on low-carbon electricity purchase options are not solely individual choices, but a result of different of factors including national energy portfolios, market dynamics, and cultural factors. These vary greatly between countries.
- Austere and resource-efficient behaviours influence individuals' energy-saving choices, affecting consumption profiles. People's self-perception of austerity and resource-efficiency influences the way they describe their own energy lifestyles.
- Economic savings are a prime motivator for energy-related actions, although less attention is payed to the energy bill than to other expenses.
- Increased comfort is considered as important as economic savings, while sustainability values are not a motivating factor for resource-efficient behaviours and consumption habits.

Individual adoption of energy self-consumption schemes (prosumerism)

- Individual environmental and place-related identities directly predict intention to use energy more sustainably. This effect is mediated by personal and social norms.
- Positive feedback is a key element for engaging in the energy transition. This is obtained from family, friends, neighbours, etc. and can be part of the regional identity.
- Some national governments increase the fixed costs of electricity bills reacting to decreased overall volumes of consumed energy due to increase in share of prosumers. Increasing volumes of RE consumption will further modify the cost structures of electricity bills, opening up business opportunities to lower the power contracted and level out consumption peaks.
- Micro-finance and the participation of local authorities as co-investors will be key elements for incentivising the production of CRE.

Collective investment and ownership schemes of renewable energy installations

- There is high interest of citizens to invest in CRE when it consists of a 20-year investment on a visible wind energy cooperative. Stakeholders with strong environmental motivations, financial incentives, and social support systems are enabling factors driving the development of collective RE initiatives.
- Barriers preventing collective RE initiatives include: lack of environmental concerns, weak sense of community, complex legislation & regulatory uncertainty, bureaucratic burdens, weak market signals, and technical challenges of the power grid. This results in eroded trust and reduced social acceptance on end-use consumers, and reduced investor confidence.
- Collaborative approaches between municipalities & communities are effective in promoting CRE. This must be supported by targeted information-provision and training services that facilitate intellectual ownership. This may trigger better-tailored regulatory frameworks and administrative requirements.

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1. INTRODUCTION

The overarching goal of Work Package 7 (WP7) is to harness the scientifically-grounded knowledge obtained in the ECHOES project with respect to energy-related choices and behaviour; and to advance a set of policy-prescriptive recommendations and strategies tackling individuals' acceptance, engagement, and complicity with energy policy measures and instruments advancing the Energy Union and SET-Plan. In order to do so, WP7 consolidates and integrates the results obtained from all foregone WPs, and aims to establish a consensus amongst scientists, civil society, and policy makers on the most crucial and decisive driving factors meaningfully influencing the energy choices and related behaviour of individuals and collectives in the context of a low-carbon energy transition in Europe.

WP7 will result in the realisation of three main deliverables summarising the knowledge gaps identified from earlier scientific work and synthesizing the main findings and knowledge obtained throughout the project (D7.1); estimating the potential impact of the main driving factors along with their policy implications and potential (D7.2), and evaluating the relevance of the project's scientific outcome for energy stakeholders playing a relevant role in the energy transition (market actors, regulatory bodies, environmental agencies, policy makers, etc.) as well as its potential and utility for impact-maximising policy making (D7.3).

1.1 Overview of the ECHOES project

The aim of ECHOES (Energy CHOices supporting the Energy union and the Set-plan) is to address the knowledge gap resulting from insufficient data and inconsistency of existing research on the individual and collective energy-related behaviours, cultures and lifestyles, the resulting social changes and levels of acceptance/engagement, the political feasibility, and the institutional aspects to be considered in order to facilitate and catalyse a more holistic and multidisciplinary understanding of the main driving factors influencing particular energy related choices and behaviour, and by extension the level of acceptance and engagement of individual citizens and communities in the low-carbon energy transition in Europe.

Therefore, the overarching objective of ECHOES is to unlock the policy potential of an integrated social science perspective bound by central socio-cultural, socio-economic, socio-political, and gender issues that influence individual and collective energy choices and social acceptance of the energy transition in Europe. In doing so, ECHOES fosters the implementation of the European Strategic Energy Technology Plan (SET-Plan[1]) and advances the low-carbon energy transition through the decarbonisation of the EU's future energy system.

Central to all research activities in ECHOES are the technological foci of a) smart energy technologies, b) electric mobility, and c) buildings. ECHOES addresses the challenges related to each focal area by employing the innovative theoretical concept of "energy collectives" which covers determinants of energy choices from the perspective of (1) individual decision-making as part of collectives (micro), (2) collectives constituting energy cultures and life-styles (meso), and (3) formal social units (macro).

Smart energy technologies are at the core of an integrated roadmap towards realizing an energy revolution as exposed by the SET-Plan.[2] This includes geographically distributed, modular, small-scale renewable energy generation technologies (typically rooftop photovoltaic (PV), solar thermal and micro wind/hydro, heat pumps and bioenergy), in addition to a range of "demand side" technologies (e.g. in-home displays, home automation, smart

[1] see http://ec.europa.eu/energy/en/topics/technology-and-innovation/strategic-energy-technology-plan

[2] see https://ec.europa.eu/energy/sites/ener/files/documents/set-plan_progress_2016.pdf

home appliances, smart meters and control systems, etc.) and energy storage. The combined implementation and integrated coordination of smart energy technologogies on these two fronts (the 'production' side and the 'demand' side), offer incredible potential for streamlining use efficiency, sufficiency, and reliability of supply. However, important challenges remain regarding the integration of smart energy technologies into existing energy lifestyles and related energy consumption habits and decisions, making their appropriation a matter of societal acceptance and system interaction that merits a deeper and more nuanced analysis to then elaborate a more informed approach for developing targetted policy measures adressing those particular challenges.

The SET-Plan identifies *electric mobility* as one of the core technologies to be implemented and further developed to enhance road transport sustainability, as both passenger and goods transportation account for a substantial amount of the environmental impact of EU Member States (Hertwich & Peters, 2009). Electric mobility, however, goes beyond its more 'logic' function of reducing transport-related carbon emissions, and further adopts a role as a demand and grid flexibility device/instrument. In this sense, electric vehicles are foreseen to endow electricity grids with enhanced flexibility for successfully adapting to the increased penetration of clean, yet variable and intermittent, smart energy generation technologies, and thereby ensuring reliability of supply and avoiding system failure.

The last technology focus, *buildings*, include construction activities, insulation, energy efficiency upgrading, heating, cooling, illuminating, and energy use behaviour in closed spaces. An efficient use of the territory resulting in compact urban structures, was outlined among the four main aspects of key importance for urban sustainability (Leipzig Charter on European Sustainable Cities, 2009). Furthermore, the significant reduction of energy demand from buildings infrastructure is a prerequisite for meeting Europe's GHG emissions reduction targets, with the end goal of having Nearly Zero-Energy Buildings (NZEBs) by 2020.

1.2 Aim and scope of the knowledge consolidation report

As a fundamental component of WP7, Deliverable 7.1 results in the elaboration of a consolidated scientific knowledge base stemming from the correlation of the main findings obtained throughout the ECHOES project with the existing literature in order to advance consensus on the key factors and relationships driving (or meaningfully influencing) specific energy choices and related behavioural patterns illustrative of particular energy lifestyles, for three different levels of decision-making relating to the social units representative of the three main "energy collectives" identified in the ECHOES project. These are:

The reviews levels of perspective
• *MICRO-level*: Exploring the impact of groups as small-scale energy collectives that provide a social identity for individuals and that guide personal cognition, motivation, and behaviour by distinct group-processes (e.g., group norms, collective efficacy beliefs, collective action) in the context of individual or household decision-making. This perspective also includes how norms, values and emotions around energy choices in such smaller groups emerge and stabilize. • *MESO-level*: Cultures or lifestyles as constituents of medium-sized energy collectives (e.g. industries, companies, NGOs, and associations): a set of energy practices, cognitive norms, and material culture (e.g., technology, available financial resources) that jointly influence people's decisions about energy-related behaviour, but varying across different social contexts and roles (including gender). Introducing the concept of "energy memories" as a container of previous individual (micro-level) or collective energy choices and experiences.

- *MACRO-level*: Formal decision-making units acting as policymakers and/or energy providers, collective decision-making units, which are more formally structured that shape people's energy-related choices but are in turn also influenced by the decisions of the individual actors, and small groups of individuals.

For all three levels of perspective, an initial comprehensive review of the existing literature revealed a number of different knowledge gaps, representing a departure point informing the multi-perspective, multi-disciplinary analytical work during the early stages of the project. Specifically for each level of perspective, the identification of critical knowledge gaps was obtained through a comprehensive literature review tailored as follows:

At the MICRO-level

An individual centred approach was employed in order to uncover how commonly used concepts such as values, worldviews, personal and social norms, attitudes, habits and routines, emotions, objective and subjective constraints and facilitators interact to determine decisions in the three technology focal areas of ECHOES. The factors received good support by the literature review, though the concepts of emotion (most importantly guilt and pride) as a driver of energy and social identity/identification were found as missing

At the MESO-level

Focus was placed on the socio-cultural aspects influencing energy use and behaviour. The adoption and use of the novel conceptual tools of energy culture, energy lifestyles and energy memories forwarded allowed to construct an analytical lens that placed the decision-making units into a cultural and historical context and facilitated explanations of energy use behaviour that go unnoticed by the individual or societal focus.

At the MICRO-level

Efforts consisted on mapping the exogenous drivers and barriers influencing the adoption of each technology and for the three different formal units; that is, formal, collective, and individual decision-making units. This produced an interesting overview of which factors are particularly relevant for one specific decision-making level and/or technology, and which factors are of overarching importance.

By synthesising and consolidating the data collected and analysis conducted throughout the lifecycle of ECHOES (WPs 2-6), Deliverable 7.1 distils the conclusions from the consensus achieved on a) the soundness of the results obtained, b) the expected influence/impact on actual (energy) behaviour, c) the relevance to practice and decision-making, and d) the required changes on energy governance at national and European levels. The resulting knowledge base distilled form this process is then embedded into the wider volume of research conducted outside the scope of the project. By doing so, this knowledge consolidation report corroborates the commonalities – and identifies the contradictions – between different academic disciplines about the key driving factors and relationships that shape and meaningfully influence energy choices and related behaviour (energy lifestyles); and builds the consensus necessary between different lines of scientific knowledge on the project's most fundamental question, that is*:*

What specific (policy-relevant) techno-economic factors, incentives, socio-communal configurations, and institutionalised relationships drive or meaningfully influence energy-related choices, behaviour, and lifestyles; and how can these be harnessed to foster and accelerate Europe's low-carbon energy transition?

This consensus-building exercise serves as an important building-block for evaluating the relevance of the project's outcome to energy stakeholders (D7.2) and advancing a set of empirically-grounded and evidence-based policy-ready recommendations on how to best harness the scientifically-validated and consolidated knowledge obtained at the conclusion of the data gathering and analysis activities conducted throughout the project's lifecycle (D7.3),

thereby providing the ground work needed to then fully exploit the newly-obtained knowledge and maximise its policy relevance and impact.

1.3 Deliverable structure

This report is structured as follows:

- Chapter 1 starts with a general contextual background of the current legislative developments and policy commitments behind the EU's ongoing transition towards a carbon-neutral economy.
- Chapter 2 introduces some of the key conceptual tools utilised for the ECHOES project (energy memories, energy cultures, energy lifestyles, and place attachment), provides an overview of the main data collection and analysis tools/procedures utilised in the throughout WPs 2-7, and elaborates on one of the most significant tools utilised throughout EHOES; that is, the elaboration of an international survey conducted across 31 European countries.
- Chapter 3 provides an overview of previous research and existing knowledge on key the factors influencing energy choices and behaviour, structured according to the three distinctive technological domains (i.e. smart energy technology, electric mobility, and buildings) and under the three different decision-making levels (micro, meso, and macro) identified in the ECHOES project.
- Chapter 4 outlines the critical knowledge gaps identified after a comprehensive review of existing knowledge (ch.3) and pairs these with the main scientific findings of ECHOES addressing (in full or partly) the critical knowledge gaps identified.
- Chapter 5 reflects on the policy relevance of the main findings disclosed in ch.4, and makes the case for incorporating SSH-related knowledge as a key resource and critical tool aiding and informing policymakers. It concludes with an outline of suggested next steps.

2. CONCEPTUAL AND METHODOLOGICAL APPROACH

The research conducted throughout the duration of the ECHOES project benefited from a key conceptual approach which consisted on the adoption of the theoretical concepts of 1) energy culture, 2) energy memories (a new development in the ECHOES project), 3) energy lifestyle and 4) group processes and place attachment. Combined, these theoretical concepts aided in structuring the relationship between culture, social practice, social structures, and energy choices according to the historical embeddedness of energy decisions with respect to the ECHOES technological focus areas: electric mobility, smart energy technology and buildings.

From a practical standpoint, the conceptual tools outlined above were developed in line with the progressive development of the project itself and utilised as "conceptual resources" to aid in the design and implementation of the various different methodological tools employed for data collection and analysis throughout the execution of various different deliverables, while simultaneously better elaborate a coherent and more comprehensive interpretation of results, as well as the potential policy impacts stemming from them.

2.1 Key concepts: energy cultures, energy memories, energy lifestyles, and social identity and place attachment

The concept of *energy culture* (Stephenson et al., 2010) reflects the shared lifestyle-based behavioural patterns and resulting energy dynamics and consumption patterns characteristic of certain energy collectives conformed of individuals aggregated under similar energy choices, uses, consumption routines and habits. Unique combinations of different material cultures, cognitive norms, and energy practices will shape in different ways the processes through which new technologies are progressively introduced, accepted (or rejected), acquired, used and diffused across collectives and societies. Different adoption and acceptance rates of new energy technologies will in turn shape and influence the innovation trajectories and processes of technology development and implementation, along with their pace of adoption and penetration rates.

A constituting element enriching and further developing an individual's or community's energy culture comes from the novel concept of *energy memory.* This introduces a temporal and historical dimension reflecting the path of development up to the status-quo of both the technological and cultural aspects of national collectives. The addition of a temporal-historical dimension to the encompassing concept of energy culture (which is a concept that does not explicitly take the past into account) introduced above serves to close the chronological gap of more general and theoretical concepts like "collective memory" (Halbwachs, 1950). It provides the relevant knowledge from historical and empirical research reflecting the set of specific practices, beliefs and normative ideas that we inherit from past developments. Therefore, due to the significant role played by country-specific inherited and institutionalised cultural parameters and trajectories, energy-related specific behaviours inherit a temporal dimension, which the concept of *energy memory* aims to encapsulate and properly reflect.

The concept of *energy lifestyles* focuses on the energy-related consequences of the way people conduct their lives. As such, understanding the aggregated influence that habits, behaviours, norms and values have on the energy choice patterns and consumption profiles of different societal groups is highly relevant for addressing the energy-related impacts of the lifestyles representative of different societal groups.

Furthermore, people's place relationships may strongly dictate the opposition or support to renewable energy implementation that certain groups or communities may manifest when confronted with specific, tangible renewable energy developments. The concept of *place attachment* therefore addresses the bonding that occurs between individuals and their meaningful environments (Giuliani & Feldman, 2003; Low & Altman, 1992) in order to advance a more rounded understanding of the reasons behind public opposition to unwanted local renewable energy developments (e.g. the NIMBY effect). Specifically, place attachment is a complex phenomenon described as

"*positively experienced bonds, sometimes occurring without awareness, that are developed over time from the behavioural, affective and cognitive ties between individuals and/or groups and their socio-physical environment*" (Brown & Perkins, 1992, p 284). Its systematic addition into broader analyses of social acceptance to RE developments offers a potentially important variable that has not yet been investigated with respect to energy memories development. Its relevance is related to understanding public responses and place protective behaviours to local energy development proposals, and how have these been influence by the historic energy memories inherited by individuals and local communities.

Group processes, as outlined by Social Identity theory could also be a key factor to understand individual and collective energy choices. Recent theorizing and an emerging research literature (Fritsche et al., 2018) suggests in fact that social identity processes have been somewhat overlooked in earlier environmental psychology research. According to the social identity approach (Tajfel & Turner, 1979; Turner, Hogg, Oaks, Reicher & Wetherell, 1987), in many situations people perceive, think, feel, and act as representatives of collectives instead of their individual person. When people identify with a group, they see the world from the perspective of their ingroup and adopt collective beliefs and intentions as their own through a process of self-stereotyping (i.e., adopting the stereotype about one's own group as a description of the self; Hogg & Turner, 1987). This psychological process should be of high importance for motivating people's pro-environmental action and decisions. Within the ECHOES project we adopted a Social Identity Model of Pro-Environmental Action (SIMPEA; Fritsche et al., 2018; see also other ECHOES documents such as deliverables D4.1 and D4.2). The SIMPEA proposes that the degree to which people identify with groups and to which they consider these groups to be collectively efficacious and characterized by pro-environmental norms determines both their appraisals of and responses to environmental crises. Regarding pro-environmental responses, ingroup identification as such is assumed to foster people's sustainability efforts when they perceive green ingroup norms, which might be genuinely the case for environmental action groups but may also occur among groups who are not intrinsically associated with environmental action, such as city dwellers, occupational groups, or EU citizens.

The combined use of these key concepts serves to illustrate a more dynamic, permeable, and rounded model of individual and group energy choices, uses and behaviours that differs substantially from the stricter model of techno-economic rationality derived from market dynamics largely determined by available supply and demand forcings, and price formation mechanisms. By incorporating market exogenous key determinants related to the cultural heritage and socio-spatial embeddedness of energy collectives, the project employs a more nuanced, dynamic, and representative socio-cultural approach enriching the more traditional techno-economic approach to energy choice, use and behaviour.

Furthermore, these concepts place the decision-making units into a cultural and historical context and tap into explanations of energy use behaviour that go unnoticed by the individual or societal focus. But most importantly, understanding the relational ties between these theoretical concepts serves to obtain a broader and systemic, yet more refined and structured understanding, of the influence that past/historical (and inherited) socio-cultural dynamics, geographical location (and distribution), identification with different social groups, material and economic paradigms, and technological developments have on our manifested energy-related decisions, choices, consumption patterns and habits, and lifestyles. Understanding the causal relationships that these inherited societal traits have with every-day individual and collective energy behaviours results in the agency necessary to advance a better tailored, more targeted, purposeful, predictable and timely sustainable energy transition.

2.2 Methodological tools for data collection

This report does not delve exhaustively on the data collection 'architecture' employed throughout the lifetime of the ECHOES project, nor does it provide a comprehensive overview or complete documentation of the project's data collection activities. Such an effort is tackled in Deliverable 3.4. However, the main activities are summarized below.

A comprehensive literature review (Deliverable 3.1) – consisting of an initial screening of several thousand sources, followed by an in-depth review of 597 sources – was conducted as a means to map out the existing research on all three ECHOES "energy collectives" for every single technology focal area addressed in the project. This was a necessary pre-requisite allowing to identify current research gaps in the scientific literature, which served to orient and anchor the project's positioning within the broader body of scientific knowledge on applied behavioural social science within the energy domain. The in-depth review further served to guide and structure the methodological process and refine the data collection strategy (Deliverable 3.2) to more comprehensively address the ECHOES research questions and tackle the knowledge gaps identified.

In parallel to the literature review, two meta-analyses (Deliverable 4.1) were elaborated to identify the missing link between the major individual, social and environmental psychological factors, mechanisms and processes influencing and shaping people's actual and observed pro-environmental and energy-saving behaviours, at two different levels: a) individual level predictors such as attitudes, intentions, values, awareness, emotions; and b) group membership and related social identity processes such as social/environmental identity, connectedness to nature, and place-rated identity and attachment. In tandem with the qualitative literature review conducted previously, this 'quantitative' review provided by the meta-analytical exercise jointly advanced a robust knowledge base for guiding and further refining the design of the data collection methods and related knowledge-production processes implemented *a posteriori*.

Building on the literature review and meta-analyses, a review of key policy documents (Deliverable 3.3) was conducted at different levels of governance targeting EU, Member State, regional/provincial and local jurisdictions. The aim of this exercise was to *systematically* analyse how consumers are integrated into policy documents on different levels, which assumptions about the factors influencing their decision making are directly or indirectly reflected in the documents and which policy measures are directly referring to SSH knowledge. A brief analysis of an electricity company's strategy documents was included on top of the policy potential analysis in order to contrast policy documents with business strategies and learn if there are differences between public & private sectors in regards to their view, understanding, approach, and treatment of energy consumers in Europe.

Following from this exercise, a sociological exploration of the energy-related behaviour of consumers/prosumers (Deliverable 5.3) was conducted through a newly developed three-way approach on impact based energy lifestyle research consisting of (i) the shaping and performance of different "energy lifestyles" across Europe (Deliverable 5.1), (ii) innovation and transformation through grass roots organizations, and (iii) the impact of *energy memories* (Deliverable 5.2). This three-way approach was operationalized through the elaboration of case studies in six different European countries where a mixed-method data collection & analysis approach was applied. This approach consisted of a combination of quantitative (e.g. linear regression models) with qualitative tools (e.g. in-depth interviews and focus groups) facilitating a more nuanced capturing of information in regards with, for instance, body language, tone of voice and expressions, and giving respondents a chance to emphasize what they believe to be important (as there are fewer external constraints to their utterances).

This mixed-method approach allowed to comprehensively investigate the transformation of energy production & consumption patterns (as well as evaluate the role of innovation) by placing a strong focus on all energy- and climate-relevant behaviours conducted by individuals rather than by exclusively focusing on psychological variables or selected behaviours. As such, all factors (psychological, sociodemographic, cultural, infrastructural etc.) suspected to influence energy and climate relevant behaviour could be used as explanatory variables. This allowed a systematic assessment of the driving factors behind different forms of energy behaviour and thereby determining what specific factors could be directly accessed for effective policy interventions. Furthermore, these case studies also served to conduct an exhaustive enquiry about energy-related historic national key events, and evaluate their consequences in terms of drastically modifying or progressively shaping national energy cultures and thereby changing certain energy behaviours and lifestyles (Deliverable 5.2). In addition to this a netnography analysis on online communities and e-mobility was conducted (Deliverable 6.6).

