The NATCONSUMERS Handbook

A guide to introducing ICT tools for customer engagement in energy savings

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The Future of Energy Reduction in Communication

The residential sector accounts for a quarter of all energy consumption in the EU. Reducing household energy use across Europe is therefore critical to efforts to cut carbon emissions. However, altering the ways in which people use energy within their homes is difficult. It is not easy to change long-established habits, nor is it easy to target such a diverse population in order to help these changes come about.

Previous efforts to communicate with consumers have been very much focused on price or simplistic comparisons as means to motivate changes in consumption. These approaches are focused primarily on information provision, on the assumption that all humans are 'rational actors' who will respond to financial drivers. Through the NATCONSUMERS project however we have taken a new approach, based around understanding householders as **individual people**, rather than as homogenous, energy consuming agents.

> **We thought we needed to start a conversation with the end customer. It's not about dictating to them and ordering people to do things, it's about creating a conversation**

To do this, the NATCONSUMERS project has developed a methodology for communicating with consumers using **'Natural Language'** — communication which is friendly, emotionally intelligent, relevant and simple. The NATCONSUMERS tool is designed to raise awareness about how people use energy within their homes, and to give them advice about how to use energy more sustainably. Capitalising on the roll-out of **smart-metering** across Europe, the project utilises **smart-meter** data to provide **tailored advice** to householders.

The primary function of the NATCONSUMERS tool is, therefore, to help people save energy. This, in turn, has broader impacts in terms of reducing CO_2 emissions, lowering consumers' energy bills, reducing **energy poverty** in vulnerable households and improving the relationship between consumers and utility companies.

Through the use of our tailored mechanism, which allows energy advice to be personalised for each individual user, we believe a 5–10 percent reduction in energy consumption in the residential sector is achievable.

The NATCONSUMERS handbook

This handbook has been produced as a guide to the NATCONSUMERS framework. It provides readers with a background of what must be considered to generate effective energy efficiency advice, built upon the findings from our research and user-engagement throughout the NATCONSUMERS project. It also provides readers with a step-by-step guide to the NATCONSUMERS mechanism, which can be used to replicate the process, thereby allowing readers to construct their own **Natural Language** advice tools.
The handbook is designed to be used by any organisation with a mission to reduce domestic

energy consumption through consumer engagement. This could include any advice provider, whether they are government, consumer organisation, charity or business. We expect the handbook to be particularly relevant to energy suppliers and district network operators, many of which are obligated to engage with their consumers to reduce energy consumption.

The mechanism has been designed for use by organisations across the EU, with all methodologies and protocols adaptable to any European region. Whilst the NATCONSUMERS project has focused on electricity consumption, we anticipate the process will also be easily adaptable to other energy fuels (such as gas), assuming appropriate data is available.

The NATCONSUMERS mechanism: Overview

The underlying premise which NATCONSUMERS is built upon is that for energy efficiency advice to be truly effective, it must be tailored. Tailored advice has been found, through multiple studies, to be much more effective than more generic recommendations. Variations in consumers' characteristics and behaviours lead to heterogeneous energy demands, influenced by both individual preferences and physical variables. As such, if we are to change these energy demands, our advice must be similarly heterogeneous to ensure it is relevant and actionable for the consumer in question.

Moreover, advice must also be presented to consumers in **Natural Language**. This means that advice messages should be easy to understand, avoiding jargon or technical language, and should be communicated in a friendly, emotionally intelligent way. In order to communicate in **Natural Language**, we must ensure advice is both relevant and interesting to consumers. When determining what the content of a message should be, we must consider the household's context to ensure the advice provided is relevant to them. When determining how the message should be communicated, we must understand the consumer's attitudes and values, to allow the message to be framed in terms which will be of interest.

In order to achieve this within NATCONSUMERS, we have created three segmentation models. The first utilises **smart-meter** data to categorise consumers based upon their electricity **load profile** — that is based on their patterns of energy usage over time. This allows us to identify typical electricity usage profiles. The second segmentation is based on socio-demographics. This has been used to investigate how much electricity households use, or the total 'volume' of consumption. Combined, these two segmentations allow us to paint a picture of a user's overall energy usage, in terms of both patterns and quantities of use. Subsequently, this allows for users to be compared to other households with the same profile, that is, comparison to a **benchmark segment**. The results of these two segmentations help to determine the **content** of advice messages — they allow us to identify what subject matter will be relevant to each household.

The third segmentation has been constructed from a survey of consumers' attitudes and values. From this, we can identify what interests each householder — for example, are they interested in saving money, protecting the environment, making their home more comfortable, etc. — and can therefore re-frame the message in terms that they will take note of. This segmentation therefore identifies **how** we should communicate with each individual.

These three segmentation models have been used to build the NATCONSUMERS **Natural Language Generator**. This generator inputs smart-meter data and consumer attitude data, and outputs **Natural Language** energy efficiency advice. Within the NATCONSUMERS project, we have tested this mechanism with a proof-of-concept web-tool.

In this handbook, we will describe the construction of this **Natural Language Generator**, to allow readers to replicate and adapt the tool for their own consumers. In **Section 1**, we will provide the context for the NATCONSUMERS project, providing some background into residential energy consumption and the factors which must be considered to generate effective energy advice. This section outlines the underlying theoretical framework which sits behind the NATCONSUMERS mechanism.

In **Section 2**, we will focus on implementation: how to create a NATCONSUMERS **Natural Language Generator**. This is split into a three-part framework, focusing first on how to characterise consumers, secondly on how to generate **Natural Language** advice itself, and thirdly how to develop an **engagement concept** through which to transmit the advice.

In **Section 3**, we will discuss outcomes. In this section we show the potential impacts of a **Natural Language** advice tool, both from the perspective of the power system and from the perspectives of different market actors. We conclude with a series of recommendations for the further development of NATCONSUMERS-based advice.

This handbook provides an overview of and guide to the NATCONSUMERS framework. Further details on each of the chapters can be found within the in-depth project reports, available at **www.natconsumers.eu**. These reports are cited throughout this handbook as reference sources for further information, and may be of use to anyone wishing to implement the framework.

1. Getting to grips with household energy

1.1 Knowing your quintessential

Energy is an expensive and increasingly scarce resource. Despite widespread recognition of diminishing fossil fuel reserves and their negative environmental impact, a significant proportion of energy consumption continues to be wasted through inefficient practices. Data published by Eurostat in 2013 showed that the total energy consumed by the EU-27 [1] in 2011 was 1.103,3 Mtoe (million tonnes of oil equivalent), an increase of 3% compared to consumption in 1995, but a decrease of 8% compared to 2005.

In the context of promoting energy savings, **households constitute one of the sectors with the highest levels of consumption, accounting for 25% of total EU-28** energy use in 2014 [2]. Moreover, if we consider small commercial buildings, this percentage increases to 38%, making it the highest energy end-user sector. In order to achieve the ambitious energy efficiency goals agreed by EU Member States in the short term (20% energy savings by 2020 [3]) and in the longer term (27% or more improvement in energy efficiency by 2030 [4]; The European Commission (EC) proposed to increase this to 30% in a recent communication [5]), the residential sector is a strategic priority. Furthermore, the increase in electricity prices at EU level, 2,4% in 2015 and 4% per year for the period 2008–2012 [6], is squeezing household budgets and has become a subject of public debate in most EU countries [7]. For low-income households, energy costs can reach a third of the monthly family budget. In these families, **energy poverty** is an everyday issue.

Energy Poverty

Energy Poverty, or fuel poverty, is an EU-wide problem present in many member states and is highly inter-related with other poverty issues. Households are considered to be in **energy poverty** if they are unable to adequately heat their home, or meet other energy services, at an affordable cost. This occurs due to a combination of high energy prices, low incomes, and poor energy efficiency of homes. Relatively few EU countries currently quantify levels of **energy poverty**, or even have an official definition of it. However the EC estimates that around 11% of households in Europe are currently in **energy poverty** [8].

The impacts of **energy poverty** can be severe. It can lead to indebtedness (arrears) or disconnection and can result in mental or psychical illnesses. Paying high energy bills may lead to much lower disposable income for other essentials such as food and transport. Poor dwelling conditions can cause anxiety, lead to social exclusion and isolation, and have a negative impact on self-esteem and the capacity to manage. Living in cold dwellings has also been associated with cardio-vascular and respiratory diseases, and there is a strong relationship between cold homes and Excess Winter Deaths [9]. **Energy poverty** can form a self-perpetuating cycle: humidity in dwellings can lead very quickly to the degradation of the building, causing changes to the properties of the walls, doors and windows, further increasing thermal loss. The more a dwelling deteriorates, the more it is difficult to keep it warm and to prevent excess humidity [10]. Often energy poor households are not only affected by **energy poverty**, but are in a situation of multiple deprivations. They are sometimes threatened by deep poverty, are large families with many inactive adults, or belong to ethnic or migrant groups who are already struck by the negative discrimination of the majority.

Many policies, business activities and research initiatives aimed at reducing domestic energy consumption have been implemented at a national and European level. Most have focused on technical installations and structural changes, and have predominantly adopted an instrument-oriented approach, for example, improvements to the building envelop, heating and cooling systems, lighting or green ICT. Whilst some of these actions have been very successful, many fail due to low user engagement and participation. Approaches which focus on instrumentation tend to ignore the different factors affecting user behaviour and the demographic make-up of the sample group, and often do not take into account the inbuilt biases in the selection of households to the given Energy Efficiency (EE) programme. This is the most important obstacle for the uptake of energy efficiency products and measures by consumers. The issue is discussed extensively in the Energy Efficiency Directive 2012/27/EU, which makes clear that:

an integrated approach, including the variety of different factors affecting individual and collective behaviour, needs to address all aspects of energy supply and demand.

Historically, many measures aiming to change energy behaviours have focused on broad public information campaigns. However, many energy using behaviours are habitual, automatic processes, which are resistant to change. To influence such behaviours, more targeted, tailored information regarding individual energy consumption is required [11]. The current widespread roll-out of **smart-meters** provides a new opportunity for such engagement.

What are Smart-meters?

With traditional electricity metering systems, data operators rely on human resources to physically take meter readings in order to gather household energy usage data. This manual data collection process means meter readings occur at only monthly or annual frequencies. As such, both the data operators and the households receive only aggregated consumption data, which has highly limited utility.

By contrast, the **smart-meter** is a new kind of energy meter that can digitally send meter readings to data operators. Smart-meters are the next generation of metering technology for every kind of usage (electricity, natural gas, piped water, central heating systems etc.). They enable two-way communication between the device and data operator. This means they can be controlled remotely, thus the operator can switch it on and off centrally. The similarity between traditional metering and **smart-metering** is that both have a settled point of delivery. This means **smart-meters** can only measure the total household consumption, like the regular metering system, rather than monitoring usage at a more disaggregated level (such as an appliance-by-appliance breakdown). The main differences between smart and regular metering systems are with regards to the granularity and data reading frequency. Concerning granularity, **smart-meters** can register household energy usage within a day, commonly every 15 or 30 minutes. Granularity depends on the device adjustments, so it is possible to measure and store usage data at anything from one minute to one hourly frequency. The technology also makes possible for householders to access real-time data within their home, although the utility cannot access this level of granularity. Whilst the **smart-meter** can take readings at this frequency, there is no real-time connection between the data operator and the device. This means the frequency at which the operator can access data is restricted by their data collection process. This is called the data reading frequency.

Smart-metering provides customers with more information on how they use energy and enables customers to reduce their energy usage. The major benefits to customers are:

Smart-metering means the end of estimated billing — consumers can get more accurate bills which are based on real usage data in every payment period;

Consumers can be better informed on their energy consumption and costs. By making their energy usage more easily understood, they can make smarter decisions to save energy and money.

Time-of-use tariff functionality can be added to allow consumers to reduce costs by increasing energy consumption during off-peak cheaper tariff periods.
The European Union asked all member governments to look at a smart-metering system as part of their measures to upgrade their energy supply and tackle climate change. But smart-metering roll-out is in different stages in different countries across the European Union.

Energy consumption itself is invisible to users. People tend to have only a vague idea of their energy usage for different purposes or appliances, and therefore of the potential to save energy by changing their consumption patterns.

In this context, consumer feedback is an essential element for effective learning, and to raise social awareness and change consumers' attitudes. Making energy more visible and controllable to the customer is therefore essential.

The potential of feedback experiments to promote more efficient behaviours and attitudes has been studied in several reviews. Darby [12] compiled and made a deep study around 38 different feedback pilots developed in the period 1975–2000. In the same line, Ehrhardt and her colleagues [13] examined 57 studies worldwide. The impact assessments of both reviews show that reductions in energy consumption ranging from 5–20% were achieved using different types of feedback methodologies.

VaasaETT keeps an up-to-date database consisting of, at the time of writing, close to 140 demand response and feedback programs around the world involving over 630,000 residential, commercial and industrial customers. The database compiles the findings of both feedback and dynamic pricing programs with and without appliance automation. The VaasaETT database, being the largest of its kind, is able to provide statistically robust, quantified answers to questions related to, for instance, the potential of energy consumption feedback to reduce customers' bills, consumption levels or to manage consumption over time. **Data extracted from the database indicates that feedback pilots organised in Europe (68 pilots) have led to consumption reductions of 7.38% on average.**

These studies highlight several limitations which must be further investigatedto achieve greater impacts. As such, considerable uncertainty still exists when attempting to quantify potential energy savings from feedback. Most evidence stems from small-scale trials and pilot projects, which are often short timescale, specific to particular geographic areas, and use different experimental designs, all of which restricts comparability between the studies. Furthermore, we have found that in previous studies feedback has often been very generalised, and so is not directly comparable to the NATCONSUMERS methodology.

For direct feedback, information from energy meters may be expressed in terms of energy, costs or CO2 emissions, however this data then needs to be interpreted by the user in order to be meaningful to them and to assist their decision making. For indirect feedback, typically consumption information provided refers to the total monthly or bi-monthly electricity consumption, without any breakdown of usage into periods of the day, week or month, and without discussing any detected patterns or trends.

However, consumers need appropriate frames of reference in order to determine whether their energy consumption is excessive or not. Currently, most people can only make comparisons with their own historical consumption, rather than comparisons with other, similar households to determine what level of consumption should be considered 'normal' (normative feedback).

Whilst fine-granular **smart-meter** data is increasingly being made available, it has not yet been exploited to a large extent for feedback experiments. As previously noted, data on electricity usage is often compared at a monthly or bimonthly level, but shorter periods can reveal much more relevant information about unsustainable practices. Historical data comparison is suitable for people who are aware of their energy use and environmental consequences, but not for families or individuals with high consumption and many inefficient habits.

1.2 Knowing your consumers – why energy use varies

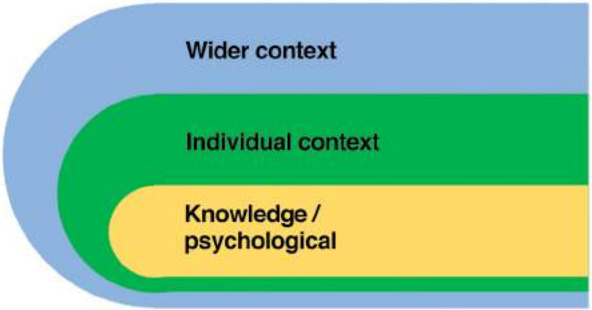
More details are available in D3.1 report of the project.

The aim of NATCONSUMERS is to generate advice and feedback which is tailored to each individual consumer. In order to do this, we need to have a full understanding of these consumers, and the ways in which energy use varies between them. Every person uses energy in different ways, for different reasons, and so the advice which is relevant to them will vary. As such, for every individual consumer we need to understand the different ways in which they use energy and why —– how much energy do they use? At what times of day? For what purposes? Only with this knowledge can relevant, tailored advice be generated. Furthermore, we also need to understand what interests each individual, and therefore what type of messages will catch and retain their attention.

To do this, we need to have an appreciation of the factors which influence energy use, and how these factors may constrain people's opportunities to alter their usage. There are, of course, a multitude of different factors influencing energy use, many of which are not independent of each other, nor of the behaviours they produce. Rather, there are complex interactions between different factors, and cyclical relationships between these factors and behaviours. For example, habits around day-to-day practices such as washing and cooking are strongly influenced by social norms, yet these social norms are themselves produced and reinforced by the behaviours they generate [14].

Separating out these factors for investigation is therefore difficult, and different authors have attempted to categorise them along a range of different axes. For the purposes of NATCONSUMERS, we have divided these factors into 3 groups, based upon scale:

Figure 1 Factors influencing energy usage



In this chapter, we will explore these three groups of factors in more depth, and then briefly discuss the results of a survey into them, exploring general trends and how they vary across Europe. We will then discuss how this knowledge contributes to the creation of tailored NATCONSUMERS messaging.

The insights in this chapter are drawn from a range of sources: a review of the literature around energy use and behaviour change, three workshops with energy system stakeholders, a survey of consumers, and a series of focus groups conducted in Italy, Hungary and Spain.

1.2.1 Factors influencing energy use

In order to investigate the multiple factors influencing energy use, we have developed a 3-part framework, adapted from Wallenborn [15], which separates factors based upon the scale at which they act:

1: Wider context factors

This represents the broad, socio-technical regime within which we operate; as Wallenborn [ibid: p15] describes it: "the age and society in which consumers live". This provides the structural context within which all behaviours take place and all energy usage decisions are made.

2: Household context factors

This is the household level context, which explains people's personal capabilities to act. It incorporates physical factors such as building characteristics (building size, insulation, etc.) and socio-demographic characteristics, both of which act to constrain the choices available to householders.

3: Individual context factors
The individual context influences how people choose to behave, and is made up of psychological factors such as motivations, attitudes and values. This group also incorporates factors around knowledge and awareness of energy use, and the sense of connection or isolation people have from their consumption.

The relative importance of these different sets of variables is contested. When looking at the impacts on current energy use, many studies find that the psychological variables (that is, the 'individual context factors' above) have little or no identifiable impact on behaviour. This is often described as an 'attitude-behaviour gap'. For example, Wallenborn et al. [16] found socio-demographics to be much more powerful explanatory variables of behaviour than attitudinal variables. Similarly, a study into environmental behaviours by Ramos et al. [17] found that attitudes had no influence on pro-environmental habits, and limited impact on purchasing decisions, whilst demographic variables had much greater impact. It has also been argued, however, that whilst contextual factors have a more easily measurable impact on behaviours, psychological variables play an important role as the mediator between context and behaviour [18]. Context determines what behaviours are possible, but psychological variables influence people's decision to undertake that behaviour.

