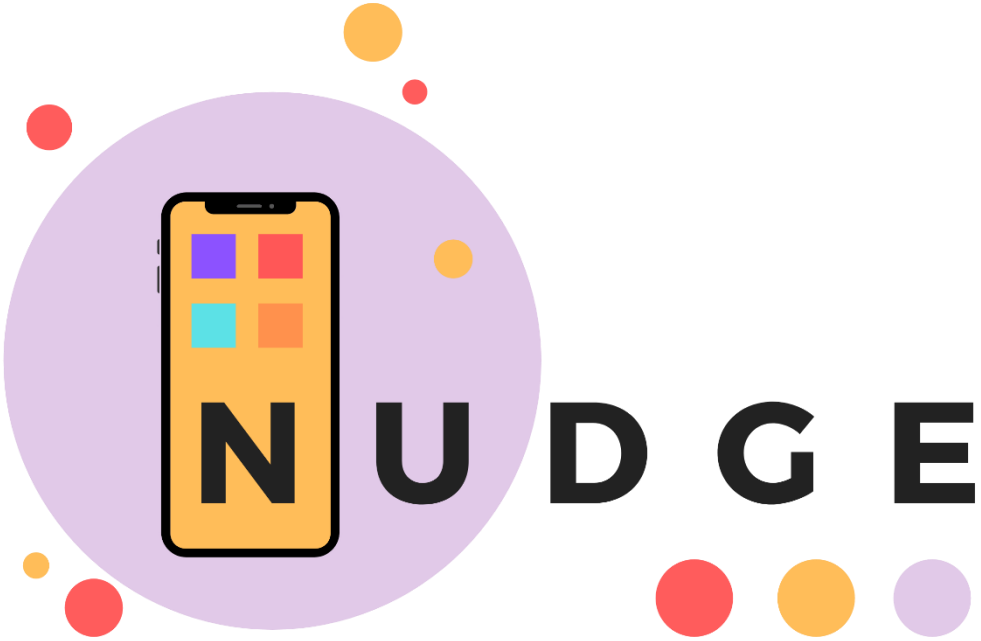

Nudging consumers towards energy efficiency through behavioural science

Deliverable 5.3
Report on recommendations for policy makers and relevant stakeholders

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About

Efforts to induce energy-friendly behaviour from end-users through behavioural interventions are characterized by a lack of customer personalization ("one-size-fits-all interventions"), a partial understanding about how different interventions interact with each other and contrasting evidence about their effectiveness, as a result of poor testing under real world conditions.

NUDGE has been conceived to unleash the potential of behavioural interventions for long-lasting energy efficiency behaviour changes, paving the way to the generalized use of such interventions as a worthy addition to the policy-making toolbox. We take a mixed approach to the consumer analysis and intervention design with tasks combining surveys and field trials. Firmly rooted in behavioural science methods, we will study individual psychological and contextual variables underlying consumers' behaviour to tailor the design of behavioural interventions for them, with a clear bias towards interventions of the nudging type.

The designed interventions are compared against traditional ones in field trials (pilots) in five different EU states, exhibiting striking diversity in terms of innovative energy usage scenarios (e.g., PV production for EV charging, DR for natural gas), demographic and socio-economic variables of the involved populations, mediation platforms for operationalizing the intervention (smart mobile apps, dashboards, web portals, educational material and intergenerational learning practices).

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Project partners

Nudging consumers towards energy efficiency through behavioural science

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Executive Summary

NUDGE explores the potential of applying behavioural insights to energy policy, drawing from psychology and behavioural economics to assess the role of 'nudges'—subtle changes in how choices are presented—in encouraging energy efficiency and conservation.

Our research reveals that behavioural nudges, which subtly alter choice presentation, are effective in promoting energy savings and the adoption of efficiency measures. These interventions are cost-effective, respect individual choice, and can be specifically targeted to influence behaviours like reducing energy consumption.

Implementing behavioural interventions presents unique challenges, such as targeting specific demographics like high energy users, testing various approaches for sustained impact and measuring accurately the impact of behavioural interventions as energy policy tools. Insights from five pilot studies conducted under the NUDGE project provide valuable lessons for policy implementation.

A holistic and evidence-based approach is essential for the success of these interventions. This includes integrating behavioural strategies with regulatory support, traditional energy-saving methods, incentives, adaptability, and a strong ethical framework. Aligning behavioural nudges with regulatory measures, such as pricing structures and tax incentives, can significantly enhance their impact. Furthermore, leveraging technological advancements in conjunction with these interventions can create a more cohesive approach to energy savings.

Ethical considerations, including informed consent, data privacy, and transparency, are paramount. Employing effective communication strategies, such as public awareness campaigns and personalized feedback, can significantly increase the engagement and effectiveness of these interventions.

Collaboration among diverse stakeholders, including governments, energy providers, technology companies, and consumer groups, is vital for a comprehensive approach to intervention development. Platforms for knowledge sharing foster cross-sectoral learning and effective implementation. Ongoing monitoring and evaluation, utilizing tools like key performance indicators and A/B testing, ensure that these interventions remain effective, ethical, and adaptable to changing conditions.

We conclude that behavioural interventions, when thoughtfully designed and ethically implemented, offer significant promise for enhancing energy efficiency and help public and private actors to affect energy demand. Their success depends on a multifaceted approach that combines supportive policies, evolving social norms, and continuous research and adaptation to changing circumstances.

1. Introduction

1.1. Background and context

Behavioural sciences have become increasingly recognized for their valuable contributions to policymaking, due to their systematic study of human behaviour through observation and experiments, integrating knowledge from psychology, economics, sociology, and other fields.

In contrast to traditional rational choice theory, behavioural research shows that real human decision-making diverges in important ways from theoretical assumptions. For example, people are influenced by cognitive biases, care about others, struggle with too much choice, and dislike losses more than they like equivalent gains.

Given the influence of human behaviour on important policy areas like health, energy, and tax compliance, policymakers are more open to using behavioural sciences to design better policies. Behavioural economics applies psychological concepts to explain economic decision-making anomalies. Behavioural insights are the practical findings from behavioural sciences research into how people behave and decide in everyday life. Behavioural approaches can complement or enhance conventional policy tools like regulation and taxation.

Nudging represents just one specific behavioural technique that uses subtle changes to the choice architecture to guide people towards better decisions. While the present project focuses exclusively on NUDGES, it is important to remember that it is not the only available technique, and that behavioural insights can support a wider range of policy tools (Ciriolo, 2011; Kahneman and Tversky, 1973; Thaler and Sunstein, 2008; Rabin and Thaler, 2001).

1.2. Behavioural factors influencing energy consumption

Energy consumption in the residential sector accounts for a significant portion of overall demand, resulting in large greenhouse gas emissions. Thus, reducing household energy usage through efficiency and conservation represents a key target for energy and climate policy.

Traditional economic perspectives suggest that consumers make rational trade-offs between the upfront costs and long-term savings of energy options. However, an extensive body of behavioural science research reveals that energy choices are also driven by less rational psychological and social factors that often lead to suboptimal decisions.

A fundamental issue identified by studies is present bias. Most individuals overly focus on the short term and steeply discount future outcomes. This bias explains the observed energy efficiency gap - consumers forego efficiency investments like weatherization that would pay back over time through lower bills, instead prioritizing immediate costs and benefits. Similarly, status quo bias leads people to passively accept default energy contracts and tariffs even when alternatives like renewable power may better match their values.

Social and normative influences are also strong behavioural drivers. Field experiments find that providing feedback comparing a household's energy usage to similar neighbours can motivate conservation, leveraging concepts like conformity and social norms. Identity factors related to home and morality also affect energy behaviours, with some pro-environmental actions serving as symbolic proof of one's green values and community.

Behavioural science offers numerous policy tools to address these biases and influences. Defaults, personalized feedback, and financial framing emphasizing long-term savings can be combined with traditional regulations and incentives to reduce consumption and accelerate efficiency. Ongoing collaborations between behavioural researchers and policy makers can further clarify the most effective mechanisms for unlocking energy savings through improved understanding of human behaviour.

1.3. Use of nudges for energy demand reduction

Nudges represent a promising avenue for addressing behavioural biases and leveraging decision heuristics to reduce home energy consumption. These subtle interventions tweak the choice architecture people face rather than mandating or economically incentivizing changes.

For example, presenting daily rather than annual electricity costs frames usage in a more salient short-term manner that helps overcome present bias. Similarly, simplifying information through energy use monitors, personal feedback, and conservation tips nudges people towards greater efficiency by making best practices more understandable and attention-grabbing.

Defaults also powerfully exploit status quo bias. Enrolling households in renewable energy plans by default dramatically increases adoption compared to requiring opt-in signups. Smart thermostats with preset energy-saving settings that allow easy opt-out provide another low-friction nudge.

Peer comparisons and norms can encourage conservation through desires to conform, avoid guilt, and maintain a positive self-image. Showing households their usage compared to average neighbours provides a salient signal to reduce waste. Collaboration with community groups and competitions can also effectively activate group norms and identities.

While nudging alone may not achieve maximum efficiency gains, techniques like framing, defaults, simplification, and norms represent a valuable component of policy mixes. Thoughtfully designed nudges address key behavioural obstacles and tend to generate highly cost-effective energy savings in residential settings. Their flexibility and low imposition on consumer freedom merit continued innovation and testing.

1.4. Overview of the nudge project

NUDGE has been conceived to unleash the potential of behavioural interventions for long-lasting energy efficiency behaviour changes, paving the way to the generalized use of such interventions as a worthy addition to the policy-making toolbox. The project puts focus on three main areas:

- Understanding the behavioural factors that influence energy consumption. NUDGE has conducted surveys, interviews, and focus groups with consumers to understand the factors that influence their energy consumption. It has taken a mixed approach to the consumer analysis and intervention design with tasks combining surveys and field trials. Firmly rooted in behavioural science methods, it has been studying individual psychological and contextual variables underlying consumers' behaviour to tailor the design of behavioural interventions.
- Designing and testing nudging interventions: NUDGE designed and tested a variety of nudging interventions that can be used to encourage people to use less energy. These interventions have been based on the tools and insights from behavioural science, such as defaults, framing, and social norms. The designed interventions are compared against traditional ones in field trials in five different EU member states, exhibiting striking diversity in terms of innovative energy usage scenarios (e.g., PV production for EV charging, DR for natural gas), demographic and socio-economic variables of the involved populations, mediation platforms for operationalizing the intervention (smart mobile apps, dashboards, web portals, educational material and intergenerational learning practices).
- Evaluating the effectiveness of nudging interventions: NUDGE has evaluated the effectiveness of the nudging interventions in different settings. The results of the evaluation are used, also in the context of this report, to inform the development of new policies and practices to promote energy efficiency.

The NUDGE project has the aimed to make a significant contribution to the EU's efforts to reduce energy consumption and combat climate change by understanding the behavioural factors that influence energy consumption and developing effective nudging interventions. As such the four project objectives of NUDGE have been to:

1. Tailor the design of behavioural interventions to individual psychological and contextual variables by leveraging the data collection capabilities of digital mediation platforms and data analytics.
2. Execute extensive field trials (pilots) that address multiple instances of consumer behaviour, implementing different mixes of behaviour-based and traditional interventions even across participants of the same pilot.
3. Develop a systematic core and contextual research protocol to continuously measure the impact of the implemented behavioural interventions.
4. Consolidate the findings of pilots into recommendations towards policy makers and relevant stakeholders.

The fourth objective is the culmination of all scientific efforts, stakeholder consultations, nudge development, field trials, and statistical analyses and has succeeded in the provision of policy recommendations, which are bundled together in Deliverable 5.4 and further elaborated in the present report.

The NUDGE project has therefore aimed and achieved to derive evidence-based policy recommendations for policy-makers as well as for other relevant stakeholders (such as energy service providers, energy communities, and intermediaries). A key focus has been to derive evidence-based recommendations for efficient energy consumption for consumers and consumer associations.

In addition to this publication, the NUDGE project has developed an online tool targeted towards the different stakeholder groups in order to provide tailored and easy-to-access information.

The NUDGE project has also provided input for a series of workshops addressing and raising awareness among policy-makers at various levels of the policy-making hierarchy, and has offered contributions to consultation processes of national and EU-level policy-making activities.

2. Methodology

This report derives policy recommendations through two avenues:

1. It builds on the results of the Randomised Control trials, and the ensuing analysis of survey and sensor data, realised in the context of the NUDGE project
2. It reviews additional academic literature on household energy consumption to identify success factors for the effective implementation of behavioural interventions

2.1. Methodology for analytical work of the NUDGE project

Three nudging interventions are sequentially tested in four pilots, with the exception of the Belgian pilot, which uses educational nudges through courses. The experiment design is based on a research methodology that allows for the analysis of consumption changes over time, between participants, or changes between participants over time.

The analysis evaluates participants' perceived effect based on collected survey data and their actual effect based on collected sensor data. The data is collected before the first and after each nudging period. Metadata on weather, household composition, and interaction with nudging tools are also available. The actual effect of the nudging interventions is estimated based on sensor data, and the perceived effect is based on survey data.

Two evaluation strategies are used for the assessment of the nudges: comparing the differences in consumption over time or between the treated and non-treated participants. The Difference-in-Differences (DiD) econometric technique is used to determine the causal effect of the nudges on consumption behaviour.

The analytical work addresses challenges such as dealing with confounding factors, learning effects, and lower than expected data quality. Strategies to cope with these challenges include using two-way-fixed effects to control for time- and subject-dependent confounding factors, starting with more subtle nudges and continuing with more interactive ones to mitigate learning effects, and employing various data quality measures to handle data gaps and outliers.

The analytical methodology of the NUDGE project provides a comprehensive approach to evaluating the effectiveness of nudge interventions in real-life settings, taking into account various challenges and analytical decisions to ensure robust results. For more details, please refer to the NUDGE project Deliverable (D2.3) titled: *Final report on the evaluation of nudging interventions through pilot data.*

2.2. Methodology for the literature review on effective policy implementation

The methodology for conducting the literature review on household energy consumption and energy behaviour involves several systematic steps. To comprehensively examine the existing body of knowledge in this field, a structured approach is adopted, which includes a systematic literature search, screening, data extraction, policy intervention analysis, result analysis, and the derivation of targeted policy recommendations.

The initial step of this methodology encompasses a comprehensive literature search conducted across reputable academic databases such as Google Scholar, Web of Science, and Scopus. This search is carried out using specified keywords including "household energy consumption", "energy efficiency", "energy behaviour" and "energy policy implementation". The objective is to identify a wide range of scholarly resources and articles related to household energy use and conservation.

Upon completing the literature search, the next step involves screening the search results for peer-reviewed articles published in academic journals. This screening process is crucial to ensure that the literature selected is academically sound and relevant to the topic of interest, specifically on how to effectively implement behavioural measures to reduce household energy consumption.

