D4.3 Policy Brief

The Role of Behaviour and Heterogeneity for the Adoption of Technologies

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About REEEM

REEEM aims to gain a clear and comprehensive understanding of the system-wide implications of energy strategies in support of transitions to a competitive low-carbon EU energy society. This project is developed to address four main objectives: (1) to develop an integrated assessment framework (2) to define pathways towards a low-carbon society and assess their potential implications (3) to bridge the science-policy gap through a clear communication using decision support tools and (4) to ensure transparency in the process.

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Executive Summary

Models built for strategic European energy policy assessments often make compromises in terms of how they represent human behaviour and decision making, which is a design choice that is usually forced on model designers by a lack of data availability on consumer preferences. As a result, it is often difficult for energy models to depict uptake levels and technology diffusion rates for new consumer technologies in households that are in line with real world observations. As part of the REEEM project, a multinational research team from the UK, Finland and Croatia took steps to address this critical shortcoming in energy models by carrying out detailed surveys on 3000 European households in their respective countries, and using these to build databases of attitudes, preferences, and lifestyles. Discrete choice modelling, a technique used to understand which factors drive decision making, was used to identify the critical determinants of consumer purchases in domestic heating and privately owned vehicles. It was found that costs are usually an influential factor when it comes to technology choice, but also that there are a range of other considerations that exert a powerful influence on decision making. In particular, consumers appear to strongly prefer technologies with which they are familiar and have already purchased previously, suggesting that preferences are extremely "sticky". For European climate policy, this means that while it might be initially very difficult to implement a changeover from high carbon to low carbon technologies, once the switch has already taken place these become the "new normal", and consumers may unlikely to regress to older systems. The wide variety of non-cost factors that were found to influence decisions might also suggest alternative avenues for policymakers to explore when seeking to create momentum towards systemic change.

Context

Energy models are widely used in Europe for informing policy development and for exploring various aspects of possible energy futures, both at the EU level and in individual Member States. Depending on their sectoral focus, their level of detail, and their complexity, models often simplify their representation of real world processes in some areas, usually because data are not available or because making the models extremely large would require very expensive computing capacity. In the types of large-scale model that are typically used for national strategic policy assessments, such as developing Paris Agreement compatible technology roadmaps or understanding investment priorities for expanding the use of clean energy, human behaviour is often an element that is radically simplified.

Many large-scale models rely on an economic utility perspective, in which costs are the main driver of uptake, to represent technology diffusion. So, for example, when the costs of a new technology, such as an electric car, fall below the costs of a petrol or a diesel car in a model, the results of that model then show that these electric cars will be selected and purchased by consumers. The same logic is often applied in other sectors, like power stations or industrial plants. But energy scientists know that this approach simplifies the complexity of real world decision making, particularly in households.

In the real world, behavioural specialists have long observed that decision making about consumer purchases varies significantly between different social groups, classified by attributes like age, income, education and lifestyle. It has also been observed in retrospective analysis of energy market trends that some technologies have diffused either much more quickly (such as residential photovoltaics) or much more slowly (such as many energy efficiency measures) into the mainstream than most energy models might have anticipated. It is likely that the difference between modelled behaviour and observed behaviour in these areas can at least be partially attributed to non-economic considerations entering the decision matrix of individual consumers[1–5].

As part of the Horizon 2020 REEEM project, we sought to improve the characterisation of individual behaviour in European energy models, specifically by gathering data on the real-world factors that influence consumer decision making around heating systems and private vehicles.

Methods

Anonymous surveys of 3000 Europeans living in the UK, Finland, and Croatia (1000 people in each country) were used as the basis for creating databases of household preferences for domestic heating and personal travel. This information can be combined with socio-demographic information about the participants, their attitudes, and their lifestyles, to build up a better picture of the factors that determine technology selection in these critical parts of the energy system. Parts of the survey were designed to be used for *discrete choice modelling*[6]. This is a consumer research and behavioural economics technique that specifically tests how people trade-off different features of technologies (performance, cost ease-of-use etc.) against one another, so we can see for example, whether costs really matter, and in which populations.