With regards to creating energy efficiency advice, therefore, both contextual and psychological factors must be considered. We must develop advice which is relevant to the wider and household context each individual is living in, but must also consider their individual context to understand what would motivate them to take note of the advice.

1.2.2 Wider Context

The 'wider context' is made up of structural and institutional factors at a broad, landscape level, which act as external constraints on people's behaviour. These are factors which will vary from country to country, such as climate or political context, and will shape the reasons for which energy is needed in day-to-day life. Whilst such factors are not changeable, when developing energy feedback and advice it is important to be aware of the national context, to ensure the advice constructed is relevant. The diagram below shows five main landscape level factors, and the ways in which they are relevant to constructing tailored energy advice.

Figure 2 **Main wider context factors**

Physical

- Climate has a major impact on energy use, mainly through its influence on heating and cooling (air conditioning) requirement
- Daylight hours can also have a significant impact on energy use, particularly electricity consumeption from lighting

Political

- Political influence takes many forms:
  - Regulation – e.g. standards on appliance nergy efficience what products are available to consumers
  - Education – this can influence the way energy is perceived, and can lead to long-term, systematic changes in behaviour
  - Support – government support for new technologies (e.g. electric vehicles, solar panels etc.) or energy efficiency grants and loans after the options available to consumers

Financial

- The broad financial landscape influences energy affordability – for example, during the 2008–2012 financial crisis, there was an increase in energy saving behaviours in many European countries, but a descrease in household investment in energy efficiency measures (Barquero, 2015)

Technological

- Technological development can influence energy use in positive and negative ways. For example, the increasing prevalance of electrinic appliances and devices may increase concumption, which developments in device energy efficiency reduce it
- The growth of 'smart' and interconnected devices can also bring new levels of control over energy use

Socio-cultural

- Cultural norms influence on energy use through peoples' conscious desire to conform to what is 'normal'. This can dictate, for example, how often people shower, wash their clothes etc. Social norms often become locked in with infrastucture. For example, in Sweden, owning a sauna is a social norm, which leads to the installation od more saunas, which reniforces this norm
- Also important is the state of the 'energy conversation' in a country – the general way in which energy is perceived by society. For example, in Norway, where the major of electrocity is generated ny renwable hydropower, electricity is seen as a 'celan fuel' – advice around the environmental impacts of electrocity use is therefore meaningless

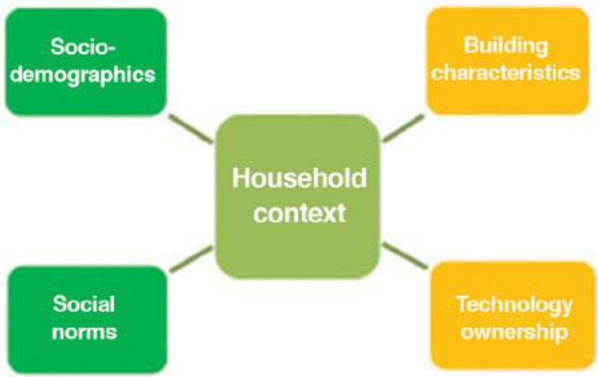
Whilst many of these wider context factors broadly vary by country, it is nonetheless important to recognise that many of these factors act across political boundaries, whilst others will vary considerably even within a single country. Considering climate, for example, there is a general trend for warmer temperatures in southern Europe and colder temperatures in northern Europe. Within larger countries such as France or Spain however, climate may vary quite considerably even within national boundaries. Since the aim of NATCONSUMERS messaging is not to alter structural factors at national scale, we need to further investigate household and individual level contextual factors which can lead to similarities across borders and differences within them. Accounting for these lower scale factors (discussed in the following section) will show us how, for example, a consumer in Spain may find themselves more similar to a consumer in Germany or the UK than to another Spanish consumer.

1.2.3 Household context

At a household level, the property you live in and the people you live with have a significant influence on your energy use, and on your opportunities to change it. Not all energy saving behaviours are available to all — for example, someone on low income or living in rented accommodation may not be able to invest in energy efficient appliances. Understanding the context of each particular household is therefore necessary to effectively tailor advice, ensuring the advice provided is relevant.

Household factors can be split into two main categories: social factors and physical factors. Social factors include both socio-demographics and social norms, whilst physical factors include a property's building characteristics and appliance characteristics, as detailed below.

Figure 3 **Main household context factors**



1.2.3.1 Socio-demographics

A number of socio-demographic factors influence the ways in which households use energy. **Income** has been found, in many studies, to have a major influence on both levels of energy consumption and propensity to take up energy-savings measures. In general, higher incomes tend to be related to higher energy consumption, up to a 'saturation point' beyond which additional income does not lead to a continued growth in consumption [19] [20]. Studies have also found that lower income households are more likely to take on energy saving behavioural measures (such as turning down the heating), whilst higher income households are less willing to compromise on levels of comfort. However, higher income households are willing to invest in energy efficiency measures, such as insulation or new appliances, whilst lower income households may be unable to do so [21].

Another important socio-demographic factor is **age** or **generation**. In particular, households with retired occupants or with young, pre-school children are more likely to be occupied throughout the day, and so tend to have higher energy consumption. Whilst these households may have higher consumption, they also have greater potential for demand management —

that is, shifting certain practices to off-peak times and avoiding the evening peak.

Tenure also influences energy saving behaviour, particularly the likelihood to invest in energy efficiency measures. Since renters do not have a permanent stake in the value of their home, they are less likely to invest in it. Landlords however also have limited incentive to invest in energy efficiency measures, since while they will bear the costs, the bill savings will be seen by their tenants [22] [23].

1.2.3.2 Social norms

Social norms are prevalent at many different scales. Whilst some social norms are broadly consistent within a country or region (for example, those discussed as 'wider context' factors), others are more variable, and are determined at a household or neighbourhood level. This can take the form of **'collective conventions'**, that is undertaking actions because they are seen as 'normal' by their social group. For example, people may recycle because they see that all the other households on their street do so, or may leave lights and appliances switched on because their family or housemates do so.

Social norms can also be expressed as conformation to **'social pressures'**. People often associate particular types of behaviour with particular types of people, which can either encourage or discourage them from doing these actions themselves. For example, some behaviours might seem like 'extreme' actions which people associate with 'eco-warriors', whilst others may seem like overtly wasteful behaviours which are associated with selfishness.

1.2.3.3 Building characteristics

The amount of energy a household uses will, of course, be impacted by the property they live in. For example, larger homes with more space to heat and light will require more energy. Older homes often have lower energy efficiency than modern homes due to their build characteristics, and so tend to require more energy. Fuel type is also an important consideration when giving energy efficiency advice, since heating, cooling and hot water account for the majority of energy used in a home.

NATCONSUMERS messaging is focused on electricity use, and so it is important to identify homes with electric heating or air conditioning in order to tailor specific advice to them. However, the NATCONSUMERS process could easily be adapted to different fuels, depending on availability of smart-meter data.

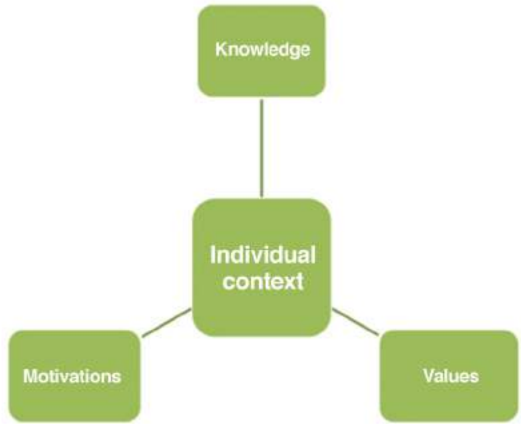
1.2.3.4 Technology ownership

The type, number and efficiency of appliances in a home all have an important influence on electricity consumption. Different types of appliances use different amounts of energy, depending on their function, size and efficiency. In general, smaller appliances use less energy than larger equivalents. As such, households with larger, older or less efficient appliances will use more energy than a household with smaller or more modern, efficient appliances.

1.2.4 Individual context

Both the 'wider' and 'household' context factors identified influence the opportunities which are available for people to reduce their energy use, and the constraints which prevent particular energy saving behaviours. However, people do not simply act as 'rational actors', whose behaviours can be predicted by an easily measured set of variables which determine the costs and benefits of different actions. Whilst contextual factors may make a particular behaviour more or less likely, whether people actually engage in it will depend upon their motivation to do so [24]. Motivation is dependent upon people's knowledge and understanding of the action or behaviour, the way in which they cognitively evaluate the behaviour, and whether the behaviour is regarded as in-line with their underlying values and beliefs.

Figure 4 Main individual context factors



Knowledge is a prerequisite for action; for people to intentionally change behaviour, they must be made aware of their energy use and be informed about the consequences of this [25]. Essentially, people need to understand **why** they should change their energy use, and **how** they can do so. Understanding 'why' requires an appreciation of self-efficacy — understanding that energy-saving actions have positive consequences, whether personally or in terms of wider society [26].

The first stage of any advice provision must therefore be to build up people's knowledge around the consequences of their behaviours, either the direct consequences on an individual's energy bill or levels of comfort, or the broader consequences on the environment and natural systems. The second stage of advice provision must be to build up knowledge on how they can change behaviours, that is, developing their action-based knowledge.

Indeed, within focus groups conducted for the NATCONSUMERS project, we found that energy awareness amongst the general public is low. In Hungary, where many people only have their electricity meter read once a year, people commented that they only check their meter when their bill is due, and so have little understanding of how their energy use varies throughout the year or how their actions contribute to their consumption. In Hungary, respondents claimed that they do not think there are many actions they can take to reduce their electricity consumption, whilst in Spain we found that the energy saving actions people could think of spontaneously were very limited.

NATCONSUMERS messaging must therefore act to educate and inform, building up consumers' knowledge both in terms of what they can do and why they should do it.

Whilst knowledge is a pre-requisite for behaviour change, it is not, alone, sufficient to stimulate action. Beyond understanding how and why they should act, people must be motivated to do so. To develop advice which plays off people's motivations, we must understand each individual's attitudes and values. Attitudes reflect the way we perceive or comprehend an idea, object or behaviour, and our emotional evaluation of it. Values are the more durable, stable underlying belief-systems; they form the underlying principles which guide our world-view [27]. Understanding the attitudes and values which steer the way in which people will evaluate a piece of advice is important to creating effective messaging which is more likely to resonate with the consumer. As Mirosa et al. [28: p469] states: *"If we want to change behaviour, it must be recognised that it is unreasonable to expect people to behave in ways they are opposed to".*

In the context of energy saving, there are a range of different drivers which may influence the way in which people choose to behave, depending upon their underlying values, attitudes and motivations. A selection of such drivers can be seen in the diagram below.

Figure 5 **Possible drivers of energy saving**

1.2.5 Trends in the factors

More details are available in D3.3 report of the project.

Each of the factors discussed in this chapter will vary from individual to individual, hence the need for messaging to be tailored. In the following chapters, we will discuss how to build up this tailored user-experience using segmentation. However it is interesting here to note some broader trends and national variations in these factors, which can be identified from a survey carried out by the NATCONSUMERS project across four countries: Hungary, Denmark, Italy and the UK.

There are few trends of interest, at a national level, in the household context factors — the type of home you live in, the appliances you own, and the socio-demographic make-up of your home cannot be generalised across a country, but are relevant only on a case-by-case level. Of more interest however are general trends in individual context factors. In our survey, we questioned individuals, both directly and indirectly, around a range of motivational drivers. From this, we found that:

- Financial considerations are the primary driver for the majority of consumers (almost two-thirds of those in the survey). Regardless of nationality or socio-demographic group, money is universally a driver for behavioural change. What was not tested in our survey however was how much financial impact a behavioural change needs to have for it to be considered worthwhile. Whilst financial savings may motivate most people, it seems likely that those in higher income groups would require higher financial incentives to stimulate a change in their behaviours.

- Comfort and convenience is a key driver for 29% of people. This is most pronounced in Italy and the UK. However, in Hungary, comfort and convenience is a much weaker driver.

- Social pressures or prestige are a strong driver for around a quarter of people. This is a stronger driver however in Hungary and Italy where it is a key driver for almost a third of the people. In Hungary, where a consumer society has been prevalent only since the 1990s, the importance of recognition and prestige through material goods is higher.

- Environmentalism is a relatively weak driver; it was only found to be a strong driver for 13% of people. Amongst those for whom it is an important driver, it does not appear to have any impact on their day-to-day behaviour; people who prioritise the environment were no more likely to be undertaking energy saving behaviours than those who do not.

These drivers are further explored in Chapter 2.1.3, which explains how segmentation can be used to identify each individual's main drivers through a much reduced set of questions.

1.2.6 What this means for advice generation

More details are available in D1.4 report of the project.

The three groups of factors described in this chapter, wider context, household context, and individual context, form the basis for NATCONSUMERS advice generation. Only by understanding these factors, and how they vary for each individual, can we provide feedback and advice which is truly tailored.

There are two main aspects to the tailoring of messages:

- **What** should the message say — what content is relevant to that individual, at that point in time
- **How** should the message be said — how should the advice be framed to make it resonate with that consumer, at that point in time

The former is largely dependent upon the wider context and household context. These contextual factors determine what it is relevant to tell someone, based upon their individual circumstances. The latter is more dependent on individual context factors; in what style and tone should the message be framed, and in relation to what drivers, to make it catch and retain the interest of the consumer.

When identifying what message to deliver to a particular person, we must be pertinent of what behaviours are actionable and what are non-actionable. Many of the factors which influence energy use, such as demographics or building characteristics, are not changeable — our advice should account for these as contextual factors, but cannot change them.

Other factors are actionable, for example, 'lack of knowledge' is a factor which influences energy consumption and can be tackled by providing useful information on the consequences of energy using activities through NATCONSUMERS messaging.

'Old, inefficient appliances' is a factor which increases consumption, and again which could be influenced by NATCONSUMERS advice. However, whilst this factor is actionable, it will only be relevant to those with sufficiently high disposable income to be able to upgrade their appliances.

Another area of particular importance to consider for NATCONSUMERS messaging is that of trust. Our focus groups revealed that low consumer trust in both **smart-meters** and energy suppliers could form a major barrier to the acceptability of energy efficiency advice. Many people regard **smart-meters** with suspicion; they are fearful of intrusions into their privacy and inappropriate use of their data. This was found both in our focus groups in Hungary, where **smart-meter** roll-out is at a very early stage and awareness of **smart-meters** is very low, and our focus groups in Italy, where **smart-meters** are much more prevalent, and are already installed in most households.

A second area of mistrust is in the energy suppliers themselves; consumers have limited trust in their suppliers, particularly in countries with histories of poor billing accuracy, such as Hungary. Consumers are therefore wary of energy efficiency advice provided by a supplier, questioning why they would send such messages, and what their interest is in reducing energy use, when their business profits from the sale of energy.

A first objective of NATCONSUMERS feedback must therefore be to build trust and reduce consumer fear. Consumers must be made aware of how their smart-meter data is being used, how this can help them, and why they are being given this advice before they will trust in and respond to it.

Data must be handled transparently and stored securely, and the consumer must know how, why and by whom their data has been used. Some consumers suggested that handling of data or verification of advice by a third party, independent organisation, such as a consumer organisation, could help to build trust in the advice.

1.2.6.1 Messaging style

More details are available in D3.3 report of the project.

The discussion within this chapter has focused primarily on how we determine what message to give people, based on their wider and household context, and within what argumentation to provide the message, based on their individual context. Beyond this however we can add a further layer of complexity: in what tone or style should the message be presented? The same message can be presented in a variety of different tones, ranging from factual, to witty, to confrontational. Take, for example, a simple message recommending someone to turn their devices off standby. This message could be presented in a range of different styles:

Factual	The standby mode of your devices consumes electricity. You could save energy by switching them off at the wall.
Conversational	You know that the little red light on your TV means it's not totally off but in standby mode... It's actually draining your wallet.
Confrontational	Are you serious? You're leaving your devices in standby? It saps so much energy! Turn them off completely!
Poetic	Silent. Discreet. Devices in standby. Deceivingly inactive. Secretly consuming.
Creative	The surface is dark. Empty. Only a little red light survives. The eye of a dragon. A powerful energy monster snoring in silence.
Sarcastic	Rest mode. Sleep mode. Wake up button. You know your devices aren't really alive, right? They don't need to go to sleep or take a nap. You can turn them off completely. Believe me, they will be fine.

Different people will respond to these various styles in different ways. Some may find a particular message irritating, whilst others may find it entertaining. From our survey, we found that confrontational messages tend to be the most emotive — they are most likely to annoy people, but also most likely to spark a response from them.
Further investigation through focus groups however found that there is no particular style which is most suitable to a particular person; rather, the style which is appropriate will vary depending on the sender of the message and the stage of conversation.

Messaging style must be aligned with the consumer's perceived image of the sender of the message.

For example, consumers do not expect to receive friendly or humorous messages from their energy supplier. In particular, consumers will not accept confrontational message from their suppliers — they refuse to be 'told off' by a company they are giving their money to. However, a smaller, independent organisation, which does not have any negative history with the consumer, can afford to be more humorous and creative, in order to stimulate a reaction.

The stage of communication is also important.

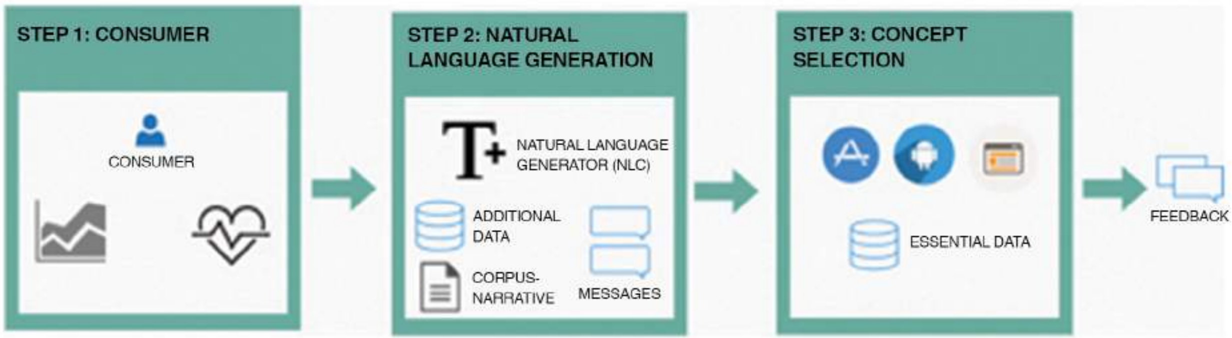
Whilst initially messages should be quite factual and informative, over time this could develop into a more conversational style, and ultimately offer more challenging statements which push people to consider their actions more closely. As trust in the service and the effectiveness of the advice increases, the tone of the advice itself must develop.