The approach followed requires a review of established theoretical frameworks related to energy consumption behaviour, such as the Theory of Planned Behaviour, Value-Belief-Norm Theory, and Social Practice Theory to gain a deeper understanding of the various psychological and social factors influencing household energy consumption. While these have been described thoroughly in the NUDGE deliverable (D2.2) *Research methodology for assessing the effectiveness of interventions regarding change of energy efficient behaviour*, these concepts are considered when promoting specific recommendations. To this degree, internal, external, and social factors impacting household energy consumption are extracted from the literature, including attitudes, awareness, motivations (internal); dwelling characteristics, heating systems, and energy prices (external); and household dynamics and social norms (social).

Policy interventions and strategies assessed in the literature, aiming to alter household energy behaviour, are identified and synthesized into a coherent implementation guide. This includes informational strategies such as regulatory support, incentives and rewards, public awareness campaigns, personalised messaging, and behavioural triggers; and activities important for improvement of policy implementation, such as monitoring and evaluation and knowledge sharing. The results are systematically reviewed to determine the most effective policy options based on evidence found in the literature.

These findings help inform the derivation of targeted policy recommendations aimed at promoting energy-saving behaviours and reducing household energy demand. These recommendations are

constructed with a solid foundation in existing academic literature, ensuring their evidence-based nature and have relevance to real-world policy implementations.

3. Analytically derived policy recommendations

The present section outlines the policy recommendations that derived from the NUDGE project. It is the outcome of the analytical work realized using data from surveys, sensors and app information gathered from the five project pilots, including training material from the Belgian pilot. These recommendations have been verified and supported in their development in the context of focus groups and stakeholder consultations realised throughout the project, and further disseminated in the context of policy consultation and dissemination activities. These recommendations can also be found in a more accessible form for dissemination in the dedicated Deliverable D5.4 *Compilation of provided policy briefs.*

3.1. Nudging households to achieve climate & energy policy goals

Household engagement is pivotal for the effective transition to sustainable energy practices. As per 2021 data, household energy consumption constituted a notable 27% of the European Union's total energy usage1. The domestic energy sector presents intricate challenges, including the heterogeneity in energy use and end-usage patterns among EU member states, compounded by the varied behaviours of residents. Indeed, the energy consumption patterns in homes, especially heating and cooling, are significantly influenced by occupant behaviour, even surpassing the impact of the buildings' physical attributes.

The dynamics of household energy consumption are further complicated by the rise of 'prosumer' households. These are residences that not only consume but also produce energy, predominantly through solar photovoltaic systems, and utilize it for their own needs. While this introduces prospects for a more adaptable energy infrastructure and the enhanced integration of renewables, it simultaneously brings forth challenges related to grid stability and the necessity for suitable regulatory frameworks.

The modification of consumer behaviours is instrumental in addressing several critical issues. Firstly, it can substantially diminish energy demand and residential greenhouse gas emissions. Additionally, it unlocks latent potential for flexibility in energy usage, particularly among prosumer households, and heightens the energy-saving capacities. Finally, it aids households in coping with escalating energy costs and mitigating the effects of energy poverty.

Behaviour change on a macro scale can be achieved through policy and economic stimuli. Yet, finer behavioural steering, circumventing the broadly debated mechanisms of prohibitions or fiscal means, can be achieved through 'nudges'. These nudges subtly alter the decision-making environment—via technical adjustments and non-directive suggestions such as preset options, peer comparisons, and informational outreach—to encourage more beneficial decisions among energy users.

The strategic and efficacious deployment of such nudges, however, encounters substantial obstacles:

- Prevalent external factors, such as the legal milieu and market dynamics (e.g., pricing structures), exert a more pronounced influence.
- There is significant variability in the behaviour and profiles of energy consumers, characterized by differing degrees of intrinsic motivation, awareness, and interest in energy conservation, as well as preferences for thermal comfort.
- Monitoring and measuring the impact of nudges presents its own set of complexities.

Below are some recommendations on how to use nudging to the achievement of climate and energy policy goals in households

Understand the varied energy user profiles: Different individuals exhibit unique patterns in their energy use, driven by diverse motivations for either consuming or conserving energy. This variation necessitates the adoption of a variety of nudging techniques, ensuring that all consumer types are effectively targeted for energy efficiency. This approach is detailed comprehensively in the policy brief of the NUDGE project titled Profiling and nudging energy consumers to heat efficiently.

Offer a Comprehensive Perspective of the Energy Landscape: For nudges to be truly effective, it's critical to comprehend the relationship between energy-saving behaviours, the nudges themselves, and external factors like regulatory frameworks. Adaptability to evolving aspects of the energy sector, such as new technologies or external changes, is equally important. The NUDGE project exemplifies this through its adaptations in response to the COVID-19 pandemic and fluctuating energy prices, both of which significantly influenced consumer energy behaviours.

Provide real-time energy consumption feedback: One of the most crucial elements in increasing consumer awareness and enabling informed adjustments in energy usage is real-time feedback. Technologies like smart meters and other smart sensors play a pivotal role here. These tools not only facilitate personalized information and interventions based on individual consumption patterns but are also vital in expediting the deployment of smart meters across Europe. Making such data available to consumers as promptly as possible is essential for effective energy management.

Optimise nudges through default settings and existing situations: It's crucial to recognize the diversity in energy users' motivation levels and the general challenge for most individuals to engage with new topics in their busy lives. To effectively nudge consumers towards energy savings, it is advisable to use approaches that are low-effort and time-efficient. This can be achieved by utilizing existing situations (like energy bills or heating maintenance) or channels for nudging, rather than creating new ones. Additionally, setting up default nudges with straightforward opt-out/opt-in mechanisms can be highly effective. Digital infrastructures, such as smart meters and sensors, play a pivotal role here. They can set energy-saving options as the default choice, providing users with easy-to-adopt

interventions tailored to their energy consumption patterns. However, the reliance on hardware like smart meters underscores their significance in this strategy.

Enhance nudges by fostering new behaviours: Behavioural interventions in energy policy should be dynamic, evolving alongside technological advancements to maintain relevance and effectiveness. Policymakers need to anticipate and prepare for these changes, requiring a deep understanding of new technologies, market trends, and consumer behaviour. This foresight allows for the development of resilient and adaptable policies. In practice, this involves implementing nudges around emerging technologies like electric vehicles (EVs) and other residential electrified systems, where new routines are being established. These technologies, typically featuring digital interfaces, offer opportunities for low-cost integration of nudges.

Address ethical considerations in nudging: Ethical considerations, including consumer and data protection, are paramount. This encompasses ensuring informed consent, transparency, and respect for individual autonomy. It's essential that people are fully informed about the interventions, their objectives, and the data collection processes involved. This transparency helps to mitigate potential negative reactions, especially to interventions perceived as overly paternalistic.

Promote nudges supporitng mutliple benefits of energy efficiency: The implementation nudges focused on a non-energy benefit (indoor air quality and health) in NUDGE have resulted in positive outcomes, with evidence showing that participants were able to identify periods of greatest accumulation of airborne particulate matter and carbon dioxide and take action to reduce exposure. This nudge resulted also in a significant increase in the participants' intention to save energy and in the perception of participants' self-positioning in relation to energy issues. Another important finding was the participants' recognition that they would be more motivated to save energy if indoor air quality and comfort aspects were included in the process.

The employment of nudging for policy purposes necessitates a continuous monitoring process to evaluate effectiveness and improve implementation. This approach is vital in ensuring that nudging strategies, which are designed to subtly influence behaviour in a desired direction without restricting choice, are achieving their intended objectives and can be adapted as necessary to enhance their impact. Therefore, it is advised to:

Link nudging and energy conservation: Research findings indicate that for nudges to effectively influence energy-saving behaviours, a robust and direct connection between the intervention and the resulting behaviour is crucial. This is because often the impact of such interventions is relatively modest. Establishing a direct link is vital; otherwise, attributing any observed changes in energy consumption to the intervention becomes challenging due to the small size of the effects and the presence of numerous external variables. Therefore, it's important to set realistic expectations for the impact of these nudges and choose Key Performance Indicators (KPIs) that accurately reflect this.[8]

Utilise digital tools for extended observation: Continuous and long-term observation of energy usage patterns is vital for understanding behavioural adaptations in response to nudges, including potential rebound effects, and adapting to external factors like regulatory changes and price fluctuations. In this context, smart meters are invaluable for both monitoring and facilitating various nudging strategies. Despite their importance, current adoption rates suggest that full integration of smart meters across the EU might not be achieved until around 2030, which could delay the effective implementation of digital-driven behavioural interventions.

Improve cooperation and information exchange: Effective behavioural interventions in energy usage require collaborative efforts and the sharing of knowledge among various stakeholders, including government entities, energy suppliers, technology companies, and consumer groups. The exchange of anonymized data is particularly crucial for understanding consumer behaviours and how they interact with nudging tactics and external regulatory environments.

Monitor both positive and adverse outcomes: To fully grasp the effects of different nudging strategies, it is essential to monitor not only their positive impacts but also any potential negative consequences. This is especially important when nudging objectives might conflict with other goals, such as energy conservation versus comfort. Identifying and addressing any unintended adverse effects is key to enhancing the acceptance and effectiveness of nudges, allowing for necessary adjustments.

Addressing the influence of external factors in nudging strategies is an essential aspect of effective behavioural intervention design, particularly in the context of promoting energy-efficient behaviours and supporting climate and energy policy goals. While nudges themselves can be powerful, their effectiveness is often contingent upon external factors such as regulatory frameworks, economic incentives, and cultural norms. These factors can either amplify or diminish the impact of nudging strategies.

Ensure compatibility of nudges with policy incentives: Nudges have been found to bolster the effectiveness of existing policy incentives, rather than counteracting existing disincentives. When nudging strategies are in harmony with external incentives, such as economic benefits through energy pricing or regulatory frameworks, a synergistic effect is often observed. In contrast, nudges may be less effective when there is a mismatch with regulatory conditions or similar external factors.

Harmonise behavioural interventions with external elements: It's crucial to comprehend the influence of regulatory frameworks and other external factors like pricing on energy-saving behaviours. The subtle yet significant impact of nudges can be easily overshadowed by these external influences. Understanding the interaction between these elements is vital for designing effective nudges. Such nudges can unlock difficult-to-reach energy-saving potentials, ensuring they contribute to and align with the overarching goals.

Enhance regulatory frameworks with digital solutions: Supplementing regulatory frameworks with digital tools and informative resources can significantly boost their

impact. Leveraging nudges to convey critical regulatory information related to energy consumption to consumers can catalyze behavioural changes. For instance, smart meter applications or energy management systems can be employed to communicate vital information about energy consumption regulations and self-consumption or production.

Behavioural interventions should be viewed as integral components within broader energy policy frameworks, as this approach enables a comprehensive and synergistic approach to energy conservation. Here it is important to make sure that the enabling conditions are set right to deliver and monitor behaviour change (smart meters, channels to distribute energy knowledge and potential nudges, availability of data and knowledge about energy consumption behaviour). By seamlessly integrating behavioural insights with technological advancements, policymakers can harness the full spectrum of tools at their disposal to drive substantial and enduring energy savings. However, subtle interventions require supporting regulatory, technical, and digital conditions. The other way around, restrictive self-consumption regulation, unappealing digital interfaces, and mal-functioning flexible technologies can easily overrule the small, positive nudging effects. At the same time, if nudges are thoughtfully aligned to these conditions, they can unlock hard-to-reach efficiency and flexibility potentials

3.2. Profiling and nudging energy consumers to heat efficiently

Space heating constitutes the predominant component of household energy consumption in Europe, accounting for an average of 63% across the European Union. This figure reaches as high as 81% in Luxembourg, the highest national level within the EU. Notably, even in Mediterranean countries with typically hot-summer climates, such as Portugal, space heating still represents a significant 30% of final energy consumption.

The primary driver of household energy demand, surpassing even building characteristics, is the behaviour of the occupants, particularly in terms of heating and cooling. Therefore, a comprehensive understanding of these behavioural patterns is crucial for effectively reducing building energy consumption.

Households collectively contribute to 25% of Europe's greenhouse gas (GHG) emissions. Consequently, addressing the high energy use for space heating is a vital component of Europe's strategy to mitigate GHG emissions. This issue gains additional complexity considering the reliance on natural gas for space heating in the EU, which averages 38% and reaches higher percentages in countries like Hungary (84.2%), the Netherlands (84.9%), and Italy (59.5%). Moreover, the current geopolitical landscape, notably the repercussions of the Russian invasion of Ukraine, further underscores the urgency of this issue, intertwining energy consumption patterns with broader political and environmental challenges.

In addition to mitigating greenhouse gas (GHG) emissions, decreasing energy consumption for space heating addresses other critical challenges. These include reducing reliance on Russian gas and other fossil fuels, aligning with the objectives of the REPowerEU plan. Such reduction also

plays a key role in aiding households to cope with the current high energy prices, enabling them to conserve energy and consequently lower their bills this winter.

Therefore, it is imperative to consider strategies beyond the adoption of more energy-efficient appliances and home renovations. Understanding and influencing user behaviour, such as identifying factors that motivate individuals to lower their heating, becomes a crucial component in the broader context of reducing energy consumption.

Drivers of behaviour change relating to heating consumption

The NUDGE project has conducted an in-depth exploration of non-financial, technical interventions that can effectively influence household energy consumption behaviour. This approach focuses on utilizing 'nudges,' a concept rooted in behavioural science, which involves subtly guiding behaviour through various interventions and indirect suggestions, such as push notifications and social comparisons.

To successfully design these nudges, it is imperative to understand the factors influencing individuals' intentions to reduce heating-related energy consumption. A comprehensive survey, encompassing 3,129 respondents across 29 European countries, has shed light on six critical factors, which have been systematically ranked based on their impact.

The survey reveals that 'Perceived Behavioural Control' – the individual's assessment of the difficulty and ability to perform a certain activity – and 'Subjective Norm' – the perceived social pressure to engage in that activity – emerge as the most significant factors. Understanding and predicting the intent to reduce heating-related energy consumption hinges on these two elements, making them vital in developing effective interventions.

'Attitude' towards energy consumption, influenced by factors such as financial concerns, comfort considerations, energy knowledge, and environmental awareness, plays a significant role. 'Personal Moral Norms', shaped by awareness of the societal consequences of actions and the responsibility associated with them, along with 'Willingness' – how positively a person views the activity and their perceived similarity to individuals who perform it – also contribute, though to a lesser extent. Interestingly, the survey indicates that age has a small but noticeable negative impact on the intent to reduce heating-related energy consumption.

Policies aimed at influencing heating behaviour can be significantly enhanced by considering how to effectively design nudges and related strategies. These should focus on impacting key factors:

Enhancing Perceived Behavioural Control

Targeted Information Campaigns and Policies: Direct engagement with customers is crucial for increasing their perceived control over heating choices. This involves designing information campaigns and policy initiatives that provide easy, low-threshold access to practical information. For example, offering guidance on achieving specific energy-saving goals, showcasing successful examples, and enabling customers to make informed decisions can be influential. Practical

suggestions, such as lowering the thermostat by one degree or turning off heating in unused rooms, can positively influence habit formation and facilitate behavioural change.