Policy alternatives and recommendations

Our analysis considered over 200 different factors that affect consumer choices in heating and transport, summarised below in Tables 1 and 2.

Table 1 - Factors affecting consumers' heating technology choices in the three countries.

Category		UK	Finland	Croatia
Socio-demographic	Age	●	●	●
	Gender		●	●
	Area	○	●	
	Region		●	○
	Household income	●	●	●
	Education level	◐	◐	
	Number of children	●	●	●
	Number of residents	●		
	Work status	●	●	●
Dwelling	Type	●	◐	○
	Age	●	◐	○
	Number of bedrooms			●
Economic	Capital cost	○	●	●
	Annual cost	○	●	●
	Heating bill		●	

Environmental	GHG emissions	● (high)	● (high)	● (medium)
Technological	Ease of use	● (low)	● (high)	● (medium)
	Heating hours per day	● (high)	● (high)	● (high)
	Experience (e.g. used to install a particular system)	● (low)	● (high)	● (low)
Ownership of heating system	Existing systems	● (high)	● (high)	● (high)
Knowledge of heating system	Familiarity with heating systems	● (high)	● (medium)	● (low)
	Easy-of-use	● (medium)	● (medium)	● (high)
	Costs	● (low)	● (high)	● (medium)
	Reliability		● (low)	● (medium)
	Climate change impact		● (low)	● (medium)
	Local pollution impact	● (low)	● (high)	● (high)
	Space requirements	● (low)	● (low)	
	Impacts on the resale value of homes	● (medium)	● (high)	● (medium)
	Environmental credentials	● (medium)	● (low)	● (low)
Psychological	Environmental friendliness	● (low)	● (low)	● (low)
	Access to information	● (medium)	● (low)	● (low)
	Personal innovativeness	● (medium)	● (medium)	● (low)
	Importance of advice	● (high)	● (high)	● (high)
	User control	● (high)	● (high)	
	Maintenance costs	● (high)		
	Installation costs	● (high)		
	Typical reasons and rationale for heating system replacement	● (medium)	● (medium)	● (medium)

Note: ●: high relevance; ●: medium relevance; ●: low relevance.

Table 2 – Factors affecting consumers' vehicle technology choices in the three countries.

Category		UK	Finland	Croatia
Socio-demographic	Age		● (high)	● (high)
	Gender	● (high)		● (high)
	Area	● (low)	● (low)	● (low)
	Region		● (medium)	● (medium)
	Household income	● (high)		● (high)
	Housing tenure	● (high)		● (high)
	Education level	● (low)	● (low)	● (medium)
	Number of children		● (high)	
	Work status	● (high)	● (medium)	● (high)
Dwelling	Type	● (high)	● (medium)	
	Age	● (high)	● (high)	● (medium)
	Number of bedrooms		● (high)	

Economic	Capital cost	● (high)	● (high)	● (high)
	Annual cost	● (high)	● (high)	● (high)
Environmental	GHG emissions	● (medium)	● (low)	● (medium)
Technological	Driving range	● (low)	● (medium)	● (low)
Ownership of heating system	Number of cars owned		● (high)	
	Car type	● (high)	● (medium)	● (medium)
Knowledge of vehicles	Familiarity with car technologies	● (high)	● (high)	● (high)
	Driving range			● (low)
	Easiness of use	● (low)		● (low)
	Costs	● (low)		
	Safety	● (low)		
Transport behaviour	Ownership of driver license	● (high)	● (high)	● (high)
	Ownership of private parking space	● (high)		
	Main reason(s) for using a car	● (medium)	● (medium)	● (medium)
	Frequency of various driving ranges	● (medium)	● (low)	● (low)
	Frequency of various travel modes	● (high)	● (high)	● (low)
Psychological	Environmental friendliness	● (low)	● (medium)	● (medium)
	Access to information	● (low)	● (medium)	● (medium)
	Personal innovativeness	● (medium)	● (medium)	● (medium)
	Brand	● (high)	● (high)	● (high)
	Model		● (high)	● (high)
	Costs	● (high)	● (high)	● (high)
	Noise	● (high)	● (high)	
	GHG emissions	● (high)	● (high)	● (high)
	Performance	● (high)	● (high)	
	Reliability	● (high)	● (high)	
	Safety	● (high)		● (high)
	Style	● (high)		