Psychological studies within ECHOES (experimental and correlational surveys) also suggested that social norms and decision observability motivate people to be more supportive of renewable energy and might thus increase support for renewable energy, even at a financial cost to oneself. When exposed to pro-environmental social norms, and when having the perception that their actions are being monitored or are observable by others, people might decide to more systematically pursue renewable energy options and invest personal money to this purpose. Also, after taking these sustainable decisions, people might experience feelings of happiness and pride, might make energy policy interventions more easily accepted by the public at large. In a different set of studies (correlational) we also showed that people that are to a chronically strong pro-environmental and energy-sensitive working context and organizational culture, such as in the case of employees of an energy company in Italy, ecological behavior at the workplace and willingness to donate money for an organization that counteracts global climate change can be more systematically linked to factors such as job satisfaction, identification with the organization, environmental identity and collective self-efficacy. These factors, in turn, can be directly or indirectly linked to emotional processes feelings of guilt for not acting in an eco-friendly way, feelings of pride for acting in an eco-friendly way, collective pride and moral anger (Deliverable 4.2).

2.2.1 International survey

This was complemented by the elaboration of an international survey consisting of a comprehensive questionnaire on individuals' energy related behaviours, attitudes and choices covering six main areas of life (Housing, Mobility, Diet, Consumption, Leisure, and Acquisition of Information) and pairing them with their socio-demographic characteristics, economic and financial profiles, and energy and resource consumption and mobility patterns. Furthermore, the survey included measures relating to social identity and emotional drivers of energy decisions. This permitted to foster a more holistic understanding of how different societal groups conduct their everyday lives and how they make energy and climate relevant decisions in different areas of life. The survey was implemented across 31 European countries (EU-28, Norway, Turkey, and Switzerland) during a 4-month period, with about 600 respondents recruited in each country through a random sampling procedure, and a total sample of over 18,000 completed surveys.

2.2.1.1 Choice Experiment on collective investment schemes

One key element of the international survey was the design of a choice experiment utilised to identify respondents' levels of interest in participating in a collective investment scheme to finance different kinds of community-based renewable energy (CRE) installations. Responses were scrutinised and utilised to then investigate what specific set of investment attributes and related operational conditions, as well as governance models of CRE initiatives, drive citizen participation in collective investment schemes to finance localised forms of RE generation.

The Choice Experiment section of the survey presented respondents with eight different choice scenarios (see Figure 2.1 below for an example of a choice scenario). Each choice scenario consisted of three different options to choose from: two hypothetical investment opportunities (option A, option B), and a third "opt-out" option (option C) provided in the case where a respondent had no interest nor intention to invest in any of the investment opportunities being offered by options A or B. Respondents were asked to choose which of these three options they would prefer if confronted with the same situation in real life. Respondents were then sequentially shown each of the eight choice scenarios with the three choice options in each scenario (option A, B, or C), and were asked to choose their most preferred option. This resulted in 8 different choices per respondent, with a final sample totalling 144,000 data points obtained from the responses to the Choice Experiment. The order of the choice scenarios shown to respondents was randomized. Furthermore, in order to ensure a representative sample of the wider populations from all 31 countries, quotas were drawn from sociodemographic indicators pertaining to age, gender, and income levels.

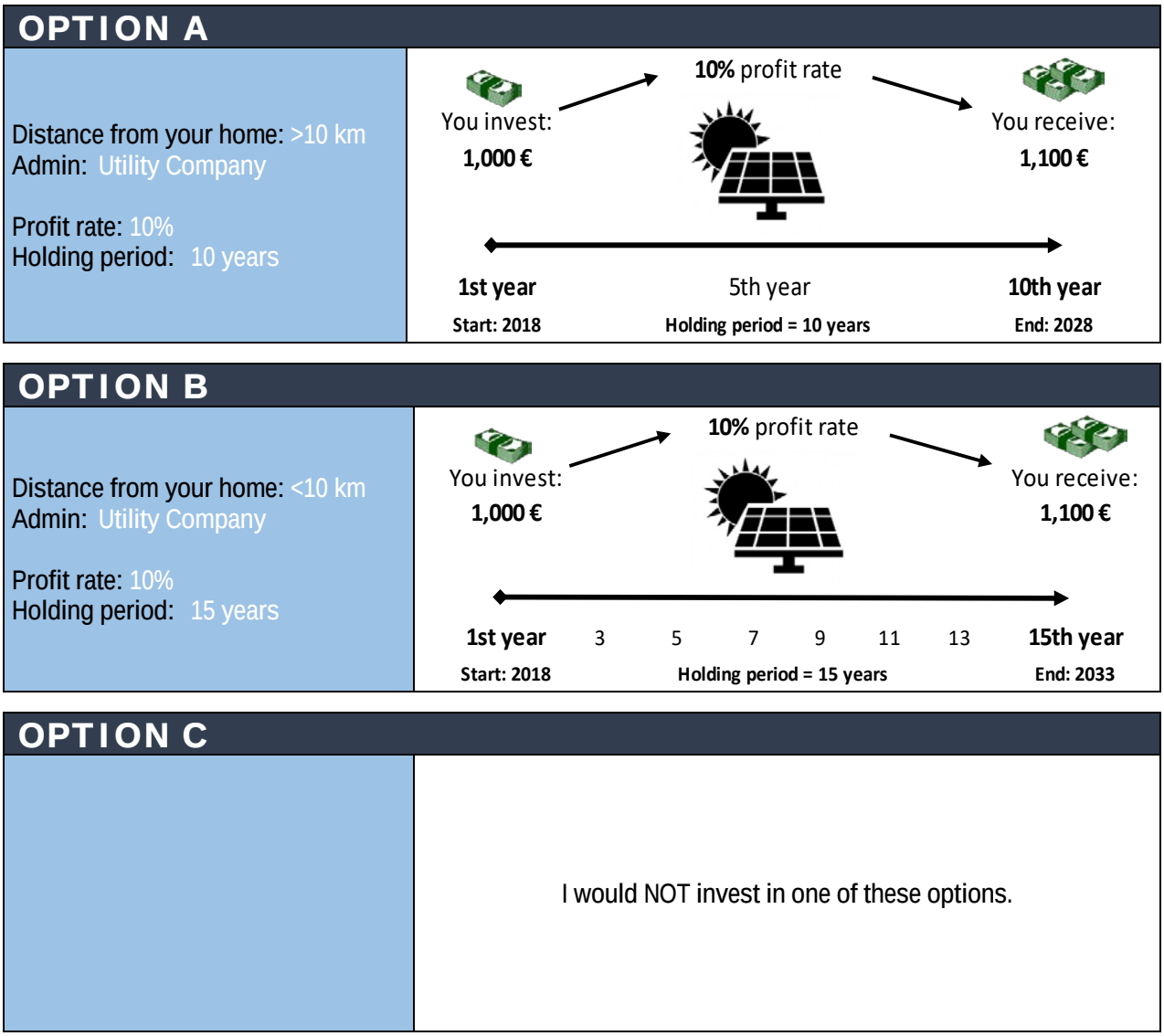


Figure 2.1. Example of choice scenario from the English version of the survey.

Responses were statistically analysed employing a probabilistic discrete choice model (the 'alternative-specific multinomial logit' model) in order to estimate the probability that the average representative individual survey respondent explicitly selects one particular option given the effects that different financial, operational, and governance variables included in the choice options had on the respondent's choice decision. In other words, the probabilistic discrete choice model was used to estimate the likelihood that any one specific option under any given scenario is explicitly selected instead of competing options under that same scenario, as well as the changes (increase or decrease) in that likelihood given any modifications in the design settings – that is, in the values of the different financial, operational, and governance variables presented to the respondent. Figure 2.2 below provides a schematic display of the CE design, along with the conceptual purpose of the 'alternative-specific multinomial logit' model as an analytical tool.

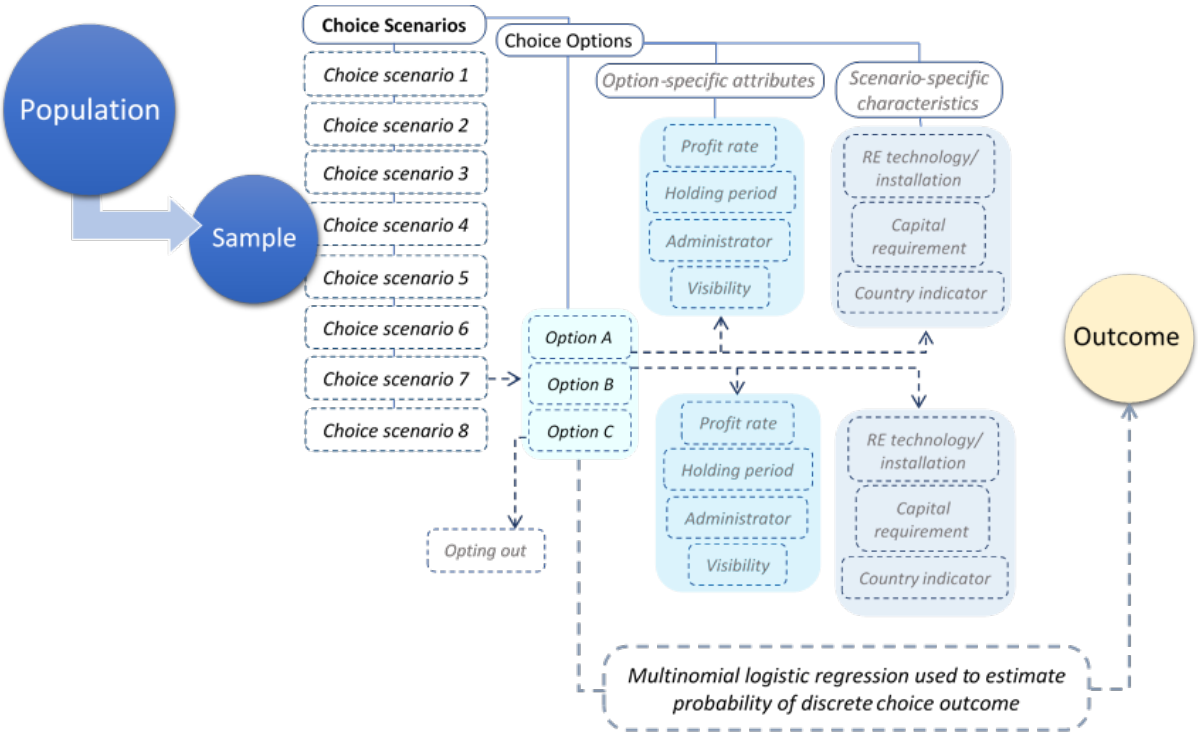


Figure 2.2. Schematic display of Choice Experiment design, including the conceptual purpose of the 'alternative specific multinomial logit' model as an analytical tool to estimate probability of choosing an investment option (Pons-Seres, 2019).

Once identified, the most preferred variables where then bundled together under an "optimal investment scenario". This allowed to increase the average representative respondent's willingness to invest in community-based RE generation schemes, and thereby to calculate the optimal capital requirement asked for that would lead to the maximum possible level of investment in community-based RE generation schemes by the average representative individual citizen in each country sampled. Individual results were aggregated at the country level in order to maximise the expected total investment for the EU-28. This is referred to as the country's *social potential* for collectively investing and participating in community-based RE generation schemes. For a more detailed explanation of the analytical procedure described above, please refer to Pons-Seres (2019).

2.2.1.2 Voluntary donations to support climate change mitigation

Participants were incentivized to complete the survey in two ways. The first is from the survey panel providers, who offer a small standardized base incentive. The value of the base incentive varies slightly between nations and panel providers but is generally around €0.5. In most cases, these base incentives are paid out as currency equivalent points, which can be saved or traded in for a variety of consumer products. The second incentive for this survey was provided by the ECHOES project, which offered an additional €5 to each respondent who completed the survey. This incentive was given to facilitate a large sample of data collected in a timely manner, and as a means of mitigating self-selection bias whereby only panelists interested in energy topics would agree to take the survey if only the base incentive is offered. This extra €5 incentive was also paid out via the survey panel points systems when participants elected to take the incentive.

The final question of the survey thanked respondents for their participation and then offered them the opportunity to donate some or all of their €5 extra incentive to carbonfund.org, a climate activism and carbon offset non-profit organization. Respondents could then choose to donate 1, 2, 3, 4, or 5 Euros (or equivalent national currency), or indicate they did not want to donate. While roughly 70% of respondents decided not to donate anything, the other 30% decided to donate: 15% of the full sample donated 1€, roughly 8% opted for a maximum 5€ donation. We use this donation question to estimate the respondents' revealed preference to pay for GHG mitigation at the time they took the survey, with payment values censored at €5, the upper bound.

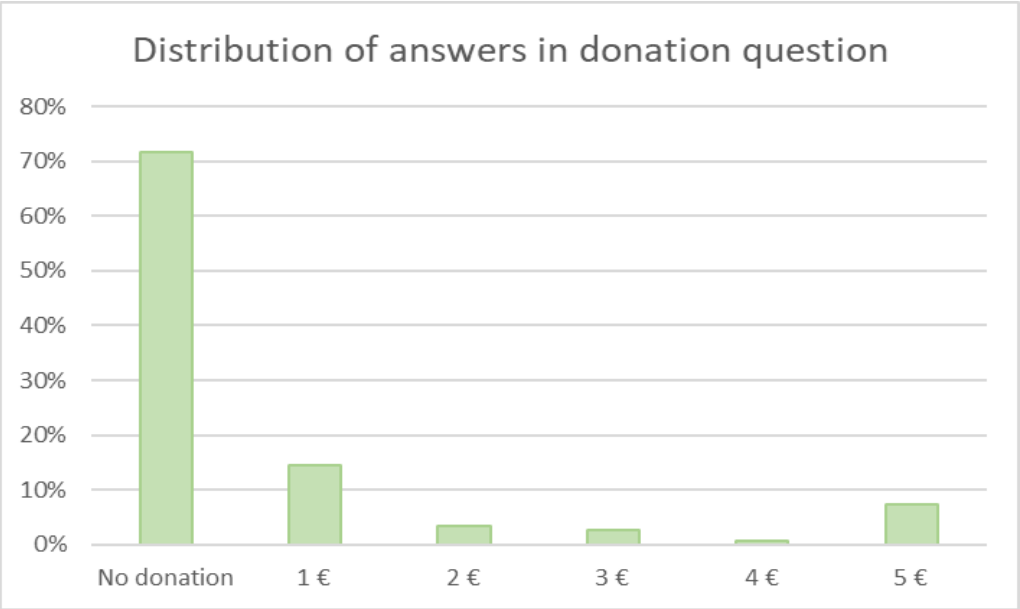


Figure 2.4: Distribution of answers on donation questions in ECHOES survey (all the respondents)

The average willingness to donate across the 31 surveyed countries is estimated at 0.67€, the distribution of the mean willingness to donate for a climate change mitigation by country is shown in Figure 2.4. As expected we find evidence for high heterogeneity across the countries with lowest average country willingness to donate observed in our sample in Austria (0.21€) and the highest demonstrated in the United Kingdom with 2.53€ average willingness to donate. While the heterogeneity can be explained by Considering individual characteristics, gender perspective plays a role as the mean willingness to donate is higher for female respondents (0.68€) than for male respondents (0.66€). Also households that reported to have children under 14 years old show higher willingness to donate of 0.70€. Such socio-demographic factors can be further used in policy making design of measured tackling climate change mitigation. Looking at further individual level factors, we find that promoting ancillary benefits of climate change mitigation measures like job creation increases the willingness to support and to pay for GHG mitigation in our setting. While providing more information helping to decrease the denial of climate change is required, highlighting ancillary benefits available to consumers in the short-term and requiring less or no scientific knowledge to understand might facilitate significantly the efforts.

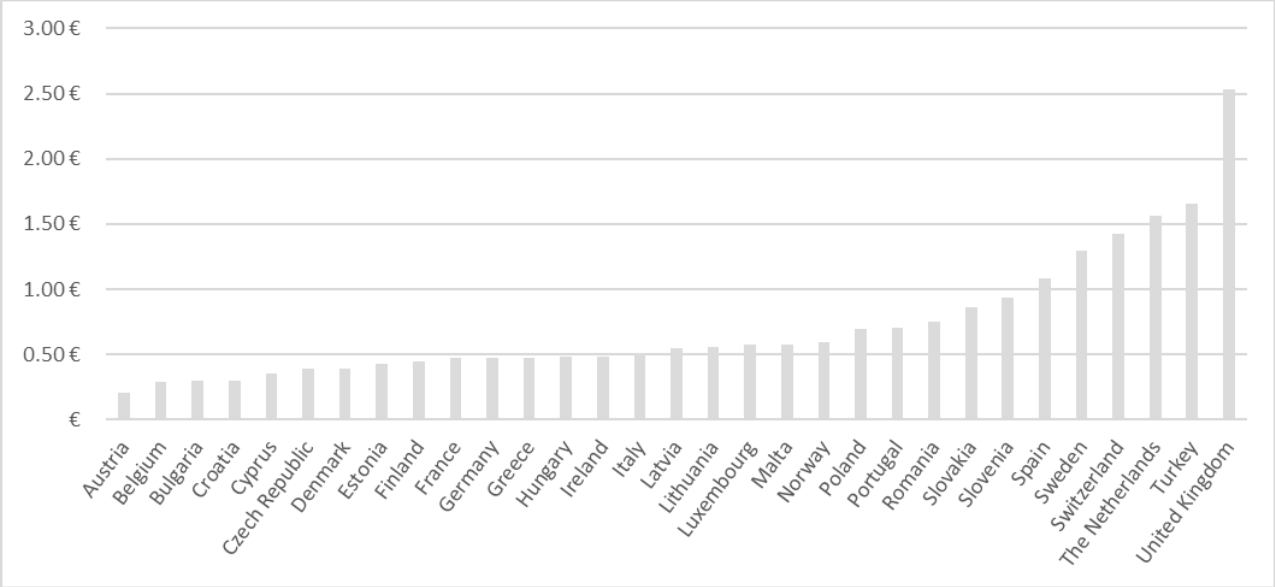


Figure 2.4: Average willingness to donate for climate change mitigation across 31 European countries.

2.2.1.3 Acceptability of higher costs for green public transport

The survey further asked about individual respondents' attitudes (e.g. feelings of satisfaction or dissatisfaction) and use of existing public transport systems in their areas, further enquiring about their considerations regarding the environmental performance of the public transport systems servicing them.

The respondents where then introduced to a hypothetical scenario presenting them with a situation whereby the current fleet of public transportation vehicles in their areas would be upgraded to a more environmentally friendly *and costly* public transport alternative that would lower carbon emissions and decrease air pollution. The costs associated with this transition would be paid for by the local residents either a) via more pricey public transport tickets, or b) through higher monthly taxes. For both alternatives respondents were asked to categorically state (via YES/NO responses) whether this change to a more expensive and environmentally friendly fleet of public transport vehicles should take place.

Responses were scrutinised to in order to identify the acceptance (and hence the level of support manifested) of the average individual respondent to transition towards a cleaner and more expensive public transportation system. Specifically, responses were statistically analysed with a logit regression model (the 'efficient Bayesian logit regression' model) in order to estimate the influence that a) the different levels of satisfaction/dissatisfaction with the current public transport system, and b) the frequency of use of the current public transport system, had in determining the average representative individual respondent's willingness to pay (in other words, the level of financial support manifested) for a greener – yet more expensive – public transport alternative.

Individuals' responses on personal energy-related behaviours and pro-environmental attitudes obtained from other sections of the survey were also taken – along with other indicators pertaining to gender, age, and income levels – and analysed employing the same methodology in order to further estimate the effects that a more expensive and greener public transportation system had on the willingness to pay of, for instance, a 47-year old woman who is a heavy public transport user with a self-reported pro-environmental behaviour and positive attitude towards renewable energy.

3. EXISTING KNOWLEDGE ON DRIVING FACTORS

3.1 Existing knowledge by social domain

3.1.1 MICRO-level

At the micro level, a comprehensive review of the individual-centred approach was conducted. This revealed how commonly used concepts such as values, worldviews, personal and social norms, attitudes, habits and routines, objective and subjective constraints and facilitators interact to determine decisions in the three technology focal areas of ECHOES. Results of the ECHOES Meta Analyses suggest that collective or social identities can be powerful drivers of pro-environmental action intentions when people associate them with pro-environmental values and goals in their everyday life, and that strengthening personal connections to nature and pro-environmental beliefs should be a focus of educational policies, as it has broad-range effects on people's receptiveness concerning pro-environmental behaviour changes. Also, emotions and affective factors (such as pride for reaching "save energy" goals) can be a relevant motivational driver of energy saving behaviour. The role of emotions in energy saving might be particularly relevant for specific social groups (for instance among men, compared to woman), while the link between identity and pro-environmental behaviour seems to be stronger among women than men. This would imply that men might be more successfully addressed by campaigns or policies that make use of behaviour-specific emotional arguments, while women might be more effectively reached through campaigns or policies based on an overarching social identity focus. Likewise, the link between pro-environmental values and energy saving behaviour seems stronger among younger people, and this would suggest that value-driven appeals could be particularly affective in policies and campaigns targeting younger generations. Finally, the relations between attitudes, intentions and actual energy saving behaviour is less strong than one might expect, and it is still not completely clear whether individuals' intention to save energy can be considered as a real proxy of behaviour in the energy domain. The scientific understanding of this crux might be relevant to tailor policy campaigns and interventions because.