Engaging Intermediary Actors at Local Levels: When European and national policies seem too remote to directly influence customer behaviour, it becomes essential to engage intermediary actors like energy service companies or utilities. These entities can be instrumental in enhancing customers' perceived control by being held accountable for providing additional guidance, possibly through information on invoices or by promoting smart meter usage. Such measures can bridge the gap between high-level policy and individual action.

Timely and Accessible Consumption Data: For customers to make truly informed decisions, they must have timely access to their consumption data. This enables them to observe the direct impact of their energy-saving measures. Therefore, policy should aim to revise current information requirements, which often limit consumption data reporting to an annual basis. More frequent and accessible data provision would empower customers to track and adjust their behaviour more effectively.

Strengthening the Influence of Subjective Norms:

Leveraging Social Influence: Highlighting the energy-saving behaviours of others can effectively motivate individuals to reduce their own consumption. The context of Europe's efforts to decrease energy dependency and manage high energy prices presents an opportunity to link individual energy-saving actions to broader goals. Publicizing survey results, such as the percentage of people prioritizing energy conservation, can be a powerful tool in reinforcing intentions to reduce heating-related energy use.

Improving Attitudes Towards Energy Consumption:

Balancing Environmental and Financial Considerations: Strategies that positively address environmental and financial aspects can enhance attitudes toward reducing energy consumption. However, it's crucial to mitigate concerns about the loss of comfort. Ensuring that reductions in consumption minimally impact comfort levels is important in maintaining public support for these measures.

Efficient Heating: Nudging Diverse Energy Consumers

Understanding how to nudge individuals towards more efficient heating requires recognizing the complex interplay of multiple factors influencing energy consumption behaviour. This complexity has led to the emergence of diverse energy consumer profiles, each responding differently to various interventions. To design effective policies and successful nudges, it is essential to tailor interventions to these distinct profiles.

NUDGE has identified six unique types of energy usersand mroe ifnromation can beretreived from the NUDGE Deliverable D1.1, *Profiling of energy consumers: psychological and contextual factors of energy behaviour*, September 2021. For each profile, we have explored interventions likely to influence their behaviour positively. By aligning these tailored interventions with the specific needs and behaviours of each user profile, a more effective and balanced policy mix can be formulated. This approach is instrumental in reducing heating-related energy consumption, leveraging the subtle power of nudges to encourage more sustainable energy use patterns.

In the table that follows, we introduce these six energy user types and the corresponding interventions that have shown potential in modifying their heating behaviours. This understanding forms the foundation for a nuanced and comprehensive policy strategy aimed at enhancing heating efficiency across a broad spectrum of consumers.

Profile	Key points/Short description	Intervention type	Description
Environmentally conscious and well-informed energy consumers	"Idealistic energy savers", combination of high concern about the environment with good knowledge and strong sense of personal responsibility for action	Reinforcement	**Feedback & awareness:** keep the interest warm through regular but sparse information about energy-saving (selected notifications, regular marketing campaigns)
Concerned but comfort-oriented energy consumers	clear intentions for acting in an energy-friendly manner but strong concern about comfort, concerned about the monetary cost involved in higher energy consumption	Confronting	**Reminding of consequences:** prompt the user to consider the consequences of an action e.g., increasing the target temperature of the thermostat or the air-conditioning, insisting on the extra cost it incurs. It could be the net increase of the energy bill, projecting the impact of the action at monthly/annual level.
Concerned but lacking awareness energy consumers	Concern about the environment, awareness of consequences but lack of know-how to practically save energy	Facilitating	**Default:** Turn energy-friendly operational settings of devices (thermostat, air conditioning equipment) into defaults, to save the user from the "burden" of learning what is appropriate and what is not.
		Reinforcement	**Just-in-time prompts and tips:** Provide the user with

			tips and recommendations exactly upon the time she mingles with devices' settings that have an impact on energy consumption.
Materialistic energy consumers escaping personal responsibility	combining lower than average energy-saving intentions with a low anticipation of personal responsibility to act and high concern for the financial implications of energy-saving activities	Confronting	**Reminding of consequences:** prompt the user to consider the consequences of e.g., increasing the target temperature of the thermostat or the air conditioning, insisting on the extra cost it incurs. It could be the net increase of the bill, projecting the impact of the action at monthly/annual level.
Prone to social influence energy consumers	low intentions for heating-related energy saving behaviour but strong sense of subjective norms, no distinct differentiation in other features	Social influence	**Enabling social comparison:** leverage different means (from written text and diagrams printed on a paper to online social platforms and dynamic query response systems) to facilitate the comparison with other peers (friends, neighbours, consumers of similar demographic characteristics).
		Social influence	**Goal setting & commitment:** get the consumers to sign a formal commitment to reduce the energy they consume, many times in return of some (nonmonetary) reward.
Indifferent energy consumers	low perception of self-efficacy and possible impact of	Facilitating	**Default:** Turn energy-friendly operational settings of devices

	personal action, low concern and awareness about environmental matters.		(thermostat, air conditioning equipment) into defaults, to save the user from the "burden" of learning what is appropriate and what is not.
		Reinforcement	**Feedback & awareness:** use tips, notifications, marketing campaigns, to sensitize this group of users and overcome their reservations about the efficacy of their behaviour.
		Reinforcement	**Hedonic goal:** stress the big picture and the impact on big things, possibly with some exaggeration, to render energy-saving a goal.

In summary, there are four key learnings from studying behaviour changes in household heating consumption:

1. Understanding the behaviour of household occupants is crucial in addressing energy demand, as it is the second most significant factor influencing energy consumption, surpassing even the characteristics of the building itself.
2. The motivation to alter energy consumption behaviours hinges on six key factors: perceived behavioural control, subjective norms, attitude, personal moral norms, willingness, and age. These elements collectively shape an individual's approach to energy use and conservation.
3. Importantly, people exhibit diverse energy usage profiles, influenced by varying motivations to either use or save energy. This diversity necessitates tailored approaches in policy design to effectively nudge different groups towards energy efficiency.
4. Policy design must include a comprehensive assessment of how various policies impact these diverse energy usage profiles. Understanding these nuances enables the development of more effective strategies that cater to the specific needs and motivations of different household occupants, leading to more efficient energy use and significant progress in energy conservation efforts.

3.3. Energy literacy

The role of energy-related topics in public discussions is growing, often leading to divisive debates. A critical factor for the success of ecological transitions is ensuring that consumers are well-informed and can make sustainable choices regarding their energy use. This becomes even more vital when it comes to embracing new energy technologies and adapting to energy-related policy changes. To foster a balanced, objective public dialogue on these subjects, promoting high levels of energy literacy among the populace is crucial. Energy literacy encompasses a broad understanding of various aspects related to energy production and consumption. This includes knowledge of different energy sources, the extent of energy production and use, pricing dynamics, and environmental impacts (Białynicki-Birula et al. 2022). Enhancing energy literacy serves multiple key goals:

- Enabling consumers to comprehend and manage their energy use, such as in domestic settings.
- Assisting consumers in understanding energy pricing and the implications of new pricing models (Reis et al. 2021).
- Addressing issues of energy poverty, as detailed in the NUDGE policy brief.
- Increasing public awareness and acceptance of crucial energy-related matters.

However, there is a noticeable gap in energy knowledge among consumers, often limiting their ability to contextualize various viewpoints in public debates or understand factors influencing their energy use. Since changing established habits is more challenging than adopting new ones, imparting energy literacy is especially vital for young people and students – the future energy consumers.

Within NUDGE, a specific field trial centered on project-based education related to household energy consumption for children in Belgium. This trial aimed to enhance children's comprehension of the consequences of daily choices on household energy use. To achieve this, the trial expanded the existing educational materials, introduced smart meters into the homes and schools of participating children, and utilized dashboards for visualizing the gathered consumption data. The overarching goals were to facilitate intergenerational learning and create opportunities for the application of acquired knowledge in practical contexts.

The outcomes of this field trial underscore the need for improved energy education among young learners, and provide a foundation for developing more effective energy education strategies and initiatives. Specifically, it found the following:

The level of energy knowledge among the students was found to be quite limited. They were unaware of how their houses were heated and lacked knowledge about the various dimensions and magnitudes of energy consumption. This finding underscores the need for improved energy education among young learners to raise their awareness of energy-related issues.

Engaging in public discussions on energy-related subjects, such as energy prices, was observed to stimulate interest in the field among the students. This suggests that fostering public discourse on energy matters can play a vital role in increasing awareness and engagement among young

learners. It highlights the importance of creating opportunities for students to participate in conversations about energy-related challenges and solutions.

The research indicated that gamification strategies, including energy knowledge tests, and the practice of social comparison were well-received by the students. They demonstrated a keen interest in comparing their own energy and water consumption patterns with those of their peers and with average figures. This finding suggests that incorporating gamified elements and opportunities for social comparison into energy education can be an effective way to engage and motivate students to learn about energy conservation.

The study emphasized the importance of having a digital tool for automated home energy consumption measurement, accompanied by a comprehensive visual dashboard. Such tools are essential not only for students but also for all household residents. They enable individuals to monitor their consumption, make comparisons, and gain insights into the consequences of various daily decisions.

While there were positive effects of intergenerational learning in the context of energy education, it is important to highlight the inherent challenges in assessing or evaluating these effects. This suggests that while intergenerational learning can be beneficial in transmitting knowledge and behaviours related to energy conservation from one generation to another, quantifying its impact may require innovative evaluation methods.

Based on the observed outcomes, the following paragraphs outline some general directions for measures that policymakers can implement:

- **Strengthen energy education in public schools and educational institutions**: Enhance energy literacy by making energy and energy consumption a mandatory subject in public schools. The primary goal is to ensure that a significant number of students understand the general principles of home heating and cooling, cost considerations, and various heating options. Additionally, students should grasp the impact of their behaviour on overall energy consumption. Extend this educational effort beyond schools to include other educational venues, facilitating the dissemination of energy knowledge to parents and the broader community, thus promoting widespread understanding and replication potential.
- **Promote smart meter deployment with user-friendly dashboards:** Facilitate access to tools that allow individuals to monitor their energy consumption at home and in educational settings. Providing this capability is pivotal in raising awareness about energy consumption, enabling people to comprehend their own usage patterns, and understand how their behaviour affects energy consumption.
- **Utilize non-educational channels to promote energy awareness and literacy:** Acknowledge that understanding personal energy consumption is crucial for behaviour change and acceptance of new technologies and regulations. Therefore, in addition to educational channels, leverage non-educational avenues to foster energy awareness and literacy. This may involve incorporating visually appealing and easily comprehensible information about energy consumption, prices, and potential energy savings into routine situations such as heating system maintenance or energy bills.

- **Encourage intra-household communication on energy matters:** Foster intergenerational learning and knowledge transfer within households by promoting open dialogue about energy consumption and production. Public information campaigns can serve as a catalyst for such communication. For children, educational programs should engage them in energy-saving practices, while for parents, strategies should focus on optimizing energy use based on their responsibilities and lifestyles. Open communication within families is crucial, as it fosters collaboration and environmental awareness. Behavioural science insights, measurement and feedback systems, and community engagement can support these efforts.

3.4. Consumers

The promotion of sustainable behaviour in the field of housing energy saving is a complex issue influenced by several factors. Behind every sustainable behaviour there are, in fact, influences stemming from both global and cultural factors as well as more distinctly individual factors. These include, in particular, habits, intentions and contextual conditions. In the field of energy saving, therefore, the provision of socially appropriate infrastructures for the realisation of a certain behaviour or the development of incentive policies are intertwined with the intentions of individuals towards sustainability issues, which are themselves influenced by attitudes (certainty of results and evaluation of results), social factors (roles and norms) and affective factors (perception of self and loved ones) and established habits (frequency of past behaviour) in the field of energy consumption.

This holistic perspective on the promotion of sustainable behaviour in the context of energy efficiency not only considers the broader societal and cultural influences but also emphasizes the pivotal role of individual attitudes, social dynamics, and personal habits. By integrating these insights, strategies for encouraging sustainable energy use can be more effectively tailored to meet the needs and concerns of consumers.

The project 'NUDging consumers towards enerGy Efficiency through behavioural science' (NUDGE) was conceived to unlock the potential of behavioural interventions for lasting behavioural changes in energy efficiency, paving the way for the widespread use of such interventions as a valuable addition to the policy toolbox.

To this end, a Europe-wide survey (available in 15 languages and filled in by more than 3,000 people in 29 countries) was first carried out with the aim of gaining a better understanding of energy consumers' behaviour in relation to energy efficiency and the factors that act as barriers or facilitators to energy saving. The survey identified six different consumer profiles and based on their distinct characteristics, the most appropriate nudges were defined, which are described below.

3.4.1. Consumer profiles

NUDGE was initiated with the primary objective of harnessing the potential of behavioural interventions to bring about enduring changes in energy efficiency. This initiative seeks to establish the widespread adoption of such interventions as a valuable addition to the policy toolkit, with a focus on making the information more consumer-oriented. To accomplish this goal, an extensive Europe-wide survey was conducted, spanning 15 languages and involving over 3,000 participants from 29 countries. The primary aim of this survey was to gain a comprehensive understanding of consumers' behaviours related to energy efficiency, as well as to identify the various factors that either hinder or facilitate energy conservation efforts. For more information please refer to the relevant report *Profiling of energy consumers: psychological and contextual factors of energy behaviour*.

The results of the survey have unveiled six discrete consumer profiles, each marked by distinct attributes and behaviours concerning energy consumption. Leveraging the unique characteristics of these profiles, customized nudging approaches have been formulated. The subsequent sections provide comprehensive descriptions of these strategies, with a special focus on their pertinence and suitability for consumers. It is essential to emphasize the consumer-centric aspect of these strategies. By tailoring nudging techniques to match the specific traits and behaviours of different consumer profiles, individuals can receive more effective and relevant guidance on energy consumption. This consumer-focused approach enhances the practicality and applicability of these strategies, making them more accessible and beneficial for a wide range of individuals.