2. The NATCONSUMERS framework

In the next three chapters of this handbook, we investigate how the insights discussed in the previous Chapter can be translated into a workable Natural Language mechanism. This process is outlined by the 3-stage NATCONSUMERS framework:

Stage 1 — Classify consumers
Stage 2 — Natural Language generation
Stage 3 — Develop/select an engagement concept

Figure 6 The 3 stages of NATCONSUMERS framework



Stage 1 — Classify consumers

As described in the previous chapter, the ways in which consumers use energy, and the ways in which they respond to advice, are highly variable. In order to create advice which is tailored to each individual, but which can be implemented by automated processes and at mass scale, it is necessary to group consumers with similar characteristics. Within NATCONSUMERS, consumers are grouped by three separate segmentation processes. This multiple-segmentation maximises tailoring, whilst still allowing a workable mechanism to operate at scale. The process for classifying consumers is explained in Chapter 2.1.

Stage 2 — Natural Language generation

In Stage 2, the data collected within Stage 1 from smart-meters and surveys is transformed from numerical data into linguistic advice messages. This process relies upon a corpus of messages — a collection of potential narratives, each of which can be adapted based on the segmentation data derived in Stage 1. The construction of a Natural Language Generator is described in Chapter 2.2.

Stage 3 — Development/selection of engagement concept

In Stage 3, we must identify the interface through which we will communicate with consumers. Each potential interface, whether that be a website, application, written feedback, audio feedback, etc. is described as an **engagement concept**. There are an infinite number of potential concepts; in Chapter 2.3, we discuss one methodology for generating such concepts, and the outputs generated.

After introducing the three stages we present a demonstration **tool** in order to evaluate our proposed methodology on small scale.

2.1 Stage 1 — classify consumers: How to get your message across

More details are available in D4.1 and D4.2 reports of the project.

2.1.1 Why segmentation?

Over the past 10–20 years, several (partly EU-financed) projects have been launched which attempt to reduce residential households' energy consumption through behaviour change. These projects have shown that by changing behaviours and habits, energy consumption can be reduced by anything from 2 to 15%. The amount that consumers save in these studies depends largely on how we fare when giving well-targeted advice to consumers. Generic advice, being meaningless for the consumer, will not work, or will only bring about minor changes in consumption. For advice to be effective, the messages must be targeted; the customers should feel that the information they are given is relevant, and that the advice is useful.

Effective advice is built upon two pillars within the NATCONSUMERS engine:

– a multi-dimensional segmentation of consumers;
– Natural Language based messaging, which is based on the aforementioned segmentation.

The former is discussed in this chapter, the latter in Chapter 2.2.

Segmentation is a means of classifying consumers into groups of people who display similar characteristics across multiple variables. By tailoring messaging to each of these groups, it will be possible to create seemingly tailored information on a mass-scale. Within NATCONSUMERS, the combining of multiple segmentation models (to form our multi-dimensional segmentation) will allow for enhanced tailoring of messages whilst creating a tool which can be utilised at scale.

The segmentation engine gives the foundation of tailored advice, as it decides what kind of message the consumers should receive, and in what type of argumentation the message should be wrapped.

Essentially, this segmentation engine is built upon two pillars, one of which defines 'what' we should tell the consumers, while the other defines'how', on the basis of the argumentation, we should tell it.

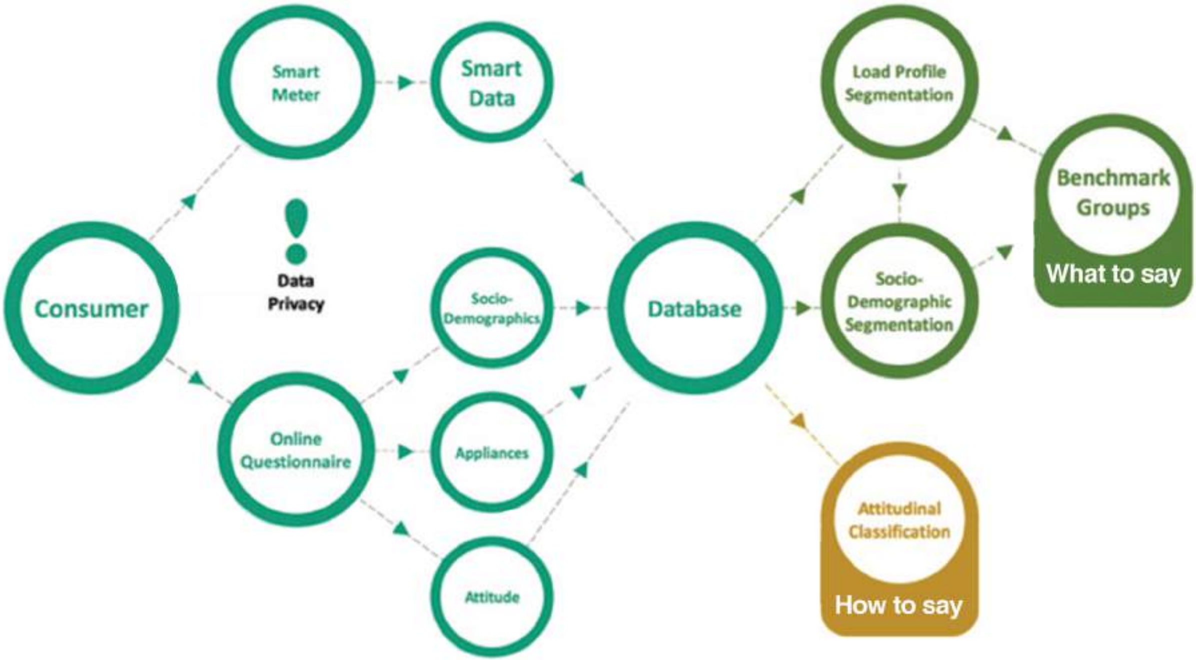
This process can be seen in the following figure.

As the figure above shows, the segmentation engine uses two data sources; one detailed consumer dataset based on **smart-meters**, and one survey-based dataset which contains socio-demographic and attitudinal data. We suggest applying three separate segmentations based on the two data sources in order to create tailored messages.

1. Load profile segmentation: Based on the dataset obtained from **smart-meters**, we place consumers into **load profile** segments which differentiate groups based on their daily, weekly and monthly electricity consumption patterns. This segmentation shows how consumers typically use electricity over time (at daily, weekly, and monthly scales), for example, whether a household's **peak consumption** is typically in the afternoon or evening, whether they consume more than average in the winter or summer, etc.

2. Socio-demographic segmentation: The purpose of demographic segmentation is to try to differentiate consumers by the volume of their consumption, that is, how much electricity they use, using the data available to us from households. The primary aim of this classification is to find what counts as a **benchmark (reference) segment** to the given customer, in other words, a group to whom it would be meaningful for them to be compared to when making comparisons.

Figure 7 Flowchart of segmentation engine



3. Attitude-based segmentation: Attitude-based segmentation helps to define the optimal argumentation for the messages. Some customers are responsive to arguments around saving money. Others are motivated by environmental aspects, whilst still others may be attracted to being able to try an exciting, new, technological invention. The importance of these attitudes and values was discussed in terms of 'individual context factors' in Chapter 1.2.4, and will be further built upon in the upcoming Chapter 2.1.3 of this handbook.

2.1.2 The content of messages — load profile and socio-demographic segmentation

2.1.2.1 Logic behind the load profile and socio-demographic segmentation

More details are available in D4.2 report of the project.

The NATCONSUMERS segmentation engine has to serve two goals at the same time, on the one hand, it has to determine **what** the messages sent to consumers contain, on the other hand it has to contain indication of **what kind of argumentation** the advice should be embedded into. Socio-demographic segmentation and load profile segmentation primarily deals with the former. In order to understand the necessity of the two segmentations and their logical connection, we have to take a step back and briefly refer to how the planned advice will be built up.

NATCONSUMERS gives feedback about the electricity use of consumers primarily and fundamentally on the basis of **smart-meters** placed in the homes of users. This advice can be built up in many ways, but different **smart-meter** based **indicator variables (indicators)** make the foundation of most of the messages. Here are some short examples of this (in these examples we have not put argumentation next to the outlined messages or the advice, we simply introduce the core of the message):

1. In peak periods, your household consumes twice as much electricity as households similar to yours
2. Households similar to yours consumed 12% less electricity in the past month/2 months/ year etc.
3. Based on the last 30 days, you are within the top 10% of lowest energy consumers compared to households similar to yours

Fundamental principles in creating Indicator variables

- Don't use alert-type messages which reflect changes within only a small time-interval, as over short time periods, data is often very noisy.
- When making comparisons where weather is not incorporated into the models, always use the 'similar households' **benchmark segment**, rather than making comparisons to the user's own past consumption. Self-comparison can lead to several problems, for example, differences in temperature or a cloudy sky may cause large differences in the pattern of energy consumption — if we do not include weather within our model comparisons against historic consumption will be strongly biased. If we add weather component to our models, self-comparison is also possible.
- Use at least of one month's worth of data to make any comparisons (minimum 25–30 days). Within shorter time periods, the data could be noisy and is sometimes biased.
- Take account of the impact of different tariffs when we make within-day comparisons (and same with weekdays, weekends. People may adapt their energy usage in line with peak and off-peak charging times.

- The indicators have to be easily understandable for the consumer

The previous three examples present different types of indicators which can be used when giving advice. Each of the three messages are based on the users' **smart-meter** data. Some of the messages consider the volume of consumption (that is, how much energy is used), some concentrate on the patterns. The first core message considers the different attributes of an average daily consumption (in this case, '**peak consumption**' within a day), while the other two messages are based on aggregating data over time.

In all of the messages, it is not enough to know only the user's own consumption; we also need a **benchmark segment** for comparison. For all three messages, we need to know the average quantity of energy consumed by the **reference group**. For the first message, we also need to know when in the day the **reference group** uses electricity, that is, its 'consumption curve', in order to assess **peak consumption**.

In theory, the **reference group** can be composed in two ways. One option is to compare it with the consumption of "neighbours", those living in the neighbourhood. The advantage of this option is that it allows users to be compared to people that they know, thereby stimulating a greater sense of competition. It can work well in cases where nearby households are very similar to each other, that is, the homes are of a similar size and build, they have a similar lifestyle, and overall the difference in their consumptions is small. Whilst this territorial gathering is typical in many cases, it is not ubiquitous.

For many households therefore, comparisons against their neighbours can be meaningless — there is little sense, for example, in a two-person household being compared to a large five-person family down the street; their lifestyles and consumption patterns will be entirely different. Moreover, to provide this neighbourhood-level comparison, we need the service-provider to have sufficient users within a neighbourhood able to provide consumption data, which is a condition that is not necessarily met.

If we dismiss comparative messaging based on neighbourhoods, then we need to define "similar households" in another way. In the NATCONSUMERS project we evaluate it in the following two dimensions:

- ***The consumption curve of the given household has to be similar***
- ***The consumption volume of the given household has to be similar***

The first is explained by **load profile** segmentation, the second by socio-demographic classification. The **load profile** segmentation defines consumption groups by their patterns of energy use on a daily, weekly and yearly basis. The socio-demographic segmentation delineates the groups based on differences in the overall quantity of energy a household consumes over a year. The organic interconnection of these two types of segmentation establishes the '**benchmark group**' against which households can be compared.

Theoretically, there are multiple ways in which these two segmentations could be merged. In NATCONSUMERS, we have used the following process:

- First, using households' consumption curves, the characteristic load profile segments are identified and separated
- Within these load profile segments, socio-demographic variables are used to separate consumers with different volumes (quantities) of consumption.

Our statistical testing proved that this method yielded the most consistent results; the consumption of various groups could be clearly differentiated, whilst the individual socio-demographic subgroups inside each load profile segment kept the curve pattern characteristic of the basic segment. This solution is also preferable because the size of the final groups created is not too small (which would risk the reliability of the comparison).

2.1.2.2 Load profile segmentation

2.1.2.2.1 Methodological considerations

More details are available in D4.1 report of the project.

There is fast growing literature dealing with consumer segmentation based on load profile historical data. Most experts highlight that there are some basic requirements to meet and preparatory procedures to be carried out for any reliable segmentation process based on smart-meter data (such as having a sufficiently long historical data series, proper granularity of smart-meter data, need for standardization, data validations etc.).
With regards to the temporal breakdown of the load profile classification, the predominant intention in the literature is to identify daily consumption patterns. Other aspects of time, for example, days of the week or seasons,

receive relatively low attention, and are treated as secondary conditions. In the NATCONSUMERS project we recommend a more sophisticated method of **load profile** segmentation compared to other projects. The key idea of our approach is an enhanced and integrated concept of time differences within electricity consumption.

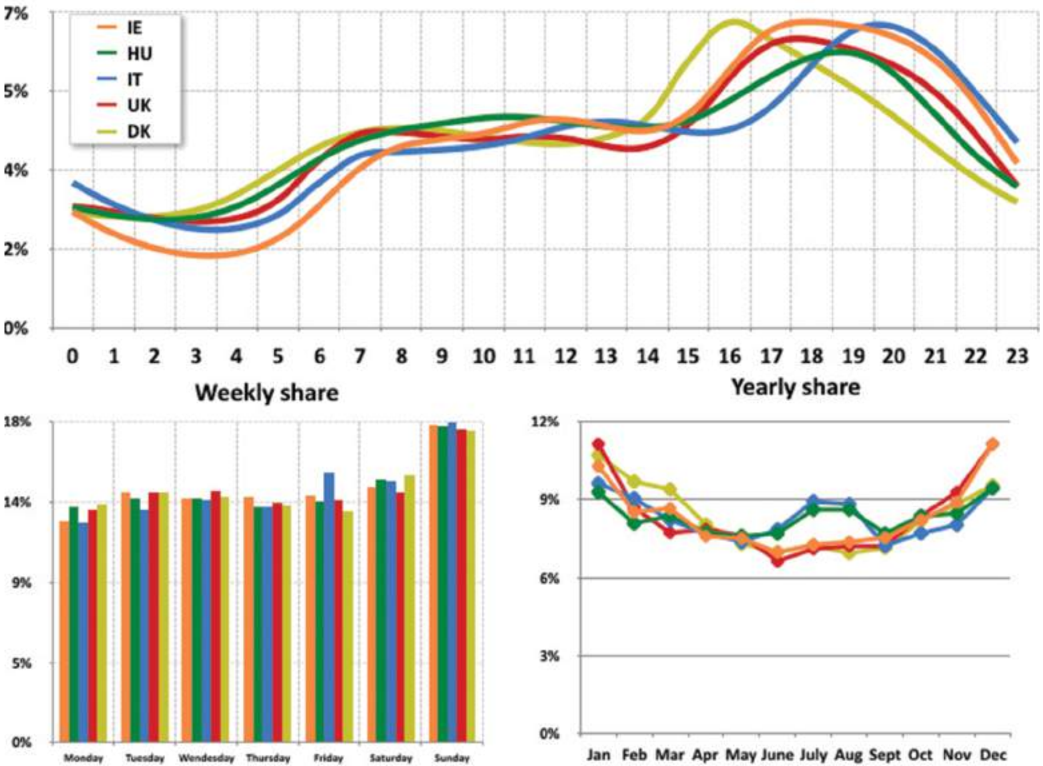
We argue that beyond 'daily' shapes (which are arguably the most important ones), there are other aspects of time which might be regarded as inherent parts of load profile segmentation. We therefore suggest the use of weekly and yearly time aspects in load profile segmentation procedures alongside the commonly used daily profile.

There are a wide range of classification methods available which could be used in **load profile** segmentation procedures. These methods are different in many ways; each has their own advantages and disadvantages. The most common approach in segmentation is the use of hierarchical or K-means algorithms. As **load profiles** are time-sequenced data, it is also possible to use special distance functions like Dynamic-Time-Warping (DTW) for input into hierarchical or K-means clustering. These are all heuristic models. Model-based approaches such as finite mixture modelling [29] could also handle the segmentation. After testing the different methods, for our segmentations we used Ward's hierarchical clustering.

2.1.2.2.2 Typical load curves in Europe

In NATCONSUMERS the project we analysed **smart-meter** data from 5 different European countries [30]: Hungary, Ireland, Italy, Denmark and the UK. Despite the many differences between these five countries, the basic structure of their residential electricity consumptions is rather similar. There is a downward tendency throughout the night until 3:00–4:00am, after which comes a small peak in the morning and a high peak in the evening. The level of consumption is lower on weekdays and higher on weekends, especially on Sundays. The most observable difference between the countries applies at a yearly basis, with summer peaks in Hungary and Italy, and winter peaks in Ireland and the UK.

Figure 8 Basic structure of electricity usage in the five examined countries



After analysing the five countries' data, we formulated some conclusions about the **load profile** characteristics. There are at least three **load profile** curves that could be identified in (nearly) all the countries. We called the first of these groups the Double Risers. Although there are some variations by country, the main profile curve is similar. The peaks in their consumption are not extremely high; they have a very small morning peak and an average afternoon/evening peak between 5:00 p.m. and 8:00 p.m. On weekly and yearly basis the segment produces an ordinary consumption structure.