The comprehensive action determination model (CADM, Klöckner, 2013) was used as a point of departure for identifying and evaluating the relevance of these concepts and their relations to each other. The CADM was found to be a rather common tool of analysis for energy in buildings and electric mobility, whereas for adoption of smart energy technology, technology adoption models (TAM)[3] were found to be more commonly employed. Furthermore, the concepts of emotion (most importantly guilt and pride) as a driver of energy and social identity/identification were found as missing in the CADM model. Thus, a model of social identity model of pro-environmental action (SIMPEA, Figure 3.3) was proposed as a complementing approach and suggestions were made for where and how to integrate emotions into both models (CADM and SIMPEA).

In general, most of the determinants mentioned above have received considerable attention in past research, with some differences between the technologies in focus here. It is for example likely that the emotion reaction resulting from mismatch between own behaviour and social norms (a feeling of guilt or shame) is not specific to the building focus, but will in the same way be found in the other technological foci. Figures 3.1, 3.2 and 3.3 show the main findings at the micro level when using the CADM model as a reference framework but integrating factors that the review showed may play an important role but were not included in the original model. The darker green background highlights the predictors appearing often in the literature for the specific technology. The grey arrows show the relationship of the predictors and the target behaviour. The text boxes that have dark green borders are those mentioned in the literature and are found in the CADM. The text boxes with grey borders are predictors or factors that are not found in the CADM model but were found in the literature review. The other lines in the CADM model were not shown in order to make the key research on the specific technology more visible. Dotted boxes show

[3] Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management science*, *46*(2), 186-204.

specific types of predictor sub-category (for example, injunctive and descriptive are two types of social norms) that were specifically mentioned in the literature. At the micro level for the buildings, social norms and environmental behaviour were highlighted in blue to show that a mismatch between them would result in an emotion (circle).

For smart energy technologies, existing knowledge indicates that:

- Several models and theories are used for technology acceptance studies, some related to the CADM, some with roots in technology adoption studies.
- The higher the perceived risk, the more negatively it affects the acceptance of technology and the intention to use.
- The higher the perceived usefulness, the lower are the concerns about risk.
- The consumers' understanding of the user related aspects of the smart grid (and a basic understanding of its functionality) is necessary due to its influence on perceived ease of use and perceived usefulness.
- The technology acceptance model (TAM) is the most robust model in considering technology acceptance. However, extensions of the TAM with moral / normative aspects appear to strengthen the approach

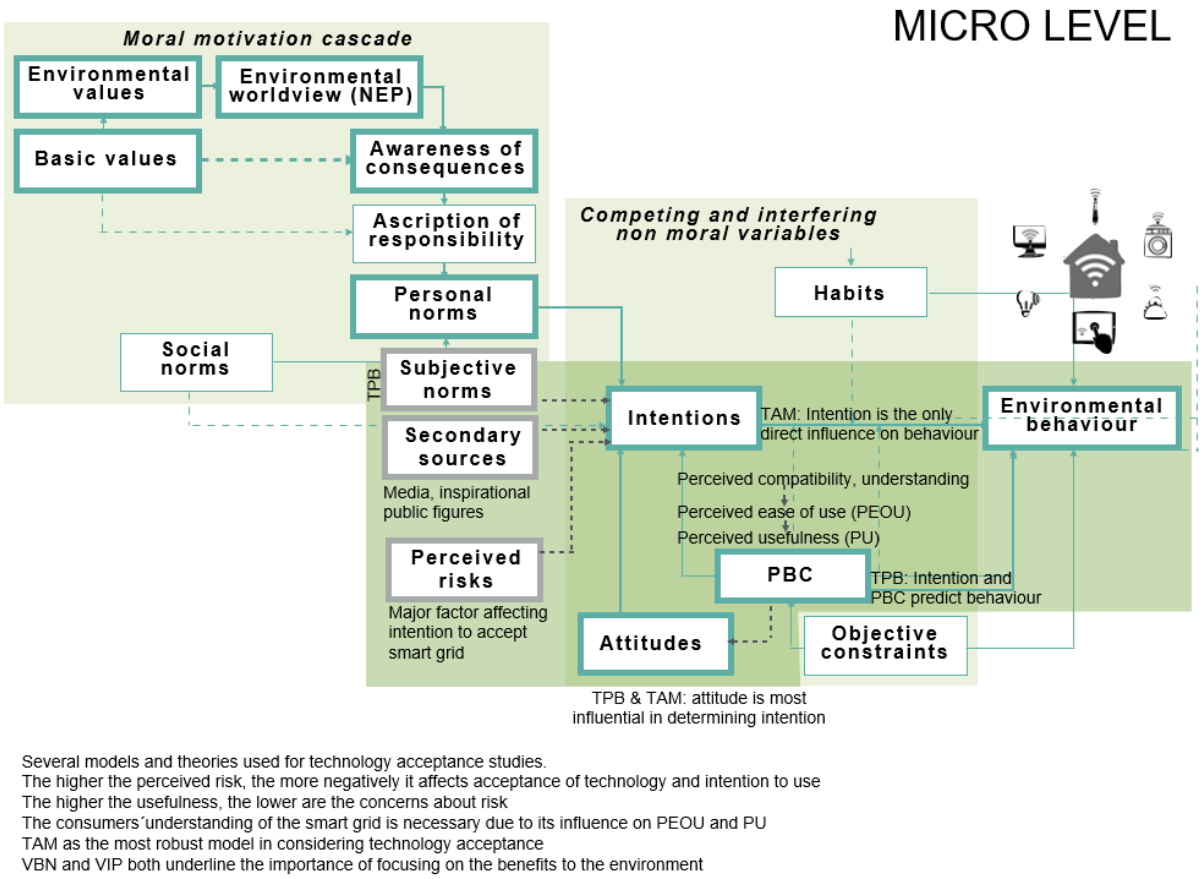


Figure 3.1: Relations between individual factors driving certain energy choices of smart energy technologies.

For electric mobility, existing knowledge indicates that:

- There is a clear absence of causal effects of long-term experiences with e-vehicle (EV) on adoption and on habit formation, especially when keeping with the same purchasing habits of EVs after the ownership of the first one.
- A research gap in the attitude-internalized objective constraint.
- Distal factors may play a closer role to influencing behaviour and attitudes for electric mobility which basically is a big investment decision for the customers.

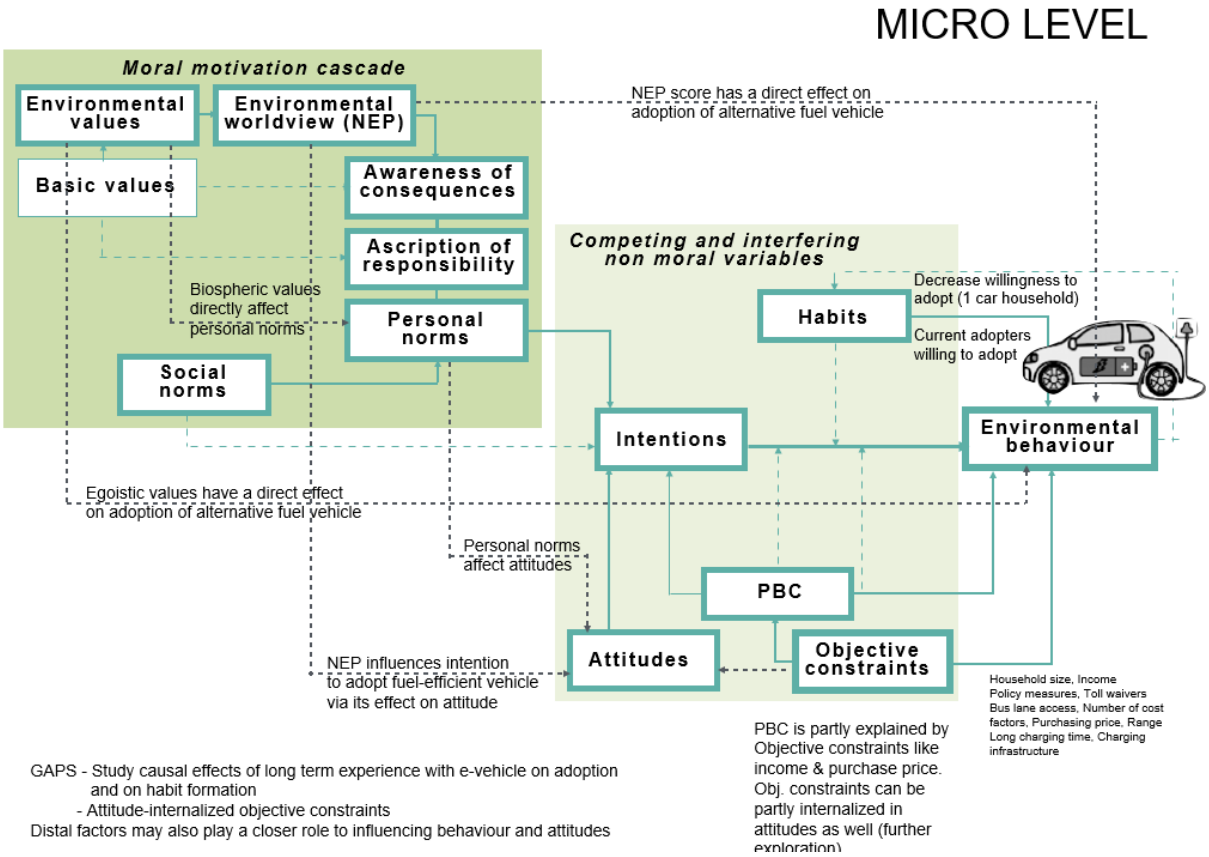


Figure 3.2: Relations between individual factors driving certain energy choices in electric mobility

For energy choices and use in buildings, existing knowledge indicates that:

- Social norms influence curtailment, investment & purchase intentions & behaviours.
- Normative interventions should target the most receptive: certain personality traits, identify with norm source, heavy energy users or previously indifferent ones.
- Combining normative interventions with behaviour visibility or increased energy prices and consumption feedback triggers increased responses from individuals.
- Feelings of guilt may appear when mismatch between social norms and behaviour occurs. This can in turn activate personal norms.

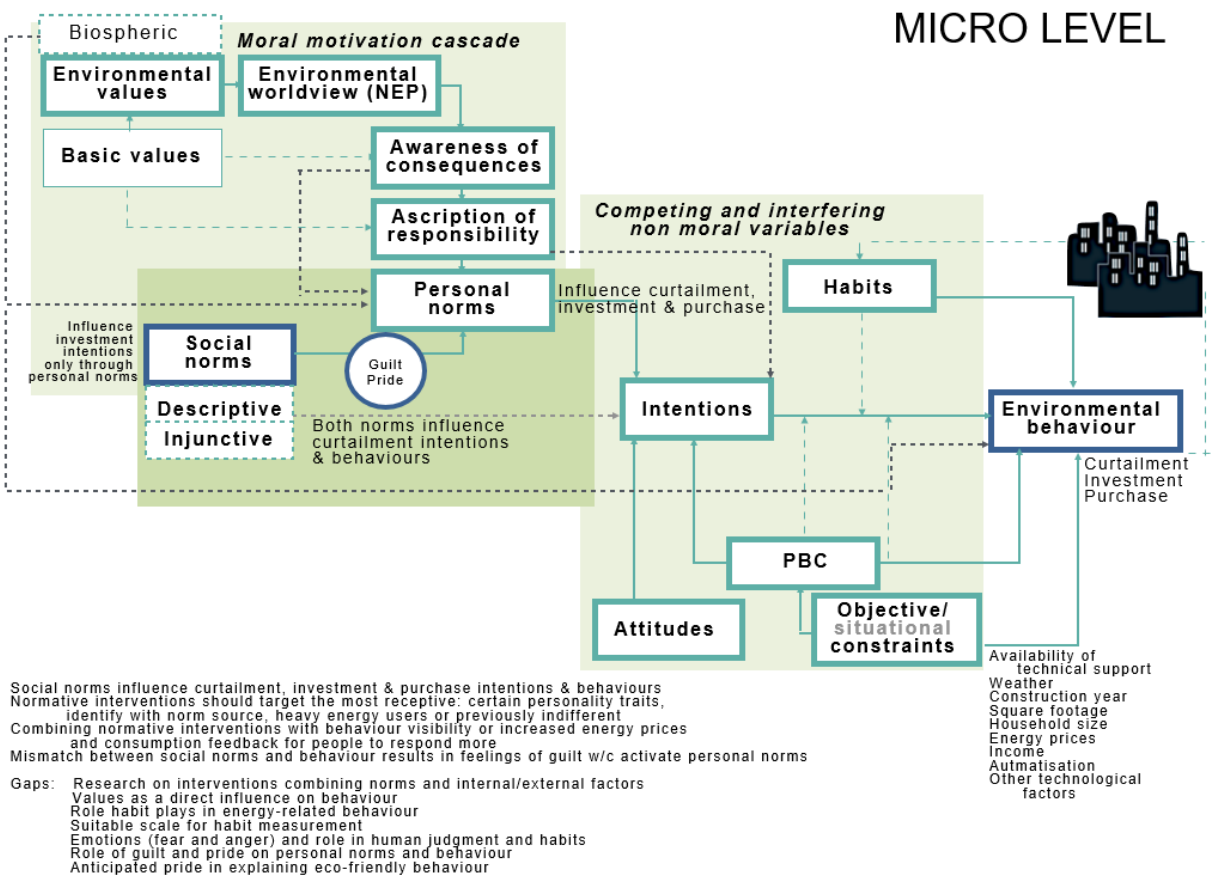


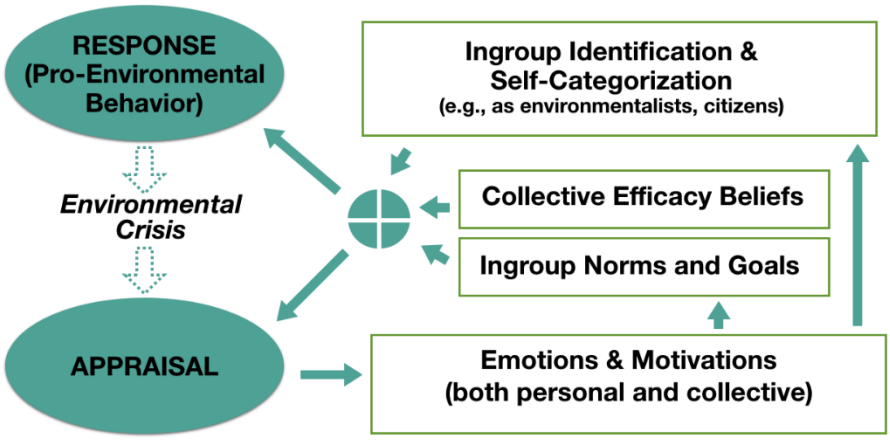
Figure 3.3: Relations between individual factors driving certain energy choices in buildings

It is important to note that the extended CADM is only one of the two micro-perspectives taken in ECHOES, the other one being the SIMPEA model. The model proposes that identification with a group (e.g., citizens of a city, a country or the EU) leads to activation of a "we" thinking rather than an "I" thinking. If ingroup norms and goals of that group propose energy saving behaviour and if the decision-making individual perceives the group as capable of solving the problem together (collective efficacy), energy saving behaviour is more likely and situations are more likely interpreted as relevant for the topic. Using the SIMPEA model (see Figure 3.4 below), the existing knowledge regarding social identity and energy choices for all technological domains included in ECHOES shows that:

- There is a strong attention given to groups such as "supporters of the transition to renewable energies".
- Resource contribution in smaller groups is higher than in larger groups when social identity is salient.
- Higher levels of social abstraction increase endorsement of sustainability and concerns over climate change.
- EU as the salient identity increases acceptance of EU-wide projects for transitioning to renewables.
- Collective action is triggered by perceiving that one's own group can contribute to certain climate & energy goals or other environmental sustainability objectives. Furthermore, the smaller the group size, the greater one's belief in collective efficacy.
- Downward comparisons on in-group results in higher willingness to engage in pro-environmental actions.

- Individual sustainable behaviour is more often shown when the in-group receives feedback on past performance.
- Individuals who are made to believe that they perform more poorly than their in-group have the highest intentions to take more pro-environmental actions.
- Anticipated emotions can guide behaviour when making eco-relevant decisions (i.e. underlining the role of emotions as feedback).
- Post decisional emotions can positively encourage or reinforce pro-environmental actions.
- Pride, anger or guilt can be considered as group-based emotions used to collectively motivate actions.

Figure 3.4: Social Identity Model of Pro-Environmental Action (SIMPEA)



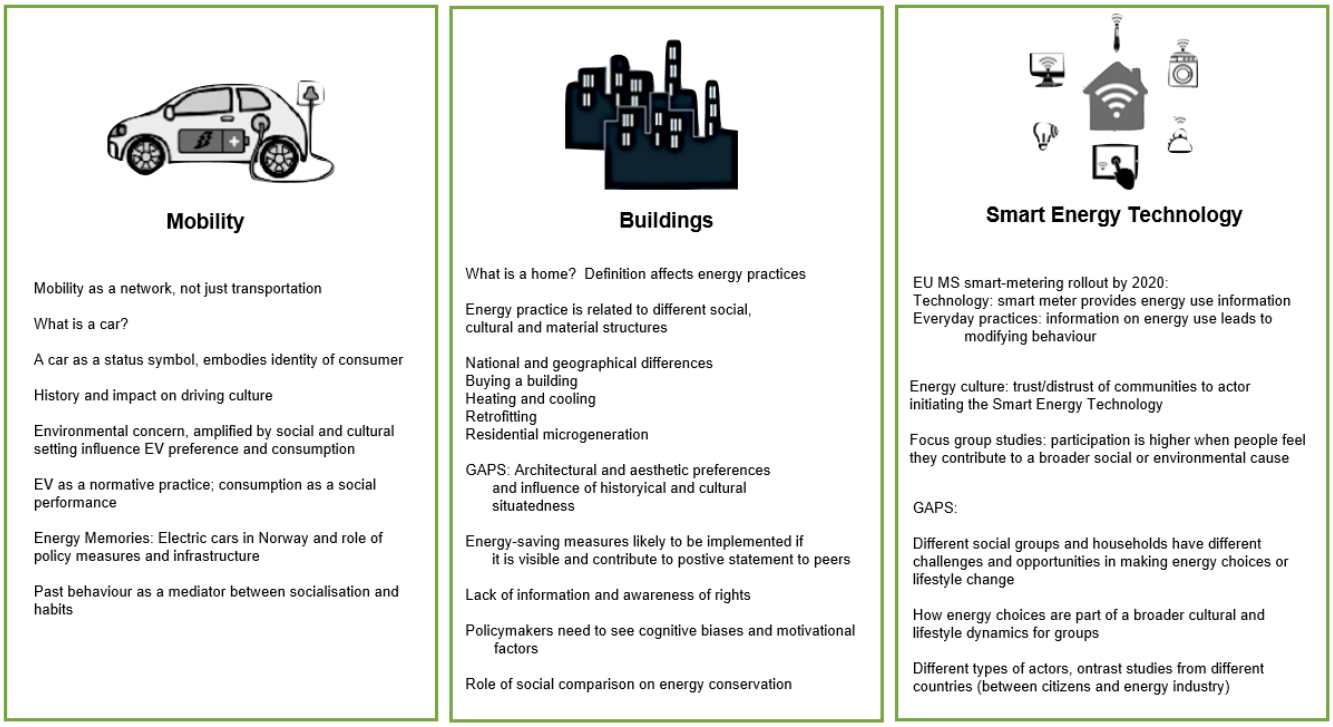
3.1.2 MESO-level

At the meso-level, the key conceptual approach for evaluating the existing knowledge has been through the lens of the theoretical concepts 1) energy culture, 2) energy memories, 3) energy lifestyle and 4) group processes and place attachment (please refer to section 2.1 for a description of these concepts). Here, the social and historical embeddedness of energy decisions regarding the three technology foci was the core of the analysis. Important gaps identified at the general level are that 1) there are advantages and analytical improvements of using the energy memory approach over the related concepts of energy culture and energy lifestyles because energy memories not only includes the cultural and contextual rooting of the behaviour, but also the temporal/historical dimension; and 2) place attachment and place-related meanings are not investigated with respect to the energy memories development.

Furthermore, there is a pressing need to move beyond the single user-centred focus of individual energy choices towards a broader and more comprehensive analysis of the aggregated and/or collective energy choice dynamics of different social groups and, most importantly, of how such dynamics inherit and embody past practices and institutional legacies. In line with this perceived need (with the exception of the social group of "early adopters" or "frontrunners", which has been more thoroughly investigated), there is need for a more fine-tuned analysis that disaggregates different social groups facing substantially different challenges and opportunities for unlocking new kinds of energy choices (and therefore energy consumption patterns), or changing their energy lifestyles (e.g. Heargreaves et al., 2010; Heargreaves et al., 2013; Wallenborne et al., 2011; Naus et al., 2015; Throndsen et al., 2017, Nicholls and Strengers 2015). Hence, through its multi-layered and temporal approach to energy decision-making, habits and routines, and choice dynamics at the micro, meso, and macro levels, ECHOES advances a

more aggregative and empirically anchored understanding of how individual and collective energy choices of new and diverse groups of citizens manifest, represent, operate and reproduce the broader material, economic, cultural and lifestyle dynamics they are embedded in different governance levels. Furthermore, the increased attention given to the role of culture and lifestyles in shaping action, holds great policy potential for improving technology design, applicability and adaptability, interaction, and use. At the technology-specific level, the main findings are presented in Figure 3.5 below.

Figure 3.5: Meso-level themes relevant to energy choices in the three technology foci.