Consumer profile	Type of Nudge	Description
Environmentally conscious and well-informed energy consumers	Reinforcement	*Feedback and awareness*: maintaining interest through regular but infrequent information on energy saving
Concerned but comfort-oriented energy consumers	Comparison	*Remind of the* consequences: Invite the user to consider the consequences of an action, e.g. raising the temperature of the thermostat or air conditioning, insisting on the additional cost involved.
Concerned but unaware energy consumers	Facilitating	*Default*: turn the energy-saving settings of devices (thermostats, air conditioning systems) into default settings, to spare the user the 'burden' of learning what is appropriate and what is not.
	Reinforcement	*Real-time hints* and tips: provide users with hints and tips exactly when they interact with device settings that have an impact on energy consumption.
Materialistic energy consumers who shirk their	Comparison	*Remind of the* consequences: Invite the user to consider the consequences of an action, e.g. raising the temperature of the

personal responsibilities		thermostat or air conditioning, insisting on the additional cost involved.
Energy consumers prone to social influence	Social influence	Enabling social comparison: using different means to facilitate comparison with other peers (friends, neighbours, consumers with similar demographic characteristics).
	Social influence	*Target setting and commitment*: getting consumers to make a formal commitment to reduce the energy they consume, often in exchange for a (non-monetary) reward.
Indifferent energy consumers	Facilitating	Default: turn the energy-saving settings of devices (thermostats, air conditioning systems) into default settings, to spare the user the 'burden' of learning what is appropriate and what is not.
	Reinforcement	*Feedback and awareness*: use suggestions, notifications, marketing campaigns, to raise awareness among this group of users and overcome their reservations about the effectiveness of their behaviour.
	Reinforcement	*Hedonistic* goal: emphasise the big picture and the impact on the big issues, possibly with some exaggeration, in order to turn energy saving into a goal.

The results of the survey were used in the subsequent phases of the project, which involved the design and implementation of five field initiatives (pilots) to test a wide range of energy-saving behavioural interventions, targeting consumers in 5 different EU countries (Greece, Belgium, Germany, Portugal and Croatia), in different environments (residential, energy communities, schools), belonging to different age groups (including young children), belonging to different income classes (low, medium, high), served by different energy carriers (electricity, natural gas), with the inclusion of prosumers and drivers of electric vehicles. More information on the design of interventions can be found in the NUDGE deliverable on its *Research methodology for assessing the effectiveness of interventions regarding change of energy-efficient behaviour*. Specifically, the pilots aimed at:

- Increasing self-consumption (Germany, Croatia);
- Improving energy knowledge (Belgium);
- Optimising the charging of electric vehicles with self-generated photovoltaic energy (Germany)
- Reducing heating-related consumption (Belgium, Portugal and Greece)
- Reducing electricity consumption (Portugal)
- Improving indoor air quality (Portugal).

Three nudging interventions were tested in sequence in each of the four pilot projects, excluding the Belgian one which provides educational nudges through courses during the school year. Most of the pilot projects started with nudging interventions that provided feedback on participants'

consumption and aimed to increase their awareness. These were followed by more interactive nudges, particularly those with push notifications, just-in-time prompts, gamification or goal setting.

	Germany	Croatia	Belgium	Portugal	Greece
Nudge 1	Feedback and awareness	Stimulating empathy	Educational nudges and pupils as multipliers for two school cohorts	Feedback and awareness	Feedback and awareness
Nudge 2	Gamification and goal setting	Feedback and awareness		Push notifications	Just in time' suggestions
Nudge 3	Default	Gamification and goal setting		Push notifications, feedback and awareness	Push notifications

The results of the pilots show some positive cases of energy savings ranging from 0.4 to 3.5 per cent and as high as 15 per cent in the case of nudges aimed at smart charging of electric vehicles. However, it is not possible to deduce consistent evidence of the effectiveness of nudges across all pilots due to some major limitations represented by:

- Power constraints due to sample size and permissible testing periods;
- Low interaction with mobile apps that convey nudges;
- Exogenous restrictions to optimisation (holidays, weather);
- Conflicting regulatory incentives.

The results of the pilots nudging interventions to promote energy conservation are effective in certain situations, resulting in energy savings ranging from 3% to 16%. However, their effectiveness varies across different countries and seasons. In some cases, there are no significant nudging effects, and outcomes can be inconsistent due to various factors, including household limitations, regulatory barriers, and market constraints. It is essential to understand these limitations and address mismatches in regulatory incentives to maximize the impact of energy-saving nudges. More nuanced information can be found in the 2023 NUDGE Final report on the evaluation of nudging interventions through pilot data.

3.4.2. Evidence and Recommendations

The promotion of new behaviour is an obstacle course whose outcome is never a foregone conclusion: even when the strategies adopted succeed in changing a person's attitude on a certain issue, this change is not always matched by the adoption of new behaviour. Furthermore, even if a strategy is successful in promoting sustainable behaviour in one group of people, it is not certain that the same strategy can be generalised to other groups of people or that it will be effective in the long term.

Although the experiments of the NUDGE project, through the pilots carried out in the five countries indicated, for the reasons already described, do not provide certain indications regarding the effects of the nudges used in terms of a substantial change in energy consumption behaviour, we feel we must reiterate the importance of continuing to support and implement actions and projects that go markedly in this direction, taking into consideration the criticalities that emerged both from the survey and from the pilots. In particular, attention should be paid to the following critical issues:

Prioritizing consumer needs and preferences is paramount, ensuring that the proposed solutions align with their expectations and concerns to achieve practical and effective results in reduce energy demand. The valuable insights gained from the survey have guided the development of recommendations that offer actionable nudges tailored to each consumer profile.

Additionally, the outcomes of the pilot studies have yielded crucial data, serving as the foundation for crafting consumer-centric recommendations that have helped formulate the following recommendations that are highly applicable and actionable for consumers.

The issue of environmental awareness is often undermined by a general lack of understanding regarding how individual actions impact the environment. Environmental concerns are typically embedded within intricate systems, evolving slowly and subtly, making them less apparent in our daily lives. This obscurity often leads to a perception of these issues as distant or insignificant, impeding the development of genuine environmental consciousness. This is particularly true for energy consumption. Our daily energy use, and its consequent environmental impact, remain largely unnoticed, both by ourselves and those around us.

Invest in educating and raising awareness about these matters. Such efforts are critical for cultivating a deeper understanding of environmental issues among citizens. Effective coordination between European and national levels is crucial, alongside the active participation of various associations, including those for consumers and environmental advocacy. This collaborative approach can amplify the reach and effectiveness of these initiatives, making them more relatable and practical for consumers. By doing so, it can foster a more environmentally conscious society, where individuals are better informed about the consequences of their daily choices on the environment.

Improve awareness on the efficacy of individual actions. Many people are not fully aware of the impact their personal actions can have in making positive changes, especially in environmental contexts. To remedy this, it's crucial to implement methods that boost understanding of the significant effects individual behaviours can have on the environment. For example, informing individuals that a mere two-degree decrease in their thermostat setting could result in a 15% reduction in energy consumption is an effective way to illustrate the substantial influence of personal choices. Enhancing knowledge about the beneficial effects of individual actions is a key strategy in strengthening people's confidence in their ability to make a difference.

Regulatory bodies and energy providers can take active steps in facilitating the spread of knowledge regarding the use of available tools for monitoring energy usage. This includes simplifying energy bills, the introduction of smart meters, and the installation of other real-time data-providing devices concerning energy consumption and its associated costs. These measures

will enable individuals to have better control and understanding of their energy usage, thereby promoting more responsible and efficient energy consumption behaviours.

Consumption profiles require different approaches depending on the type of consumer. The examination of consumer behaviour patterns, as revealed by the survey, indicates distinct consumption profiles, each necessitating tailored strategies. One notable challenge in fostering sustainable habits is the interplay of conflicting internal motivations. For instance, when considering the decision to reduce home heating in winter, an individual's commitment to sustainability may be overridden by a stronger desire for personal comfort. Although implementing a variety of interventions can reshape an individual's values and bolster their intention to conserve energy, it's crucial to also nurture their motivation during the implementation phase, to counterbalance competing contextual drives.

Address habit inertia through feedback mechanisms. The influence of existing habits on future actions is more substantial than that of mere intentions. This is because habits are deeply embedded through subconscious sustaining processes, which present significant challenges to modification. In addressing this, the utilization of feedback is recommended. The effectiveness of feedback can vary based on its timing, frequency, and content. Generally, feedback given shortly after an action tends to be more impactful. Regarding frequency, more frequent feedback tends to yield better results. Concerning content, feedback tailored to an individual's specific consumption habits is more effective than generalized information. Additionally, feedback that compares an individual's performance with others seems more effective than feedback based only on personal data. However, feedback focused solely on economic benefits from energy savings is often ineffective and can even be counterproductive, as the monetary savings are usually minimal, leading individuals to perceive the efforts as unrewarding.

Make digital tools widely accessible. In the pilot studies, households had access to various technological resources like applications, interfaces, and devices that helped them track and manage their consumption patterns. This access enabled these citizens to make informed decisions about their consumption habits. This is crucial to prevent the situation where only individuals in medium to high-income brackets can engage in conscious consumption, while those in lower-income groups, who are most affected by energy-related expenses (refer to energy poverty), remain excluded. The goal is to democratize access to these tools, ensuring that all citizens have the opportunity to modify their consumption behaviours in an informed manner.

Ensure data confidentiality. In the realm of data confidentiality, consumer hesitancy to divulge detailed, particularly real-time, consumption information to external entities is a notable finding from the Survey. To address this concern, it is advisable to ensure that consumers are thoroughly informed about the processing of their data in alignment with national laws, emphasizing the safeguarding of their privacy rights. This approach aims to build trust and transparency in data handling practices.

3.5. Case study: Energy Communities in Croatia drawing inspiration from Austria

Croatia's energy policy has been evolving dynamically, especially since the regulatory changes introduced in 2021 and again in 2023. These changes signify a commitment to renewable energy and its sustainable consumption. This approach aligns Croatia with broader European trends, exemplified by countries like Austria, which have developed effective models for energy communities.

Croatia's legal framework distinctly separated 'self-consumption' for households and public institutions from the 'final customer with own production' model for other customer categories. However, the practical implications of this approach, especially for households, led to significant shifts in investment returns and consumer behaviour. In response, the Croatian government amended its policy in July 2023. From 2024, households will not lose their self-consumption status if they have surplus of exported energy and all households who already lost their self-consumption status due to surplus of exported energy, will be switched back to self-consumption model. Self-consumption model will be available for new consumers until the end of 2025, and the Ministry aims to formulate the new system by March 31, 2025, initiating its application on January 1, 2026. This change, aimed to be fully implemented by 2026, opens new avenues for sustainable energy practices in Croatia.

The Austrian model, with its focus on Renewable Energy Communities (RECs) and Citizen Energy Communities (CECs), offers valuable insights. Austria's integrated and community-focused approach supports not only individual self-consumption but also collective energy management and sharing. Drawing inspiration from Austria, Croatia can further refine its regulatory system to enhance the economic viability and sustainability of renewable energy consumption.

Effective engagement in energy-efficient practices hinges on users perceiving tangible benefits, especially financial. Past regulatory frameworks led to counterproductive behaviours like shutting down PV systems or installing excess capacities that fed into the grid rather than serving local needs. To address this, the regulatory framework must align with user interests, offering incentives for efficient energy use and local consumption.

3.5.1. Policy Recommendations for Energy Communities

Despite legal recognition of energy communities within its framework , Croatia has yet to see the formation of energy communities, largely due to operational uncertainties and barriers. These include restrictive definitions of eligible entities, complex regulatory environments, high financing costs, and diverse membership and education needs. In contrast, Austria's energy community model is more facilitative, offering flexible legal structures and economic incentives. To emulate this success, Croatia should consider the following steps, described in Table 1.

Table 1. Comparison of Energy Community Frameworks: Austria and Croatia

Aspect	Austria	Croatia
Expand Legal Definitions	Offers a flexible legal framework allowing various organizational forms, including associations and	Currently, the legal framework is more restrictive, limiting the types of entities that can form energy

	cooperatives, to form energy communities. This inclusivity fosters diverse participation.	communities. Amending the law to include a broader range of entities, similar to Austria, could enhance community formation.
Simplify Operational Processes	Has streamlined processes for establishing and managing energy communities, reducing bureaucratic hurdles and making it easier for communities to operate.	Faces significant administrative barriers that hinder the formation and management of energy communities. Adopting a simplified approach like Austria's could encourage the development of these communities.
Provide Financial Support and Incentives	Offers economic incentives, such as reduced grid fees, making it financially viable for communities to participate in energy sharing and production.	Currently, high financing costs and a lack of incentives are major impediments. Introducing financial schemes similar to Austria's could lower costs and risks, promoting the establishment of energy communities.
Educational and Support Programs	Likely has initiatives to educate and support potential members, contributing to the successful implementation and operation of energy communities.	Needs to develop comprehensive programs for educating potential members and providing operational support, which would help in overcoming the current knowledge and experience gaps.

In the realm of energy communities, the approaches of Austria and Croatia present an interesting contrast. Austria has notably set a benchmark in supporting these communities. The Austrian Distribution System Operators (DSOs) play a crucial role, offering reduced grid fees and efficiently allocating energy among community members. This significantly lowers operational costs and streamlines energy distribution. Moreover, Austria's administrative process is commendably efficient, characterized by clear guidelines and simplified procedures that facilitate the registration and operation of energy communities. On the other hand, Croatia faces several challenges in this domain. One of the primary issues is the unclear role of DSOs in supporting energy communities. Unlike Austria, where DSOs actively contribute to the growth and efficiency of these communities, Croatian DSOs lack specific provisions or incentives, which hampers the establishment and smooth operation of energy communities.

Administratively, Croatia's framework is mired in complexities. The process of registering as an energy community involves multiple steps and often unclear requirements. This complexity can deter the formation of new communities, a stark contrast to the Austrian model. Furthermore, Croatian regulations stipulate that energy communities must operate under non-profit regulations and include a full-time qualified worker, adding to the operational challenges, especially for smaller

communities. Financial hurdles are another significant challenge in Croatia. Energy communities often struggle with high financing costs, facing difficulties in accessing loans or funding due to the perceived risks by financial institutions. This financial burden significantly hampers the viability and sustainability of these communities.

To align Croatia's approach more closely with Austria's successful model, several steps could be beneficial. Enhancing the role and responsibilities of DSOs in Croatia to mirror Austria's supportive approach would be a significant step. This could include introducing incentives similar to Austria's reduced grid fees and technical assistance. Streamlining the registration process for energy communities in Croatia, making it more transparent and straightforward, would also be advantageous. This change would ease the path for new communities to form and operate, removing the administrative barriers that currently exist.

Another recommendation for Croatia is to reconsider the requirement for a full-time employee in each energy community. Allowing more flexibility in operational structures would enable smaller or emerging communities to sustain themselves more easily.

Finally, improving financial accessibility is crucial. Working with financial institutions to offer more accessible loans and lower interest rates, and introducing financial assistance programs, would help overcome the financial barriers faced by Croatian energy communities.