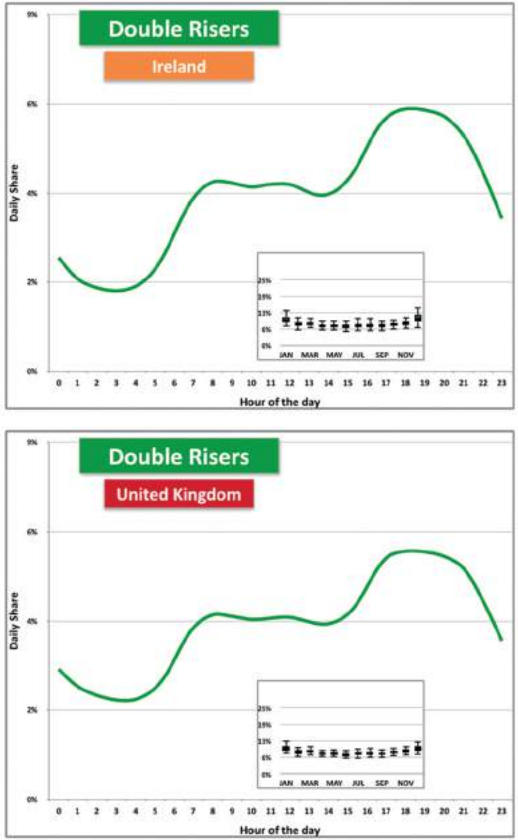
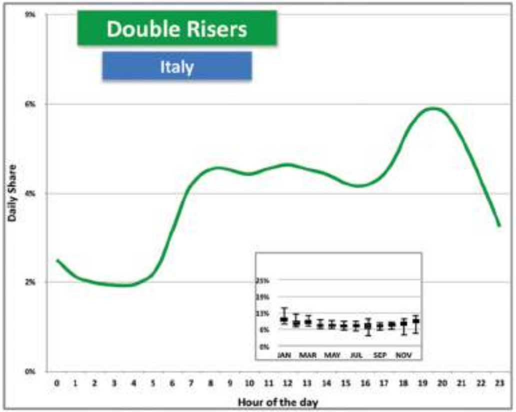
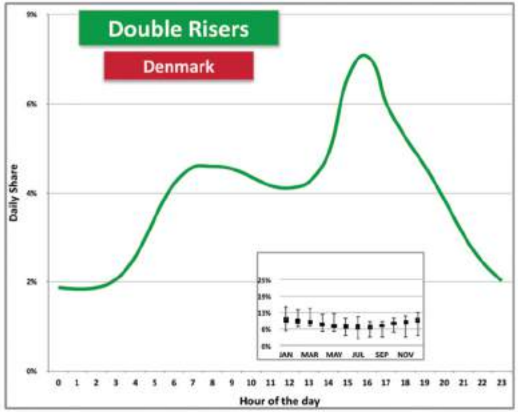
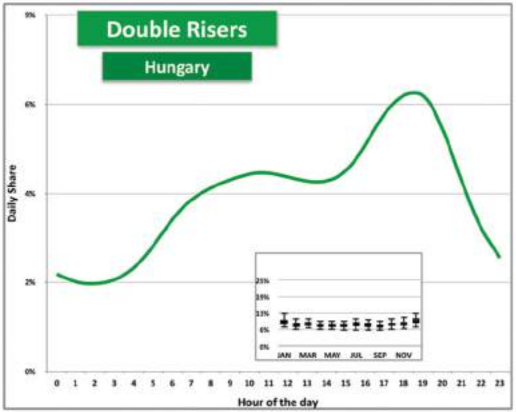


Figure 9 **Load profile of Double Risers segments**

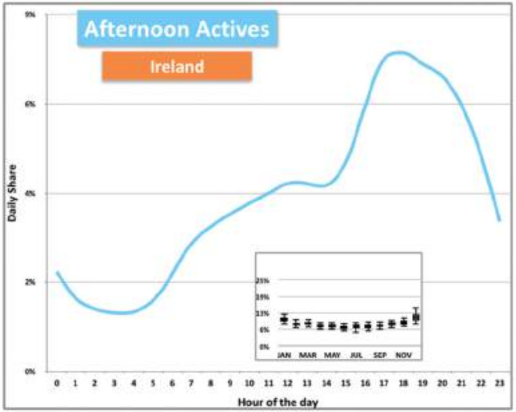


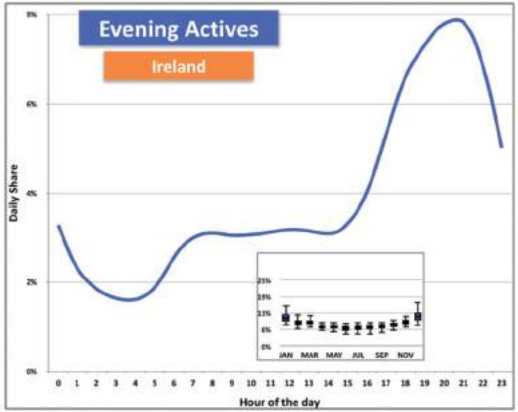


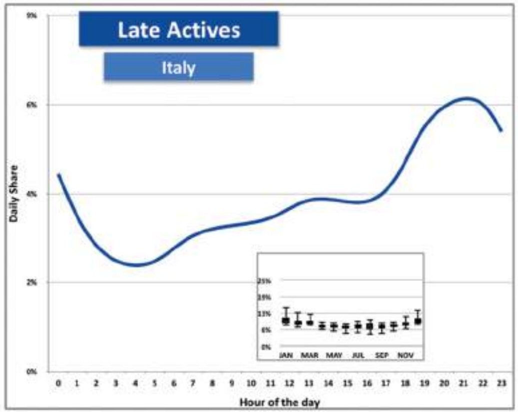


The second general group identified in all countries is the Afternoon, Evening, and Late Actives segments. In some countries these two segments merge, in other countries, they stay separate. In Italy we could call them Night Actives as their consumption goes on until midnight. The common characteristic of these segments is that they do not produced morning peaks (except in the UK), only afternoon/evening peaks, but these late peaks are expressly high.

Figure 10 Load profile of Afternoon/Evening/ Late Actives segments

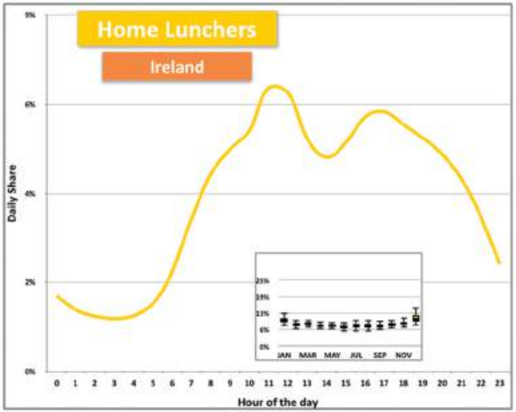






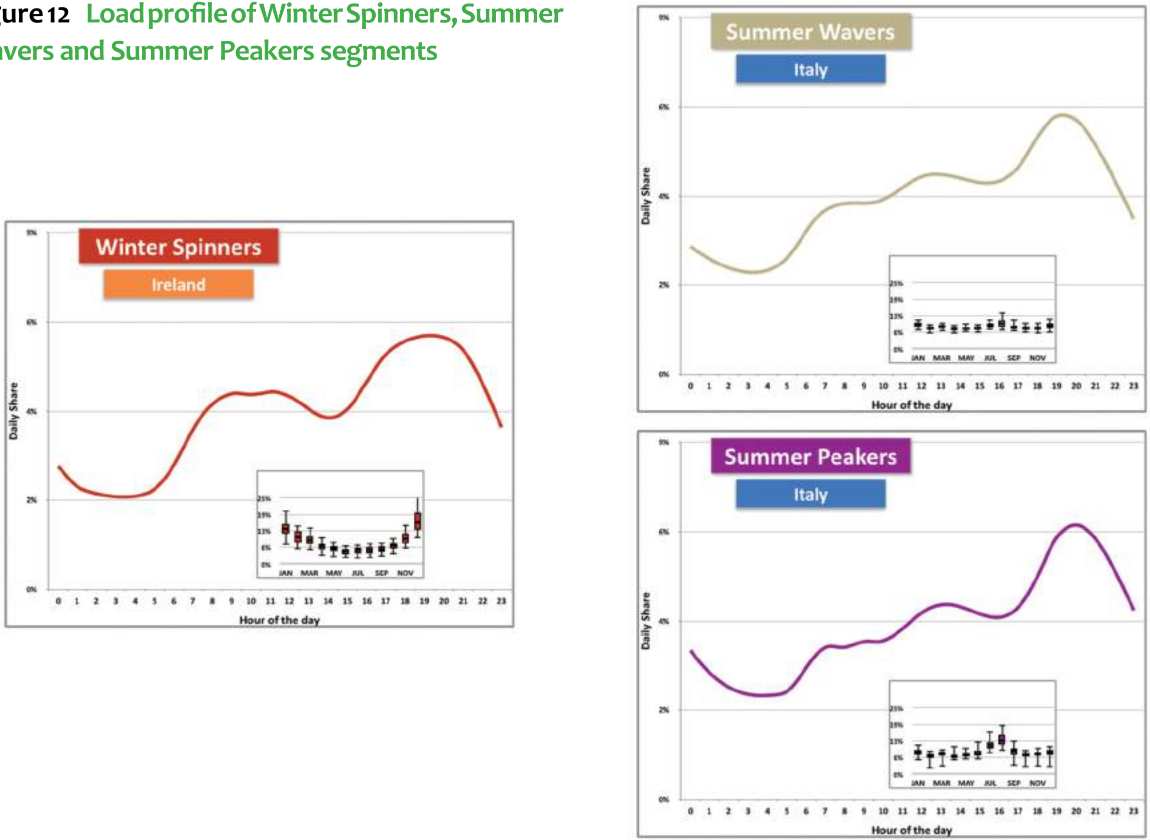
The third general group has a bi-modal consumption structure, with a morning/forenoon peak and an afternoon peak. In the case of Ireland and Hungary, the forenoon peak is higher than the afternoon peak. The forenoon peak is a clear indicator of a home-based household member, who stays at home during the whole day. We called this segment Home Lunchers.

Figure 11 **Load profile of Home Lunchers segments**



Beside the general consumption profiles, the hierarchical clustering also identified country-specific **load profiles**. In Ireland, the UK and Denmark there is a group called Winter Spinners (who probably use electric heating), in Italy there is a Summer Peakers segment and in Italy, Denmark and Hungary, there is a Summer Wavers segment (which is an indication that they probably use electric air conditioning). The common feature of these segments is that their daily **load profile** is rather standard, only the yearly consumption pattern reveals the main attributes of these segments. This highlights how important it is to use yearly data in **load profile** segmentation, as this can help to find unique country-specific segments.

Figure 12 Load profile of Winter Spinners, Summer Wavers and Summer Peakers segments



Methodological lessons

The results of our analysis have clearly shown that it is worth using an enhanced and integrated concept of time differences in **load profile** segmentation. There are a large number of classification methods which could help us in **load profile** segmentation (Hierarchical Clustering, K-means clustering, Latent-Profile analysis, DTW time series approach etc.). We have to take many aspects into account when choosing from these methods (sample size, assumptions about data distribution, process time, outliers, non-convexity of the variable space, availability on different software platforms etc.).

The hierarchical clustering of **load profiles** provided an efficient way to segment the electricity profiles of consumers. The other clustering methods (K-means, Latent Profile, DTW Time Series) have given different outcomes in **load profile** classification. All clustering techniques could be adequate to classify **load profiles**, but in our case study Hierarchical Clustering performed the best with regards to interpretability and usability.

2.1.2.3 Socio-Demographic Segmentation

More details are available in D4.2 report of the project.

To develop the socio-demographic segmentation, we analysed the relationship between the yearly energy consumption volume of households (kWh/year) and their socio-demographic criteria. Since this segmentation is understood as a development of **load profile** segmentation, we wanted to do the modelling equally for Hungarian, Irish, Italian and British households [31]. The outcome of the segmentation is the creation of a mathematical-statistic model which helps determine the size of a household’s yearly energy consumption merely on the basis of socio-demographic criteria, with an acceptable statistical accuracy.

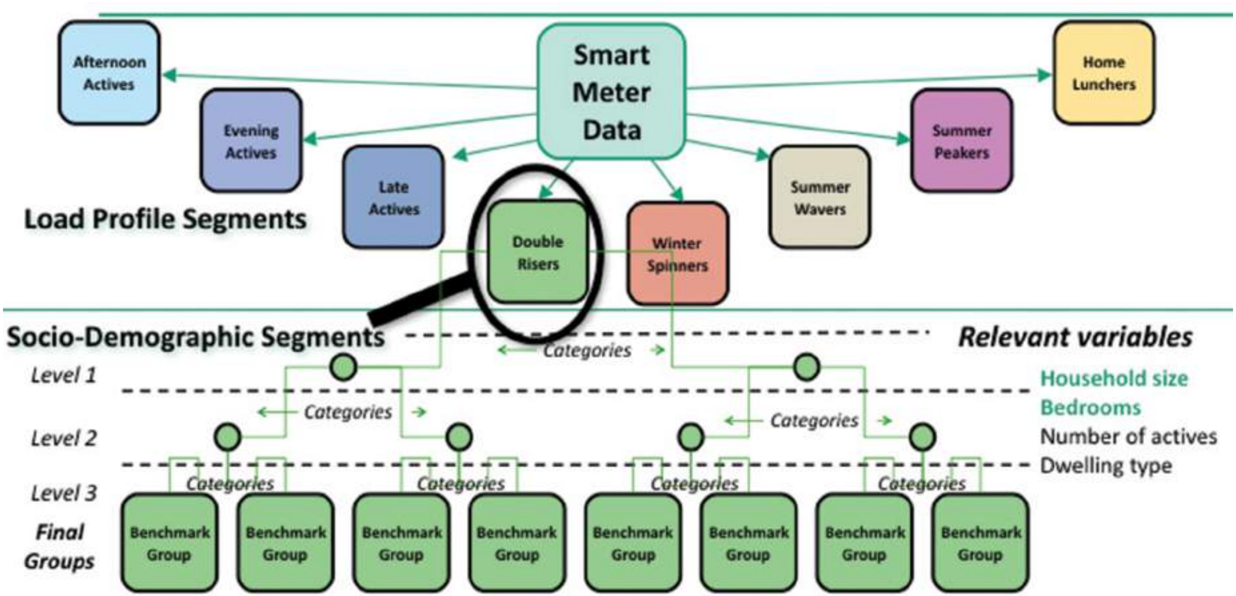
Therefore, to conduct the socio-demographic segmentation we had to rely on two “single source” data sources, different in content but connected on the level of individual households.

In addition to **smart-meter** data of household energy consumption, the anonymised databases used for our analysis also contained socio-demographic criteria to a varying extent by country. In the data preparation phase of the analysis, we consolidated the socio-demographic criteria found in each country's database and the data on energy consumption at a household level. We sought to create socio-demographic variables with unitary content and structure by country, but the lack of data or different meaning of the given criterion often prevented us from doing so.

The most suitable method for revealing and interpreting the relationship between socio-demographic factors and yearly energy consumption was found to be the **CHAID** (Chi-squared Automatic Interaction Detection) analysis technique.

The output of **CHAID** analysis is a graphic model, a decision tree. The target variable of the decision tree in this case is the Standard Yearly Consumption. In the structure of the decision tree, every top signifies a control variable referring to a concrete value, and every downward branch corresponds to an output of the control [32]. The model can be easily understood and interpreted because the decision tree contains only output values, the algorithms in the background are hidden from the average user.

Figure 13 Socio-demographic classification logic



From our analysis of the decision trees, we found that the most important socio-demographic explanatory variables of yearly energy consumption volume are:

- the number of people living in a household (household size),
- the variable describing the size of the household (surface area or number of bedrooms),
- the type of dwelling (for example, flat, detached house, semi-detached house etc.),
- the number of economically active people in the household.

The decision trees obtained also point to a hierarchy of the explanatory variables. For almost all decision trees, the first node is the number of people living in a household.

That is to say, of all the analysed socio-demographic variables, the yearly energy consumption volume shows the strongest linear relation to the household size.

In load profile segments where the numbers of households are very low, it was exclusively the household size which was used as an explanatory variable in the model describing the size of the yearly consumption volume. In this way, the household size alone gives a certain orientation about the yearly energy consumption volume of a given household.

For larger load profile segments (that is, segments which represent a larger proportion of the population), following household size, the secondary differential factors are variables describing the surface area of the household. As such, the yearly consumption volume for larger subgroups is specified by the 'dwelling size' variable. The 'dwelling type' and the 'economic activity of household members' variables appears only after the two primary explanatory variables, on the third level of the decision tree.

Because of the anonymity of the databases, we were not able perform any statistical analysis on the relationship between a given household and other households in their immediate neighbourhood with relevant socio-demographic criteria. We hypothesise that the yearly energy consumption volume of households of the same size and surface area and located in the same micro-environment could be very similar. This hypothetic relationship could be called the "neighbourhood relationship". Information about the micro-environmental relationship of households in socio-demographic segmentation could be a further important and relevant input variable to this analysis.

As highlighted earlier, we decided to subordinate socio-demographic segmentation to load profile segments, and find socio-demographic groups inside load profile segments which have a similar consumption size. This method ensured that the consumers who were grouped together in the final classification were similar not only in their consumption volume but also in their load curves, which makes a much more valid and reliable comparison.

Our results confirmed that this logic is operational, the segments are clearly separated from each other in the size of consumption, but the load curves in the subgroups do not slip compared to the curve on the highest level of the profile.
The load profile and socio-demographic based benchmark segments formed by this logic are actually only a part of the overall NATCONSUMERS segmentation engine. This engine is completed by an attitudinal segmentation, which supports the argumentation part of the messaging. This is the subject of the following section of the handbook.

2.1.3 The argumentation of messages — attitudinal classification

More details are available in D4.2 report of the project.

2.1.3.1 Logic behind attitudinal classification

In the previous section of this handbook, we presented the logic behind the creation of benchmark segments, for which we used the load profile segmentation and socio-demographic segmentation described above. However, these two segmentations are only a part of our segmentation engine, helping choose to whose consumption we compare the energy use of a given household. However, this segmentation does not say how to present arguments for changing consumption. This is the role of attitudinal segmentation.

The basic logic of attitudinal segmentation is to find the attitudes which may work as arguments to change energy consumption, then segment the consumers with the help of these attitudes, classifying them into groups which divide, as clearly as possible, the energy consumers into groups based on their behaviour and habits.

For each segment, we can predict which argument the consumers of that segment will respond to positively, neutrally, or negatively, thus the **Natural Language Generator** (defined in the next chapter of the book) can choose the most relevant argument from the **corpus** of messages. The messages defined in this way are accurate, targeted and relevant, and can obtain higher efficiency than general, meaningless recommendations and suggestions, so the likelihood of changing the consumers' behaviour is maximised.