3.1.3 MACRO-level

The review at the macro level has been completed by distinguishing three sub-levels that all focus on the three technological focuses, through the mapping of:

1) *Factors important in decision-making*: elements such as, for instance, dynamic pricing, reconstitution of energy generation, market behaviour and performance, usage and information flows, etc. are all key factors to take into consideration (Clastres, 2011). Policymakers can play a coordinating or facilitative role in regards to the development of transparent standards, best practice guidelines, or quality control procedures and rights of recourse for installations and systems.
2) *Barriers*: for instance, *community acceptance* of infrastructure (whether grid infrastructure, transport infrastructure, or buildings) is crucial. Community acceptance, in turn, is affected by a variety of factors and variables. *Confusion*, for instance, may play an important role in this regard. The public's beliefs about energy networks are rather detached from reality, and it is crucial to gain trust and acceptance from communities as a whole (Tobiasson and Jamasb, 2016). Therefore, there is a need for policies and governance structures to initiate a systemic shift to a low consumption paradigm in order to move people out of their comfort zone of carbon-intensive living (Lorenzoni et al., 2007).
3) *Motivators*: transparent standards, best practice guidelines, or quality control procedures and rights of recourse for installations and systems, as well as strategic Infrastructure and development of innovation

systems, are all crucial driving elements to accelerate the diffusion and implementation of smart grids (Negro, Alkemande and Hekkert, 2012), more sustainable public transport systems, and more energy efficient building codes and practices. Also, on the level of the collective decision-making unit, *energy self-sufficiency* becomes an important motivator.

4) *Research gaps*: an evident need for more research on energy choices in collective social units as well as research which takes into account the necessary interplay between the formal, collective, and individual levels. The research on the rollout of smart grids and other smart energy technologies has tended to be top-down, and to focus on the end-user through a conventional lens of the "passive consumer". There is therefore a need to uncover and better understand the impact and acceptance of different technologies from a bottom-up perspective, looking at the ways in which the technologies and people interact, rather than simply identifying which qualities makes a person more or less likely to accept or adopt them.

Figures 3.6, 3.7 and 3.8 show the main findings about determinants of energy choices at the macro level for each technological domain in ECHOES.

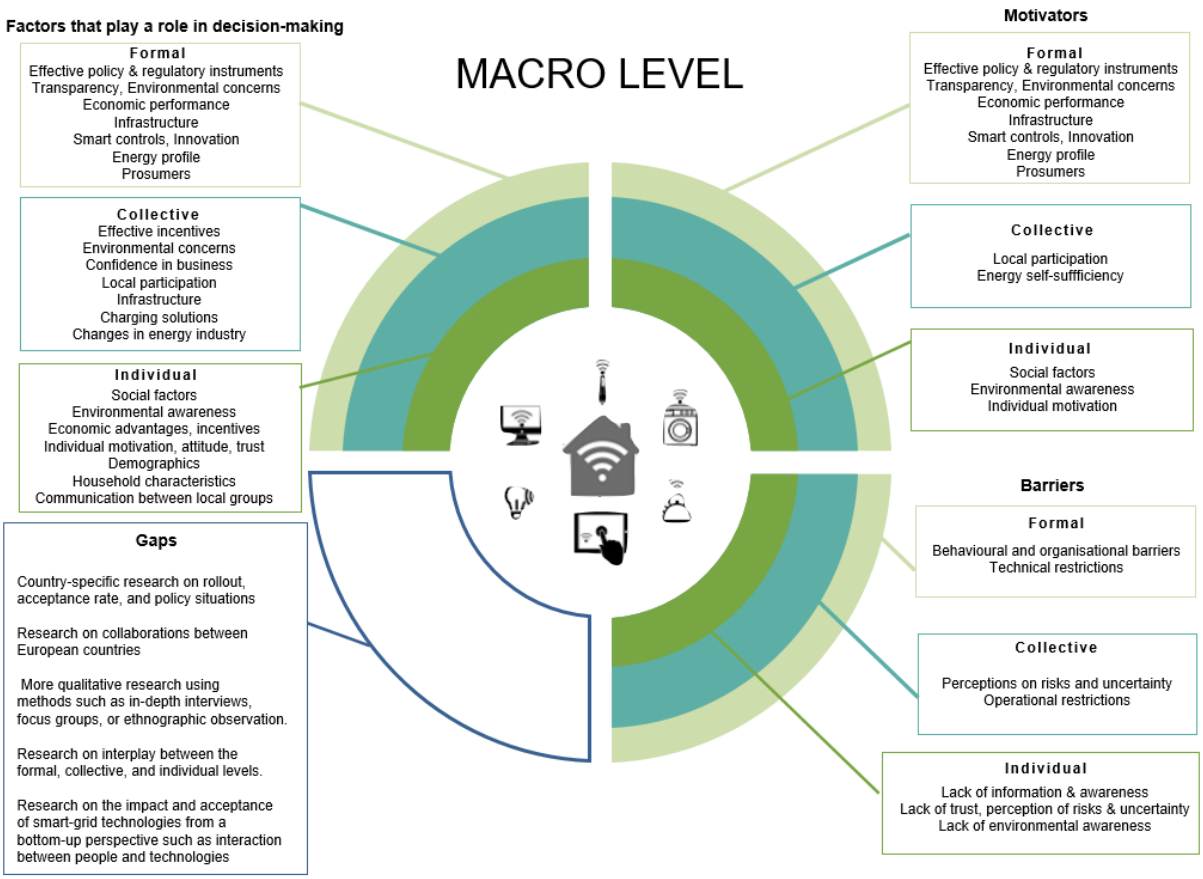


Figure 3.6: Macro-level determinants of energy choices for smart energy technology.

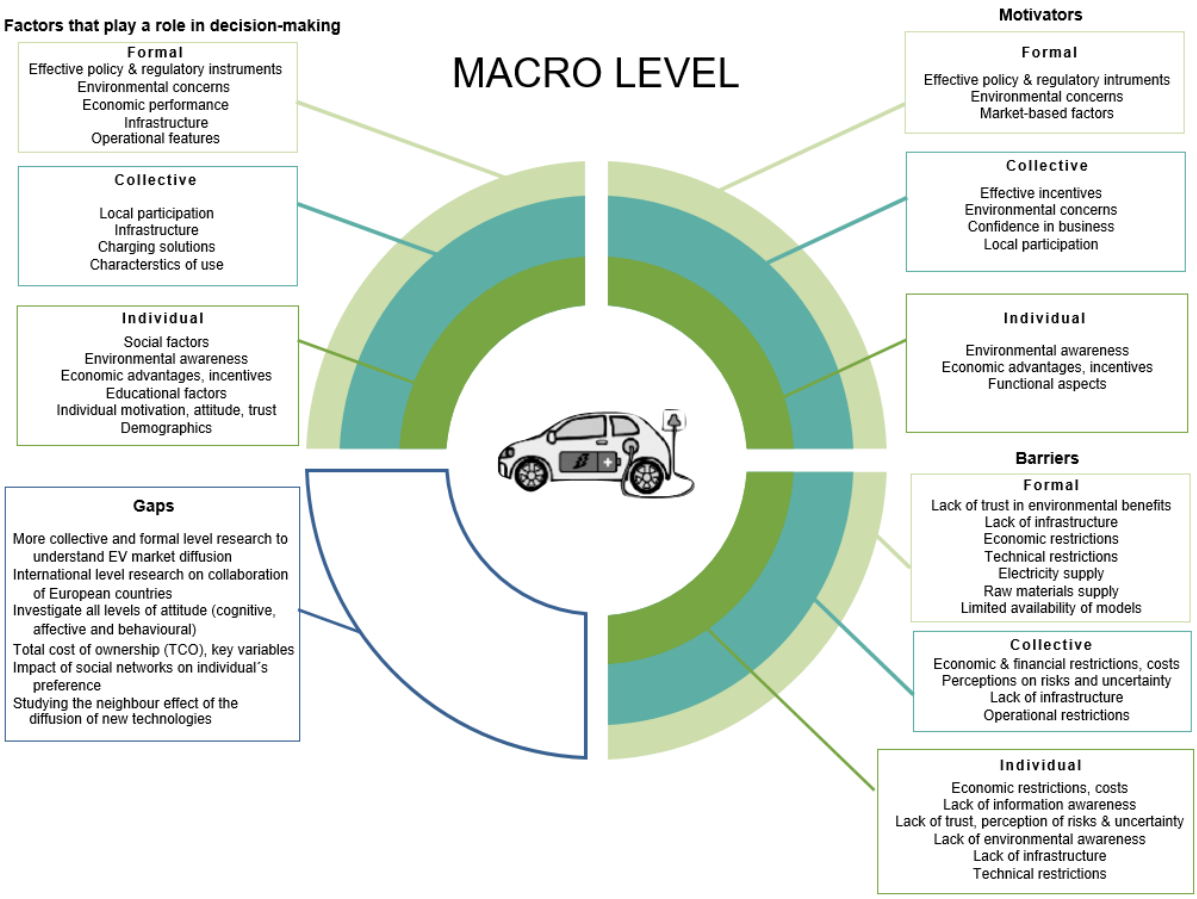


Figure 3.7: Macro-level determinants of energy choices for electric mobility.

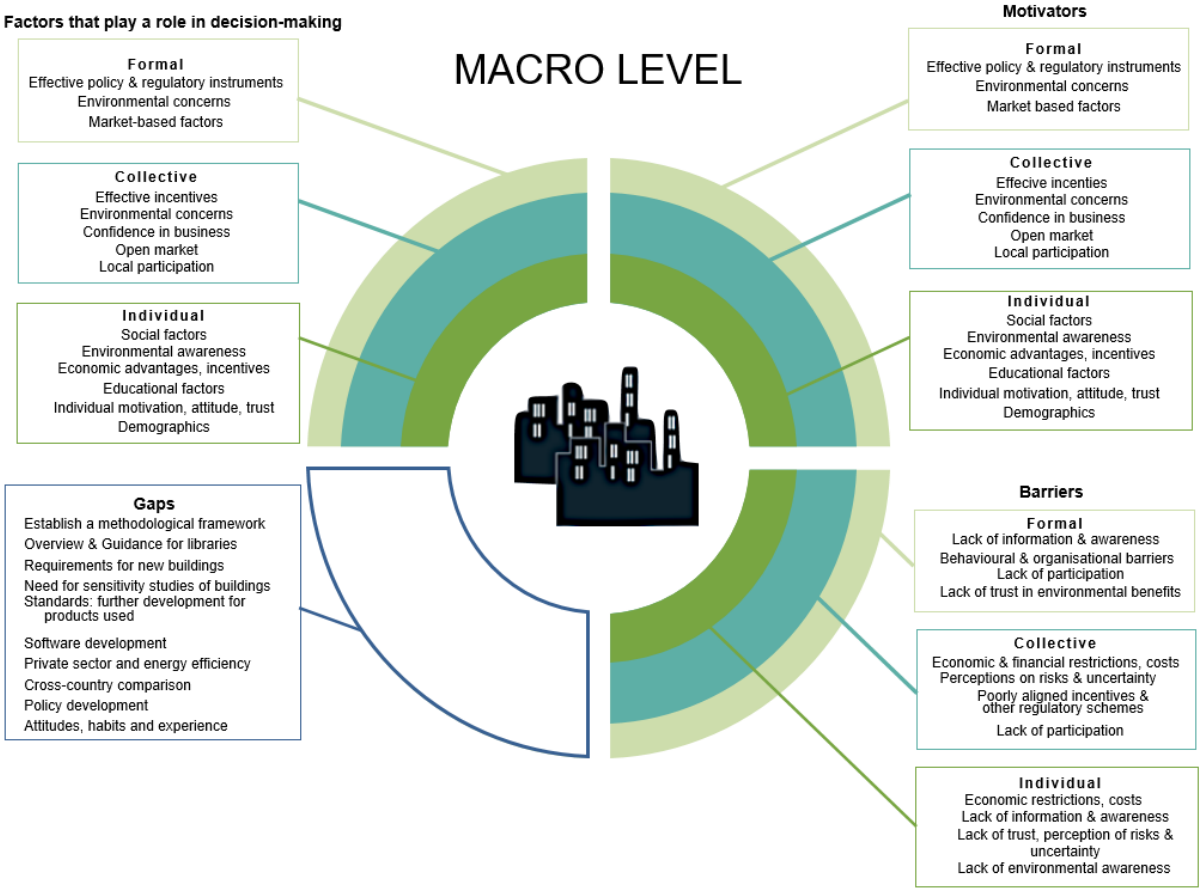


Figure 3.8: Macro-level determinants of energy choices for buildings.

3.2 Overview of main knowledge gaps: technology-oriented and domain-specific

The idea in this section is to provide a general/brief overview of the activities conducted at each decision-making level (micro, meso, macro) early on in the project in order to identify the "critical knowledge gaps" that would then be addressed in later stages of the project (and as reflected in the following sections below).

Figure 3.9 summarizes the research gaps identified in the three technology foci and the three ECHOES perspectives.

			
MACRO	More collective and formal level research to understand EV market diffusion International level research on collaboration of European countries Investigating all levels of attitude (cognitive, affective and behavioural) Total cost of ownership (TCO), key variables Impact of social networks on individual´s preferences Studying the neighbour effect of the diffusion of new technologies	Establishing a methodological framework Overview & Guidance Requirements for new buildings Sensitivity studies of building standards: further development for products Software development Studies on private sector and energy efficiency Cross-country comparisons Policy development Exploring attitudes, habits and experience	Country-specific research on rollout, acceptance rate, and policy situations Research on collaborations between European countries More qualitative research using methods such as in-depth interviews, focus groups, or ethnographic observation Research on interplay between the formal, collective, and individual levels More research on the impact and acceptance of smart-grid technologies from a bottom-up perspective such as interaction between people and technologies
MESO	Mapping of advantages and for making analytical improvement of using the Energy memory approach Place attachment and place-related meanings investigations with respect to energy memories development Research on mobility as a network Definition and meaning of car as a concept History and impact on driving culture EV as a normative practice; consumption as a social performance Electric cars in Norway and role of policy measures and infrastructure Past behaviour as a mediator between socialisation and habits	Mapping of advantages and for making analytical improvement of using the Energy memory approach Place attachment and place-related meanings investigations with respect to energy memories development Architectural and aesthetic preferences and influence of historical and cultural situatedness Exploring the role of social comparison on energy conservation	Mapping of advantages and for making analytical improvement of using the Energy memory approach Place attachment and place-related meanings investigations with respect to energy memories development Exploring advantages and analytical improvement of using the Energy memory approach Exploring place attachment and place-related meanings with respect to energy memories development Exploring how energy choices are part of a broader cultural and lifestyle dynamics for groups Studies on different types of actors, contrast studies from different countries (between citizens and energy industry)
MICRO	Studies on causal effects of long term experience with e-vehilcle on adoption and formation of habits Exploring attitude-internalized objective constraints Exploring the role of distal factors in influencing behaviour and attitudes	Research on interventions combining norms and internal/external factors Studying values as a direct influence on behaviour and the role habit plays in energy-related behaviour Finding a suitable scale for habit measurement Exploring emotions (fear and anger) and their role in human judgment and habits Role of guilt and pride on personal norms and behaviour Exploring anticipated pride in explaining eco-friendly behavior	Further studies of human understanding of smart grids and smart energy technology (meters, et cetera) Further exploring and testing of choices and priorities and the role of technologies in relation to this (energy feedback)

Figure 3.9: Main research gaps per technology focus and decision-making unit.

As a general conclusive remark, the existing knowledge reveals the existence of predominantly fragmented and disciplinary-isolated analyses of particular factors influencing energy related decision-making within a specific level (micro-, meso- *or* macro-) with a specific technological domain (smart energy technology, electric mobility, *or* buildings). Consequently, it remains unclear if differences between, for instance, individual barriers/levers are substantial and common to all technological foci or rather circumstantial due, for instance, to studies that advocate for a particular effect/influence selecting only one of the three technology foci. As stated in section 3.1.1 above, it is for example likely that a certain emotional reaction resulting from a mismatch between an individual's own behaviour and his/her social norms (e.g. a feeling of guilt or shame) is not specific to the building focus, but will instead play a significant role in in the other two technological foci.

The abovementioned example serves to illustrate a major shortcoming of the existing literature and current state of scientific knowledge. It shows absence of disciplinarily-comprehensive and integrated analyses with a multilevel perspective whereby the different social units/energy collectives are collectively addressed to identify both the unit-specific and common/shared overarching factors influencing energy-related choices, along with the decision-making processes underpinning such choices, for each technological focus included in ECHOES. As such, the relevant research identified is not conducive to confidently predict decisions in a satisfactory way, nor does it allow to derive integrated policy or market recommendations. This is an important conclusive insight that has opened up

an opportunity for ECHOES to advance a more holistic and comprehensive multilevel approach for uncovering the relational ties between unit-specific factors and energy related-choices and behaviours in relation with the focal areas of smart energy technology, eco-mobility, and buildings.

4. CRITICAL KNOWLEDGE GAPS & MAIN FINDINGS

4.1 General energy policy

Building on the literature review (Deliverable 3.1), an analysis of key policy documents (Deliverable 3.3) from various different EU/national jurisdictions revealed certain generalised/broad tendencies – common to all technology domains – shaping the way through which European citizens are positioned and integrated into a transitionary period of national energy systems. Such tendencies are common to all technology domains analysed under ECHOES, and point towards a change in the view and understanding of the renewed role ascribed to European citizens acting as *energy consumers* co-driving and co-shaping a gradual transition towards an energy paradigm based on net carbon emissions.

A brief analysis of an electricity company's strategy documents was included on top of the policy potential analysis in order to contrast policy documents with business strategies and learn if there are differences between public & private sectors in regards to their view, understanding, approach, and treatment of energy consumers in Europe.

The analyses were necessarily restricted to the selected Member States and are especially selective with respect to the private sector documents where only one company was included. However, we are confident that the documents reflect general tendencies.

Critical knowledge gaps applicable to all technology domains reviewed under ECHOES have been identified. These include:

Critical knowledge gaps & main findings

- Individual citizens – in their role as consumers – have made their way into the centre of the political agenda in energy policies. A clear tendency can be seen in newer policy strategy documents: these assign consumers a more proactive role in the energy transition (which also falls under the prosumer role – albeit not exclusively). Alternatively, older policy documents depict consumers as rather passive recipients of energy services without themselves exerting any kind of influence or clear impact on the energy system. This shift in policymakers' shared view and conceptualisation of energy consumers' renewed role within the energy transition demands a more comprehensive and holistic understanding of consumer decision-making within the energy domain.
- The main underlying assumptions about consumers reflected in the policy documents reviewed are: a) Consumers either lack or have incomplete information allowing them to make good (economically rational) choices that increase their personal benefit (utility) while simultaneously benefitting the energy system (e.g. demand-side flexibility) and the environment (e.g. lower consumption). b) Consumers make decisions based on economic considerations, which means that shifts in energy systems need to be accompanied by either making the politically preferred alternative less costly (e.g. via economic incentives such as subsidies or tax exemptions) or making the politically non-preferred alternative more costly (e.g. via taxation instruments, penalties, or bans).
- A comparison of the policy documents reviewed with established knowledge from the social science fields represented in ECHOES shows an interesting simplification of human decision-making. This was repeatedly found in most policy documents reviewed. Although economic considerations and lack of (or incomplete) information are important elements influencing consumer decision-making, both the existing literature and the new findings produced in ECHOES demonstrate clearly that these elements are far from being the only factors influencing and shaping consumer decision-making in the energy domain.
- Interestingly, a reduced number of newer policy documents depict a richer and more elaborated picture of human (individual) decision-making; most of them either connected to electric mobility or smart metering. In these newer policy documents additional factors such as trust in market actors and stability of funding

schemes, enjoyment of driving experience, the identity defining role of a car, etc. come up as relevant factors influencing individual decision-making.

- An estimation of revealed willigness to support a carbon offset programm is provided using data from ECHOES donation questions in the survey. Unlike previous studies that focus on stated acceptance or support of climate change mitigation programs usually in the frame of one country or region and focusing on individual level heterogeneity, in the ECHOES setting revealed willigness to pay with actual donation was realized. Results of this experiments demonstrate an urge to increase awareness of ancillary benefits of climate change mitigation like job creation, and to improve information flow affecting an individual's agreement or rejection of measures for tackling climate change irrespective of the measure's characteristics as well as the heterogeneity of these among the EU countries.
- A general conclusion points at how the richness and contribution of social science knowledge is as of today not reflected well enough in policy and strategy documents. In the analysed example from the private sector, the picture is slightly different, where the strategy documents clearly reflect a deeper understanding of the irrationalities of the energy consumer's decision-making.

4.2 Key findings under each technological domain

4.2.1 Smart energy technologies

Smart energy technologies are at the core of what the integrated roadmap for realizing the SET-plan describes as an "energy revolution" (2015, p.1). The term encapsulates a range of distributed, small-scale renewable energy production technologies, typically rooftop solar thermal and PV, micro wind, heat pumps and biomass. It further incorporates a range of efficiency or "demand side" technologies such as smart meters, home automation systems and in-home displays, smart home appliances and user-interfaces, and new tariffs, along with energy storage technologies (including electric vehicles). These technologies allow to, on the one hand side, phase in increasing amounts of renewable energy characterised with high variability profiles and relatively limited reliability, and to consume it more efficiently and cost-effectively, thereby providing significant opportunities for both consumers and utilities to save on energy costs. On the other hand side, they provide greater and more detailed monitoring on energy production volumes and consumption patterns by households, but also commercial and industrial stakeholders.