3.5.2. Policy Recommendations Energy Efficiency in Croatian Energy Communities

The challenge of nudging users towards energy efficiency, particularly in energy communities like those in Croatia with oversized photovoltaic (PV) systems, requires a nuanced approach. The aim is to encourage behaviours that maximize the use of renewable energy while minimizing wasteful practices. Here are specific recommendations tailored to the Croatian context and its energy communities:

- **Mandating Real-Time Energy Data Access:** Enforce policies requiring Distribution System Operators (DSOs) to provide real-time energy consumption and production data to end-users. This step is crucial for enabling users to make informed decisions about their energy use, particularly for those with oversized PV systems, avoiding additional investments in external smart meters.
- **Dynamic Tariff and Feed-In Policy Structuring:** Adjust energy tariffs to encourage energy self-consumption and make feed-in policies more attractive for surplus energy within energy communities.
- **Establishment of Energy Sharing Mechanisms:** Implement legal and technical frameworks to facilitate energy sharing within communities. This approach allows users with excess energy to share or sell it to others, promoting community-wide energy efficiency and collaboration.
- **Flexible Distribution Key Implementation:** Advocate for the creation of adaptable models for distributing energy within energy communities. Such a system would facilitate a more effective and equitable allocation of energy, tailored to the real-time usage patterns of

community members. As an illustration, while Austrian regulations permit various types of energy sharing keys within communities, in practice, DSOs typically provide just a static and a dynamic key. In contrast, Croatian DSOs have yet to establish a defined sharing key system.

In Croatia, adopting Austria's successful energy community model means enhancing DSO roles, simplifying regulations, and providing financial and educational support. This would help overcome barriers to forming sustainable energy communities and benefit citizens with oversized PV systems in self-consumption models. Key strategies include enabling real-time energy data access, developing dynamic tariff and feed-in policies, establishing energy sharing mechanisms, and introducing flexible distribution keys. These measures would promote informed energy usage, foster self-consumption, and encourage efficiency.

However, it's crucial to address broader challenges that have been observed in the Austrian model, such as limited economic benefits, challenges in data accessibility, and uncertainties regarding network structure and access. A more integrated approach, including sector coupling, is necessary to ensure the long-term viability of energy communities without an excessive reliance on subsidies.

To effectively navigate these complexities and tailor solutions to the Croatian context, it is recommended that the Ministry recognize the importance of establishing a dedicated working group. This group should consist of energy community experts, stakeholders, and policymakers who can collaboratively develop strategies and solutions that are not only feasible but also beneficial for Croatian citizens beyond 2026. This collaborative approach will ensure that the policies and frameworks developed are well-suited to the specific needs and circumstances of Croatia, paving the way for a sustainable and efficient energy future.

4. Recommendations for effective implementation

4.1. Cross-Cutting and General Recommendations

Behavioural interventions have emerged as a powerful tool in the domain of energy conservation and efficiency. These interventions leverage insights from behavioural science to encourage individuals and organizations to adopt energy-saving behaviours. While behavioural interventions can be highly effective, they are most impactful when integrated into broader energy policy frameworks. In this section, we explore general recommendations from the literature for the successful implementation of behavioural interventions, highlighting the need for synergy with traditional energy-saving strategies, the role of incentives and rewards, the importance of regulatory support, adaptability to changing circumstances, transparency in data usage, and the ethical considerations that must underpin these interventions.

4.1.1. Regulatory Support

To enhance the effectiveness of behavioural interventions in the realm of energy conservation, it is imperative to complement them with supportive regulatory measures. Research in the field underscores the importance of this dual approach, emphasizing how behavioural insights can significantly augment the implementation of crucial energy-related policies and initiatives. By aligning pricing structures, offering tax incentives, and integrating behavioural insights into policy design, policymakers can leverage the full potential of behavioural economics to foster positive energy-saving behaviours among consumers

As Borenstein et al. (2015) aptly point out, one prime example of the synergy between behavioural insights and regulatory measures lies in the alignment of pricing structures with behavioural incentives. By doing so, policymakers can harness the power of behavioural economics to nudge consumers toward energy-saving behaviours. For instance, time-of-use pricing can encourage consumers to reduce energy consumption during peak periods by making energy use more expensive during those times. Such pricing strategies have been shown to be effective in reducing peak electricity demand and promoting load-shifting behaviours (Faruqui & Sergici, 2010).

Tax incentives for energy-efficient technologies represent another valuable regulatory tool that can be harmonized with behavioural interventions. Research by Allcott and Greenstone (2012) demonstrates that tax incentives can play a pivotal role in encouraging the adoption of energy-efficient technologies and practices. These incentives effectively reduce the upfront costs of energy-efficient upgrades, making them more financially attractive to consumers.

The integration of behavioural insights into the design of energy efficiency standards and emission reduction targets can enhance their efficacy. Behavioural economics principles can inform the framing and communication of these standards, making them more salient and understandable to consumers (Allcott & Mullainathan, 2010). This, in turn, can facilitate compliance and drive greater energy savings.

4.1.2. Integration with traditional energy saving strategies

Behavioural interventions should be viewed as integral components within broader energy policy frameworks, as this approach enables a comprehensive and synergistic approach to energy conservation. By seamlessly integrating behavioural insights with technological advancements, policymakers can harness the full spectrum of tools at their disposal to drive substantial and enduring energy savings.

The integration of behavioural insights into established energy policy frameworks aligns with the principles of behavioural economics, which emphasize the significance of choice architecture and decision context in influencing human behaviour (Thaler & Sunstein, 2008). By embedding nudges and incentives within policy measures and regulations, policymakers can create an environment conducive to energy-efficient choices, thereby enhancing the overall effectiveness of energy conservation initiatives (Thaler & Sunstein, 2008).

Empirical research underscores the significance of this integration, revealing that the combination of behavioural interventions with conventional strategies, such as the adoption of energy-efficient technologies and adherence to stringent building standards, results in significantly enhanced and more sustainable energy conservation outcomes (Gillingham et al., 2009).

Gillingham and colleagues (2009) shed light on the pivotal role played by the synergy between behavioural interventions and technological solutions in promoting energy efficiency. Their research findings indicate that while behavioural insights are influential in shaping individual and collective energy-saving behaviours, these effects can be magnified when coupled with advancements in energy-efficient technologies.

4.1.3. Incentives and rewards

Nudging and behavioural insights can be complemented and enhanced by the strategic use of incentives and rewards. While nudging and behavioural insights create a foundation for encouraging energy-saving behaviours, the integration of financial incentives, rebates, and loyalty programs can significantly amplify the impact of energy conservation initiatives.

Financial incentives, such as direct cash rewards or reduced energy bills, have demonstrated their effectiveness in stimulating energy-saving actions. According to a study by Gillingham et al. (2009), financial incentives directly linked to energy conservation actions, such as reducing electricity consumption during peak hours, have shown substantial positive outcomes. Participants in these programs not only reduced their energy consumption during incentivized periods but also exhibited sustained behavioural changes beyond the incentive period.

Rebates, another form of financial incentive, have been widely adopted to encourage energy-efficient product purchases (Buettner et al 2021). Consumers are often offered cash-back rewards or discounts when they opt for energy-efficient appliances or home improvements. These rebates not only make energy-efficient choices more financially attractive but also contribute to long-term energy savings by promoting the adoption of efficient technologies.

Loyalty programs, which reward customers for their ongoing engagement in energy-saving practices, have gained traction in various sectors. Studies by Kivetz and Simonson (2002) and Bolton et al. (2000) emphasize the effectiveness of such programs in maintaining customer loyalty and encouraging sustained participation in energy conservation efforts. These programs often provide customers with points, discounts, or exclusive offers as they continue to save energy or make environmentally conscious choices.

One of the key messages that governments should convey in their public campaigns is that there are various forms of assistance available for people who want to save energy. By highlighting the existing subsidies, grants and support schemes, governments can encourage more people to take action and invest in energy-efficient solutions. Belgium provides direct links to the regional pages where people can find detailed information on financial support for insulation, heat pumps, solar panels and personalised energy advice. Switzerland also guides consumers to the most suitable grants and support schemes for their needs, through user-friendly paths on their website and on their francs énergie website.

These campaigns show that making information tools more accessible and lowering the barrier for people to act can increase the uptake of energy saving measures. Ideally, governments should provide a centralised platform where people can find all the relevant information, but if that is not possible, they should ensure that the different websites are well-connected and offer unique benefits.

4.1.4. Adaptability to changing circumstances

The energy landscape is undeniably dynamic, subject to continuous transformation influenced by technological progress and shifting consumer preferences. As Davis and Vandenbergh (2018) emphasize, this ever-changing nature necessitates a forward-thinking approach to policy design. Policies aimed at promoting energy efficiency and sustainability should inherently possess the quality of adaptability, aligning with the ongoing evolution of technology and socio-economic conditions.

Behavioural measures, especially when having a long history of application, can help meet urgent needs. In 2022, Finland was well prepared to launch its down a degree campaign and limit energy use as a reposnse to the war in Ukraine. A joint effort between the Prime Minister's office, various ministries, the Energy Agency, Motiva and the Investment Fund Sitra ensured a coherent and consistent strategy that lasted over time.

The integration of innovative technologies, such as smart meters and IoT sensors, into behavioural interventions exemplifies the need for adaptability. These technologies offer real-time data collection and analysis capabilities, allowing for the development of more responsive and personalized interventions. Policies should facilitate the seamless incorporation of these advancements to enhance intervention strategies (Irizar-Arrieta et al., 2020). It should also be possible to approach benefits and concerns around privacy, trust, and ease of use, that determine the intention to use IoT services or products (Kim and Park, 2022)

Davis and Vandenbergh's (2018) perspective underscores the importance of recognizing that behavioural interventions, as integral components of energy policy, should not remain static but evolve in tandem with the emerging technological landscape. This adaptability is crucial for ensuring that these interventions retain their relevance and effectiveness over time. The contend that policymakers bear the responsibility of anticipating and preparing for these changes proactively. This forward-looking approach entails a comprehensive understanding of emerging technologies, market dynamics, and consumer behaviours. Such insight enables policymakers to formulate interventions that are not only effective today but also resilient and adaptable for the future.

As the socio-economic landscape evolves, policy frameworks should remain agile in addressing emerging challenges and opportunities. Policies that foster collaboration among stakeholders, as well as encourage innovation and entrepreneurship, can help navigate the complexities of a rapidly changing energy landscape (Frondel et al., 2017).

4.1.5. Ethical considerations

Ethical considerations are fundamental in the realm of behavioural interventions, particularly when it comes to data collection and utilization. This aspect of behavioural interventions cannot be understated, as it not only safeguards individual rights but also contributes to the overall effectiveness and acceptance of such interventions. It is important to acknowledge that ethical challenges and criticisms do exist in this domain. Researchers and experts have raised concerns regarding the potential for ethical breaches and unintended consequences in behavioural interventions, particularly when they involve data collection and behaviour modification.

Ethical considerations, consumer protection, and data privacy are paramount in these analyses and cover issues such as informed consent, transparency, and respect for autonomy. These principles ensure that individuals are fully aware of the interventions, their purpose, and the data collection processes involved. Respecting individuals' autonomy in making decisions related to their energy consumption is essential for the ethical conduct of behavioural interventions. Ensuring that interventions align with ethical principles is vital for their acceptance and sustainability. It safeguards the rights and well-being of individuals participating in interventions while maintaining public trust in the process. (Marteau et al., 2012).

Ethical principles are the bedrock upon which behavioural interventions should be built, and these principles extend to various dimensions. One of the primary ethical considerations is obtaining informed consent from individuals who are subject to behavioural interventions (Thaler & Sunstein, 2008). Users should willingly opt into such programs, and they should be provided with clear information about the nature and objectives of the interventions. Consent ensures that individuals are not coerced into altering their behaviour and that they have the autonomy to opt out if they wish.

One significant criticism pertains to the issue of informed consent. While obtaining consent from users is a fundamental ethical principle, it can be challenging to ensure that consent is truly informed. People may not fully understand the implications of data collection and its potential

impact on their behaviour (Harrison et al., 2022). This raises the need for improved communication and education about the nature and objectives of behavioural interventions. One of the key criticisms pertains to the potential for manipulation within behavioural interventions. Critics argue that when individuals are subjected to nudges and other behavioural techniques without their explicit consent, it can be perceived as a form of manipulation (Carrigan et al 2016). Such interventions may infringe upon an individual's autonomy and decision-making, potentially leading to a sense of coercion.

Privacy is another ethical concern that demands meticulous attention. Behavioural interventions often involve the collection and analysis of personal data, and stringent measures must be in place to protect the privacy of individuals. Users worry about how their personal information is used, stored, and shared. Data should be anonymized and aggregated whenever possible to prevent the identification of specific individuals. Privacy protection is essential for maintaining trust and upholding individual rights (Acquisti et al., 2015). Addressing these concerns requires not only robust data protection measures but also clear communication about data handling practices to alleviate user apprehensions. Data privacy specifically, is a fundamental aspect of behavioural interventions, given the collection and analysis of personal data (Thaler & Sunstein, 2008). Stringent data protection measures must be in place to safeguard the confidentiality and security of individuals' information. Compliance with data protection regulations, such as the General Data Protection Regulation (GDPR) in the European Union, is essential to ensure that data is handled ethically and legally.

Transparency plays a pivotal role in ensuring that individuals have a clear understanding of how their data is gathered and how it is used to shape their behaviour. As Sunstein (2016) emphasizes, this transparency is vital for establishing trust between users and the entities implementing behavioural interventions. When individuals are fully aware of the data collection process and its purposes, they are more likely to engage willingly in the desired behaviours. Moreover, transparency empowers individuals to make informed decisions about their energy usage and their participation in energy-saving programs. The ethical principles guiding behavioural interventions should extend beyond mere transparency. The principle of beneficence should be a guiding force, ensuring that interventions are designed to benefit individuals and society as a whole (Hausman & Welch, 2010). This implies that interventions should be rigorously evaluated for their effectiveness and potential harm.

Behavioural interventions should be scrutinized for unintended consequences. While the primary goal may be to encourage energy-saving behaviours, there is a potential for adverse outcomes, such as increased stress or unintended energy consumption patterns (Hofmann et al., 2014). Ethical considerations demand that interventions are continually monitored and adjusted to mitigate any negative effects and ensure that the well-being of users is not compromised.

To address these ethical challenges and criticisms effectively, best practices have emerged from both ethical literature and practical application. One promising approach is to provide users with detailed information through plain language and user-friendly interfaces, ensuring they understand the goals and mechanisms of interventions (Loewenstein et al., 2013). Additionally, offering users the flexibility to opt in and out of interventions at any time empowers them to make autonomous choices (Marteau et al., 2012; Hausman & Welch, 2010). This approach respects

individual autonomy and allows users to make informed choices about their participation. Furthermore, ethical design thinking is gaining traction, where ethical considerations are integrated into the entire development process of interventions (Liedtka, 2014). This approach emphasizes continuous ethical reflection and iterative improvements to address emerging ethical challenges and unintended consequences.

A promising approach to addressing ethical concerns is the incorporation of participatory and deliberative processes into the design and implementation of interventions (Dolan et al., 2010). Engaging users and stakeholders in decision-making ensures that interventions are aligned with their values and preferences, reducing the risk of paternalism.

4.2. Communication strategies

Effective communication strategies are pivotal in the success of behavioural interventions for energy saving. This section draws from the rich literature on psychology, environmental science, and communication studies to present various communication techniques, leveraging technology, tailoring messaging, personalization, feedback mechanisms, social norms, and behavioural triggers to promote energy-efficient behaviours.