For an efficient segmentation, we must find the relevant attitudes and values that define people's relation to energy. Since, in this context, the consumers must be segmented along a specific target, we could not use standard marketing segmentation groups. Based on previous research (see Chapter 1.2.4), we created a questionnaire which surveyed the population's knowledge and attitudes about energy, completed with background demographic variables and further questions about energy use.

The detailed analysis of attitudes found in the literature, and the elaboration of the segmentation model based on these, required a large amount of quantitative data. In order to obtain this, the most optimal and cost-efficient solution was online data collection.

Methodology for compiling user data

Since the NATCONSUMERS project aims to create a segmentation model applicable across the EU, it was important for the survey to collect responses from a range of countries. As discussed in our previous report, people's choices around energy use are to some extent moderated by the 'wider context' in which they live. Different regions within the EU provide different political, financial, climatic and cultural landscapes within which energy using practices occur. As such, it was important for our survey sample to cover a range of different regions which present different 'wider contexts' in which individuals make behavioural decisions.

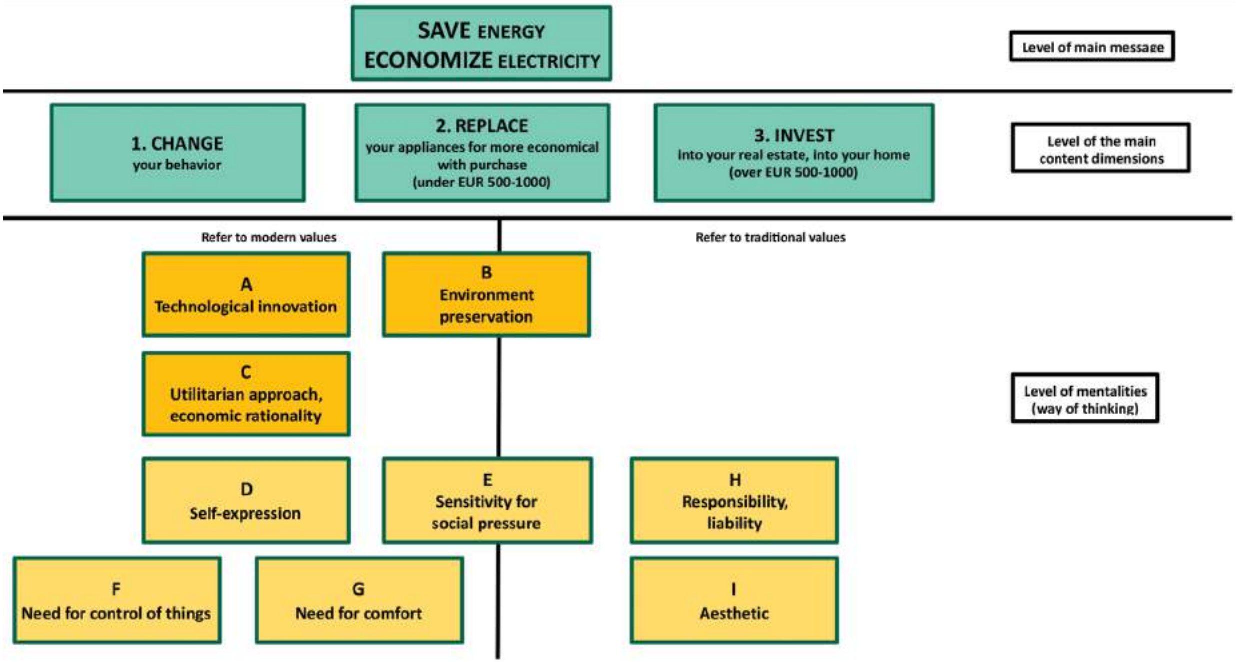
Four countries were chosen for the survey: the UK, Hungary, Italy and Denmark. These countries were chosen following the second workshop of the NATCONSUMERS project, in which representatives from a variety of nations across the EU presented on the state of the energy markets in their regions. The country choices were also informed by the outcomes of the first NATCONSUMERS workshop, in which variations in factors influencing energy use in different EU regions was discussed. The four countries selected were chosen to give a spread of different energy systems and different levels of engagement with energy use

In each of the four countries, a sample of 1,000 individuals aged 18–65 were surveyed. This sample size was deemed the most cost effective to provide a nationally representative sample. People living in shared accommodation — those in student campuses, residential care homes, sheltered housing or military barracks — were excluded from the sample as these people have limited or no control over energy use in their residence. Anyone working for the advertising or marketing industry or within the energy industry was also excluded from the sample as this could provide a conflict of interests which would bias their responses.

Based on the empirical analyses of the above mentioned surveys, we defined a theoretical concept in which we formulate our energy saving messages.

Our analyses clearly showed that the three most distinct attitude dimensions relate to technological innovation, environmental preservation, and economic rationality.

Figure 14 Level of mentalities



The importance of these dimensions is not surprising; similar results have been found in previous studies regarding attitudes and energy use. In the design of our messages we consider these as primary factors, which form the basis for out attitudinal segmentation. In the following table (Figure 14) these three primary factors are indicated with darker orange colour and letters A, B, and C.

In addition to the primary factors in our theoretical model, we also retained some **secondary factors**. These are attitude facets which either have been identified as important theoretically according to the literature — "sensitivity to social pressure", "control", "comfort", and "aesthetics" — or have emerged during the first stage of the related analysis — "self-expression" and "responsibility".

2.1.3.2 Attitude segments

These primary and secondary attitude dimensions have then been used to create an attitudinal segmentation, classifying consumers in each of the four countries studied. Of course, the resulting structures in the four countries are not exactly the same, as these countries differ significantly in their societies, ways of thinking, mentality, and values. However, overall we found quite similar structures across the four countries, where the differences also proved to be meaningful. The results are just as similar and just as different as the way the mentalities of the populations of the European countries are similar and different. In each of the four countries a six-cluster solution was accepted, however, due to the inter-country differences overall we defined seven attitude segments — six in each country, with one segment missing in each country.

The seven attitudinal segments we have identified are the following:

The **“Environmentally sensitive — cost-conscious”** segment is characterized by being susceptible to environment-related messages, as well as communication based on efficiency and economic rationality. By contrast, they are not at all interested in technology-innovation related topics. This segment has been identified in all four countries. The largest such group was detected in Denmark.

The **“Environmentally insensitive — cost-conscious”** segment is only receptive to economic arguments, messages which can provide direct financial gain. This group is not at all interested in environmental protection, and is not particularly concerned about technological innovation. This segment can be found in all four countries. However, this group is smaller in the United Kingdom and Hungary than in Denmark and Italy.

The **“Technology fan”** segment’s most important feature is that it is extremely open to technological innovation. This segment has also been identified in all four countries. In Italy and Hungary this group proved to be somewhat larger than in the UK or Denmark.

For the **“Not cost-conscious”** segment the defining feature is that they are not interested in messages around savings or economic rationality. At the same time, technological innovations interest them more than average, but far less than in the case of the “technology fan” segment. We have not identified this segment in Italy, but it could be detected in the other three countries.

The **“Moderately green”** segment is characterized by moderate environmental sensitivity, but not nearly as strong sensitivity as in the “Environmentally sensitive, cost-conscious” segment. For technological innovation and efficiency arguments, they respond rather negatively in Italy and Hungary, while in the United Kingdom they respond similarly to the average population (that is, also not positively). This segment has not been identified in Denmark.

The **“Environmentally insensitive — not cost-conscious”** segment was only identified in

Denmark and Hungary. We have not found similar segments in the other two countries. Even where this group was detected, its size was fairly small (under 10%). It is characterized by a strong negative attitude towards environmental arguments, as well as negativity towards economic arguments. They are characterized by a stronger-than-average interest in technology, but this interest is smaller than in the case of "technology fans".

"Unconcerned": In the three Western European countries (UK, Italy, Denmark), we have identified a segment that could not be mobilised by any of technological innovation themes, environmental attitudes, or financial savings arguments. This segment was not found in Hungary.

Figure 15 Patterns of Attitude Segments

	Technological innovation	Environment preservation	Utilitarian approach, economic rationality	size
1. Environmentally sensitive - cost-conscious	– – –	+ + +	+ +	15 - 29%
2. Environmentally insensitive - cost-conscious	– –	– – –	+ +	9 - 20%
3. Technology fan	+ + +	◎	◎	15 - 30%
4. Not cost-conscious	+	◎	– – –	13 - 16%
5. Moderately "green"	–	+ +	–	13 - 22%
6. Environmentally insensitive - not cost-conscious	+	– – –	– –	0 - 9%
7. Unconcerned	– –	– –	– –	0 - 23%

+ affirmative attitude
– dissending attitude
◎ indifferent attitude

From the table, it is clearly identifiable which communication message types can best address each segment:

- The **saving, cost-conscious, economic rationality** arguments could be effective for segments 1 and 2.
- Arguments based around **environmental preservation** can be used for segments 1 and 5 with good results.
- And for the **technological innovation based** communication, segments 3, 4 and 6 could be susceptible.

The distance between segments and primary attitude dimensions varies through the classes. Usually only one driver is important per segment, or maximum two (in the case of **environmentally sensitive — cost-conscious** segment).

The argumentation logic in the NATCONSUMERS engine will mainly rely on the primary drivers.

In the case of the **unconcerned** segment, none of the primary drivers seem to be important. Here, it is possible to use the secondary attitudes (drivers) to create the advice. From the secondary attitudes, it was found that social pressure could be a strong motivator for the **unconcerned** segment. As such, messages comparing consumption to peers could be effective for this group. Admittedly, only weak correlation was found between the classification and the secondary attitude variables, and these correlations were also country specific. Similarly, only weak relationships were found with socio-demographic variables.

2.1.3.3 Golden questions

More details are available in D4.2 report of the project.

The segmentation introduced above could be used as a kind of compass for those using NATCONSUMERS' consultation services, to help them decide which main attitude dimensions could be important when designing messaging, and what kind of segments these build up. For practical implementation of NATCONSUMERS messaging however, we are aware that in most cases it is not possible or appropriate to ask consumers to fill out such a lengthy questionnaire as was used in our analysis.

Here, therefore, we will show how the segmentation introduced above could be reproduced with a smaller number well-directed questions (we will call these the "golden questions").

The first step in (re)building the segments is the identification of those questions which are most related to the classification. Logically, the most applicable questions are those from which the segments were built up, that is, the basic motives of the factors used in defining the segments. However, further variables can also be important to include. Based on statistical testing, we identified the following questions as potential golden questions:

To what extent do you agree or disagree with the following statements?

- I always like to have the latest technologies
- I think it's fun to try new thing
- I'm always looking for ways to save money in my day-to-day life
- I am concerned about climate change
- What friends or neighbours think of my home is important to me
- I'm happy to spend money on things which make my life more convenient

These golden questions can therefore be used to place consumers into their appropriate segmentation group without the need for a lengthy questionnaire.

2.1.4 The role of the segmentation engine in the NATCONSUMERS processes — possible ways

In the NATCONSUMERS project, a smart, data-driven framework has been created which is able to fulfil the different needs of different consumers. This can be interpreted on many levels. On the one hand, it must be tailored to accurately reflect the energy consumption of households. This is possible through the use of smart-meter data.

On the other hand, it also has to be accurate regarding the exact and proper definition of theoretical consumption. Different types of households exist, with different consumption patterns, with different appliance usage habits, in small, medium and large houses. The consumption of a chosen household is hard to interpret without any benchmarking. The same energy consumption volume could be high in one household with one specific characteristic, and, at the same time, low in other cases.

In order to calculate the correct benchmark segment, a special mix of load profile and socio-demographic segmentation was suggested. The load profile segments identify the typical consumption curve of the households on daily, weekly and yearly bases. The socio-demographic classification built under the load profile segmentation helps differentiate the consumption volume of households within the same load profile segment. The output of this joint classification is the benchmark segmentation.

The third level of tailoring covers the argumentation logic behind the messages. The use of Natural Language means speaking with the consumers in an easily understandable way. The messages also have to be as relevant as possible. The argumentation of messages could be created in many different ways. It could be worked into the direct content of the messages (*'if you do this,* ***you could save X euros'****, compared to 'if you keep consuming the same way as before,* ***the environmental impact will be …****'), or it could appear on the level of advice and tips ('if you could shift X % of your energy consumption during peak hours (6pm–8pm) until after 10'o clock* ***you will save X euro****, as your current tariff is cheaper overnight than during peak hours').*

To find the best argumentation we suggest targeting those attitudes of the consumers which are primarily related to their energy consumption habits.

In the attitudinal segmentation part of the handbook, different methods were suggested to handle this issue.
This complex segmentation framework described in this chapter will add the required inputs to the Natural Language engine of the NATCONSUMERS smart data-driven advice service. This process will be presented in the next chapter.

2.2 Stage 2 — the Natural Language Generator: The art of engaging

2.2.1 What is Natural Language?

When providing energy efficiency feedback and advice, delivering useful and relevant message content is essential to the success of the feedback. However, to achieve the maximum potential impact, the messages must also be presented and delivered in the correct way. For this reason, we have developed under NATCONSUMERS a 'Natural Language' based advice system. This system suggests communicating in a natural, emotionally intelligent, easy-to-understand way, with language which varies and evolves according to the user.

In Natural Language processes, the numerical data is transformed into easily interpretable linguistic content, extracting relevant information that will then be presented to the user in an easy-to-read, conversational format.

This approach has its roots in the computing-with-words paradigm, which has contributed significantly to natural-language generation from complex datasets. These developments provide a powerful tool to help overcome the problems which arise when trying to extract relevant information for very large datasets. Within the context of energy consumption, information


ABC
$ac^2+bc^2=?$
education
BACK TO SCHOOL
success
$a^2+b^2=c^2$
E = Mc²
Back to School!
H_2O

such as this is often transmitted using graphs and charts (bar charts, pie charts, etc.). However, this style of presentation can often be complex for users to understand; therefore, a more accessible approach is required, such as the one offered by **Natural Language**.

Within NATCONSUMERS, we define the '**Natural Language** of Energy' as a communication process. It is a process which develops with its audience and which speaks to them in a natural, emotionally intelligent, accessible way. It is an iterative process; a conversation which develops between the user and the interface. In order to be effective, **Natural Language** must be pitched at the correct level depending on both the message sender and the recipient. This means that it is context-dependent and reflects a situation or a person. It has no end-goal, but develops in complexity over time. In this way, **Natural Language** should be considered an ongoing dialogue, rather than simply one-off advice.

Within NATCONSUMERS' advice, we use **Natural Language** to speak about relevant energy issues faced by the consumer, and the behaviours and measures they can undertake to reduce consumption. It addresses a consumer in their own context, making sure communication is relevant to each individual consumer: the environment they live in, their social situation, their knowledge, abilities or interests. The **Natural Language** of energy constantly grows and develops with new data and the level of interaction with the customer.

The Natural Language of Energy communicates on many levels and through many means. It is not necessarily a language of words — it could be nudging, pictures, hardware, a light, a sound — and even more. It seeks to meet the customer in the most engaging manner. This means that lasting engagement is more important than instant reactions, which soon wear off.

2.2.2 The Natural Language Generator process

More details are available in D5.2 report of the project.

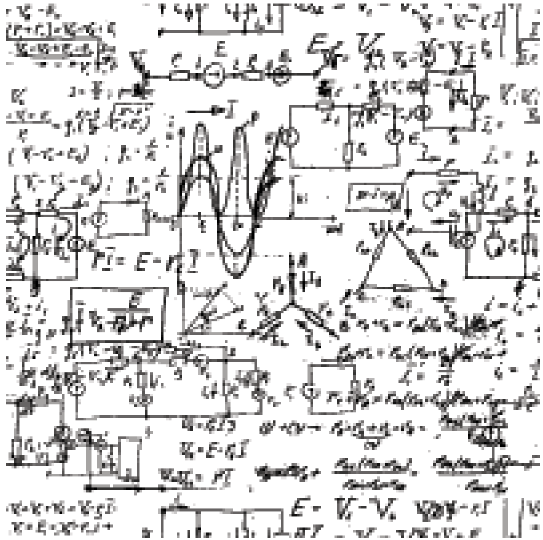
In this chapter, the segmentation engine produced in Stage 1 is built into a Natural Language Generator. This allows the collected data to be converted into **linguistic messages** using the three segmentation models to ensure these messages are effectively tailored.

As stated above, Natural Language communication is a very broad concept: it is not simply text or written language, but can encompass a range of different forms of communication. However, in this chapter, to simplify the explanation of Natural Language generation, we will consider only written text as the main output of our methodology to generate personalised advice.

Our methodology is based upon the concept of a Natural Language Granular Model, which is a traditional model for Natural Language generation. The Natural Language Granular Model is based on the idea that any variable, numeric or categorical, can be mapped into a linguistic description of this variable. This linguistic description of the variable is called Computational Perception while the process to build this Perception is called Perception Mapping. Each Perception Mapping process produces a Computational Perception, or a short linguistic description for a particular certain phenomena. For example, "The weather is becoming worse" is the linguistic description of the following quantitative variable ($\Delta P\downarrow = P_{10} - P_{11}$), which is a calculation showing that atmospheric pressure is going down. Atmospheric pressure changes are a well-known indicator of weather evolution.

The idea of Natural Language need not only be text: you would probably recognise icons such as  to represent the same information. We often use in day-to-day life text and images to represent a certain reality which is originally measured as a quantitative variable such as $\Delta P\downarrow$ in the example above. While a **Computational Perception** can be seen as the linguistic description itself (despite the formal concept involving a higher level of complexity), the **Perception Mapping** (PM) can be considered as the process of "translating" this quantitative variable — $\Delta P\downarrow$ — into the Computational Perception: "The weather is becoming worse". The process to determine when a changing in pressure $\Delta P\uparrow\downarrow$ means "The weather is becoming better/worse/more stable" is the **Perception Mapping** process

The idea behind the adjective 'granular' in the model is that these linguistic descriptions can be grouped together (aggregated) in order to build higher level and more complex descriptions of the phenomena. To achieve this complexity, the model uses the so-called **logic (business) rules**. These rules establish the ways in which **Natural Language** expressions combine to construct the final **narrative**.