Furthermore, smart energy technologies are increasingly associated with the emergence of a "smart grid". This term is used as an umbrella heading to amalgamate the myriad of different technologies coordinated through an upgraded electricity network that can intelligently integrate a two-way interaction between all users connected to it – generators/suppliers, consumers and those that do both (prosumers) – in order to efficiently deliver sustainable, economic and secure electricity supplies through the introduction of intelligent metering and monitoring systems (Sonnenschein et al. 2015; Ardito et al. 2013; Fang et al. 2012). Developing smart grids and putting in place smart technology solutions is seen as an important priority across Europe, in order to reduce carbon emissions, achieve future goals of sustainability, and assure electric stability to cities and their citizens Schleicher-Tappeser, 2012; Zgajewski, 2015; Giordano, 2013; Colak et al., 2013; Gangale et al., 2013). Furthermore, Smart Grids can contribute to sustainability objectives by facilitating the reduction of CO_2 emissions, enabling the integration of large-scale renewables, and increasing energy efficiency in the power sector. New business models and business practices, new regulations, as well as more intangible elements like consumers' behavioural changes and social acceptance (attitudes) towards smart energy technologies all play a key role in either hindering or enhancing the realisation of a smart grid.

The critical knowledge gaps identified throughout the ECHOES project execution, as well as the main findings obtained addressing them (either fully or partly), are outlined in the following subsections within the 'smart energy technologies' domain:

4.2.1.1 Data availability for smart energy technology

Critical knowledge gaps

- The availability of data on smart energy technologies is assessed low in regards with the ECHOES focal areas. Especially, the acceptance of smart energy technologies and consumer behaviour are the areas with the lowest available data. Consequently, important knowledge gaps stem from a lack of data availability and insufficient analysis follows.
- There is no clearly established and agreed-upon definition of "smart energy technology". Different actors identify, understand, and describe smart energy technology differently. This undermines the decision-making process of policy makers and their communication with potential entrepreneurs, sub-national jurisdictions (e.g. provincial governments, municipalities), local communities, and other interest groups (e.g. consumer associations). An up-to-date, multidisciplinary and multifocal database would serve as a valid tool to partly adress this challenge. However, building and maintaining a database with continual updates represents a substantial effort, since the stock of household appliances renews very quickly due fast development of the smart energy technologies.
- There is a lack of readily available infrastructure qualified to make accurate measurements. Electricity of many smart household appliances constitutes only a minor impact in typical households' expenditures.

Main findings

- For smart energy technology, WP2 workshop results identify data privacy as an important factor influencing energy choices. Additionally, ease of use or access to technology (e.g. for elderly people) may also be considered as a decisive factor driving energy decision-making.

4.2.1.2 Information provision on energy demand behaviour

Critical knowledge gaps

- There is a knowledge gap regarding the adoption and use of smart meters at the household level, as well as insufficient awarness regarding the energy consumption of household appliances.
- Rather a "consideration gap" than a knowledge gap: As stated in Deliverable 3.3, in the case of smart meters a predominance of information provision, and consequently data management, protection, and presentation can be generalized for close to all analysed documents and mostly addressing the individual decision-making level. Information provision mostly contributes to the "mechanical" assumption that data input leads to economically driven behaviour change without establishing the underlying motivation cascade in detail. Other potential motivations such as environmental values may equally be served by information provision but are not explicitly stated. The assumed motivation for behaviour change therefore mostly stays on the level of economic incentives for individuals or companies. Besides these behaviour-related approaches, suitable data provision is equally supposed to improve transparency and trust and thereby facilitate the active role of consumers in the energy transition.

Main findings

- For the smart meter case reviewed under Deliverable 3.3, a broad range of policy (EU and national) and roll-out related documents was analysed regarding their consideration of the social science perspective (during which the above stated "consideration gap" was identified). This analysis was complemented by interviews with national organisations to gain insights on actual roll-out experiences.

- As concluded in the literature review conducted under Deliverable 3.1, the smart meter rollout strategy in Europe had not been as succesfull as initially expected. This was further refined with the in-depth interviews and focus groups conducted under Deliverable 6.2, concluding that the reason for this perceived lack of success in smart meter rollout policies and strategies has to do with the low acceptance levels of smart meters at the household level (as opposed to higher acceptance rates within collectives). This is further exacerbated by the fact that there are very few attempts to provide end-use energy consumers with consistent and reliable information regarding their energy use behaviours and related consumption patterns.
- Education-provision policies and awareness-raising campaigns – particularly among the younger generations and for new energy technologies – are found to be needed on a prolonged and consistent basis in order to expedite the technology learning curves of end-users. Accelerated learning curves can in turn enable a faster-paced transition towards energy-saving and energy-smart consumption patterns and behaviours at both micro and meso levels. A critical target group should be younger generations (along with other first-time users). This group will need knowledge-provision tools on new energy technologies along with built-in user-friendly interfaces in order to accommodate, absorb, and internalise the user-related challenges of technological change in regards with user acceptance, consumption behaviour and patterns, as well as for enhancing flexibility and adaptive capacity.
- The literature review (D3.1) suggests that, besides individual and economic motivations, the contribution to a broader scope may equally be an important behavioural driver. Whether this perspective is equally addressed ultimately depends on the specific information provided to consumers in the context of smart meter introduction. For instance, a broader motivation would be to provide information on the need for energy efficiency and climate change in general, addressing the element of awareness on consequences in the moral motivations cascade.
- Regarding the differentiation between societal groups, on the individual (micro) level, we find that more attention should be paid to personal and social norms, social identification, and habits. On the meso-level, customers' segmentation is needed to identify and develop policies to tap into energy lifestyles, culture, and memories. On the macro-level connected to formal decision making, a structured approach for identifying significant impact factors and elaborating "decision making" frameworks for the formal units and individuals within them could be useful for smoother and faster dissemination of new generation smart meters. This would rather apply to national and local level policies than to EU level policies when it comes for specific rules and incentives, and roll-out schemes. In the UK, for instance, a strong consideration of the social science perspective and consumer involvement could be observed. However, on EU level the above stated "mechanical" behaviour assumption (i.e. information provision leads to economically driven behaviour change) is embedded and could be expanded in order to provide room for a broader consideration of social science insights.

4.2.1.3 Lifestyle-specific energy use

Critical knowledge gaps

- Current knowledge about who uses which existing technologies and who adopts certain new technologies is not well covered in existing empirical literature, especially if not only one certain behavioural domain is to be addressed, but behavioural patterns across different areas of life are of interest.
- Similarly, the patterns in which sustainable technologies spread in different European societies are not satisfactorily covered by existing longitudinal survey panels. It is therefore practically impossible to reliably determine the reasons for halting adoption or even rejection of sustainable technologies by potential users.

- The impact of prosumerism in terms of saved energy or (in the case of indirect rebound-effects) additional energy demands is widely unknown due to a very limited number of studies covering energy and climate relevant behaviour across different areas of life.
- The regularly used approach of identifying energy lifestyle groups on the basis of psychological parameters is characterised by a particularly pronounced inconsistency between expected and observed behaviour of the respective groups.

Main findings

- With the aim of creating a more comprehensive understanding of energy and climate relevant lifestyles, Task 5.2 assessed the behavioural patterns of survey respondents of 31 European countries across six areas of life (Housing, Mobility, Diet, Consumption, Leisure, and Information), using data collected in 2018 in the course of a joint survey effort involving WPs 3 – 5. The dataset resulting from the survey conducted in ECHOES contains cross-domain information about energy behaviour and equipment use, which provides a more holistic starting point for assessing the question “how sustainable technologies and behavioural patterns are distributed in European societies” than this would be feasible with a single-domain perspective.
- With regard to the generation of in-depth knowledge about the "high" and "low" impact groups in the various countries, it has been shown that the number of universal driving factors is limited. This finding follows the guiding hypothesis that a focus on the "average citizen" strongly limits the potential knowledge gain and that the identification of relevant subgroups promises more meaningful insights.
- It appears worthwhile to emphasise the role of those people who, under given conditions, already have a particularly low lifestyle-specific (energy) impact. By providing information about how existing low-impact lifestyles look like, and by emphasising that the low-impact group already represents a significant part of the population, sustainable lifestyles within a society can be characterised in a more tangible way, which holds the chance that new role models emerge. The view on the 10% of the population with the highest energy impact at a first glance indicated a problem in the mobility sector. However, policy design based on a sector-centric approach would be too short-sighted in this respect, which again underlines the importance of a holistic perspective on energy relevant behaviour: With regard to high-impact groups, the extremely high energy demand for mobility was among factors which are crucial in determining lifestyle-specific patterns of energy behavior. This is because mobility behaviour, in particular, is shaped to a good extent by everyday routines external to the sphere of mobility.
- Consistent with previous studies and literature screened in Deliverable 3.1, linear and logistic regression models showed that psychological parameters under control of other variables are mostly no strong predictors of energy behaviour patterns or resulting impacts. Therefore, ecological attitudes or values, for example, may not be used as proxy variables for corresponding behaviour. Nevertheless, they have proved helpful as explanatory variables in certain cases.
- With regard to behaviour, mobility has turned out to be the main (behavioural) factor in distinguishing between high-energy and low-energy lifestyles and to be the most energy intensive behavioural domain (by average) in six different European countries (Austria, Bulgaria, Italy, Norway, Spain, Turkey). Additionally, different forms of mobility behaviour showed to be integrated into specific behavioural patterns across the remaining areas of life.

4.2.1.4 Choice & awareness of low-carbon electricity purchase options

Critical knowledge gaps

- There is insufficient understanding of the impact that different market structures have on low-carbon electricity purchase options of individual end-users, as well as on the actual availability of different low-carbon electricity purchase options as viable alternatives to conventional sources.
- There is limited information availability concerning the source of electricity available for purchase by individual users (e.g. households).

Main findings

- As evidenced by the literature review conducted under Deliverable 3.1, the literature recognizes the importance of choices regarding low-carbon electricity purchase options. However, the issue is rather introduced and discussed usually by implicitly assuming that such options are readily available and known to decision makers. At this point, the variety of the low-carbon electricity purchase options are discussed, mostly from the perspectives of individuals as decision-making units.
- The qualitative research techniques utilized by Deliverable 6.2 (focus group studies and in-depth interviews) point to different perspectives on these issues. First, there are significant differences between countries. The differences arise both in terms of the existence of low-carbon electricity purchase options as viable alternatives and in terms of the availability of information concerning the source of electricity available for purchase. These are affected by the countries' energy portfolios as well as market dynamics and cultural factors. Therefore, the choices on low-carbon electricity purchase options are not solely individual choices, but a result of myriad of factors. Another aspect is related with collective decision-making units. These have a different set of factors in effect in terms of choices of low-carbon electricity purchase options. With the high amounts of electricity consumption, collective decision-making units need to be analysed as a separate case.
- Austere and resource-efficient behaviours influence the individuals' decisions on, for instance, energy-saving choices and related consumption profiles. Furthermore, people's self-perception of austerity and resource-efficiency influences the way they describe (and understand) their own energy lifestyles, as well as more specific actions or inactions under specific areas such as, for instance, electric mobility (e.g. going by foot or public transport, not having a car or not using it much).
- Economic savings are also considered a prime motivator for actions related to the energy transition, although it is common to observe that for the most part individuals pay less attention to the energy bill than to other expenses.
- Additionally, gains in comfort and health-related considerations may be considered just as important as economic savings, while sustainability values – albeit expressly desirable – do not appear to be the main motivating factor behind manifested resource-efficient behaviours and consumption habits.

4.2.1.5 Individual adoption of energy self-consumption schemes (prosumerism)

Critical knowledge gaps

- Lakc of knowledge whether individual (personal) and place related identities, alongside group (social) identity, can directly predict intention via personal norms and social norms (both descriptive and injunctive) (Udall et al., Under Review a-c). These predictors are yet to be tested for intention to opt for an individualized RES solution such as prosumerism (e.g. using energy in such a way that contributes to transition to a low-carbon energy system).

- No clear understanding of the role and impact of social identity variables on pro-environmental behaviors.
- Limited understanding of the reasons motivating the contradiction between claimed public support to RES and the difficulties encountered in practically introducing RES projects.
- Lack of understanding about the role and relevance of public support through financial enablers for promoting RES uptake (e.g. micro-grant schemes).
- Lack of knowledge on the ways through which different energy market structures affect prosumerism, and particularly on the relevance these may have for the uptake of prosumer alternative rives in emerging energy markets. There is particularly very limited evidence regarding the actual impacts of prosumerism on energy markets and on individuals.
- Insufficient knowledge on the role of utility companies in steering or influencing the evolution of individual adoption and prosumerism.

Main findings

- Some of the knowledge gaps identified were addressed in WP4, through the use of structural equation modelling. The relevant data was collected via an international survey sent out to 31 European countries, comprising 18,040 completed surveys. The knowledge gaps were be summarised in a series of four different schematic diagrams showing the relationship of correlation between the different driving factors (independent variables – e.g., identity) and the acceptance and use of the technological focus/topic (dependent variable - intention to use energy in a way that helps bringing the transition to a renewable energy system).
- The knowledge gaps that were successfully addressed through the methodology outline above are: Individual (personal) and place related identities can directly predict (both individually and collectively) the intention to use energy in a way that helps bringing the transition to a renewable energy system via personal norms and social norms (both descriptive and injunctive) (Udall et al., Under Review a-c).
- In particular, we assessed how identity (individually-, group-, and place-focused identity types) predicts energy intention, and energy policy acceptance via social and personal norms, which we name as the identity-norm-action model (INAM). Furthermore, this model is studied from a multi-group perspective, by focusing on the effects of framing energy choices on different group-size levels, reflective of policy - framing choices, as follows: Municipality, Country, or European Union (EU), compared to individually-focused choices. We also focused on the effects of these framing on different Pro-Environmental Energy Behaviour (PEB) types: i.e., buildings PEB-Focused, mobility PEB-Focused, or smart technology PEB-Focused compared to general PEB-focused choices.
- Results reveal that, irrespective of the group-size reference frame (EU, Country, Municipality), and PEB type (buildings, mobility, smart technology), the main consistent drivers of energy policy acceptance are pro-environmental behavioural intentions and an individually-focused identity (individualistic perspective). Furthermore, what we think others expect from us (injunctive norms, social influence perspective), what we expect of ourselves (personal norms, individualistic perspective), and what we see others doing (descriptive norms, social influence perspective) are correlated with an individually-focused identity. Personal norms are affected by place-focused identity, and injunctive norms. Finally, a group-focused identity predicts these injunctive norms. We can thus recommend that policy acceptance can be promoted by making it personally relevant (cueing intention and an individually-focused identity), which is PEB-focused. Furthermore, there is a need for policies to support consumer-driven energy choices towards pro-environmental energy behaviour from an individualistic, and social influence perspective.
- The individual-level psychological factors at the basis of energy choices assessed in the ECHOES survey are: 1) Economic and Social Political Ideology; 2) Emotion Regulation; 3) Consideration of Future Consequences; 4) Mindfulness; 5) Collective Pride; 6) Moral Anger 7) Climate change perception; 8)

Anthropocentric climate change perception. All measures were taken on a 5-point Likert type scale (ranging from 1 = strongly disagree to 5 = strongly agree), so that higher scores indicate greater factors (only Anthropocentric climate change perception was measured on a 3-point scale). Results reveal that an economic outlook in political orientation is significantlly and positively related to a social outlook in political orientation, emotional suppression and mindfulness, and negatively related to consideration of future consequences, collective pride, moral anger, climate change perception and anthropogenic climate change perception, while a social political outlook is positively related to emotional suppression and mindfulness. Individuals' emotional suppression is significantly positively related to cognitive reappraisal, consideration of future consequences, mindfulness, collective pride and moral anger, and negatively related to anthropogenic climate change perceptions. Cognitive reappraisal was significantly and positively related to following variables: consideration of future consequences, mindfulness, collective proud, moral anger and climate change perception. Individuals' perception about future consequences of their actions was significantly and positively related to following variables: mindfulness, collective proud, moral anger, climate change perception and anthropogenic climate change perception. Individual differences in mindfulness were significantly and positively related to following variables: collective proud, moral anger and climate change perception. Feelings of collective proud were significantly and positively related to following variables: moral anger, climate change perception and anthropogenic climate change perception. Feelings of moral anger were significantly and positively related to following variables: climate change perception and anthropogenic climate change perception.

- Positive feedback is a very important element for people to engage in the energy transition. The positive feedback is obtained from the family, friends, neighbors, or members of the same associations, and can even form part of the regional identity.
- In some national jurisdictions, government authorities are modifying the costs structures of electricity bills by, for instance, significantly increasing the fixed costs of the electricity bill (i.e. the capacity payment), making the variable part (i.e. the actual consumption) much less relevant as a factor determining the final electricity bill of end-use consumers. This affects industrial, commercial, and private consumers alike and works in detriment of energy saving behaviors. It is expected that the cost structures of electricity bills will be substantially modified in the foreseeable future due to the progressive introduction of increasing volumes of renewable energy. This trend is expected to increase due to the drastically different cost structures of renewables (where the majority of costs are capital costs and marginal operating costs are minimal) when compared with their conventional counterparts (where marginal operating costs are more significant and play as big a role as the capital costs). However, this also opens up new business opportunities for technologies that lower the power contracted and level out the consumption peaks, such as microgrids. On some instances, however, national jurisdictions introduce a special capacity tax for renewable energy systems with the objective of making alternative energy solutions economically less attractive (since the prosumer is penalized for lowering the capacity payments). This may slow down and even hamper the acceptance and adoption of clean energy alternatives in both the consumption and production sides.
- Policy on RES implementation should be sensitive to the local context. For instance, promoting micro-funding schemes for small-scale RES for households and SMEs in order to undertake action;
- These micro-funding schemes would have a considerable impact – and are therefore deemed a key element with high potential – for incentivising the production of community-based renewable energy (e.g. in residential areas) in countries with a high share of private ownership on dwellings where formal entities to implement such collective decisions (i.e. the homeowner associations) are already constituted. Furthermore, the involvement of local authorities as investors or initiators of public-private partnerships for deploying localised forms of renewable energy generation could catalyse the increased uptake of renewable energy generation installations.

4.2.1.6 Collective investment and ownership schemes of renewable energy installations

Critical knowledge gaps

- Lack of knowdledge on new forms of collectively-owned energy infrastructure that can emerge through citizen involvement and participation. What enabling factors and barriers for collective action can be identified, and how can policy makers harness such enabling factors and minimise bariers to then formulate energy-relevant framework conditions conducive to citizen participation and ownership? To what extent can these enabling factors/barriers influence and drive changes in energy consumer and prosumer behaviour? These questions point towards a lack of relevant knowledge about context-specific enabling factors and barriers related to RES participation from inidvidual citizens; national legal frameworks, administrative procedures, technical expertise, social and economic affordability, public acceptance, etc. can all work as enablers or barriers and as such they need to be thoroughly investigated.
- There is no existing knowledge on individual citizens' potential to participate in community-based renewable energy (CRE) initiatives. Specifically, no research efforts have been conducted to either quantify or monetise individual citizens' potential to jointly finance CRE initiatives. Furthermore, no research has yet aimed to translate different levels of financial participation in CRE into GHG emissions reductions. As such, important knowledge gaps remain regarding the quantification of individual citizens' measurable potential in decarbonising Europe's energy system and, by doing so, quantifying their GHG abatement potential within a transitionary period towards a carbon-neutral energy system by 2050. In light of these knowledge gaps, important questions remain unanswered regarding

  a) the optimal combination of economic incentives, socio-communal configurations, and policy instruments that can maximise individual citizen investments in CRE generation schemes;

  b) the volume of financial commitment that individual citizens are willing to contribute with for collectively investing in CRE;

  c) the amount of renewable energy that could be generated from citizen-financed CRE initiatives, as well as the volume of GHG emissions that could be abated from such clean energy; and

  d) the impact that such volumes of RE and GHG reductions could have for reaching EU climate & energy 2030 targets (e.g. a 32% RES share in final energy consumption, a 40% GHG emissions reduction).
- There are insufficient integrated evaluation methods that successfully address the impacts of RES initiatives after implementation, particularly regarding uncertainty of costs and benefits stemming from RES implementation strategies and initiatives.
- Deliverable 3.3 policy potential analysis concludes that aspects on values, acceptance, behaviour, or gender are seldom considered in European-level strategy and policy documents. As a consequence, there is limited knowledge on the dynamics of stakeholders' motivations and concerns in regards to RES development. This limits the capacity for learning from practical experience, building confidence and enhancing trust.
- Furthermore, the introduction of social systems in transition studies and modelling – including changes in demographics, behaviour, values, and cultures – is what is most lacking. This applies to both methods and data availability, and may lead to considerable challenges, especially when quantitative modelling is used for policymaking (which is the case both on the EU and national decision-making levels (D3.3, Chapter 2)). This has an inevitable influence on the effective incorporation of social aspects in European policymaking regarding collective investment & ownership schemes of renewable energy installations.