4.2.1. Public awareness campaings

Public awareness campaigns serve as pivotal tools for disseminating information and fostering behavioural change in the context of energy savings. They play an instrumental role in informing and educating citizens about the advantages of energy conservation and the effectiveness of behavioural interventions. As Steg et al. (2015) highlight, these campaigns are integral components of energy policy strategies and can yield substantial benefits in terms of promoting energy-efficient behaviours.

One of the key factors for a successful energy saving campaign is to define the goals and the target audience clearly from the start. This allows the campaign planners to tailor the message, the tone and the channels to the specific needs and motivations of the intended recipients. For example, in the winter of 2022, in the context of the war in Ukraine, some countries had different messaging objectives for their campaigns, such as saving money, reducing reliance on foreign gas, or fighting climate change. By segmenting their audience and understanding their preferences, they were able to craft more effective and persuasive campaigns.

For instance, Sweden focused on reducing electricity consumption among single-family homeowners, who were more likely to respond to environmental arguments. The UK, on the other hand, emphasized the cost savings of energy efficiency measures, as this was the main driver for their target group of the "it all adds up" campaing.

Advancements in technology have revolutionized the landscape of public awareness campaigns, enabling policy makers to engage with a wider and more diverse audience. Steg and colleagues

(2015) emphasize that leveraging these technological innovations is essential for maximizing the impact of such campaigns. Multi-channel communication has emerged as a powerful approach, allowing policy makers to disseminate information through various platforms and mediums.

Social media platforms have become indispensable tools for reaching a broad demographic (Eveland & Cooper, 2013). With billions of users worldwide, they offer an extensive reach for energy-saving campaigns and facilitate real-time interactions, enabling policymakers to engage directly with citizens and respond to their inquiries or concerns promptly.

Mobile apps have gained popularity as effective communication channels. They provide users with easily accessible information, interactive features, and personalized experiences related to energy conservation. These apps can offer tips on reducing energy consumption, provide real-time energy usage data, and even offer gamified elements to encourage energy-saving behaviours (Nghiem et al., 2016, Papaioanou et al, 2017).

Email and newsletters remain a valuable means of communication, particularly for disseminating in-depth information and updates to interested individuals or organizations. They allow for targeted messaging and are a preferred choice for those who prefer more detailed insights (Dillman et al., 2009).

Traditional media outlets, such as television, radio, and newspapers, continue to play a role in public awareness campaigns. These platforms can effectively reach audiences who may not be as digitally connected as others, ensuring a comprehensive outreach strategy (Eveland & Cooper, 2013).

4.2.2. Communication strategies

Tailoring communication strategies to specific user profiles is an important component of effective behavioural interventions for large populations (Schultz et al., 2007). This approach acknowledges that different demographic groups may exhibit varying responses to distinct messaging styles and communication channels, a concept well-supported by scholarly research. Schultz and colleagues (2007) emphasize the importance of segmentation in communication strategies. By categorizing individuals into homogeneous groups based on shared characteristics, such as age, gender, or socioeconomic status, policymakers can craft messages that resonate more deeply with each group's unique preferences and motivations.

Van der Linden (2015) underscores the significance of tailoring messages to the values and beliefs of the target audience. This approach aligns with the principles of the Theory of Planned Behaviour (Ajzen, 1991), which posits that attitudes, subjective norms, and perceived behavioural control influence intention and behaviour. Tailored messages that align with these factors can be particularly persuasive. To make a campaign more memorable and effective, governments should consider choosing a unique name and slogan that stand out. It is useful to create a visual identity that resonates with the audience and conveys the message emotionally through the use of images, videos, icons, colours and even mascots to appeal to the profile of the audience.

The use of specific communication channels should also be informed by research and analysis. For instance, studies in health communication have shown that young adults may be more receptive

to health-related messages delivered through social media platforms due to their high usage rates (Lo, 2020). This aligns with the idea that understanding user preferences for specific channels can enhance the effectiveness of communication strategies (Chen, 2021).

4.2.3. Personalised messaging

Implementing personalized messaging is a potent strategy that can greatly enhance the effectiveness of behavioural interventions, particularly when tailored to individual preferences and motivations.

The literature suggests that personalized messaging can significantly impact user behaviour by increasing their sense of relevance and ownership of the recommended actions, and that when individuals perceive that the information provided directly addresses their unique circumstances and goals, they are more likely to take action (Prochaska, 2013). Personalized messaging can also consider sociodemographic factors, such as age, income, and household size, to tailor messages further (Bator et al., 2019) to become more relatable and persuasive.

According to Klöckner et al. (2013), personalized messaging represents a nuanced approach to communication that acknowledges the unique characteristics and needs of different users. Personalised messaging can increase the relevance, credibility and persuasiveness of the message, as well as the engagement and satisfaction of the recipients. This strategy involves delivering messages and content that resonate with an individual's specific behaviour, circumstances, and psychological drivers, ultimately fostering greater engagement and adherence to energy-saving actions.

One of the key advantages of personalized messaging is its ability to create a more relevant experience for users. By analyzing user data and behaviour patterns, policymakers and energy providers can tailor messages to align with the individual's energy consumption habits. For instance, if a user tends to consume more energy during peak hours, a personalized message may provide specific tips on how to reduce energy use during those times. Alternatively, if a user is known to be environmentally conscious, messaging can emphasize the environmental benefits of energy-saving actions.

However, personalised messaging requires careful planning and testing to ensure that it does not backfire or cause unintended consequences.Government are able to use various methods to test and refine their messages, such as convening a representative sample for in-person focus groups, conducting regular online surveys, and applying insights from behavioural science. Representative focus groups can help create clear, consistent and compassionate communication that addresses the needs and concerns of different segments of the population.

Personalised messaging can increase the trust and rapport between the sender and the receiver, as well as the likelihood of compliance and action. However, personalised messaging can also pose ethical and practical issues, such as privacy, consent, accuracy, bias and scalability. Therefore, it is important to follow some best practices when designing and delivering personalised messages, such as respecting the rights and dignity of the recipients, ensuring transparency and accountability, avoiding manipulation and deception, and evaluating the outcomes and impacts.

4.2.4. Social norms and peer pressure

Leveraging social norms and peer pressure as motivators for behavioural change has been extensively studied and validated in the field of psychology and behavioural economics (Nolan et al., 2008). Social norms play a pivotal role in shaping individual behaviours, as they provide a reference point for what is considered socially acceptable or desirable (Cialdini, 2003). Nolan et al. (2008) emphasize that understanding and utilizing these dynamics can significantly influence energy-saving behaviours. In their study, Nolan et al. (2008) conducted field experiments involving energy conservation interventions. They found that providing individuals with feedback on their energy consumption compared to that of their neighbors led to significant reductions in energy usage. This finding underscores the power of social norms and peer pressure in driving energy-saving actions.

Research indicates that individuals often conform to perceived social norms, especially when they believe that others are engaging in a particular behaviour (Reno et al., 1993). This conformity arises from a desire to fit in, gain social approval, or avoid social disapproval (Cialdini, 2003). When it comes to energy conservation, highlighting how a user's energy consumption compares to that of their peers can effectively trigger a sense of social accountability. Studies have shown that messages emphasizing that a substantial portion of the population is already adopting energy-saving behaviours can be particularly persuasive (Goldstein et al., 2008). This approach capitalizes on the psychological principle of consensus, where individuals tend to follow the crowd when they perceive that the majority is engaged in a specific action (Cialdini, 2003).

4.2.5. Behavioural trigers

Behavioural triggers can be utilized as a potent tool in promoting energy-saving actions. As highlighted by Dolan et al. (2010), these triggers, when strategically integrated into messaging, have the potential to significantly influence individuals' behaviours in the context of energy conservation – and significantly increase their effectiveness when offered as timely reminders. Reminders serve as memory cues, prompting individuals to take specific actions related to energy savings. This aligns with the broader findings in the field of behavioural economics, where the role of environmental cues in shaping behaviour has been well-documented (Thaler & Sunstein, 2008).

A classic example of this concept in practice is sending reminders to adjust thermostats before leaving home during the winter months. Research has shown that such timely reminders can lead to substantial reductions in heating energy consumption. This phenomenon is supported by the "implementation intention" theory, which posits that explicit plans or reminders increase the likelihood of individuals following through with intended actions (Gollwitzer, 1999). But reminders are not limited to thermostat adjustments, and they can encompass a range of energy-saving behaviours, including turning off lights, unplugging electronic devices, or adjusting water heater settings. These reminders, or "just-in-time interventions" can be delivered through various communication channels, such as smartphone apps, text messages, or email notifications, depending on the preferences of the target audience

4.2.6. Real time feedback mechanisms

Offering users real-time insights into their energy consumption is a useful strategy in fostering awareness and driving behavioural change. This approach empowers individuals by providing them with immediate feedback on their energy usage patterns, thereby enhancing their understanding of the implications of their behaviours and motivating them to adopt more energy-efficient practices.

Abrahamse et al (2007) emphasize that visualizing energy consumption data in user-friendly formats is key to its effectiveness. Utilizing accessible platforms such as smartphone applications and web-based dashboards significantly contributes to the usability and impact of this information. These interfaces enable individuals to easily monitor their energy consumption and gain insights into their usage patterns, making it more likely for them to take action and make informed decisions regarding energy conservation. Abrahamse et al. (2007) further argue that visualizations should be designed with the end-user in mind, employing intuitive and comprehensible graphics that facilitate a clear understanding of energy data.

Real-time feedback on energy consumption has the advantage of immediacy, enabling users to observe the direct impact of their actions on energy usage. This instant connection between behaviour and outcomes is a powerful motivator for individuals to adopt energy-saving practices. It allows users to identify wasteful behaviours and make timely adjustments, ultimately leading to more sustainable energy consumption patterns (Karlin et al., 2015, Dogan et al 2014)

The literature supports the notion that real-time feedback, when presented effectively, can lead to substantial reductions in energy consumption (Abrahamse et al., 2005). Users who can readily access information about their energy usage are more likely to engage in energy-saving behaviours, such as adjusting thermostat settings, turning off lights, or optimizing appliance usage.

In addition to the visualization of energy data, personalized feedback has been shown to be particularly effective. Tailoring feedback to an individual's specific behaviours and circumstances increases its relevance and impact. Personalized messages can include customized recommendations for energy-saving actions based on the user's consumption patterns and goals, further encouraging them to make meaningful changes (Froehlich et al., 2010).

Feedback mechanisms offer a substantial potential for lowering energy consumption. Research has shown a connection between offering users socially tailored feedback about their energy usage and decreases in energy consumption. By adapting social network tests, researchers are able to effectively identify and separate social influence effects on peer network energy usage, suggesting that social influence and social networks can be utilized to optimize energy savings in conservation programs (Jain et al, 2013)

4.3. Collaboration and knowledge sharing

Collaboration and knowledge sharing are essential components of successful behavioural interventions aimed at achieving energy savings. In this discussion, we emphasize the significance of partnerships among government agencies, energy providers, technology companies, and consumer associations. We also delve into the role of knowledge-sharing platforms, data sharing, and capacity-building initiatives as vital mechanisms for enhancing the effectiveness of behavioural interventions.

4.3.1. Partheships for joint development and implementation

Partnerships among diverse stakeholders, including government bodies, energy providers, technology firms, and consumer associations, constitute a potent approach in advancing the development and deployment of behavioural interventions. As supported by the existing literature, these collaborative endeavors offer a platform for the synergistic amalgamation of resources, knowledge, and perspectives, ultimately fostering the creation of more effective and tailored interventions.

The concept of multi-stakeholder collaboration in the realm of behavioural interventions aligns with research that has shown that diverse stakeholder engagement can enrich the design and execution of interventions by drawing on a range of expertise (Bemelmans-Videc et al., 1998). Government agencies often possess valuable regulatory and policy-making authority, which can be harnessed to create an enabling environment for behavioural change initiatives (Bemelmans-Videc et al., 1998). In parallel, energy providers bring insights into the energy landscape and infrastructure, offering practical perspectives on the implementation of interventions (Steg et al., 2015).

Collaboration with technology companies is useful in leveraging cutting-edge tools and platforms for behavioural interventions. These companies excel in developing innovative solutions, such as smart meters, mobile apps, and IoT devices, which can enhance the effectiveness of behaviour-focused programs. Their expertise in data analytics and user-friendly interfaces is particularly valuable for monitoring and optimizing interventions.

Consumer associations play a pivotal role in this collaborative framework, representing the voice of end-users in the energy efficiency landscape. Consumer protection safeguards individuals from potential harm or exploitation resulting from interventions (Sunstein, 2017). Policymakers must actively work to prevent negative consequences and mitigate risks associated with behavioural interventions. This includes monitoring for unintended effects and promptly addressing any issues that may arise. Their involvement is emphasized in studies such as the one conducted by Steg et al. (2015), which underscores the importance of consumer associations as key stakeholders in shaping effective behavioural interventions. Consumer associations possess valuable insights into the preferences, concerns, and motivations of energy consumers, making their input instrumental in the design and implementation of user-centric interventions. Their feedback can guide the development of strategies that align more closely with the needs and expectations of consumers, thereby increasing the likelihood of intervention success (Steg et al., 2015).

The collaboration between these diverse stakeholders, as advocated in contemporary research, fosters an environment of knowledge exchange, innovation, and synergy (Andrews & Johnson, 2016). Such partnerships not only enhance the effectiveness of behavioural interventions but also contribute to the broader goal of achieving energy efficiency targets in a manner that is inclusive, informed, and responsive to the needs of end-users.

4.3.2. Knowledg sharing paltforms

Knowledge sharing platforms and networks have become indispensable tools in the realm of behavioural interventions for energy savings, offering a pivotal avenue for stakeholders to exchange vital information and insights. As underscored by Razmerita et al. (2016), these platforms play a critical role in facilitating the transfer of knowledge, best practices, and research findings, thus contributing significantly to the advancement of effective interventions in the field. The significance of these platforms lies in their ability to serve as central hubs where stakeholders from diverse backgrounds and sectors converge to share their experiences and expertise. Fadel et al (2020) emphasize that these platforms create an environment conducive to open dialogue, enabling participants to discuss their successes and challenges openly.

One notable aspect of knowledge sharing platforms is their role in fostering cross-sectoral learning. Research by Razmerita et al (2016) emphasizes that cross-sectoral learning is essential for the holistic development of behavioural interventions. When stakeholders from various domains come together on these platforms, they bring with them unique perspectives, strategies, and experiences. This cross-fertilization of ideas can lead to innovative approaches and more effective interventions.

Knowledge sharing platforms promote the dissemination of valuable insights gained through practical experiences. As highlighted by Klerkx and Aarts (2013), experiential knowledge is often as valuable as scientific research findings in the context of behavioural interventions. By sharing their on-the-ground experiences, stakeholders can provide nuanced insights that may not be evident in academic literature alone.