Following on from the previous example, if we considered not only changes in pressure but also wind, we can aggregate these two quantitative variables to build a more sophisticated **Computational Perception**. For example, if the data indicates that pressure is decreasing and the wind is becoming stronger, the **Computational**

Perception could be: "a strong storm is on its way". The challenge becomes understanding how to combine these two qualitative values ('going down' and 'stronger'). This is where fuzzy logic plays an important role, because 'going down' and 'stronger' are not single numeric values of the variables pressure and wind speed.
Indeed, 'going down' and 'stronger' each have a set of 'fuzzy numbers' that define the vertices of the membership function. For example, there are a group of values for pressure which would represent 'going down'; this group is fuzzy because it is not fixed, but will vary depending on the current relative air pressure. The same applies to wind speed.

Finally, the way in which we build the Natural Language expressions is based on templates. The templates are narratives or sentences which must be designed by someone who has a good understanding of residential energy use. These templates can then be configured or, more precisely, parameterised, by using the Natural Language Granular Model tools (Perception Mapping and Logic Rules). In practice, this process must be undertaken in reverse: rather than evaluating the data available and constructing a narrative from it, we must first determine what we want the narrative to be, and then identify the data needed to construct it. From these processes, we can create a step-by-step methodology to generate personalised advice:

1. Think about **what you want to communicate** to the residential energy consumer. To do this, we must consider the specific energy context of the individuals and must consider **what advice is relevant** for the user. We must take into account the socio-demographic and load profile segmentations described in Chapter 2.1.
2. Write narratives to communicate with the final user. A 'narrative' is a piece of advice which has been phrased for a particular

user. As such, we must consider "the tone", "colour" and any other subjective aspects of communication which are related to both the attitudinal classification we have seen in Chapter 2.1.3 and to the stage of communication with that individual. In summary, we must consider **how we want to communicate**.

3. Map the **template** of each **narrative** with keywords. These are the words (or even pieces of punctuation) which can be varied, depending on the **logic rules**, to alter the **narrative**. Keywords can be interjections, expressions and tags related to the **perception mappings**.
4. In the case of higher complexity **narratives** (second order **perception mapping** or higher), design the **logic rules** to combine two or more **computational perceptions**. Again, these rules should relate to the information gained from consumer segmentation.
5. Choose or create (where they do not exist) the quantitative indicators required by the **logic rules** and include them in the consumer dataset.

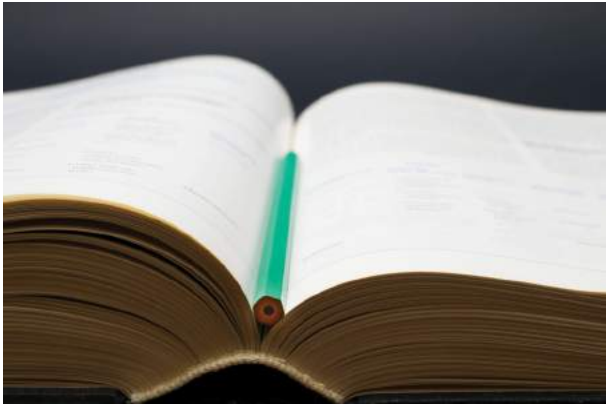
2.2.3 Corpus development

The **Natural Language Generator** is fed by a **narrative** and a **corpus**, in which data of interest to the consumer is embedded.

A narrative is a piece of advice, which has been phrased as a sentence, which can be fed to the consumer. Each narrative is in effect a template: the sentence contains 'keywords' which can be varied to alter the tone or content of the message.

As such, each **narrative** will have multiple different permutations, meaning each **narrative** can produce a range of subtly different messages.

A corpus is a collection of narratives, from which the Natural Language Generator can select the most appropriate narrative, and then tweak the keywords within it, to create a tailored end-message for the consumer. The development of the corpus and narratives is extremely important.



2.2.3.1 Corpus Characteristics

The most important feature of a corpus is representativeness: *"One of the commonly accepted defining features* of a corpus, which distinguishes a corpus from an archive (that is, a random collection of texts), is representativeness. A corpus is designed *to represent a particular language or language variety whereas an archive is not"* [33: p149]

In this sense, the corpus is heavily influenced by the attitudinal segmentation. It is very important to develop a corpus which can cover all the consumer attitudinal profiles.

Whilst the attitudinal segmentation should be the primary focus when developing the corpus, it is also important to cover the different possible load profile situations (that is, "your consumption is decreasing", "your consumption peaks at…" etc.). These should be taken into account as they provide

valuable information about consumers' consumption habits.

Corpus content selection criteria: when the content of the **corpus** is being selected, two different points of view should be taken into account:

- **External criteria:** determined by the use of the **corpus**, the selection is based on the attitudinal segmentation, and the target consumer profile.
- **Internal criteria:** determined by linguistic distribution. It is necessary to select words or expressions that maximise the flexibility of the **narrative**. For example, in the sentence "Congratulations Alberto, this month you've saved…" is a very flexible phrase — there are a range of different ways in which we could express what has been "saved". The sentence could be ended with a financial figure ("you've saved €10"), an energy use figure ("you've saved 10 kWh"), a carbon figure ("you've saved 10 kg of carbon dioxide"), etc. It is important to consider this flexibility when constructing the narratives since it maximises the number of variants each **narrative** can produce.

In addition, a good **corpus balance** must be taken into account. The **corpus** must have a wide range of text categories well balanced between data categories. Balance means there should not be too many **narratives** for one piece of data or category and too few for others. Another very important aspect is the Corpus **evolution over time**. A corpus should be able to change over time in order to include new terms needed or exclude terms which do not have success. Finally, we must take into account the full **target population**.

It should be developed considering all possible users and therefore all possible required variants using an adequate sample of the population.

2.2.4 The NATCONSUMERS agile methodology to developing a corpus

More details are available in D5.2 report of the project.

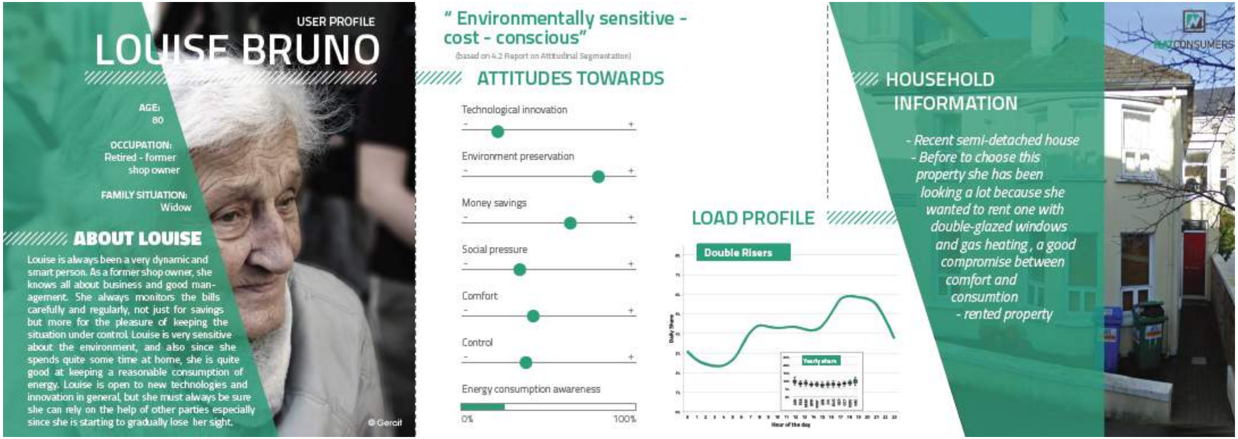
There are a variety of ways in which to develop a corpus. In the NATCONSUMERS project, a rapid methodology has been created which readers can use to quickly and easily create a base corpus which could then be further enriched as necessary in the future. The methodology defines different milestones that must be achieved.

2.2.4.1 Milestone 1 — Consolidating information

As a first step, one must summarize the information developed in Stage 1 to be used in a narrative creation workshop. This involves analysing the consumer segmentation groups generated in order to develop personas representative of each group. This information can then be used to develop messages which are targeted to a particular consumer group.

2.2.4.2 Milestone 2 — Creating templates

The outputs of these workshops are then converted into message templates. Each template will contain keywords which can be varied in order to alter the style and tone of the message by, for example, replacing adjectives,



synonyms and punctuation. By adapting the variables within each **template**, the message tone can be altered based upon either the user or the sender (as discussed in Chapter 1.2.6.1), or the **engagement concept** (which will be elaborated upon in Chapter 2.3).

Some text planning guidelines are:

- **Content selection:** The type of content to include must be selected, for example, text, images, text and images, etc. This first choice decisively influences the kind of sentences that can subsequently be formed.
- **Discourse planning:** Once the content selection has been made, how the message is structured around that content must be defined. This process defines and structures the different messages around different themes. For example, messages type 1 could be messages about

improvements; messages type 2 could be messages about emotions; and messages type n could be messages about change over time.

- **Microplanning:** this process decides how the information is linguistically expressed. For instance, the length of the sentences, etc.

2.2.4.3 Milestone 3 — Defining the data

Once the initial **templates** have been defined, it is necessary to identify what data is required to populate the **template**. What do we need to know about the household in order to tailor the keywords within that message to them?
There are two categories of data used by the **Natural Language Generator: essential data** and **additional data**. Essential data is that which is calculated before entering the **Natural Language Generator**. Additional data is calculated within the **Natural Language Generator** itself, based upon the defined **logic rules**.

2.2.4.3.1 Essential Data

Essential data includes any data which is input to the **Natural Language Generator**. This means that any information from the three segmentation models created in Chapter 2.1 must be inputted here: **load profile** group, socio-demographic group, and attitudinal group.

From the **load profile** and socio-demographic data, each user will be allocated a **benchmark segment**. The **benchmark group** is a 'similar household' to the user in question, that is, a household with a similar electricity **load profile** and similar socio-demographic characteristics. This **benchmark group** is therefore calculated from the interplay between **load profile** and socio-demographic segmentation.

In addition, a series of indicator variables can be created from each user's smart-meter data. These are variables which are used to determine the precise message content.

For example, in the message "your consumption has been very high this month", the **indicator variable** would be monthly energy consumption. These **indicator variables** must be calculated from the raw **smart-meter** data before the dataset is fed into the **Natural Language Generator**.

Guidelines for creation of indicators are:

- Indicators help express the **effects** of the energy efficiency behaviours
- Indicators should notify consumers about their progress
- Indicators should use historical and social comparison
- Indicators should be created taking in mind that they could be used in a function (within the **Natural Language Generator**) that transforms them (for example, kWh -> GHG emissions, kWh -> €, etc.).

Two examples of indicators are:

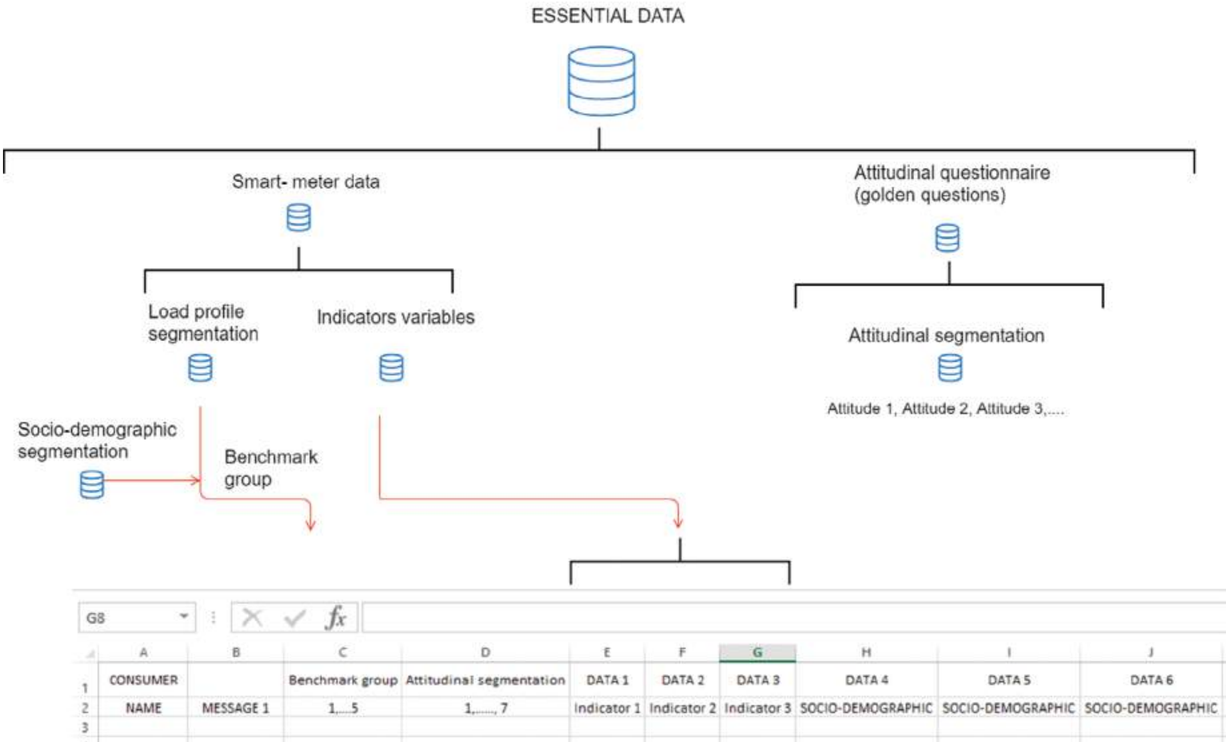
- User's consumption compared to the average consumption of their **benchmark group**; for example, to say "your consumption is higher than similar households this month" the **indicator variables** required would be the user's monthly consumption and the **benchmark group's** monthly consumption.
- User's consumption in the present month compared to the last month; for example,

to say "your consumption has decreased this month" the **indicator variables** would be the users monthly consumption for the present and previous months [34] .

Altogether, this gives us four main sources of **essential data**:

- **Benchmark group**: an identifier number that allows the **Natural Language Generator** to know the consumer's **benchmark group** (combination of load profile and socio-demographic segments), thereby allowing comparison to similar consumers.
- Socio-demographic data: additional socio-demographic data which can be very useful when personalising the message (for example, the user's name).
- Attitudinal segmentation: another identifier which tells the **Natural Language Generator** the consumer's attitude profile, and is therefore used to select the right **template**, tone and style.
- **Indicator variables**: Several different **indicator variables** can be created. It is important that these values are calculated from the raw **smart-meter** dataset before the data enters the **Natural Language Generator**.

Figure 16 **Building up Essential data**



2.2.4.3.2 Additional data

This comprises any data which is calculated **within** the **Natural Language Generator**, as part of the language generation process.

There are several different types of **additional data**:

- **Functions**: these generate new data from **essential data**, such as by transforming the data into different units which are of more interest to the consumer. For example, data on kWh consumption within the **essential data** is transformed into the equivalent cost (€) or equivalent CO2 emissions (kgCO2). **Functions** can also generate new data by combining previous data, for example, energy consumption (kWh) can be converted into energy use per person (kWh/person).
- **Branches**: these are used to establish relationships based upon the value of the data. This entails logic rules which determine what words are used under particular circumstances; for example, a branch could be: if this month's consumption is less than last month, include the word "cool".
- **Synonyms**: these are used to enrich the text, ensuring that the messages produced are always different. They allow for a diversity in phrasing despite the overall message (and **template**) remaining the same.

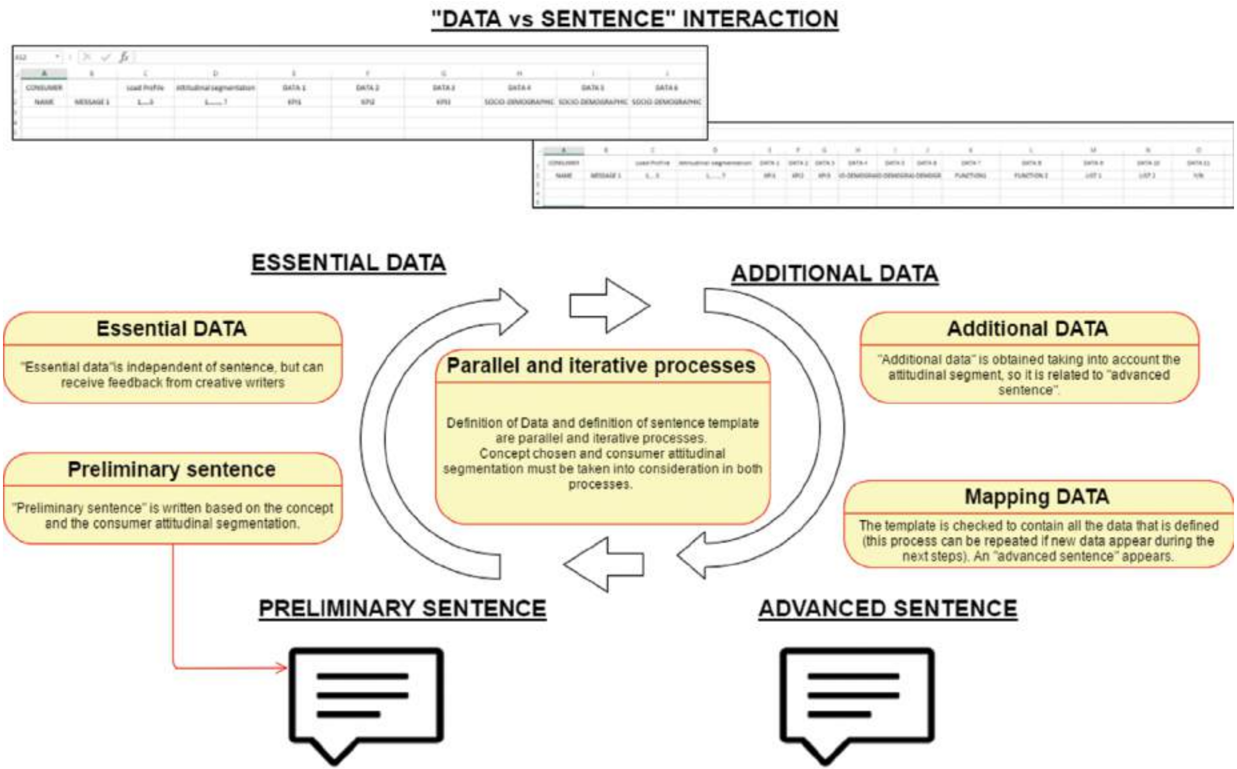
2.2.4.4 Milestone 4 — Iteration

This is the most important milestone. It is necessary repeat Milestones 2 and 3 in order to generate "*advanced data*" and "*advanced sentences*".