Note: ●: high relevance; ●: medium relevance; ●: low relevance.

Unsurprisingly, we found that the respondents in different countries had varying ecological attitudes, obtained their information about technologies from different sources, and had slightly different perspectives on what factors mattered the most when it came to selecting heating systems and cars. As an illustration of these differences, we found that knowledge of different types of vehicle and about heating systems varied significantly between countries. Around half of all respondents were knowledgeable about conventional petrol and diesel vehicles, but the proportion who expressed familiarity with electric or hybrid vehicles were 10% (UK), 25% (Finland), and 25% (Croatia) respectively. Between 70-80% of UK respondents had either *"never heard of"* or had *"only heard the name"* but otherwise knew nothing about district heating or electric heat pumps, two heating technologies that commonly appear in European low carbon technology roadmaps.

We found that costs were influential for Croatian and Finnish consumers when it came to making decisions about purchasing heating systems, but typically couldn't find statistically significant relationships between costs and heating system selection when it came to UK consumers. For Croatia, Finland, and the UK, costs do seem to matter much more when it comes to purchasing new vehicles.

For both heating systems and cars, we found that there are other significant factors beyond costs that affect decisions about whether or not to purchase a new technology. We found that for both heating systems and cars, existing ownership of a given technology and familiarity with a given technology (confidence about how it works) acts as a strong predictor of whether or not an individual will choose to purchase that technology again. For example, in Croatia, Finland and the UK, between 40-50% of petrol vehicle owners said that they would select a petrol vehicle again, with a similar result for diesel vehicles. But in Finland and the UK, between 70-90% of respondents who were existing owners of hybrid vehicles responded that they would choose hybrids or plug-in EVs in future. This suggests that consumer preferences are extremely "sticky", with future choices being strongly anchored to past experiences and knowledge. In the context of climate policy, these findings indicate that existing views and norms are more difficult to change than a direct comparison of costs might suggest. However, it simultaneously shows that once a switchover to new technologies has been made, individuals are likely to become anchored to these as their "new normal", with little prospect of slipping back towards their previous preferences. Additionally, there are a range of non-price determinants of choice found in the study that could form the basis for policy targeting in future.

Conclusions

The conclusions for energy system modelling and European energy technology policy assessment are clear. Many energy models in use today for technology road mapping exercises at the EU level or in individual member states are of the linear optimisation type, such as the widely used TIMES[7], MESSAGE[8], or OSeMOSYS[9] platforms. In their default implementations, these models typically assume that costs are significant, or often even the only drivers affecting decisions. There are a number of approaches for including behavioural factors such as those found under this study into such models. These include either (1) adding cost-specific and consumer group-specific disutility costs to technologies in models[10] or, in case costs are found to not be an influential factor for decisions, (2) constraining models to follow the choices implied by the development of the non-cost factors[11].

For both approaches, model designers need to disaggregate consumers in their models, with the challenge then being that models may become significantly larger as structural factors such as how energy demand is represented need to be replicated for each consumer group. In light of this, modellers should incrementally improve their models in how they reflect the empirical evidence on consumer behaviour. This can be done by focusing the improvements on the factors that play the largest role in determining consumers' reactions. Stand-alone sectorial technology diffusion models might need to be constructed, if a wider range of behavioural factors are to be modelled explicitly.

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