The role of knowledge sharing platforms extends beyond merely sharing information; they also foster collaboration and the establishment of networks of practitioners. These networks can be instrumental in building a community of experts and enthusiasts who are passionate about advancing behavioural interventions for energy savings.

4.3.3. Data sharing for informed interventions

Effective behavioural interventions in the context of energy conservation often hinge on the availability of data that can inform decision-making and intervention strategies. However, the sensitive nature of data collection and sharing necessitates a careful balance between gathering valuable insights and respecting privacy regulations. As Faruqui and colleagues (2010) underscore, the sharing of anonymized and aggregated data among stakeholders can be a game-changer in understanding consumer behaviour and crafting precise policy measures. The concept of data

anonymization involves the removal or encryption of personally identifiable information (PII) to protect individuals' identities while retaining the valuable behavioural data.

The importance of data sharing and collaboration is highlighted in a study by Tenopir et al (2020), who stress the significance of cross-sectoral data sharing initiatives to enhance energy efficiency efforts. Their research underscores the potential for various stakeholders, including government agencies, energy providers, and technology companies, to pool their anonymized data resources for a more comprehensive understanding of consumer behaviours and preferences. Additionally, Mittal et al (2023) emphasize the need for robust data-sharing platforms to foster collaboration among diverse stakeholders. Such platforms can serve as secure repositories for anonymized data, allowing for efficient data exchange and analysis while adhering to stringent privacy regulations. Moreover, as outlined by Faruqui et al. (2010), the insights gained from shared data can aid in tailoring behavioural interventions to specific user profiles and preferences. This personalized approach aligns with the principles of behavioural economics, which recognize that individuals' motivations and responses to interventions can vary significantly (Thaler & Sunstein, 2008).

4.3.4. Capacity building initiatives

To optimize the likelihood of successful policy implementation in the domain of behavioural interventions for energy saving, it is crucial to prioritize investments in comprehensive behavioural training programs and capacity-building initiatives. These initiatives should be targeted towards a range of key stakeholders, including policymakers, energy companies, and technology providers. As Schultz et al. (2007) assert, such programs are instrumental in equipping stakeholders with the essential skills and knowledge required to proficiently conceive, execute, and adapt behavioural interventions.

Capacity-building programs play a pivotal role in bridging the gap between theory and practice in the realm of behavioural science. These programs facilitate a deeper understanding of the psychological underpinnings of human behaviour and decision-making processes, enabling policymakers to craft interventions that resonate with target populations (Schultz et al., 2007). Additionally, these initiatives empower energy companies and technology providers to collaborate effectively with policymakers, fostering synergy in the development and execution of energy-saving strategies.

When investing in capacity-building programs, stakeholders can better navigate the intricacies of behavioural science, including the nuances of behavioural change theories and methodologies. This knowledge equips them to make informed decisions regarding intervention strategies, measurement of outcomes, and adaptation in response to changing circumstances (Cialdini, 2020).

4.4. Monitoring and evaluaton

To ensure the effectiveness and long-term impact of behavioural interventions for energy saving, it is important to establish the deployment of critical components of monitoring and evaluation. This section delves into the methodologies and considerations involved in assessing the outcomes

of such interventions, with a focus on key performance indicators (KPIs), data collection, A/B testing, expert analysis, ethical considerations, and the sustainability of behavioural change.

4.4.1. Key performance indicators (KPIs)

Key Performance Indicators (KPIs) are invaluable tools in the assessment of the effectiveness of behavioural interventions, offering a quantitative and measurable framework to gauge their impact. As Klöckner et al. (2013) emphasize, KPIs serve as essential metrics for evaluating the success of these interventions, helping policymakers and researchers objectively measure and compare their outcomes. One of the primary strengths of KPIs lies in their versatility, as they can encompass a wide range of dimensions related to behavioural interventions. Energy savings, a core objective of many energy efficiency programs, can be quantified and monitored through KPIs, providing a direct measure of the intervention's impact on reducing energy consumption (Abrahamse et al., 2005).

Changes in user behaviour, another crucial aspect, can be effectively captured by KPIs. By tracking alterations in user habits, such as shifts towards more energy-efficient practices, KPIs offer insights into the effectiveness of behaviour-focused strategies (Dietz et al., 2009). Levels of user engagement, a key determinant of intervention success, can also be assessed through KPIs. Metrics related to user participation, interaction with energy-saving platforms, or response rates to behavioural prompts can provide valuable information (Vassileva, 2012, Abrahamse et al, 2007).

Cost-effectiveness is a fundamental consideration in any policy or program evaluation, and KPIs can shed light on this aspect as well. By analyzing the costs associated with implementing behavioural interventions and comparing them to the achieved energy savings or behaviour changes, policymakers can make informed decisions regarding resource allocation (Zhang et al 2011)

4.4.2. Continuous data collection

Continuous data collection is key to comprehend the impact of behavioural intervention and to ensure their effectiveness and adaptability in dynamic contexts. As highlighted by Faruqui et al. (2010), the utilization of the Internet of Things (IoT) sensors and data analytics is imperative for acquiring valuable insights into user behaviour and energy consumption. IoT sensors, embedded in various smart devices and systems, have emerged as indispensable tools for monitoring and collecting data related to energy usage (Gubbi et al., 2013). These sensors enable the seamless capture of real-time data, encompassing parameters such as temperature, humidity, energy consumption patterns, and appliance usage. Faruqui et al. (2010) emphasize that the deployment of IoT sensors in households, energy communities, and commercial settings provides a granular view of energy consumption and user behaviour, offering a comprehensive understanding of the dynamics at play. Real-time insights derived from IoT sensors and data analytics empower stakeholders to make informed decisions promptly (Yaqoob et al., 2019). For instance, if an energy-saving intervention is not yielding the expected results or if energy consumption spikes

unexpectedly, immediate adjustments can be implemented to optimize the intervention's efficacy (Faruqui et al., 2010).

The integration of data analytics is paramount for translating the vast amount of collected data into actionable insights (Chen et al., 2014). Advanced analytics techniques, including machine learning algorithms and predictive modeling, can unveil patterns, trends, and anomalies in energy consumption data (Chen et al., 2014; Wagner et al., 2022). By leveraging these techniques, policy makers and energy providers can gain deeper insights into user behaviour, identify areas of inefficiency, and develop tailored interventions to promote energy savings.

To improve the effectiveness of the campaign, it is important to measure and adapt the communication strategies based on the immediate feedback and the attitudes of the target audience.One way to measure the immediate feedback is to use web analytics tools to track the online behaviour of the campaign visitors, such as the number of clicks, impressions, and website visits. This can help identify which resources and links are more popular, which events generate more interest, and which parts of the website need more attention. Some governments have hired user experience experts to enhance their website design based on these data.

Another way to measure the attitudes of the target audience is to conduct surveys both online and in-person. This can help obtain more qualitative data and better understand the sources, preferences, and motivations of the campaign recipients. This can help adjust the messages and the media channels used for the campaign. For example, Finland conducted a survey of over 2000 adults of different ages in 2023 to assess their views on energy and energy saving and to inform the future direction of the campaign. The survey found that 40% of respondents enjoyed saving energy, 89% of them followed the electricity price at least sometimes, and 60% of them learned new ways to save energy during the crisis. The survey also indicated that more efforts were needed to appeal to specific target groups.

4.4.3. Long term impact assessment

Assessing the long-term impact of behavioural interventions is paramount in achieving sustained energy savings and lasting behaviour change, as advocated by Schultz et al. (2007). It is imperative to continually monitor whether users revert to their previous energy-consuming habits over time or consolidate new, energy-efficient behaviours. Longitudinal studies have been widely recognized as an effective means to gain in-depth insights into the durability and persistence of the effects induced by behavioural interventions.

Schultz et al. (2007) emphasize that understanding the temporal dynamics of behaviour change is fundamental. It allows researchers and policymakers to discern whether the positive alterations in energy-related behaviours are merely temporary or if they evolve into stable and enduring patterns. These longitudinal investigations enable the assessment of the interventions' long-lasting impact, shedding light on whether the initial energy savings are maintained or erode over time.

Longitudinal studies typically involve the continuous collection of data over an extended period, extending beyond the immediate post-intervention period (Nisbet & Scheufele, 2009). By

observing participants' energy consumption patterns and behavioural choices over months or even years, researchers can discern trends and fluctuations that may not be apparent in shorter-term studies.These studies facilitate the identification of potential relapse points, where individuals may be more susceptible to returning to their previous energy-intensive behaviours (Brandon & Lewis, 1999; Nilsson et al, 2017). Armed with this knowledge, policymakers and intervention designers can develop strategies to provide ongoing support and reinforcement to prevent such relapses.

In this long-term process, the employment of dedicated teams of behavioural insights experts represents a crucial step for analyzing behavioural data and refining interventions, as emphasized by Sunstein (2017). A team of experts from different fields can help governments plan, execute and monitor campaigns that aim to change people's behaviour. Such a team should have skills in communications, policy, marketing and behavioural economics, among others. This way, the team can ensure that the campaign delivers a clear and consistent message that influences the target audience. Some countries have established dedicated teams to design and implement effective campaigns to promote energy saving behaviours among the public. For instance, Ireland has formed the Energy Security Communications Subgroup in 2022, which brings together experts from various government departments and agencies, including behavioural insight experts, who can help tailor the campaign messages and strategies to the specific needs and preferences of the Irish population. Finland also has a long-standing team that works on Energy Saving Campaign, which aims to raise awareness and provide practical tips on how to save energy.

Behavioural insight teams are essential for extracting meaningful insights from the data collected during interventions, enabling policymakers to make informed decisions and adjustments to their strategies. Regular reviews of intervention strategies based on insights gained from data analysis are imperative to the success of behavioural interventions. As Thaler and Sunstein (2008) point out, the adaptive nature of behavioural interventions allows for continuous improvement. By constantly assessing the effectiveness of various nudges and messaging, policymakers can refine their approaches to maximize their impact.

4.4.4. Mitigating negative impacts

It is ethically important to adopt a holistic approach that not only focuses on achieving positive outcomes but also actively monitors and addresses potential negative consequences. As Farrow et al (2017) emphasize, the careful design of behavioural interventions is paramount to minimizing any adverse effects. In the context of energy-saving initiatives, this means taking precautions to ensure that the interventions do not inadvertently result in unintended negative outcomes. For instance, implementing measures that could lead to discomfort or inconvenience for users should be approached cautiously.

To further support this perspective, research by Gneezy et al. (2011) highlights the importance of considering the potential backlash effects of certain interventions. While interventions may initially produce the desired behavioural changes, they can sometimes lead to resistance or opposition if not thoughtfully implemented. This underscores the significance of proactive monitoring and adjustment.

To mitigate any negative consequences that may arise, it is essential to have compassionate interventions readily available (Farrow et al., 2017). These interventions should be designed to address the specific concerns or discomfort that users may experience as a result of the behavioural strategies. In some cases, this may involve offering alternative approaches or incentives that align with users' preferences and values (Dolan et al., 2010).

5. Conclusions

The findings of this report serve as a testament to the power of behavioural interventions in influencing household energy consumption. It's clear that these interventions offer a nuanced, more human-centric approach to energy policy, one that transcends the limitations of conventional strategies which often neglect the complex dynamics of human behaviour.

Understanding and influencing user behaviour, especially in heating and cooling, is critical. The behaviour of household occupants is a crucial factor in energy demand, surpassing even the characteristics of the building itself. This insight is pivotal for developing policies that effectively reduce building energy consumption.

The NUDGE project has explored the efficacy of behavioural interventions in influencing household energy consumption, demonstrating a nuanced, human-centric approach that transcends conventional energy policy strategies. Behavioural nudges which subtly alter choice presentation are effective in promoting energy savings and the adoption of efficiency measures.

A key insight from the report is the divergence of human decision-making from traditional rational choice theory. Real-world energy choices are significantly driven by psychological and social factors, underscoring the need for policies that consider cognitive biases, social norms, and personal values. This approach is more reflective of actual human behaviour, making it a powerful tool for influencing energy consumption patterns.

Central to the success of these interventions is the adherence to ethical standards. The emphasis on data privacy, informed consent, and transparency is not merely a regulatory necessity but a cornerstone for building public trust and ensuring the long-term acceptance and effectiveness of these strategies.

Effective communication and engagement strategies are another critical element that emerged from our findings. The diversity of household profiles necessitates a varied and nuanced approach in messaging and engagement. The role of technology in enhancing these communication strategies is pivotal. Digital platforms and advanced analytics provide novel ways to connect with and motivate energy consumers, tailoring messages to individual preferences and consumption patterns. This personalization of messaging is likely to increase the relevance and impact of energy-saving measures. Involving a wide range of stakeholders – from government agencies to consumer groups – ensures a holistic perspective in addressing the nuances of energy consumption

behaviour. By prioritizing ethical considerations, policymakers can foster a sense of communal responsibility and cooperation, essential for any large-scale behavioural change.

Ongoing monitoring and evaluation are essential components, ensuring that nudging strategies remain effective and adaptable. This continuous process of assessment and adjustment is vital in keeping strategies relevant and effective. It provides a feedback loop for policymakers and stakeholders, allowing for the fine-tuning of strategies and identifying areas needing improvement.

The conclusions drawn from this report also open up a discourse on the future directions and potential of behavioural interventions in energy policy. They suggest a path forward that is not only more responsive to the complexities of human behaviour but also grounded in ethical practice and collaborative effort. This approach, which combines the best of behavioural science, technology, and ethical considerations, sets the stage for a more sustainable and efficient energy future, one that recognizes and harnesses the power of human behaviour in shaping energy consumption patterns.

5.1. Specific recommendations for EU and national legislators

Across Europe, keeping warm is a major energy drain for households. Space heating accounts for 63% of energy use on average, with some countries like Luxembourg reaching a staggering 81%. Even in sunny Mediterranean climates, like Portugal, heating still represents a significant share (30%) of overall energy consumption, and cooling is an increasingly necessary adaptation to hot weather that will be increasing demand for electricity from the grid. Since households are responsible for a quarter of all greenhouse gas emissions, reducing heating-related energy consumption is a vital step in Europe's fight against climate change. While upgrading appliances and renovating homes are important, focusing on user behaviour is an essential and impactful way to significantly reduce energy consumption. Surprisingly, even more important than the actual building itself, is how people use it. Occupant behaviour, especially regarding heating and cooling habits, plays a crucial role in determining energy demand. To truly cut back on building energy use, we need to understand how people interact with their homes.

The NUDGE project highlights the empirical effects of various intervention strategies to promote energy-saving actions and increased self-consumption. These can be effectively integrated with existing EU policies to bridge the gap between policy objectives and real-world implementation by member states.