Main findings

- Taking the Energy Culture approach, enabling factors supporting the introduction and consolidation of collective initiatives for RES implementation fall under the compartment "materials, which refers to those areas of action that can be directly shaped by policy makers. The promotion and opening of access to innovative technologies and new forms of energy generation (including new business models and social innovations), incorporating key stakeholders with a strong environmental motivation behind community-anchored initiatives, generating financial incentives (e.g. profit-making attributes through the selling of energy, reduced energy costs, etc.), introducing a social support system (for example in terms of sharing a common identity and ideas) have been identified as positive driving forces enabling the development of collective initiatives for RES implementation.
- Stemming from that same Analysis of Enabling Factors for Consumer Action (Deliverable 5.3), potential barriers preventing the introduction and consolidation of collective initiatives for RES implementation include: a general lack of awareness and environmental concerns, a certain lack of sense of community that hinders collective initiatives, an extremely sophisticated legislation generating legal uncertainty and bureaucratic burdens regarding the setting up of energy related citizen-driven initiatives, and certain technical challenges pertaining, for instance, on the adequacy and stabilisation of the existing grid infrastructure for accomodating increasing amounts of decentralised and highly variable renewable energy inputs leading to increased system stress and potential system failure.
- Legislation on incentives (i.e. funding schemes) has ample room to be clarified, simplified, and in that sense improved. New fields of action for policy makers arise, such as the promotion, coordination, and support of newly emerging local groups, and the management of energy structures including the necessary targeted technology promotion and access (e.g. grid management by smart charging).
- Some important enabling and hindering factors are more difficult to be addressed or influenced by specific public policies; such as for example the intrinsic motivation to do things better and create solutions.
- Furthermore, the results obtained through the completion of Task 6.2 (focus groups and individual interviews conducted with different formal social units) and Task 5.5 (interviews and case study analysis) indicate that certain countries exhibit a markedly uncertain or complex regulatory environment (e.g. Spain's retroactive policy changes on renewable energy support mechanisms and electricity tariffs). These regulatory uncertainties result in the erosion of trust and reduced social acceptance throughout the end-use consumer base, along with reduced investor confidence (both community and corporate investors, as well as individual and collective decision-makers) and therefore poses a real and immediate threat for a cost-efficient and timely energy transition.
- Specifically, the administrative challenges faced by homeowners collectively organised around a RES installation are a clear demotivating factor negatively influencing future collective RES investors. Furthermore, inconsistent market signals and unclear regulatory measures (e.g. non-transparent pricing standards for re-dispatching surplus electricity into the grid) harm participants' trust in public authorities and corporate stakeholders involved in the distribution grid, and by extension reduce the public's confidence and trust in the transition to clean energy alternatives and in the practical applicability of small projects in the urban environment.
- Main drivers behavind RES decisions are pro-environmental attitudes and behaviours of end-users, rather than the financial or economic considerations (investments, benefits/losses) stemming from changes towards more resource-efficient individual consumption patterns or from the adoption of shared, community or collective renewable energy decision-making and initiatives.
- The development of collaborative approaches to renewable energy consumption (such as, for instance, a municipal purchasing company co-owned between neighbourhood associations and municipalities) are seen as effective approaches to promote citizen-driven and community-based RES developments, while at the same time tackling some of the abovementioned regulatory uncertainty/complexity within domestic boundaries.

- Targeted information-provision and training services in order to facilitate the intellectual ownership of a community-led low-carbon energy transition are required. In some cases, these information provision and training services may be provided by new-coming retailers offering renewable energy or by energy cooperatives offering guidance and support to otherwise unexperienced neighbours or groups of consumers. This stands as a key enabling factor that may very well trigger upper level administrative jurisdictions to react with better tailored and more appropriate regulatory frameworks and administrative requirements.
- Regarding the lack of knowledge on the quantified potential to jointly finance community-based renewable energy (CRE) initiatives, as well as the translation of different levels of financial participation into GHG emissions reductions, the completion of the Choice Experiment and the analysis conducted afterwards (see section 2.2.1.1) indicate high interest by the average European citizen for participating in CRE generation schemes, and implies a high acceptance for RE alternatives and a potentially low local opposition. This conclusion stems from a relevant finding which indicates that 79% of survey respondents chose at least one investment option (A or B) presented to them.
- Specifically, on average respondents are more willing to invest in visible, community-administered wind farm cooperatives with relatively short holding periods and providing higher returns on their investments. This remark stems from the results illustrated in Figure 4.1 below, which illustrates the influence that the variables included in each choice option has in the choices selected by the CE respondents.

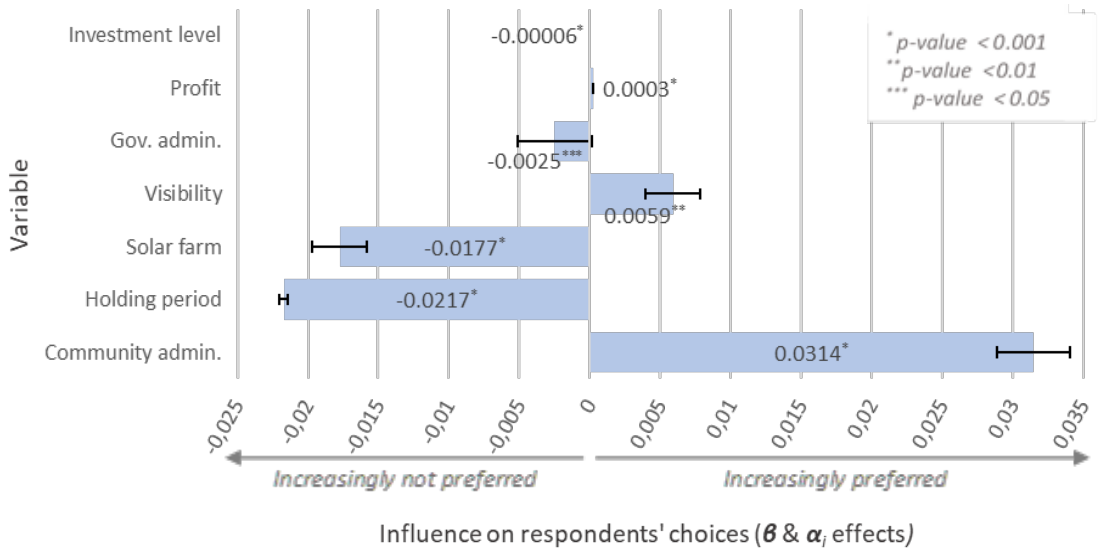


*Figure **4.1 Aggregated effects (β and α_i)** of option-specific attributes and scenario-specific characteristics (i.e. variables) in respondents' willingness to invest across the EU-28 (Pons-Seres, 2019).*

- The **β** effect is a measure of the preference given to an option-specific attribute (profit, visibility, holding period, administrator) by the average individual respondent, while the α_i effect is a measure of the preference given to a scenario-specific characteristic (RE technology, investment level, country), as manifested in the responses given by participants. The **β** and α_i effects are quantified and numerically expressed for each variable showcased by the horizontal bars. Larger absolute values indicate stronger effects of any given variable in the average respondent's choice. For any given variable, positive values indicate increased preference and reflect a stronger willingness to invest, while negative values indicate decreased preference and reflect a stronger unwillingness to invest. Standard error values are illustrated by black error bars (I–I), and p-values (*) are expressed for each variable (Pons-Seres, 2019). As illustrated

by Figure 4.1 above, the results obtained after this first estimation indicate that on average for the entire CE sample across all EU-28 MSs, individual respondents:

- Strongly prefer a community-owned legal entity (i.e. energy cooperative) for administering the RE installation they invest in. They also prefer wind parks above solar farms.
- Are more willing to invest – although not substantially – if they see the RE installation from their household. Specifically, when the RE installation is visible, respondents are on average 0.6% more likely to invest than if the installation was not visible.
- As one would expect, the higher the profit obtained from their initial investment, the more likely they will invest. Specifically, for every additional €100 obtained as profit, we observe a corresponding 2.7% increase in respondents' willingness to invest.
- The longer the holding period the lower the probability respondents will invest: for every extra year respondents have to wait to collect their initial investment and the profit obtained from it, the less attractive the investment becomes and, as such, their willingness to invest decreases by 2.2%.
- The abovementioned attributes represent the most preferred variables that, when bundled together along with combined with the 'holding period' and 'profit rate' variables, maximise the level of investment collected by the average representative individual citizen in every MS and across the EU. As such, the "optimal" investment scenario showcases a 20-year investment on a wind farm, visible to the investor (respondent), and administered by a community-based legal entity (e.g. energy cooperative). This optimal investment scenario is generalised across al EU MSs.
- Assuming that stated choice reflects real choice fo respondents, the individually-obtained funds are multiplied by each country's population with a reasonable expectation to invest (aged between 25-64) to obtain the *social potential* of each MS for collectively investing in community-administered wind farm cooperatives. When aggregated at the EU level, this results in over €176 billion that could potentially be harnessed from European citizens to collectively support community-based forms of RE development, thereby dramatically increasing the deployment of clean energy and, by doing so, accelerate Europe's low-carbon energy transition.
- This result illustrates the enormous untapped social potential of European citizens for collectively financing the development of community-based forms of RE generation. Materialising that potential would undoubtedly transform the Energy Union from a political commitment to a citizen endeavour and help realise its main goal of having "citizens take ownership of the energy transition, benefit from new technologies [and] participate actively in the market" (European Commission, 2015, p. 2).
- When evenly distributed throughout an eleven-year period (corresponding to the period between 2019-2030), the social potential of €176 billion that European citizens could contribute with result in an annual investment of €16 billion; enough to halve the investment requirements foreseen to achieve a 32% RES share by 2030. In light of this huge potential, the EU's energy-related carbon mitigation efforts could greatly benefit from the proactive financial participation and involvement of European citizens. Policies that reach out to and unlock this potential are therefore desirable and should be carefully considered for a timely and cost-effective market-driven implementation of a carbon reduction pathway responding to the climate constraints imposed by a 2°C global warming threshold.
- Furthermore, the total EU installed wind power capacity that could be 'bought' with €176 billion across the EU amounts to a total of 91 GW. This translates into the generation of 196 TWh of clean electricity, which in turn leads to an average 8.3% increase in the consumption of RES across the EU. Figure 4.2 below illustrates this last result dissagreggated for every EU MS).

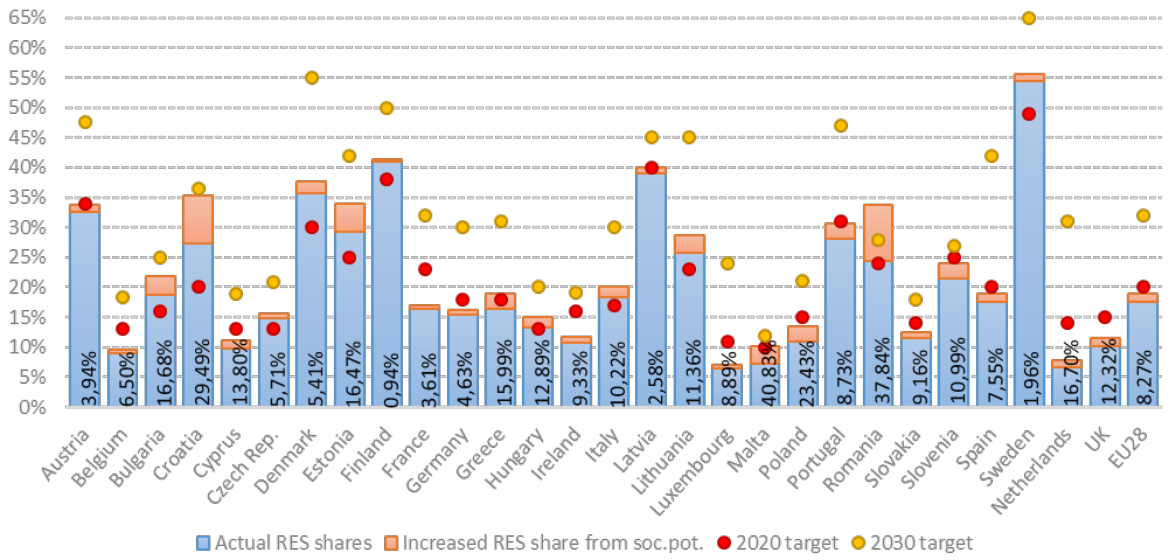


Figure 4.2 Current (2017) renewable energy shares and percentage increase from social potential under current market conditions (subsidy-free) in every Member State and aggregated at EU level; plus 2020 & 2030 national and EU-wide renewable energy targets (Pons-Seres, 2019).

- Finally, the generation of 196 TWh of clean electricity would result in the GHG abatement of over 103.4 $MtCO_2$-eq every single year. This represents a 2.3% reduction in annual emissions from 2017 EU aggregate levels (or a 1.8% annual reduction from 1990 baseline levels). Furthermore, the GHG abatement obtained across the EU amounts to over 3% of the GHG emissions stemming from the energy sector in 2017.
- Considering that the EU's average annual reduction of GHG emissions between 1990-2017 has been of 0.9% (European Environment Agency, 2018), having an additional 2.3% annual reduction from CRE generation schemes inputted into its projected annual GHG emission reductions represents a substantial acceleration of its pace of reduction and, in that respect, can be expected to improve – yet by no means resolve – the EU's performance to achieve its 2030 target within the foreseen timeframe. The EU would still need to reduce an extra 274 MtCO2-eq every year to achieve a 40% annual reduction by 2030, over twice the volume of GHGs emitted by the Czech Republic in 2017.

4.2.2 Electric mobility

The transport sector is one of the main consumers of fossil fuel and hence contributes a substantial share to the EU's total greenhouse gas (GHG) emission. It is also the only sector that still displays increasing GHG emissions (Taefi et al., 2016). This not only increases the fossil fuel dependency but also leads to severe impacts on the environment such as air pollution, noise, resource use and waste, and finally causes climate change. The SET-Plan identifies *electric mobility* as one of the core technologies to be implemented and further developed to enhance road transport sustainability effectively and expedite the GHG emission reductions derived from increased passenger and goods transportation efficiency, as both account for a substantial amount of the environmental impact of EU Member States (Hertwich & Peters, 2009). The SET-Plan, in turn, must be seen as a critical stepping stone allowing the European Commissions to realise its goal of having emission-free urban passenger transportation by 2050 (i.e. no more conventionally fuelled cars in cities) and emission-free urban freight transportation by 2030 (i.e. CO_2 free logistics in cities) (European Commission, 2011).

Key to this shift is electric mobility and in specific the introduction of electric vehicles (EV) (e.g., Usmani & Rösler, 2015). These vehicles fully or partially operate with electric motors and hence enable to reduce fossil fuel dependency and GHG emissions. However, at present, the acceptance of alternative fuel saving transport vehicles is still marginal and sales volume of EVs in the EU is very low, highlighting the need to take decisive action at all decision-making levels in order to increase the acceptance, use, and by extension market diffusion of EVs throughout society and for multiple purposes (commercial and recreational, domestic and freight, public and private).

Electric mobility, however, goes beyond its more 'logic' function of reducing transport-related carbon emissions, and further adopts a role as a demand and grid flexibility device/instrument. In this sense, EVs are foreseen to endow electricity grids with enhanced flexibility for successfully adapting to the increased penetration of clean, yet variable and intermittent, smart energy generation technologies, and thereby ensuring reliability of supply and avoiding system failure.

The transition towards more sustainable forms of mobility, however, must necessarily incorporate the mass-scale use of energy-efficient and decarbonised public transport systems involving fully electrified bus fleets and the expansion and reinforcement of subway systems, along with the increased use of alternative travel mode choices involving biking, car sharing, and electric scooters (e-scooters) through intermodality platforms acting as facilitators for the combined use of different modes of clean transport into a seamless travel experience.

The critical knowledge gaps identified throughout the ECHOES project execution, as well as the main findings obtained addressing them (either fully or partly), are outlined in the following subsections within the 'electric mobility' technological domain:

4.2.2.1 Electric vehicle adoption

Critical knowledge gaps

- Acceptance of mobility technologies is an area where the availability of SSH-related data is the weakest in the transport sector. Therefore more research is needed on the sociopolitical acceptance of low-carbon mobility technologies.
- Values and electric vehicle adoption – indirect as well as direct influences? Values are typically considered a distal predictor of behavior (Klöckner & Blöbaum, 2010; van der Werff et al., 2013; for studies in the context of alternative fuel vehicle adoption see Jansson et al., 2011; Nordlund et al., 2016). There is, nevertheless, some evidence suggesting a more proximal influence of values. In Jansson et al. (2011), egoistic values have a direct effect on the adoption of an alternative fuel vehicle, and biospheric values have a direct effect on personal norm towards purchasing an alternative fuel vehicle. Similarly, in Jansson et al. (2010), biospheric values increase the willingness to adopt an alternative fuel vehicle, albeit the direct effect of values, controlling for personal norms, ascription of responsibility and other factors, is small.
- New Environmental Paradigm and electric vehicle adoption – indirect as well as direct influences? As with values, New Environmental Paradigm is considered to be a distal predictor of behavior (e.g., Klöckner & Blöbaum, 2010). However, in Jansson et al. (2011), the New Environmental Paradigm score also has a direct effect on adoption of an alternative fuel vehicle. Similarly, in Nayum & Klöckner (2014), the New Environmental Paradigm influences the intention to adopt a fuel-efficient vehicle also relatively directly via its effect on attitude, besides its more indirect influence via the moral motivation cascade.
- Existing research (Jensen et al. 2013, 2014; Bühler et al., 2014) indicates that participants' perceptions of – and preferences for – electric vehicles have evolved after being given an opportunity to use one for a trial period of three to six months. These changes, however, did not seem to translate into increased purchase intentions. Therefore, an important venue for future research is to study causal effects of long-term experience with an electric vehicle on adoption and on its determinants (including habit formation, which was not investigated in the above studies). Data should be collected at multiple points in time, rather than just pre- and post-intervention, to gain a more in-depth insight into how preferences and beliefs develop. Also, interactions of experience with other factors should be investigated in detail.
- Consistent with theory (e.g., Klöckner & Blöbaum, 2010), perceived behavioral control is in part explained by objective constraints such as income (Nayum & Klöckner, 2014) or price (Kaplan et al., 2016). These objective constraints could potentially be partly internalized as attitudes as well (Petschnig et al., 2014). This possibility deserves further exploration in order to better comprehend whether attitudes serve as a function of objective constraints (or not) when considering the adoption of electric vehicles. By doing so, this will contribute to bridge the existing knowledge gap regarding personal attitudes and motivations towards the adoption of electric vehicles.
- Findings concerning the impact of contextual factors for constraining or facilitating the adoption of electric (and alternative fuel and fuel-efficient) vehicles are often mixed and effects aggregated across studies could conceivably be quite small. More research is clearly needed and, to that end, a meta-analytic aggregation of previous studies could be a useful tool to clarify and expand the existing knowledge on this domain.
- There is lack of knowledge concerning the role that the personal, place related, and group (social) identities of individuals have for determining (and therefore predicting) the intention to adopt an electric bike as a plausible mode of transportation. These predictors are yet to be tested and therefore merit further analysis.

- Systemic knowledge and practice testing on information strategies about technical issues such as infrastructure, charging points, charging options at apartment buildings and housing estates, range, and maintenance, are missing. Further research is needed in these areas.
- No systematic review of the existing literature considering all the individual level factor impact on electri mobility adoption has yet been conducted up until now. Therefore, comprehensive knowledge on these individual-level factors is still lacking and important knowledge gaps remain regarding the role of personal attitudes and motivations for influencing and shaping pro-environmental and energy-saving behaviours, including the adoption of electric vehicles and/or the use of more sustainable travel mode choices.
- Lack of a robust analysis investigating the climate beliefs of individuals with their adoption and use of electric vehicles.
- There is a lack of knowledge regarding the functionality and acceptance of payment methods and their processing (more complicated than normal purchase transactions).
- There is a need for continual knowledge provision on the structural determinants influencing e-mobility uptake on both the short- and long-run. These may include EV affordability (income and prices), market regulations (fuel taxes, second hand markets an scrappage), fiscal incentives (tax reductions) resources and logistics for batteries, etc.
- No robust understanding of the urban space and infrastructure needed for the uptake of and correct functioning of EVs (assuming traditional scarcity of parking space and distribution constraints are maintained, charging in historical quarters and collective housing estates, low emission zones, etc.), as well as for the introduction of more resource efficient alternatives such as e-car and e-bike-sharing, light duty EVs, etc.
- To what extent are EVs as part of the public transportation fleet affecting price and range issues, and what influence and legacy might they impose on the wider public transportation plans and measures currently in place?

Main findings

- The main factors influencing electric vehicle adoption were the implementation of incentives such as subsidies, tax reductions, and toll waivers. In cases where such incentives were discontinued, the electric vehicle adoption was severely slowed down. Results also indicate as a significant barrier for electric vehicle adoption the lack of awareness on the status of the advancements in electric vehicle technology. Likewise, in many countries, the widespread perception on electric vehicle prices being very high and the insufficiency of charging infrastructure are significant deterrents negatively affecting electric vehicle adoption.
- For electric mobility (and buildings), the WP6 interviews suggest costs (prices) are the major guiding factor influencing in decision-making. Cost considerations are followed by convenience and easy maintenance, reliability of systems. Environmental considerations appear to be a weak influencing factor shaping decision-making.
- According to WP6 interviews in Finland, in electric mobility related decision-making, collaboration and networking between organisations and actors was highlighted and understood as the means to make changes and even large transitions (and also exchange information, e.g. with international counterparts). In Finland as well as in other countries, electric vehicle owners seem to be very active in networking: sharing experiences, building a peer-community and also maintaining dialogue with companies, municipalities and authorities.
- For electric mobility particularly, in addition to general factors described above, WP2 workshop results suggest the level of autonomy as a relevant decisive factor. For example, high dependence on the

availability of charging services may turn out to be a deterring factor negatively influencing an individual's choice between electric mobility and a car equipped with a combustion engine. Relatedly to this, performance and infrastructure for electric mobility was also mentioned as a relevant influencing factor. Further, an image of being a forerunner was discussed as a decisive factor related to electric mobility. (D2.1, D2.1 Annex). In fact, forerunners were assumed very important, both in policymaking and in business (the interviews analysed in D6.1).