The iteration process helps to enrich the message and to include more relevant data. In addition, it allows new ideas to be generated regarding what data should be introduced to give the message greater impact.

Without this step, the text obtained would be too simplistic and generalist, and would not provoke any reaction from the consumer.

Figure 17 Create sentences from data



The process starts from a preliminary sentence containing **essential data**. The analysis of this sentence generates a need for new data or to transform the **essential data**. Consequently, the phrase can be transformed into an advanced sentence.

In subsequent iterations, it is necessary to construct **narratives** incorporating other concepts, such as adaptations to users' attitudinal profiles or information about the consumption pattern of the consumer (**load profile**). The more iterations, the more effective the **narratives** will be.

This process must be dynamic. It must be repeated periodically in order to update the **narratives** obtained in a continuous improvement system.

2.2.4.5 Milestone 5 — Evaluation of narratives

The above processes generate a huge number of "prototype **narratives**", that is, messages which have not been reviewed and assessed. In this milestone, these prototypes must be evaluated to decide which are of high enough quality to be included within the **corpus**. This evaluation process can be performed in different ways:

- Extrinsic evaluation
- Non task-based human evaluation
- Metric-based evaluation

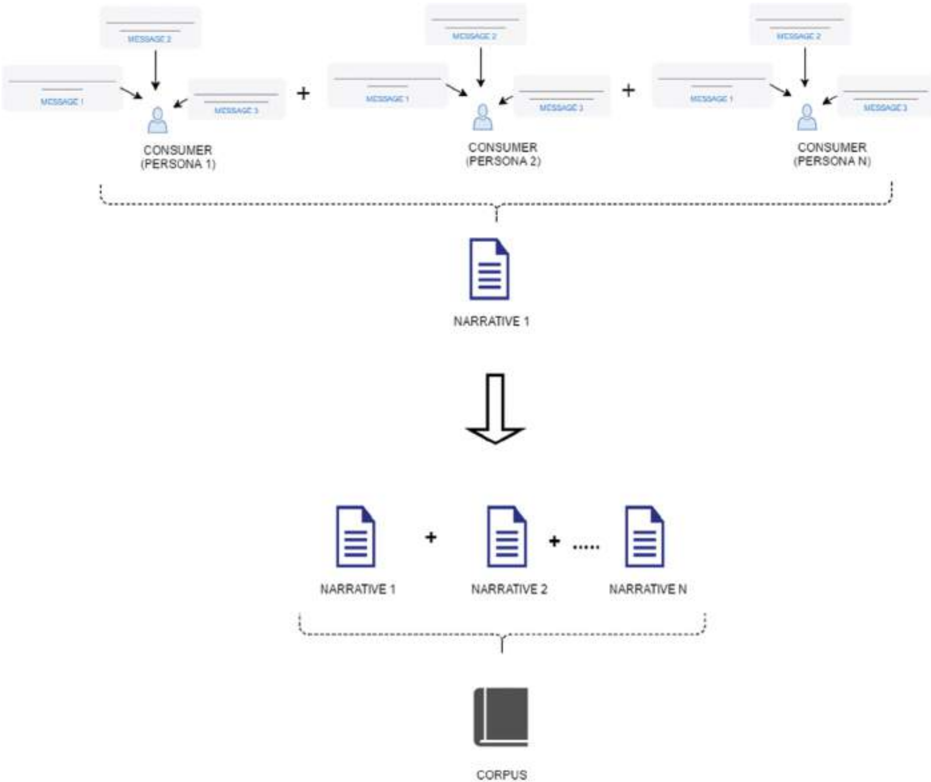
The fastest method is the "non-task-based human evaluation" method. This involves a simple evaluation by the team members, followed by testing in the **Natural Language Generator** to confirm their functionality. The most important considerations to take into account are:

- Coverage of the relevant information
- Quality of the information presented

2.2.4.6 Milestone 6 — Composing the corpus

Those **narratives** which pass the evaluation process in Milestone 5 can then be added to the **corpus**. Each **narrative** is able to generate a range of different final messages, due to the variabilities worked into the **templates**. The full set of narratives composes the **corpus**.

Figure 18 Composing narratives and the corpus



2.3 Stage 3: Development/ selection of engagement concept — Making sense and communicating evidence

More details are available in D5.1 and D1.4 reports of the project.

Through Stages 1 and 2, we have created a mechanism which allows for the generation of tailored, Natural Language messaging. Stage 3 of the NATCONSUMERS framework addresses how this message is then delivered to the consumer. Messages could be delivered in a host of different ways. Traditionally, energy feedback has been centred on written information provided with the energy bill. More recently, new feedback delivery mechanisms have been developed, for example, web-tools or mobile apps. In the future, a much wider array of feedback delivery mechanisms could become available. When developing NATCONSUMERS advice therefore, an appropriate mechanism for delivering the messages must also be developed or selected.

These potential mechanisms are described as **engagement concepts**.

Within the NATCONSUMERS project, we developed and explored a range of potential **engagement concepts** through a co-creation approach with designers. To do so, we held a Design Jam [35]. The goal of the Design Jam was to explore different ways of delivering feedback in **Natural Language** to users in a variety of different situations. What should be the delivering artefacts/media/technology to support the feedback delivery? What solution should be used for what user profile? What solution is appropriate for different geographical/ situational contexts?

In this chapter, we briefly present the methodology of the Design Jam, the outputs, and consumers' reactions to the **engagement concepts** developed.

2.3.1 Methodology of the design jam

A Jam [36] is a gathering of creative people from various fields, with various skills, who don't know one another and who join to solve a given challenge, in an intensive co-creation journey. From 110 applicants, we selected 15 designers from six countries [37] across the EU to attend the NATCONSUMERS Jam, which took place over two half days and one full day. The designers ranged in discipline from graphic to product design, service to interaction design, space to strategic design. Their challenge was to generate as many concepts as possible for the delivery of **Natural Language** energy feedback to consumers.

The designers selected were not experts in the energy sector, **Natural Language** or **smart-meter** technologies. This was a deliberate choice when selecting participants: those without experience in the energy sector could approach the challenge with a creative, fresh, open and disruptive mind.

This also ensured an open environment was created without risk of censorship or having some participants steer the process because of a feeling that they are 'more expert' than the others. In co-creation processes such as this, it is very important to ensure that everyone has the same level of legitimacy to speak out and propose ideas.

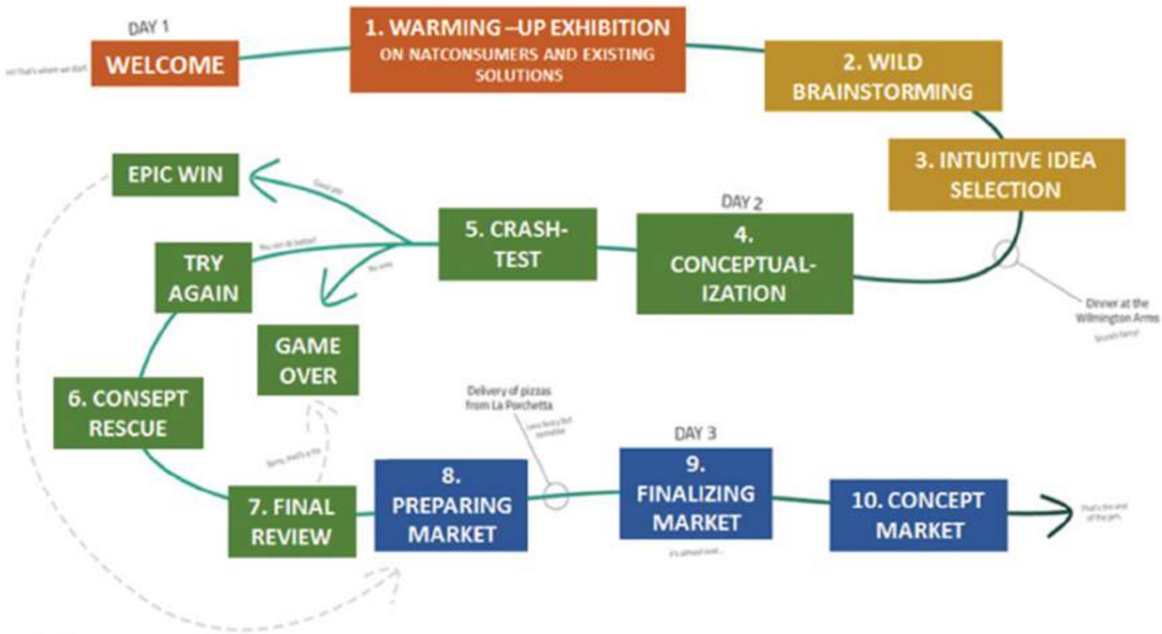
2.3.1.1 Structure of the Jam

We took a great care in developing the right methodology to achieve an effective co-creation environment for our concept development. The process was divided into 4 key phases:

1. Discovering/learning — providing the designers with sufficient information on the project and energy feedback to understand the purpose and use of the engagement concepts (step 1 — orange)
2. Ideating/brainstorming — development of initial ideas (steps 2 and 3 — dark yellow)
3. Conceptualizing — elaborating upon and refining the most promising ideas (steps 4, 5, 6 and 7 — green)
4. Sketching/presenting — visualising, explaining and presenting the final concepts (steps 8, 9 and 10 — blue)

Of course, within the framework of the Jam, the traditional design process steps of prototyping, testing, revising, etc. could not be conducted. However, the aim of the Jam was not to develop ready-to-market solutions, but rather to generate a wide range of diverse concepts.

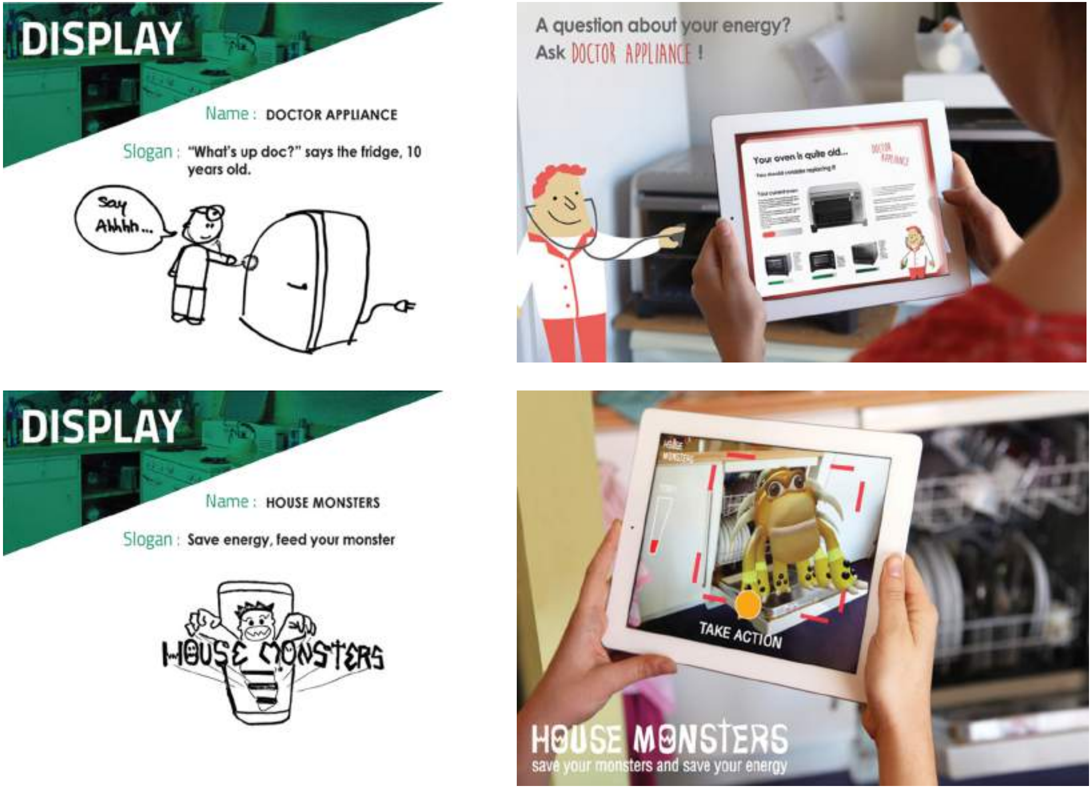
Figure 19 General flow of NATCONSUMERS Design Jam



2.3.2 Design Jam's tools and results

The concepts developed through the Design Jam process were, of course, still quite 'rough' by the end of the event (sketchy drawings, handwritten descriptions, etc.). Design Jams, because of their tight timing and intense rhythm, rarely come up with finalised products; their aim is not to develop a single, finished product, but to generate a wide range of disruptive ideas. In order to share the concepts with a wider audience therefore (for example, with users in focus groups), they needed to be slightly reworked. To do so, we chose to create, for each concept, one realistic image which captures the concept's core idea, based on the designers' original sketches .These pictures were then built into posters showing the key image, the name of the product-service-solution, and the slogan.

Figure 20 From original sketch to key images



2.3.3 Analysing the concepts

The briefing for the designers taking part to the NATCONSUMERS Design Jam was somewhat unusual: design a "user engagement framework". By asking designers to generate an engagement framework, we were able to create a set of user engagement strategies adapted to different local contexts, users' profiles, delivering interfaces/artefacts, etc.

Rather than having teams compete to get the best idea and design an efficient solution for delivering energy advice, the main value of the Jam lies in the set of design proposals as a whole, and in the new meanings generated within the on-going design conversations around how to shift energy use practices.

2.3.3.1 A framework of solutions

The NATCONSUMERS' engagement mechanism, as described throughout this handbook, has been schematised for the purpose of the Design Jam into a space reduced to 3 complex dimensions (see next figure):

Figure 21 Users' engagement framework scheme for Design Jam briefing

Local context in Europe

The design should take into consideration different implementation contexts, geographical location, smart-meter infrastructure, data recording frequency, feedback delivery speed, etc. pictured by a series of characteristic situations.

Various users' profiles

The design of the solutions should fit to various households, attitudes, load profiles etc. pictured by a series of characteristic personas. The profiles were elaborated based on the segments described in Chapter 2.1.3.

Delivering artefacts

The proposed design requires an interface through which the messages are delivered — this could be paper bills, home computers, mobile phones, smart watches, etc.

Within the Design Jam process, the development of new solutions started from a particular combination of context, profile and device. Throughout the conceptualisation phase of the Jam, these solutions were stretched and adapted to make them applicable to more and more situations. The challenge for the designers was to "stretch" their initial ideas in order to create more flexible, integrated, adaptable solutions.

2.3.3.2 Engagement patterns

Reduction of energy use is a shared issue but — as described in the Chapter 1.2 — with substantial difference between households across Europe; there is a complex mix of concerns, perceptions, and motivations, all within different physical contexts, which influence people's capacity to take action. Furthermore, when developing engagement concepts, the designers must also tackle a recurring barrier for energy advice: consumers, generally, do not find energy interesting.

Even where people are concerned by high energy bills or by the environmental impacts of energy use, energy remains a largely inaccessible and unattractive topic for discussion in daily life. This is in contrast, for instance, with food, which is also a critical issue in terms of sustainable development but is a much more engaging topic. Energy is expensive, but the possible financial gains achievable by reducing consumption tend to be relatively small. Thermal comfort and daily use of electric appliances are strongly rooted in everyday routines, and quality of life expectations are rather resistant to change.

In a nutshell, the designers taking part in the Jam have to face energy, a rather dull and uninspiring subject, from a user point of view.

The design response in such situations is to explore and develop various engagement strategies likely to involve users in an interaction with their energy consumption, despite a lack of appeal and interest. In the case of NATCONSUMERS, the identified arrangements are a particular mix of physical artefacts and service solutions, of offline and online mechanisms likely to engage users to deal with energy issues either in very direct modes or more indirect ones. Like a graphical pattern (that is, dots, lines, tiles, etc.) applied on different situations (that is, objects, fabrics, architectures, etc.) will have similar visual effects, the NATCONSUMERS engagement patterns are likely to engage users with energy reduction if applied in similar contexts, profiles and with similar delivery solutions.

Figure 22 Example of an ad poster of a concept

10 design patterns emerged from the NATCONSUMERS Design Jam:

- Medicalisation pattern: our compulsive consumption of energy is a disease and a health treatment is needed to cure it.
- Art-like pattern: energy consumption is a form of artistic expression that generates fascinating art pieces inducing curiosity and contemplation among users.
- Bio-mimetic pattern: energy consumption is a natural entropic process impacting the biosphere and the development of plants.
- Gamification pattern: energy consumption is like taking part to a large multi-player game.
- Kids leadership pattern: implications of energy consumption and benefits of its reduction are on average not strong enough to trigger adults' behavioural changes, but an intermediation through children may change the balance of forces, whereby children are leading the household energy saving drive.
- Children-scaling pattern: energy consumption may not have sufficiently engaging implications at an adult scale, but may be more engaging for a child. For example, saving €2 may be more meaningful to a child who receives this as pocket money than it is to an adult, for whom it is a meaninglessly small amount.

- Co-operation pattern: energy consumption taken individually is insignificant. Consumption and reduction of this consumption may make more sense at collective level than at individual level.
- Story-telling pattern: energy saving practices and sustainable ways of living scenarios are often expressed as dry prescriptive injunctions, missing the transformative effect of rich **narratives** and quality story-telling.
- Signalling pattern: energy topic is not particularly appealing and therefore likely to disappear in the flows of notifications reaching users all day long unless an external signal will trigger users' curiosity and engage them to check their energy messages.
- Simplification pattern: energy consumption is a complex and multi-faceted process, but trying to make it explicit and understandable can be done by simplifying the subject matter without being too reductive.

As an example, a fuller description of the medicalisation pattern is described below:

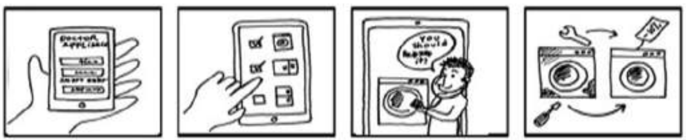
Medicalisation pattern

Our compulsive consumption of energy is a disease and a health treatment is needed to cure it. The "Doctor appliance" concept is a typical example of this engagement pattern: domestic energy consuming appliances are considered as "living beings". Similar to pets and Tamagotchi's, they may catch diseases, grow old and at a certain moment reach the end of their life and die. Therefore household members are induced to follow medical-like routines: contact an external expert (the energy doctor) for a diagnosis; get a prescription (that is, change or repair the appliance) and follow it (observe the treatment with compliance); etc.