The European Union's (EU) commitment to energy efficiency is evident in its established policies like the Energy Performance of Buildings Directive (EPBD), the Energy Efficiency Directive (EED), the Ecodesign Directive, and the Energy Labelling Directive. However, achieving ambitious energy targets requires not only setting forth policies and measures but also fostering attitudes of energy-conscious behaviour. This is where behavioural science offers a powerful toolset with substantial gaps in knowledge regarding the implementation in everyday life outside of the lab, as exemplified by the NUDGE project.

The Revised Energy Efficiency Directive (EED) emphasizes behavioural measures for energy efficiency. Article 22 outlines various tools to promote behaviour change, including public awareness campaigns, financial incentives, and targeted advice for households and businesses. Notably, surveyed savings, a method based on consumer responses to information campaigns or smart meters, is the only approach specifically mentioned for quantifying the impact of behavioural interventions (Annex V). The Energy Efficiency Directive also contains measures for accelerating the installation of smart meters across Europe, making the data accessible to consumers as soon as possible to support effective energy management. The EED further encourages energy audits and management systems in companies, and nudges can enhance their impact.

The Ecodesign and Labelling Directives improve product efficiency, but achieving optimal energy savings requires addressing consumer behaviour. Clear and accessible communication strategies are crucial. Building upon existing product labels, targeted educational campaigns can be developed that leverage mobile apps or social media. These campaigns should be tailored to educate consumers on using appliances efficiently based on their specific needs and usage patterns. This approach complements the existing regulatory framework. Ecodesign sets minimum energy performance standards, effectively "pushing" inefficient models out of the market. Ecolabel, on the other hand, empowers consumers by "pulling" their purchasing choices towards the most efficient products. Policy implementation can be improved by combining this regulatory push with behavioural interventions that encourage appropriate appliance usage.

National policymakers need to translate these policies into action by transposing EU directives into national legislation and implementing the appropriate measures through available means. This process involves developing national laws, establishing implementing authorities, and setting targets. Collaboration between national and local governments, as well as stakeholders, is essential for practical implementation. In this process, integrating behavioural science principles offers several advantages for the implementation of policies.

Nudges can act as a bridge between regulations and real-world behaviour change to enhance policy effectiveness. Their design leverages behavioural science insights to understand and address the psychological factors that influence decision-making, thus going beyond simply informing citizens about regulations and offering actionable options to citizens. As citizens take ownership of own energy consumption and make informed choices, this can lead to a further action beyond policy mandates, as repeated and long term nudges could potentially help develop new social norms and intrinsic motivations for energy conservation. However, leveraging this potential hinges critically on understanding consumers energy-related behaviour' to nudging in such real-world settings.

Building on the insights from the NUDGE project, the following paragraphs present some key actions EU and national decision-makers can take to foster successful behavioural interventions for energy conservation in households:

1. **Integrate behavioural interventions within existing strategies**: To maximize the impact of energy conservation initiatives, combine established strategies like one stop shops, subsidies for renovations and energy-efficient technologies and energy labeling with behavioural interventions. By applying principles from behavioural economics, design nudges and incentives that complement existing policies. This integrated approach can significantly boost overall effectiveness in achieving energy conservation goals. This holds especially for new technologies (e.g., electromobility) where behavioural routines are not yet fully formed and nudging can be employed to support the policy efforts for the diffusion and better utilization of such technology.

2. **Target factors that affect behaviour.** To design and execute energy saving campaings that suit the varied energy consumption patterns and motivations of households, policies and measures should address the six key factors that affect behaviour: perceived behavioural control, subjective norms, attitudes, personal moral norms, willingness, and age. Focusing on these factors can allow for more specific and effective nudging interventions that meet the distinct needs and motivations of different households. Nevertheless, these factors should not be viewed in isolation, but rather as key elements within the real-live context. Hence, policy has to consider how to place the behavioural intervention and get the consumers' attention at the time that they are actually making those decisions or at least have mental capacity to receive the nudge.

3. **Choose the right behavioural interventions.** Nudging strategies need to be directly and clearly linked to the specific energy-saving behaviours they intend to influence. They alsso have varying effectivness based on the channel used, and the profile of the person or group they are targeeting. To measure the causal effect of the nudge on the behaviour change, it is important to establish a strong and unambiguous connection between them, given the presence of various confounding factors. Policymakers should be aware that the impact of such interventions is higher when combined wiht existing measrres, but usually small on its own, and should consider the limitations and challenges that may affect their outcomes.

4. **Be aware of conflicts with other policies and measures.** Address external factors like regulations and pricing structures that can influence nudge effectiveness. To ensure that nudging campaigns are compatible with the existing legal and market conditions, policymakers need to consider the potential conflicts between them and design nudges that fit within the boundaries of current regulations. By definition, nudges are "soft" interventions that do not set binding constraints, and to guide behaviour effectively, it is important to pay attention to alignment with the regulatory and tax codes that constitute the "hard" interventions.

5. Test and tailor interventions to context before scaling up: Ensure interventions are culturally relevant and address specific energy challenges within the context of each population. Surveys and focus groups help to understand public attitudes and preferences towards energy saving behaviours. Nudges can be piloted on a smaller scale before wider implementation, allowing for cost-effective refinement based on real-world data. Since not all nudges are effective in all circumstances, this step ensures the fit of the intervention to the context. Following testing, nudges can be scaled up for regional or national audiences with targeted messaging that resonates with their specific contexts. Additionally, the emphasis on testing and refinement allows for continuous improvement and adaptation of interventions based on local contexts and evolving social norms.

6. Conduct multi-channel public awareness campaigns with tailored messaging: Design and implement public awareness campaigns that utilize a multi-channel approach, encompassing social media, mobile apps, email, and traditional media outlets. This approach allows for reaching a broad and diverse audience, maximizing the effectiveness of the campaigns. Segmenting audiences and tailoring the messaging based on demographics and motivations (e.g., environmental concerns, cost savings) can ensure the information resonates with the target audience. While broad instruments like the energy label are mandated to displayed at the time of purchase (i.e., investment) , the targeting of behaviour during the operational phase is much more complex, as it cannot be assumed that the consumers' attention is on energy-efficiency choices continuously. Diversifying and tailoring are measures to take this into account.

7. Focus on implementing default nudges that require minimal effort from consumers. When designing nudges, choose default options that make it easy for consumers to save energy. Since many energy users are not interested or motivated by new initiatives, it is better to use existing situations and channels, such as energy bills or regular maintenance checks, to nudge them. Digital infrastructures like smart meters can help make energy-saving choices the default, with easy opt-out options, so that more consumers can adopt energy-efficient behaviours without much effort. Cutting through the breadth of decisions and stimuli that consumers face in everyday life is difficult and nudges that help set consumers on the right track without constant need to re-deliver the message can help overcome this barrier to nudging effectiveness.

8. Use personalized messaging and real-time feedback mechanisms: Develop and implement personalized messaging strategies that leverage user data and behaviour patterns. This allows for delivering energy-saving recommendations that are highly relevant to each individual. Additionally, provide real-time feedback on energy consumption through user-friendly platforms like mobile apps and web-based dashboards. Real-time feedback empowers users by enabling them to see the immediate impact of their actions on energy use. When implementing

personalized messaging, remember to ensure transparency and obtain user consent when collecting and utilizing data. Design feedback mechanisms with user-friendly visualizations that facilitate a clear understanding of energy data. Do not expect the majority of the targeted population to interact with and respond to messaging when calculating the potential impact of an intervention campaign. Given the low marginal cost of sending further messages once the system is set up, the benefits are still substantial even after deducting non-responders.

9. Empower consumers through education and nudges: To empower consumers and promote widespread energy savings, consider developing campaigns and educational efforts, tailored according to energy consumer profiles. For example, offering regular energy-saving practice updates would work for environmentally-conscious consumers, while for socially influenced consumers, it would be more appropriate to highlight their energy use compared to peers and encourage public commitments to reduce consumption with potential rewards. For indifferent consumers, it would be more effective to utilize energy-saving defaults and targeted nudges to promote awareness and the benefits of conservation. The full list of profiles and associated nudge types is available from the publications of the NUDGE project

10. Design adaptable and ethical interventions: To ensure long-term effectiveness, prioritize designing energy-saving interventions that adapt to evolving technologies and consumer preferences. Integrate innovative solutions like smart meters and smartphone apps for real-time data collection and personalized recommendations. Maintain policy flexibility to accommodate these advancements. Uphold ethical principles by prioritizing informed consent, transparency, data privacy, and user autonomy. Regularly monitor interventions to address any unintended consequences.

11. Foster collaboration and knowledge sharing: To accelerate progress towards national energy and climate goals, we recommend establishing a national platform for knowledge exchange. This platform would convene government agencies, energy and technology companies, academic experts in behavioural economics, and consumer associations. Through regular meetings, workshops, and an online repository, the platform would foster collaboration, share best practices, and channel funding for pilot projects. These projects, led by partnerships between platform members, would focus on developing and testing behaviourally informed interventions for household energy conservation.

12. Invest in capacity building programs: To maximize the effectiveness of energy-saving policies, invest in capacity building programs. Train policymakers, energy professionals, and consumer advocates on behavioural science principles and best practices for intervention design and implementation. Leverage academic expertise and successful projects like NUDGE. Integrate behavioural science modules into relevant university programs (public policy, energy engineering, marketing, consumer behaviour) to equip future generations with the skills needed to design impactful energy-saving solutions. Overcome silo thinking between technical skills regarding the

design of automated solutions and the knowledge about behaviour in order to design new interventions that introduce consumers to automation and thereby act like a default.

13. Promote data sharing frameworks and standards: Develop and promote secure data-sharing platforms that comply with EU data privacy regulations. These platforms would allow anonymized exchange of user data (consumption patterns, intervention responses, demographics) among trusted members. Collaborate with CEN/CENELECT to establish standardized data collection methods across the EU. This ensures valuable insights from interventions and user behaviour can be compared and leveraged for effective intervention development across member states. Remember, transparency and user consent are paramount in utilizing these nudges, ensuring respect for privacy and individual choice.

14. Establish long-term monitoring and evaluation. To ensure the long-term success of behavioural interventions, establish dedicated teams within government agencies. These teams should combine expertise in behavioural science, data analysis, and program evaluation. Allocate resources for longitudinal studies (lasting at least 3 years) to assess the interventions' impact on household energy consumption, user behaviour change, and cost-effectiveness. By identifying areas for improvement and adapting interventions based on the findings, sustained effectiveness can be improved and thus maximize the program's positive impact.

15. Use Randomised Control Trials to estimate the impact of behavioural measures. To maximize the effectiveness and accounting of behavioural measures outlined in the EED (Article 22), national authorities should be supported in applying robust methodologies for impact assessment. The NUDGE project offers valuable tools like Randomized Control Trials (RCTs) combined with econometric methods (i.e. Difference-in-Differences, Two-way-fixed Effects, Within -subject comparison) to measure the energy savings achieved through nudging interventions (e.g., information campaigns, smart meter feedback etc). This will enable policymakers to prioritize and refine behavioural strategies for achieving the EED's energy efficiency goals. However, be informed that while the NUDGE project provides valuable tools, real-world application presents challenges. Field trials involve complexities related to the weather, economic fluctuations, and participant engagement. Robust methodologies (RCTs with econometrics) are crucial to account for these factors and ensure representative study groups, provided there are significantly large sample sizes and duration of experimentation. The goal is to strike a balance between scientific rigor and the practical realities of energy use for accurate assessment of behavioural interventions.

16. **Implement approaches that target multiple (both energy and non-energy) benefits,** such as improved indoor air quality, reduced carbon emissions, reduced thermal stress, health and wellbeing. This should include the development of regional/national assessments to establish

actions to promote active citizen participation and achieve such multidisciplinary benefits in a tailored way. This will allow for identifying suitable opportunities to assist the citizens to be more motivated to change their behaviours and act as frontrunners to achieve energy-efficient, environment-friendly and comfortable homes.

These recommendations outline how EU and national policymakers can actively implement measures to make use of the potential behavioural science. These principles include data collection mechanisms, multi-channel public awareness campaigns, personalized messaging, and real-time feedback mechanisms. These targeted interventions can nudge citizens towards energy-conscious behaviour, significantly enhancing the effectiveness of existing energy policies and supporting a transformation towards a more resilient energy landscape across the European Union.

6. A discussion on future directions

Several avenues emerge for incorporating behavioural interventions in policy implementation, presenting both challenges and opportunities.

Personalization stands at the forefront of future strategies. The effectiveness of energy-saving measures can be significantly heightened by tailoring them to individual preferences and behavioural patterns, increasing the possibility of individuals and groups to react, and thus increase policy effectivness. In this context, big data and advanced analytics emerge as powerful tools, offering the ability to customize interventions for specific user groups. However, this approach must be balanced with concerns over data privacy and limited based on ethical principles on use of personal information by both public and provate actors.

Technological advancements, particularly in the realms of the Internet of Things (IoT), smart meters, and AI-driven platforms, stand to inform energy policy. These technologies can provide real-time, actionable insights to consumers, but their integration with existing systems poses a significant challenge. The key will be to ensure that these technological solutions are accessible and equitable, avoiding a digital divide in energy efficiency initiatives.

Broadening stakeholder engagement is another critical future direction. Involving hard to reach consumers, particularly from marginalized and underrepresented communities, but also highly polluting high income consumers, is essential for developing comprehensive policy solutions. Such engagement not only leads to more culturally sensitive and locally appropriate strategies but also enhances community buy-in and the overall effectiveness of interventions.

Longitudinal studies are vital in understanding the long-term impacts of behavioural interventions. These studies will shed light on their sustainability and effectiveness over time, providing a feedback loop for ongoing policy development. However, conducting such studies requires significant investment and a commitment to long-term research, which may be challenging in a policy environment often driven by short-term goals. Moreover, there is a need to baalnce scientific rigour with the realities of field trials and the limitations posed by high administrative burden.

The ethical design and implementation of interventions remain a cornerstone of future strategies. As interventions evolve, maintaining strong ethical standards is essential to ensure that they align with societal values and respect consumer rights. This includes ensuring that interventions do not inadvertently disadvantage certain groups and that they remain transparent and avoid manipulation or patronising approaches.

Scaling up successful interventions to a broader audience presents a unique opportunity for widespread impact. This scaling process must be approached with caution, ensuring that the interventions are adaptable to different contexts and demographics. There's a risk that strategies effective in one setting may not translate seamlessly to another, underscoring the need for careful adaptation and localization of interventions.

Enhancing public awareness and education about energy efficiency and sustainable practices is another key area. Education campaigns that elucidate the rationale behind energy-saving behaviours and their broader environmental impact can play a crucial role in shifting public perceptions and behaviours.

Integration and alignment of behavioural interventions within the broader energy policy framework are crucial. Such integration ensures that behavioural strategies are not developed in isolation but as part of a cohesive and comprehensive energy policy, and that they support policy goals, instead of causing caneling-out effects.

Finally, fostering international collaboration and knowledge exchange (e.g. through EU-wide programmes or through platforms supported by the IEA) can lead to the sharing of best practices and innovative approaches.

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