- Contextual factors constraining or facilitating the adoption of electric (and alternative fuel and fuel-efficient) vehicles may include income, household size, or bus lane access for electric cars, as well as a number of monetary and non-monetary cost factors, such as high purchasing price, limited range, long charging time, and underdeveloped charging.
- The knowledge gaps identified for the electric bike adoption were addressed in WP4, through the use of structural equation modelling. The relevant data was collected via an international survey sent out to 31 European countries, comprising 18,040 completed surveys. The knowledge gaps were be summarised in a series of four different schematic diagrams showing the relationship of correlation between the different driving factors (independent variables – e.g., identity) and the acceptance and use of the technological focus/topic (dependent variable - electric bike). The knowledge gaps that were successfully addressed through the methodology outline above are[4]: Individual (personal) and place related identities can directly predict (both individually and collectively) the intention to use the electric bicycle via personal norms and social norms (both descriptive and injunctive) (Udall et al., Under Review a-c).
- In Austria, there are several e-car promoting programmes. Experiences with a public e-car sharing programme in one of the provinces were analysed in detail (Task 6.4.). This programme provides considerable co-funding for municipal or enterprise initiatives that offer public e-car sharing opportunities, accessible for anyone. The province intended to provide an impetus for behavioral change, including the later private purchase of e-cars and the PV production by e-car owners. In the practice of municipalities, E-car sharing as a pilot project is regarded as a success, meeting climate-related goals of the municipalities. One effect is that many citizens plan to buy e-cars in the future based on their positive experiences. Despite being considered a good approach and success, e-car sharing it is not yet the solution for people living in decentralized (rural) locations, because they need their own (fossil-fuelled) car to get to the e-car locations. Municipalities that tested e-car sharing co-funded by the provincial government are planning to purchase more e-cars and construct more charging points, even if external funding decreases. The municipalities are convinced that their feedback to the state administration level contributed to the success of the follow-up campaign that is now started by the province.
- On the other hand, the point of view of small private business initiatives in e-cars sharing (Task 5.5.) is somewhat different. Their approach is not to apply for any kind of funding for any of the electric vehicles, as they just never wanted that. Their interest is to put their thoughts and ideas into practice, to show them to others and to learn that it works if you do it properly. However, they claim that public decision-makers prioritize central initiatives and have committed themselves to keeping it that way for the next few years. In their view, a lot is planned in provincial or municipal energy departments and a lot of subsidies for e-mobility are used, a lot of paper is produced and at the end of the day things fail because they are simply unattractive and not tailored to the use. They complain that politics simply claims ownership of the topic and actually does not allow any competitors, and that small business operators are given no chance to implement their ideas.
- EVs have the potential to substantially alter inhabitant lifestyles due, for instance, to modifications in commuting patterns as well as to changes in preferred choices for ordinary (daily) and extraordinary (vacation) mobility preferences. Furthermore, EVs may also eventually alter – and even disrupt – the existing built infrastructure due to their different energy needs as well as the way through which these

[4] The knowledge gaps summarized are relevant for other areas such as providing consumers information about their energy use behaviour, heating & cooling (i.e. preferred temperature), renovations for energy efficiency (i.e. retrofits), and individual adoption and prosumerism.

need to be met (e.g. reduction of gas stations, increase in EV charging facilities – including households, etc.).

- Public perception of subsidies for EVs may not necessarily correlate with policy intention behind their function and utility. In other words, the wider public may perceive the idea that with higher subsidies the object subsidised may in fact become more expensive, precisely because the costs of those subsidies are eventually past on through to the final consumer, who on occasions bears the costs of the subsidy scheme in question.
- In some jurisdictions, there is the perception that EV adoption by public and corporate players obeys to a public image strategy resembling a greenwashing approach, rather than resulting from a genuine interest in transforming or transitioning towards more resource-efficient and sustainable mobility practices. This view risks having the general public rejecting or questioning the utility and validity of the introduction of EVs within urban transportation hubs and, as such, represents and important risk element to prioritise and properly tackle in order to transition urban mobility patterns towards low-carbon alternatives.

4.2.2.2 Sustainable public transport & Travel mode choices (e.g. biking, car sharing, walking, etc.)

Critical knowledge gaps

- There is a lack of understanding on how different information-provision methods can disseminate complex information in an easily accessible format in regards to different mobility options within particular regions (tickets, timetables, etc.) in order to trigger desirable choices from a range of different transport modes.
- There is limited knowledge on how to deal psychologically with the aspect of "free vs. restricted" mobility: awareness of private (freely available) and public (restricted) mobility.
- There is a clear knowledge gap in regards to the contribution that public transport alternatives have as part of an integrated public regional and urban low-carbon transportation policy that – albeit necessary – only represents one part of a broader set of solutions for achieving sustainable urban development.
- Furthermore, there is insufficient knowledge on the implications of energy efficiency measures as an element of integrated local and regional spatial planning policies (public transportation included), as opposed to sector-oriented policies.
- There is a lack of understanding on the effect that the energy efficiency of public transportation options and its related infrastructure has on regional and urban decision-making and policy choices on land use including new development location, densification and regeneration alternatives.
- There is insufficient knowledge on the energy efficiency of intermodality and related behaviour modes, as well as on the attitudes of passengers and urban logistics companies towards intermodal mobility. More specifically, there is limited understanding of context-related factors (e.g. spatial configuration of residence-occupation-recreation environments, institutionalised cultures), and personal lifestyles and experiences (e.g. users' comfort), influencing individual attitudes and behaviours to different travel mode options; and how these attitudes and behaviours potentially influence travel mode availability.

Main findings

- Mobility was included as a one of the the main areas of enquiry in the international survey conducted across 31 European countries. As outlined in Section 2.2.1.3, survey data was obtained regarding mobility related lifestyles of end-users with different energy consumption profiles, as well as on specific use patterns and attitudes towards different public transport options utilised for different purposes (e.g. daily trips towards the workplace, occasional leisure trips). Additional data regarding mobility patterns was

further obtained from the execution of Tasks 5.1 and 5.2, which employed a mixed methods approach for identifying behavioural patterns of public transport and related user preferences.

- Results indicate that public transport appears to be the preferred mobility option for work-related travelling for those individuals who have access to a reliable transport infrastructure (e.g. subway system, tramway system, public bus fleet). Private transport alternatives such as individual cars are rarely used for work-related travelling as long as reliable public transport services are available. Specifically, results stemming from the execution of Tasks 3.1 & 6.1 (addressing travel behaviours and attitudes), Task 5.2 (on travel mode choices), and WP 4 (on users' public/shared transport choices) indicate that individuals with high energy consumption profiles explicitly manifest the use of personal transport alternatives (e.g. individual car) for daily working commutes, with a particularly high user incidence for daily trips longer than 10 km in one direction. In other words, there is a generalised high use of personal travel mode options (i.e. car ownership) from high energy consumers with a daily commute to work destinations, particularly when that commute stands at 10 km (or more) of distance. Alternatively, individuals with low energy consumption profiles perform their daily work commute either by walking (when this does not take more than 15-20 minutes in one direction), cycling, public transport, or a combination. Although walking was also preferred by some high-profile respondents for health considerations.
- Alternatively, people make higher use of individual cars when it comes to their leisure trips (within the country and within the boundaries of a specific region) regardless of the individual's energy consumption profile. This occurs because of the comfort and flexibility that individual travelling alternatives provide to users. For holiday trips to different countries, air travelling is the leading transportation mode for high energy consumers, with individual car and bus/train alternatives being more widely used by individuals with low energy consumption profiles. Furthermore, convenience and comfort factors, as well as health-related considerations, seem to play a more prominent role than energy-related savings for determining or influencing individuals' travel mode choices. Additionally, time is consistently outlined as an important factor influencing travel mode choices, regardless of the energy consumption profiles (high, medium, low) of individuals.
- Consistent with logic assumptions, findings from an analysis of survey responses indicate that the higher the amount of money required to pay per trip/ticket, the lower the willingness to pay for upgrading the public transport system towards a more environmentally-friendly one. Similar results occur when considering higher taxes: the higher the amount of taxes to be paid for a more environmentally-friendly transport system, the lower the willingness to pay.
- Additionally, the more satisfied an individual is with the current transport system, the more willing he/she will be to pay for a more expensive ticket/trip if this means that the transport system will be more environmentally-friendly. Alternatively, when respondents are dissatisfied with their current transport system, their willingness to pay for a more expensive ticket/trip as a means to have a more environmentally-friendly transport system is reduced, although they would still be willing to pay for it. A similar trend is observed when correlating respondents' levels of satisfaction/dissatisfaction with paying higher taxes for a more environmentally-friendly transport system.
- Furthermore, when individual respondents view the current transport system as already being environmentally-friendly, the are not willing to pay for a more expensive ticket/trip in order to have what they might consider an even more environmentally-friendly transport system. Since they allready perceive the current one as being environmentally friendly, why pay for an unnecessary upgrade? Similarly, individual respondents are not willing to pay higher taxes; this even goes for respondents who think the current transport system is not environmentally-friendly. In other words, regardless of their view on the environmental sustainability of the current transport system, no respondents are willing to pay higher taxes for an upgrade, yet they are willing to pay for more expensive tickets (as long as they perceive the current transport system as improvable from an environmental sustainability standpoint).

- Finally, the higher the frequency of use of public transport by a given individual survey respondent, the higher his/her willingness to pay for a more expensive ticket/trip but the lower hi/her willingness to pay higher taxes as a means to upgrade the current transport system to a more environmentall-friendly version.

4.2.3 Buildings

The last technology focus, *buildings*, includes construction activities, insulation, energy efficiency upgrading, heating, cooling, illuminating, energy use behaviour in closed spaces (demand-side management). An efficient and sustainable use of the territory resulting in compact urban structures, was outlined among the four main aspects of key importance for urban sustainability (Leipzig Charter on European Sustainable Cities, 2009). Furthermore, the significant reduction of energy demand from buildings infrastructure (either through a resource-efficient building structure and envelope and/or via mass-scale retrofits) is a prerequisite for meeting Europe's GHG emissions reduction targets, with the end goal of having Nearly Zero-Energy Buildings (NZEBs) by 2020. Energy and resource efficiency, however, must necessarily be combined with a drastic increase of renewable energy production and consumption both under domestic and industrial/commercial building settings.

Along with renewable energy in buildings, the smart use of energy via interconnected, intelligent energy systems must be seen as an additional priority measure underpinning Europe's broader transition towards carbon-neutral buildings infrastructure. In that respect, factors such as information, awareness and attitude towards energy efficiency adoption and hidden costs and risk aversion, appliance standards, energy labelling and certification programmes, energy efficiency obligations and quotas, building codes, energy performance contracting, energy and fuel prices (Persson & Grönkvist, 2015; Ástmarsson et al., 2013) all play a critical role as drivers (or barriers) influencing both the formal decision-making units acting as policy makers and/or energy providers, and the collective decision-making units which are more formally structured with relatively small information and power asymmetries, as well as individuals.

Furthermore, individual energy user perceptions, attitudes and behaviour, such as environmental motivation, energy-saving behaviours, perception and visions of renewable energy perceptions of "sustainable" or "green" buildings, readiness to adopt sustainable building practices (Lilliestam & Hanger, 2016) also play a significant role within the abovementioned policy goals and as such must be taken into account and more thoroughly understood.

The critical knowledge gaps identified throughout the ECHOES project execution, as well as the main findings obtained addressing (either fully or partly) them, are outlined in the following subsections within the 'buildings' technological domain.

4.2.3.1 Renovations for energy efficiency (i.e. retrofits); heating & cooling

Critical knowledge gaps

- For energy efficiency renovations, there is an overburdened complexity inherent in renovation processes: combination of structural refurbishment with adaptation of the heating system – notion of "quality improvement of the building as a whole". This complexity stems stems from the combination of technological, social and policy aspects to address together. There is also an impairment of living (use) during refurbishment: Involvement of users. Finally, there is a need to overcoming the investment hurdle: high investment costs compared to long payback periods.

- For heating and cooling, there is a need for studies and scenario building on significant increase in the importance of cooling (in Central Europe). There is also an increased need to better understand individual perceptions of indoor climates and how to deal with it: (felt) temperature, ventilation behaviour (shock ventilation), overheating in summer (using sun protection), weak points in the building envelope (windows, thermal bridges), control options (thermostats), lighting (efficient illuminants), etc.
- There is insufficient knowledge on the challenges of household retrofits stemming from legislative imperatives rather than from homeowners' personal motivations. These include problems related to, for example, condominium management and decision-making (knowing and contacting the owners, registering condominium associations, identifying activities and expenditures; action plans, etc.).
- There is also the need to better understand how and to what extent context-specific motivations influence individual behaviour on property use and related energy use for heating, and how lifestyle and behavioural changes result from a more robust contextual knowledge.
- Urban aspects influencing thermal comfort and heating/ cooling energy needs should be better comprehended, especially those concerning location, urban morphology, etc. These are rather generally addressed, with growing negligence of bioclimatic architecture, and sensitivity to the environment. As concluded from Deliverable 3.1 the same goes with cultural differences between regions, there is a better need to comprehend changes in preferred temperature thresholds affecting specific heating/cooling-related energy consumption patterns.
- Understanding the complex dimensions of energy vulnerability/poverty in relation to heating/ cooling and its impacts on the energy transition process.

Main findings

- In some countries with a large quantity of multifamily housing stock, there is no existing tradition in joint management of the common property, and professional management of residential buildings is a virtually unknown practice. This poses a challenge for the implementation of large-scale refurbishments, as these request the active involvement and participation of all co-owners for the implementation of complex technical measures to meet high building standards. Furthermore, building retrofits can be quite costly and demand a considerable pool of funding, yet in some countries general impoverishment of the inhabitants cannot personally finance retrofits for their privately-owned dwellings without some supporting financial mechanisms (e.g. preferential loans and subsidies).
- The study of the national context dynamics within Task 5.4 outlined a dramatic picture regarding energy vulnerable households in Bulgaria. According to Eurostat (2003) 46,6 % of Bulgarian citizens are unable to sustain thermal comfort in their households, thus ranking Bulgaria in the first place among the EU-28. Furthermore, a World Bank report (2016) highlights that 39% of the households in Bulgaria are not able to cover their energy needs and 44,9% cannot reach adequate heating comfort. These studies were corroborated with the findings stemming from the discussion panel on energy memories (Task 5.4), as it provided important insights on the thermal dimensions of the social and economic crisis and the electricity schedules in 1980s-1990s in Bulgaria; confirming a prolonged social practice of switching off central heating devices at home and adapting to a reduced thermal comfort in winter (13-14 °C) due to low household incomes. These result demotrate again the span of heteregenity across European contries and importance of careful investigation of local contexts.
- Data obtained from the field, through interviews and focus groups carried out in the context of Deliverable 6.2 revealed the preferred temperatures concept as an important phenomenon influencing heating/cooling-related energy decisions and consumption patterns. There are significant differences, for instance, across countries, regions, as well as between different income groups, and even between individuals. The facets of the heating and cooling temperature choices include cultural, economic, demographic, and environmental factors.

- The in-depth interviews and focus groups carried out in the context of Deliverable 6.2 pointed out important process dynamics that deserve further analysis. These include ownership structures, the perceptions of risks and uncertainties, long return on investment periods, all of which complicate the associated process and bring challenges to the decision-making situation. Such difficulties associate with individuals jointly acting towards building renovations. Therefore, the role of the local governments in renovations for energy efficiency becomes a critical one. The local governments, usually municipalities, provide good examples for individuals, supply information on the renovation process and its associated costs, share information about how to access expert technical people, and provide consultancy on legal aspects of renovations.

4.2.3.2 Energy use in buildings

Critical knowledge gaps

- Many large-scale field experiments on normative influences on energy consumption are primarily designed as program evaluations (Allcott & Rogers, 2014) and, as such, the treatments used augment normative information with, for instance, energy saving tips. This means it is not possible to isolate the unique effect of norms in these studies, even though they are assumed to be a key element of the interventions. As a consequence, the internal validity of these field experiments is challenged. As such, there is a clear need to craft carefully designed field experiments along with complementary survey methods in order to more accurately investigate through which specific channels a given treatment influences behaviour.
- Additionally, the impact of normative interventions can be further increased – and its effect further enhanced – by targeting those who are most receptive to norms, such as people with certain personality traits (Komatsu & Nishio, 2015), people who identify with the norm source (Terry & Hogg, 1996; Terry et al., 1999; Wenzel, 2004; Louis et al., 2007; Masson & Fritsche, 2014), heavy energy users (Schultz et al., 2007; Allcott, 2011; Ayres et al., 2012; Komatsu & Nishio, 2015; Sudarshan, 2017; Asensio & Delmas, 2015), or people previously indifferent to conservation issues (Bamberg, 2003; Göckeritz et al., 2010). Furthermore, combining normative interventions with other measures can yield more effective normative interventions on those target groups previously identified as more receptive and responsive to norms. These "other measures" may include increasing behaviour visibility (people respond more strongly to norms when their behaviour is observable – Vesely & Klöckner, 2018), or increasing energy prices (people respond more strongly to price increases when they are also provided with normative information and individual consumption feedback, Sudarshan, 2017). These two additional strategies (i.e, making use of interactions between norms and various internal and external factors) should therefore be explored in more detail in the domain of energy consumption in buildings, where this type of research has so far been limited.
- A good understanding of whether and how habits shape energy-related behaviours is important for designing interventions to discontinue undesirable habits and instil new, more desirable ones. However, research on the role of habits in energy-related behaviours is limited. There is some evidence that past behaviour influences energy conservation (Macey & Brown, 1983; Webb et al., 2013; Schultz et al., 2015) and investment behaviour (Macey & Brown, 1983; Wang et al., 2017; Wolske et al., 2017). But while intuitively past behaviour can be expected to correlate with habits, they are not the same thing (Verplanken & Aarts, 1999; Bamberg et al., 2003; Thøgersen & Ölander, 2003). This is because past behaviour might be correlated with current behavior even when stable habits have not been formed – in particular when other stable factors (e.g., norms, attitudes, situational constraints) exert an unchanging influence on behaviour over time. Future research should therefore address this issue, for example by measuring habits explicitly using suitable scales.
- Overall, findings concerning the impact of situational constraints/influences on energy-related behaviour (both energy consumption and energy-related investments) are mixed, and thus more research is needed, as well as aggregation of previous results by meta-analytic means.

Main findings

- Situational influences on energy consumption may include weather conditions (Allcott, 2011; Ayres et al., 2012; Asensio & Delmas, 2015), square footage and construction year of one's home (Stern et al., 1983; Allcott, 2011; Ayres et al., 2012), household size (Allcott, 2011; Ayres et al., 2012; Harries et al., 2013; Komatsu & Nishio, 2015), energy prices (Jessoe & Rapson, 2014; Sudarshan, 2017), income (Allcott, 2011; Ayres et al., 2012; Schultz et al., 2015), as well as automatization and other technological factors (Murtagh et al., 2015).
- Situational influences on energy-related investment intentions and behaviors may include income (Welsch & Kühling, 2009; Yao et al., 2014; Korcaj et al., 2015; Rai & Beck, 2015; Yang & Zhao, 2015; Wang et al., 2017; Wolske et al., 2017), monetary costs (Korcaj et al., 2015; Wang et al., 2017), household size (Stern et al., 1983; Welsch & Kühling, 2009; Wolske et al., 2017), square footage of one's home (Wolske et al., 2017), and policy interventions, such as subsidies and regulation (Yao et al., 2014; Yang & Zhao, 2015; Wang et al., 2017; see de la Rue du Can et al., 2014 for a thorough overview of different policy measures).
- Situational influences on preferences for green electricity may include income (Clark et al., 2003; Ek & Söderholm, 2008; Welsch & Kühling, 2009), monetary costs (Ek & Söderholm, 2008; Welsch & Kühling, 2009; Litvine & Wüstenhagen, 2011; Alam et al., 2014), and household size (Clark et al., 2003; Welsch & Kühling, 2009).
- Furthermore, the concept on energy memories has been a useful conceptual resource for highlighting the inherited and institutionalised energy consumption cultures, dynamics, and attitudes throughout a 35-year long period. When properly employed, analyses utilising the energy memories conceptual resource can aid in the understanding of how the temporal evolution of resource-efficient and resilient settlements can unfold due to the historical evolution of pas energy consumption patterns, cultures, habits, behaviours and attitudes.

4.3 Integration and summary of findings

Table 4.1 presented below showcases a consolidated version of the more detailed set of main findings disclosed in the preceding section. It specifically showcases a set of empirical findings categorised, firstly, under one particular ECHOES technological focus, and secondly as pertaining to a specific subset under that particular focus.

Importantly, the majority of findings are not exclusive to the particular focus under which they are categorised, but may very well have an impact on other technological foci. In other words, the findings disclosed below are not mutually exclusive but rather porous and permeable, with important relations of influence that, when addressed through a more holistic lens, advance a detailed yet global picture with important interconnections occurring constantly and manifested jointly in the form of certain influences and explicit choices throughout the various different social domains included in ECHOES. Furthermore, the main policy findings identified at the beginning of the preceding section are also incorporated as an intrinsic element influencing all technological foci included in ECHOES.

Table 4.1 Consolidated findings of ECHOES research activities under the three different technological foci analysed throughout ECHOES.

	Electric mobility 	Buildings 	Smart energy technologies 		
General energy policy	***Sustainable public transport & Travel mode choices***	***Renovations for energy efficiency (i.e. retrofits); heating & cooling***	***Data availability for smart energy technology***	***Lifestyle-specific energy use***	***Individual adoption of energy self-consumption schemes (prosumerism)***
	• Public transport is the preferred mobility option for work-related travelling for people with access to it. In such cases, private transport alternatives are rarely used, except for high energy consumers (they prefer private transport options). There is heavier use of individual cars leisure mobility regardless of energy consumption profiles. • Time, convenience and comfort, and health-related considerations play a more prominent role than energy savings in influencing individuals' travel mode choices. • Higher satisfaction with the current transport system leads to increased willingness to pay for more expensive ticket/trip or higher taxes to upgrade public transport system. • Perceptions of the sustainability of the public transport system has a negative influence on willingness to pay for environmental upgrades. • The higher the use, the higher the willingness to pay for a more expensive ticket/trip but the lower the willingness to pay higher taxes as a means to upgrade the current transport system to a more environmentally-friendly version.	• Collective action for building retrofits is an effective solution in some countries due to acknowledge impact of measures, available national/EU financing schemes, the commitment of public authorities in training, information distribution, and mediation. • In countries with high level of energy poverty especially, the adequacy of energy assistance programs is questioned along with lack of transparency and citizen control over the energy system. • The 'preferred temperatures' concept is an important factor influencing heating/cooling-related decisions. There are significant differences across countries, regions, and income groups. Facets of the heating and cooling temperature choices include cultural, economic, demographic, and environmental factors.	• The lack of a commonly used understanding of "smart energy technology" could be partly overcome with the development of an up-to-date multidisciplinary & multifocal public database including data energy cultures, consumer behaviour, acceptance, and gender issues, regional differences, socio-demographic factors, ease of a solution, environmental and ecologic consciousness and lifestyles, awareness and level of knowledge as described in Deliverable 2.2. • Data privacy is a critical factor influencing energy choices. Ease of use and access to technology is also as decisive a factor in driving energy related choices within all three decision-making levels.	• Psychological parameters are not strong predictors of energy behaviour patterns. Therefore, ecological attitudes or values may not be used as proxy variables for predicting behaviour. • Mobility is the main behavioural factor for distinguishing between high- and low-energy lifestyles. It is the most energy intensive behavioural domain in 6 different countries.	• Individual environmental and place-related identities directly predict intention to use energy more sustainably. This occurs mediated via personal and social norms. • Positive feedback is a key element for engaging in the energy transition. This is obtained from family, friends, neighbours, etc. and can be part of the regional identity. • Some national governments increase the *fixed* costs of electricity bills, and this works in detriment of energy saving behaviours. Increasing volumes of RE consumption will modify the cost structures of electricity bills, opening up business opportunities to lower the power contracted and level out consumption peaks. • Micro-finance and the participation of local authorities as co-investors will be key elements for incentivising the production of CRE.

Electric vehicle adoption	*Energy use in buildings*	*Information provision on energy demand behaviour*	*Choice & awareness of low-carbon electricity purchase options*	*Collective investment and ownership schemes of renewable energy installations*
• Costs are the most influencing factor for EV adoption, followed by income, financial incentives, convenience and maintenance, household size, and bus lane access; environmental considerations are a weak influencing factor. Lack of technology awareness, misperceptions on high EV prices and insufficient charging points are significant deterrents. • EV owners are very active in networking: sharing experiences, building a peer-community, and maintaining dialogue with companies, municipalities and authorities. • Individual environmental & place-related identity directly predict intention to use the electric bicycle via personal and social norms. • Municipalities incorporating EV sharing pilot services view it as a success and important tool to meet climate targets. • Small businesses have important reservations about the effectiveness of municipalities' pilots and are not overly enthusiastic to transition to e-mobility. • EVs may substantially alter lifestyles due to changes in commuting and preferred choice patterns. They may also eventually alter the existing built infrastructure due to different energy needs and how these need to be met. • There are real risks challenging the introduction of EVs into urban transportation hubs due to public rejection and lack of public trust.	• Situational influences on energy consumption include weather conditions, square footage and construction year of one's home, household size, energy prices, income, and automatisation. • Situational influences on energy-related investment intentions and behaviours include income, monetary costs, household size, square footage of one's home, and policy interventions such as subsidies and regulation. • Situational influences on preferences for green electricity include income, monetary costs, and household size. • When properly employed, analyses utilising the 'energy memories' conceptual resource can aid in the understanding of how the temporal evolution of resource-efficient and resilient settlements can unfold due to the historical evolution of past energy consumption patterns, cultures, habits, behaviours and attitudes.	• The smart meter rollout strategy in Europe has not had the expected success due to low acceptance at the household (micro) level. Few efforts exist to provide end-use energy consumers with consistent and reliable information on their energy use behaviours and consumption patterns. • Prolonged education-provision policies and awareness-raising campaigns will be needed in order to expedite the technology learning curves of end-users – particularly in younger generations and first-time users. • Addressing the element of awareness on consequences related to climate change must complement economic motivations for driving user changes. • A smooth and fast rollout of smart meter technology requires a) more attention to personal norms/habits and social identification, b) a customer segmentation to identify and develop policies targeting energy lifestyles/cultures/ memories; and c) identifying impact factors that inform "decision making" frameworks including among others socio-psychological, cognitive and economic factors (Deliverable 6.2).	• High heterogeneity between countries regarding different low-carbon electricity purchase options, and on availability of information about the source of electricity available for purchase. • Choices on low-carbon electricity purchase options are not solely individual choices, but a result of different of factors including national energy portfolios, market dynamics, and cultural factors. These vary greatly between countries. • Austere and resource-efficient behaviours influence individuals' energy-saving choices, affecting consumption profiles. People's self-perception of austerity and resource-efficiency influences the way they describe their own energy lifestyles. • Economic savings are a prime motivator for energy-related actions, although less attention is payed to the energy bill than to other expenses. • Increased comfort is considered as important as economic savings, while sustainability values are not a motivating factor for resource-efficient behaviours and consumption habits.	• There is high interest by citizens to invest in CRE when it consists of a 20-year investment on a visible wind energy cooperative. It results in a social potential of over €176 billion to collectively support CRE. This would be sufficient to halve the investment requirements needed to achieve a 32% RES share by 2030. It would generate 196 TWh of clean electricity, increase by 8.3% the consumption of RES, and annually reduce GHG emissions by 2.3%. Stakeholders with strong environmental motivations, financial incentives, and social support systems are enabling factors driving the development of collective RE initiatives. • Barriers preventing collective RE initiatives include: lack of environmental concerns, weak sense of community, complex legislation & regulatory uncertainty, bureaucratic burdens, weak market signals, and technical challenges of power grid. This results in eroded trust and reduced social acceptance on end-use consumers, and reduced investor confidence. • Collaborative approaches between municipalities & communities are effective in promoting CRE. This must be supported by targeted information-provision and training services that facilitate intellectual ownership. This may trigger better-tailored regulatory frameworks and administrative requirements.

• Individual citizens – in their role as consumers – have made their way into the centre of the political agenda.

• Consumers are expected to have a more proactive role in the energy transition. However, the predominant view of consumers as economically rational actors limits our current understanding of individual citizens' new role in this new energy paradigm. Broadening the conceptualisation of energy consumers as a multi-faceted, multi-purpose, and complex energy actor will unlock a more refined understanding of the potential new contributions provided by citizens.

• The need for this renewed understanding positions SSH knowledge as a key contributor. However, the richness and contribution of SSH knowledge is as of today not reflected well enough in policy and strategy documents. Furthermore, the support for developing interdisciplinary research can be a game-changer in unlocking a more accurate understanding of consumer's energy choices and future policy-making.

4.4 Gender perspective

As stated previously the "the overarching objective of ECHOES (Energy CHOices supporting the Energy union and the Set-plan) is to unlock the policy potential of an integrated social science perspective bounded by central socio-cultural, socio-economic, socio-political, and gender issues that influence individual and collective energy choices and social acceptance of the energy transition in Europe". The gender issues were assessed and taken into account early on in the project and analysed throughout the mentioned in previous sections research activities and data collections.

While there are studies on gender perspective in the field of energy consumption, for instance some show evidence of difference in the way energy-consumption decisions are made by males and females suggesting higher total energy use by men (Raty and Carlsson-Kanyama, 2010), others focus on travel choices and that energy use for travelling was higher for men than for women in most income classes and age groups (Carlsson-Kanyama and Lindén, 1999), while more recent studies with focus on EV adoption also show that men report greater usage rates for cars and EVs, greater chances of ownership an EV, and greater distances travelled every day via a private car (Sovacool et al.; 2019), we still identified significant gap in terms of empirical research of gender specific in energy decision making during the stage of data availability assessment conducted in Deliverable 2.1. According to our finding while ppopulation data was assessed as the best-covered topic, areas such as energy cultures, consumer behaviour, acceptance, and gender issues were assessed as the ones with the weakest coverage. So inclusion of gender issues is required in the Database as defined in the respective description of Deliverable 2.2.

Looking at some specific identified during ECHOES research activities results, we find that at meso-level a set of energy practices, cognitive norms, and material culture (e.g., technology, available financial resources) that jointly influence people's decisions about energy-related behaviour, varies across different social contexts and gender. For instance, the role of emotions in energy saving might be particularly relevant for specific social groups (for instance among men, compared to woman), while the link between identity and pro-environmental behaviour seems to be stronger among women than men. This would imply that men might be more successfully addressed by campaigns or policies that make use of behaviour-specific emotional arguments, while women might be more effectively reached through campaigns or policies based on an overarching social identity focus. The scientific understanding of this crux might be relevant to tailor policy campaigns and interventions because.

Further on, during the psychological experiment in Spain reported in D4.2, another difference was confirmed suggesting that women donated substantially more to a RE initiative than men. Similar trend is confirmed by results of the survey and willingness of women to donate which was estimated to be higher for female respondents than for male. At the same time in the survey choice experiment male showed a higher interest in investment in community-owned renewable energy project than women. Such a finding can be related to the fact that women as suggested by (Lapniewska, 2019) when considering participation in an energy collective pay more attention to other factors than men including size of the community, as well as share of women participating and management structure involved. Together with the results of meta-analyses and psychological experiments such finding suggest important differences in terms of varying role of emotions as well as context and even administrative factors which can be taken into account and more effectively reached through campaigns or targeted policies. While we find no statistical difference in the survey question regarding renewable energy project the gender issues do not play an important role and same applied to willingness to upgrade the current transport system to a more environmentally-friendly version, such results again underline the importance of investigating gender specific attitude in each context related to energy consumption.

5. CONCLUSION

5.1 General

The European Commission has set a long-term target for realising a carbon-neutral economy by 2050 (EC 2011a, b). The goal of the European Union and its Member States is to promote a market-driven transition to fully decarbonised, sustainable energy system with citizens at its core. Communication "A policy framework for climate and energy in the period from 2020 up to 2030" (EC 2014) included the first proposal of the climate and policy framework up to 2030, which was discussed further in the "Clean Energy for All Europeans " legislative proposals, which were published in November 2016. The proposal has three main goals: putting energy efficiency first, achieving global leadership in renewable energies and providing a fair deal for consumers. Therefore, the central focus and aim of the so-called Winter Package are proactive consumers, who are the central players on the energy markets of the future. Future consumers across the EU should, on the one hand, have a better choice of supply, access to reliable energy price comparison tools and the possibility to produce and sell their own electricity. On the other hand, it is necessary to mitigate the societal impact of the clean energy transition and the package also recognizes the risks of "energy poverty" and thereby includes measures to protect the most vulnerable consumers against rising energy bills.

Against this backdrop, ECHOES (Energy CHOices supporting the Energy union and the Set-plan) addresses the knowledge gaps resulting from insufficient data and the fragmentariness of existing research on the individual and collective energy-related memories, cultures and lifestyles, the resulting social changes and levels of acceptance/engagement, the political feasibility, and the institutional aspects to be considered in order to facilitate and catalyse a more holistic and multidisciplinary understanding of the main driving factors influencing particular energy-related choices and behaviour, and by extension the level of acceptance and engagement of individual citizens and communities in the low-carbon energy transition in Europe.

To that end, the overarching goal of Work Package 7 (WP7) is to harness the scientifically-grounded knowledge obtained in the ECHOES project with respect to energy-related choices and behaviour; and to advance a set of policy-prescriptive recommendations and strategies tackling individuals' acceptance, engagement, and complicity with energy policy measures and instruments advancing the Energy Union and SET-Plan.

As a starting point to operationalise this overarching goal, the first Deliverable (7.1) under WP7 concentrates, firstly, on summarising the critical knowledge gaps identified from earlier scientific work. This is then followed by a synthesis of the main findings and results obtained to fully address – or partly bridge – such knowledge gaps previously summarised. By synthesising and consolidating the data collected and analysis conducted throughout the lifecycle of ECHOES (WPs 2-6), Deliverable 7.1 distils the conclusions from the consensus achieved on a) the soundness of the results obtained, b) the expected influence/impact on actual (energy) behaviour, c) the relevance to practice and decision-making, and d) the required changes on energy governance at national and European levels. The resulting knowledge base distilled from this process is then embedded into the wider volume of research conducted outside the scope of the project. By doing so, this knowledge consolidation report corroborates the commonalities between different academic disciplines about the key driving factors and relationships that shape and meaningfully influence energy choices and related behaviour (energy lifestyles).

The knowledge gaps identified throughout the project's lifetime have been organised following the three main technological foci of the ECHOES project, that is: smart energy technologies, electric mobility, and energy-efficient buildings. Specific sub-themes under each encompassing technological focus have been further developed in order to advance a more specific and refined analysis. Figure 5.1 below illustrates how these sub-themes have been organised and positioned under each ECHOES technological focus. Such a categorisation has in turn facilitated a more schematically-structured overview of the critical elements that the project has (fully or partially) addressed in

order to advance a more multidisciplinary understanding of the main knowledge-related challenges limiting our understanding of the various different socio-political intricacies either preventing or advancing Europe's transition towards a carbon-neutral energy paradigm.

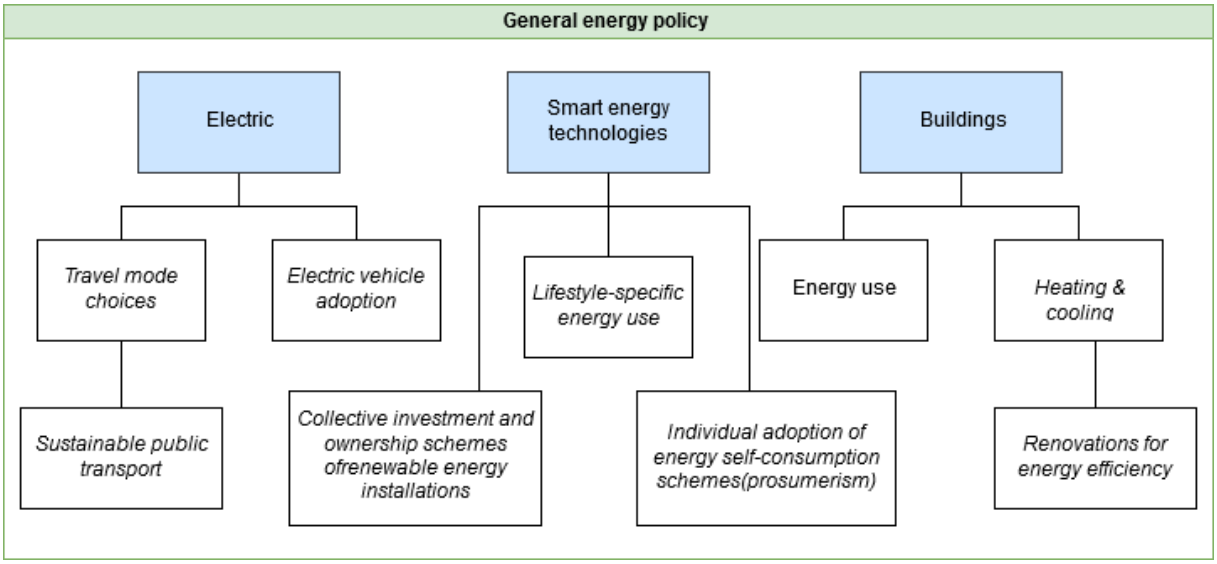


Figure 5.1 Schematic display of main findings organised under each distinct ECHOES technological focus.

5.2 Policy relevance

The delivery of this report fits well in time from a policy-potential and applicability standpoint. This report is being issued at a time when the current European legislative apparatus is being renewed, with the European Parliament's Industry, Research and Energy (ITRE) Committee, the Environment, Public Health and Food Safety (ENVI) Committee, and the Internal Market and Consumer Protection (IMCO) Committee having just finalised their renewed membership. This opens up a window of opportunity for addressing – from the very inception of these new mandates – a renewed approach towards a legislative apparatus explicitly invested in the legislative deployment of the Energy Union and SET-Plan. In that respect, it is important to emphasize the need to work towards ease of access when integrating policy advice stemming from ECHOES scientific findings. As such, these should be communicated in a policy compatible/oriented way rather than as scientific theory.

The policy relevance of the ECHOES findings stands at the intersection between scientific excellence and practical applicability, emphasizing the need to develop a user-friendly and easily approachable body of scientific knowledge that is relevant both as an academic contribution and as a legislative/regulatory prescription. In that respect, the consolidated scientific knowledge base disclosed in this report represents the first step of a wider disclosure, communication, and dissemination exercise prolonged over time and targeted towards a wide range of different decision-making units, from policy makers and corporate stakeholders all the way to civil society organisations and individual households. As disclosed in Deliverable 2.2, the development of an open access and user-friendly ECHOES database aims to substantially advance such an effort. It represents a key effort to present the relevant data collected in ECHOES in an accessible, widely utilisable and visually attractive format, displaying how different national and EU governance frameworks affect decision-making processes and individual as well as collective choices through the combination of existing SSH-relevant data and ECHOES' quantitative and qualitative novel data contributions.

5.2.1 The need, relevance and utility of SSH research for policymaking

The novelty and added value of ECHOES' multifocal, multisectoral, multistakeholder, and multidisciplinary approach to energy-related behaviour and decision-making stands with its potential to engender and establish consensus between key stakeholders about the most decisive driving factors meaningfully influencing energy-related choices and consumption patterns. It emphasizes the need to engage individual citizens and local communities (in their roles as proactive market agents) to successfully steer Europe's low-carbon energy transition, and addresses an important information deficit regarding the myriad of motivations, incentives and restrictions driving consumer and citizen engagement beyond pure economic considerations calling for monetary incentives, subsidies and price regulations (D3.3).

ECHOES therefore responds to the urgent need to harness a more holistic analysis of human behaviour and societal interaction in respect with energy technologies and provision services. The analyses conducted throughout the ECHOES project show clearly that a SSH knowledge base has a strong potential to enhance policymaking to a far larger extent than is implemented in most of the policy instruments, tools and strategies analysed (D3.3).

Taking into consideration the energy and climate policy targets of the European Union and its Member States, it is evident that there is a considerable gap between current research methods and practices, which would consider human behaviour and social aspects on different levels in the transition to sustainable low carbon society (D2.1). Generally, the bottleneck in analysis is insufficient or missing data, or if relevant data exists, it could translate to being costly, non-transparent, and/or difficult to use for certain purposes (for example, the data is unharmonized between countries or sectors, infrequently updated, or requires specific technical knowledge on databases) (D2.1).

Generally, areas of energy cultures, consumer behaviour, acceptance, and gender issues are areas where SSH-related knowledge on energy systems transitions could have a substantial impact, particularly regarding technology acceptance and consumer behaviour in regards to the technological foci of ECHOES: buildings, smart energy technology, and electric mobility. The concept of "collective energy memories", for instance, serves as a valid example to showcase the validity and relevance of introducing ECHOES-related theoretical/conceptual developments into policy-prescriptive domestic energy sector policy development:

> *Due to the added temporal dimension added to the encompassing/broader concept of "energy cultures", the concept of energy memories serves as a useful element to make better sense of the historical development and inherited cultural configuration pertaining to material and norms-related actions. Policy makers should strive to incorporate this temporal attribute for policy interventions aiming to influence/modify/steer/change energy cultures via material and norms-related actions. If these policy measures introduce this new concept, there is a higher probability that policy interventions will be widely accepted.*
>
> *Key events may also become the crucial point of targeted policy measures that take advantage of destabilised energy cultures in which the three components "cognitive norms", "material culture" and "energy practices" are no longer fully compatible. This demonstrates how decision makers could e.g. utilise the "crack" between "material culture" and "energy practices" on the one side, and changed "cognitive norms" on the other side for advancing the energy transition by supporting a "material culture" in which the newly developed norms can result in (sustainable) energy practices. It is therefore essential to recognise societal developments and trends as early as possible and to understand them as precisely as possible.*

It provides evidence that a more comprehensive body of knowledge is needed on human behaviour (i.e. consumer and investor behaviour, group behaviour) and social cultures on energy use and acceptance, in order to formulate successful policies and fair governance schemes addressing the concerns, needs, challenges and potential of individual citizens and communities across the EU. This concern has been the object of much attention throughout

the design and implementation of the WPs throughout the duration of the ECHOES project. As such, data and knowledge gaps have been tackled from the very inception of ECHOES and throughout the project's lifecycle, with the objective of producing practical and applied SSH-related knowledge for analysing, among others:

1. The techno-economical and socio-economical potential of changes in technological systems and behaviour;
2. The social and institutional barriers of the energy transition;
3. Policies and regulation required to reach the required GHG mitigation or renewable energy penetration targets.

Importantly, the undertaking of the data collection and analysis actions throughout the project's duration have aimed at addressing the overarching objective of ECHOES, which is to unlock the policy potential of an integrated social science perspective bounded by central socio-cultural, socio-economic, socio-political, and gender issues that influence individual and collective energy choices and social acceptance of the energy transition in Europe. This knowledge consolidation report therefore represents a starting point for fostering the adoption of a more multidisciplinary and SSH-oriented implementation of the European Strategic Energy Technology Plan (SET-Plan).

5.3 Suggested next steps

The consolidated scientific knowledge base disclosed in this report need to be positioned within the current regulatory landscape shaping Europe's transition towards a resource-efficient and low-carbon energy future with citizens at its core. As such, the findings obtained throughout the execution of the ECHOES project must be understood with an eye to their policy potential, applicability, and impact.

In that respect, the scientifically-grounded knowledge base consolidated in this report serves as a stepping stone for the development of a policy potential and legislative impact estimation exercise of the main driving factors influencing energy-related decision-making (Deliverable 7.2), followed up by an evaluation of the relevance of the project's scientific outcome for energy stakeholders playing a relevant role in the energy transition (market actors, regulatory bodies, environmental agencies, policy makers, citizens, citizens' collectives, etc.) as well as its potential and utility for impact-maximising policy making (Deliverable 7.3). As per the existing ECHOES working plan, these two elements will be tackled separately in the two distinct deliverables abovementioned, following from this report.

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