Figure 23 Doctor Appliance concept

DOCTOR APPLIANCE

Doctor Appliance is an app that allows you to have a full scan of the state of your appliances. It provides you with suggestions for improving the life of your appliances, detects if there are nay irregularities, gives you recommendation on your udage and when it's time to buy another one, shows you other appliances on the market with a detail analysis and all possible incentives and discounts

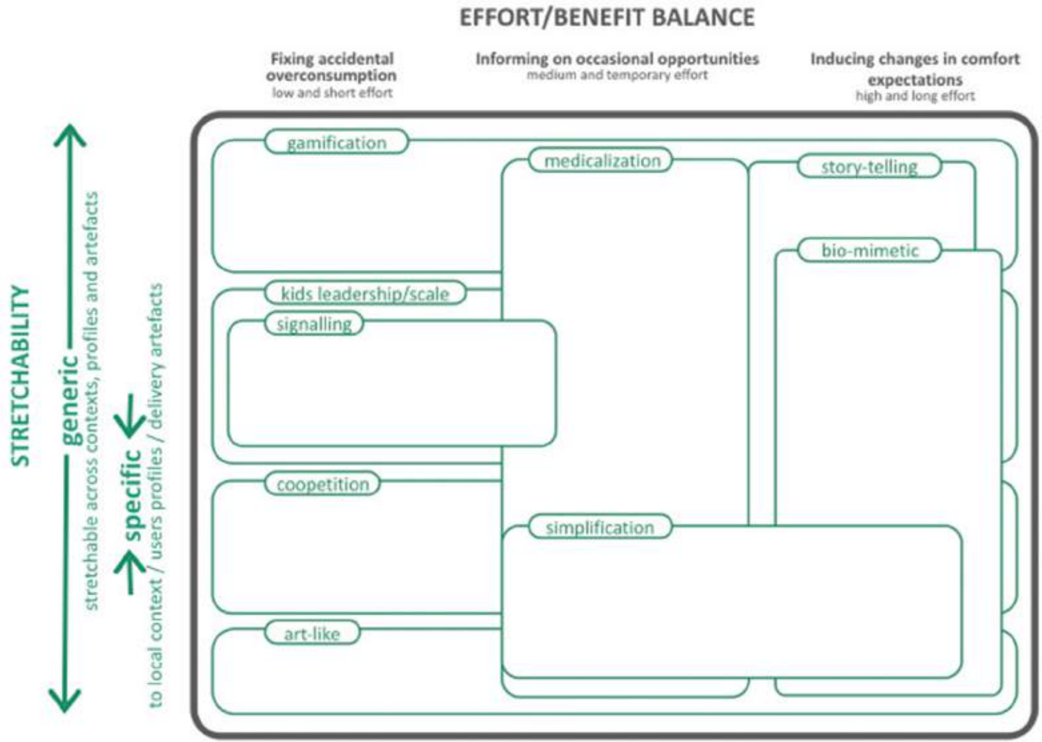


Create an account	Include your domestic appliances	Scan appliances and get information on their status	Replace the appliances that are not anymore efficient and get discounts as reward

2.3.4 Working with solution framework and engagement patterns

The different engagement patterns emerged can be organized along an axis according to the balance of effort vs. benefit for users. This scale ranges from "fixing accidental overconsumption" (achieving benefits with minimal effort) to "informing on occasional opportunities" (requiring more, but temporary, effort and providing relatively strong benefits) to "inducing changes in comfort expectations" (more demanding efforts over longer time periods).
A second axis along which these engagement patterns can be plotted is the "stretchability" of the concepts. This stretchability is a complex factor, reflecting various dimensions including local contexts, user profiles, and delivery interfaces/artefacts. In our analysis we have reduced these complex factors to a single axis: the engagement patterns range from specific (whether to local context and/or to users' profiles or to delivery artefacts) to more generic (or stretchable across contexts, profiles and artefacts).
The scheme below shows a tentative distribution of the different engagement patterns along these two axes.

Figure 24 **Tentative scheme o the different engagement patterns alongside stretchability and effort/benefit balance**



2.3.5 Consumer reactions

More details are available in D1.4 report of the project.

In order to assess and evaluate the 10 **engagement concepts** resulting from the Design Jam, we conducted ten focus groups across Italy, Hungary and Norway. The aim of the research was to evaluate the concepts' ability to stimulate energy savings and efficient behaviours among consumers, covering consumers from different social and demographic groups.

Evaluating a non-existent tool however is difficult. It requires enhanced effort from the focus group participants to discuss a theoretical concept, which they have not previously experienced and which they cannot explore through a prototype or model. Each of the 10 concepts delivered in the Design Jam is unique; in order to familiarise the focus group participants with the concepts, we created descriptive 'concept cards', which can be seen throughout the section below. These cards show a visualisation of the concept and a brief written explanation.

Figure 25 Energy Saving Community platform and Piggy Bank concept cards

ENERGY SAVING COMMUNITY PLATFORM
The Energy Saving Community Platform is a digital platform where groups of cinsummers van team up to save money by reducing their household energy consumption. The money saved goes into a common fund to be used for community projects. Community meetings and workshops allow members to define project they wish to create and to learn about consumption, to share tips and tricks on energy saving.


Consumer Association forms community to save energy


Community decides on goals


The community follows the progress of their energy savings on theonline platform


Community projects are financed by pooling together the money saved on energy consumption

PIGGY BANK
A piggy bank and an app for children show them how much money they save by changing their family energy consumption habits.
It makes energy saving simple and engaging for kids because it makes it tangible. By immediate changes such as switching off the lights their piggy bank shows them how much they're saving. The saved energy makes the difference in kids pocket money anfd engage them in saving more.


Connect your piggy bank to the smart meter of the house


Kids save money by changing their energy habits and pushing their family to also chanae


The money saved is worth at children scale and can be used by them


Kids reset the piggy bank and set new goals

Working through the concepts one-by-one, a number of themes emerged around the different concepts:

Internet access and security

The necessity of internet access for several of the concepts to work quickly emerged as potentially problematic, particularly in the Hungarian focus groups:

"All I would say is that the basis of all three concepts requires internet access and some sort of interest towards [internet-enabled] gadgets. This is fact; let's confess this is an optimistic foresight. I could say there are some who would immediately embrace these, but sadly I also know others who certainly would not."

This dependency on internet access also roused security concerns:

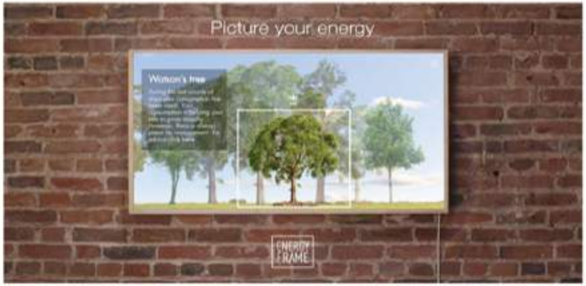
"There are always troublemakers, swindlers, people who know how to hack these devices, where Wi-fi or Bluetooth are required for connection. This means they can gain access from outside, somebody just somehow retools the electricity meter, so it looks like it does not consume that much."

However, whilst to some the high-tech nature of the concepts was seen as a barrier, to others this was seen much more positively. Amongst younger demographics (in particular, under 35s in Italy), the use of electronic devices such as smartphones or tablets was viewed favourably. For these participants, the ability to quickly monitor consumption, ideally in real-time and at both household and appliance level, was seen as the main attraction of the concepts.

"I would see it as even better if instead of having monthly monitoring, it gave me real-time monitoring that gives me advice on how to use appliances..."

Reliance on children

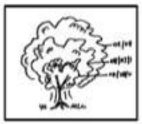
Figure 26 Picture your Energy and Energyland concept cards



ENERGY FRAME
Energy Frame is a visual representation of your energy consumption through a tree – the more you save the more the tree evolves and florishes. People can join with others and create a forest of trees and get tips and advices on how to reduce consumption. It can go from a decorative and contemplative image to a more interactive game.

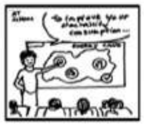

Create an account and choose the tree that will represent your energy consumption


All members of the family create a forest together


Your tree grows through time depending on your energy consumption


The app can give you advices on your energy consumption, as well as others cab give you feedbacks

ENERGYLAND
An educational systemof challanges for children that aims to teach and raise their awarness on energy saving and careful energy consumption. There are different challanges children can unlock by careful energy consumption at home. The system is managed by teachers who send challanges to kids and give them physical badges that can be shown in class and help stimulate the competition among children and schools.


At school teacher teases children with energy challanges within the course of the class


Kids change their behaviours at home and involve their parents


By saving energy at home kids unlock new challenges


Teachers reward kids with badges and stimulate competition amongst classmates

When considering the concepts which rely on ‘kids leadership’ patterns, concerns arose around the potential agency of children within the household.

Some participants did not like the idea that children would be encouraged to dictate how the household consumes energy, whilst others were concerned that, given the limited influence a child may be able to enact over the household, concepts such as Energyland which are based on competition difficult for children to engage with.

Visualisation and simplification

The participants, particularly in Italy, were very favourable towards artistic pattern-based concepts, such as Energy Frame. Interfaces which offer a strong visual impact could be a great advantage. Associated with this, participants also generally liked concepts which followed a simplification pattern. Such concepts, which have a good visual impact and a simple, easy to understand design, were seen as more intuitive to use.

Figure 27 Feeding your appliances and I challenge you concept cards

FEEDING YOUR APPLIANCES

The app simplifies household energy management: the kWh are translated into units like "energy Lego bricks". You can allocate your energy units to each of your appliance, reorganize your units according to advices on energy saving. Understanding energy management through reallocating units between your household appliances is very simple. Saved units can be stored for coming months or given to charities.

Your monthly energy consumption is broken down into units displayed by each appliance

You can control the energy consumption of each appliance

At the end of the month you see how many units you saved

And you can allocate them to appliances you wish or donate them to a charity fighting against energy

I CHALLENGE YOU

An app that provides you with interactive visuakization of your energy consumption by being connected to your smart meter. It is an intuitive and visual interpretation of data that makes it possible for you to surf in different ways through the data. It also informs you how to work better on your energy consumption. There is possibility of adding your friends and family to see how your community is workingon their energy consumption.

Include your friends and support each other to achieve goals

Visualize your energy consumption through an artistic shape

Set goals and analyse your energy consumption tracking the changing shapes

Get advices on your energy consumption

Familiarity and physicality

Another theme which emerged was around familiarity:

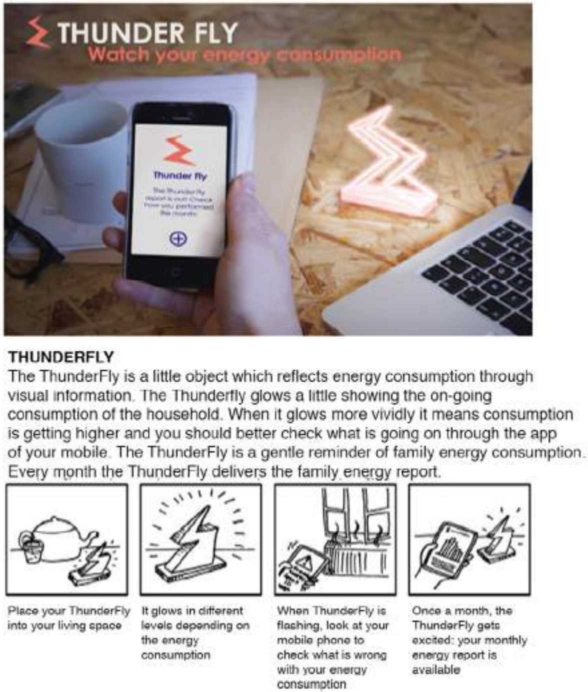
where a concept is similar to a product or service the user already knows, it was viewed more favourably.

For this reason, the Thunderfly concept was very popular in Norway. 30–40 years ago, many Norwegian households' had an energy appliance hanging on the kitchen wall where an arrow informed the household of its total energy consumption. When the arrow moved into the red area, the energy price increased. As the arrow moved when energy consumption increased — for example, when somebody turned on a heater — the household members could directly relate their behaviours to their energy use. Because the Thunderfly was regarded as similar to this device, which many people had seen before when visiting their parents or grand parents' homes in the past, it created a sense of nostalgia and positive reaction to the concept.

The Thunderfly may, in this respect, not only evoke positive emotions based on a nostalgic longing for the past. It also informed the household members about their households' energy consumption in a way that — despite its simplicity and discreetness — was considered very informative.

In Hungary the participants favoured the Thunderfly for another reason. Here, participants highlighted the importance of physically existing objects. Particularly in households where the digital skills are low, a physically existing object could help to raise interest and awareness in a more energy efficient lifestyle.

Figure 28 Thunderfly concept card



Drawing together these findings, it is clear that we must be cautious when choosing an appropriate engagement strategy; not all concepts can be effectively ‘stretched’ to all demographics, and so a single concept is unlikely to appeal to all. Energy is a low engagement topic. People therefore do not want to engage with it continuously. This means timing is very important; consumers want feedback when it is necessary, not constantly. It also appeared that sometimes feedback could be frustrating. If a household cannot afford to, for example, change their washing machine, it could be quite demoralising and frustrating to receive regular advice that the device needs replacing.

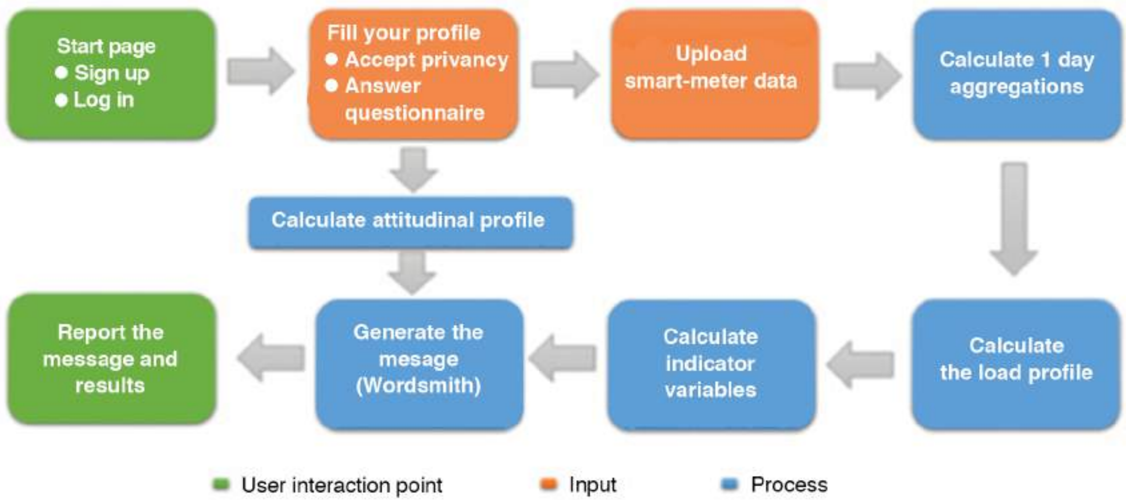
Whilst there were some common patterns across the three countries, our findings nonetheless highlight that there is no singular good solution. In Norway, where electricity generation is mostly

renewable, the environmental aspects were not so interesting. In low-income countries, where there is difficulty accessing new technological gadgets, physically existent objects could be a key element in a framework.
The engagement framework is an important aspect of the NATCONSUMERS advice system. It needs to be developed with a consideration of the national context in which the tool is being applied, and with consideration of the type of message sender and also any specific features of the target group. The patterns described in this chapter may help when choosing the best approach to communicate with end-users.

2.4 Web tool

In the previous chapters of this handbook we have described the 3 stages necessary to produce a **Natural Language** energy advice tool: **classify consumers, create a Natural Language Generator, and develop an innovative engagement framework.** As part of the NATCONSUMERS project, we have tested this methodology through the production of a web tool. This tool is not intended to be a commercial final product, nor even a consumer-facing prototype, but simply a 'proof of concept' for Stages 1 and 2 of the framework. The tool has allowed us to test, evaluate, and refine the methodology described in this handbook.
For simplicity, the engagement 'concept' chosen was a basic web tool, rather than a more complex, more innovative engagement framework as developed within the Design Jam. The user-interface for the tool has been kept simple, for use by the project partners and those interested in the NATCONSUMERS methodology. As such, it would not be appropriate to test this tool with real consumers as it stands, as their impressions of it will be heavily influenced by the lack of attractive, easy-to-use interface.

Figure 29 Web tool workflow



The diagram above shows the basic workflow of the tool. The tool is based upon two main inputs:

The consumers smart-meter data, and

A brief consumer questionnaire

These two inputs are gathered during the initial 'sign-up' to the tool, at which point consumers are also informed of the privacy policy and use of their data. Data security and transparency regarding how data will be used has been consistently identified as a key requirement for any **smart-meter**-based advice mechanisms by consumers we have engaged with throughout the project.

The tool is currently programmed to generate one message per month. A minimum of two months' worth of data is required to generate at least one message, but a lager file (with several months) may be uploaded allowing the tool to generate several, more complex messages.

Once the **smart-meter** data is uploaded, all calculations required to generate the message occur in the background, and are invisible to the user. The resulting message is then displayed to the user on-screen.

More in-depth details on the background calculations occurring within the tool are available in the Appendix of this handbook.

3. The NATCONSUMERS impacts

In this third and final section of the NATCONSUMERS handbook, we investigate the potential impacts the widespread roll-out of a NATCONSUMERS-style advice tool. In addition, we discuss how different actors, working in different sectors, could use the mechanism developed in this handbook, and outline our recommendations for such use.

3.1 …and the benefits?

More details are available in D6.2 report of the project.

3.1.1 Impacts on residential consumers and national power systems

In this chapter, we investigate the potential role of NATCONSUMERS-style energy feedback in achieving the European energy policy overarching goals, that is, sustainability and security of supply. Through a study of previous feedback trials, combined with modelling based on the load profiles developed in Chapter 2.1.2.2.2, we are able to estimate the potential impacts for both residential consumers and national power systems if a NATCONSUMERS-style feedback mechanism were to be adopted at scale.

To do so, we have defined a set of Key Performance Indicators (KPIs), which provide metrics against which impact can be measured. These have been based on KPIs used in other related projects and initiatives (for

example, VaasaETT's database of Demand Side Management programmes, Energy Union, etc.) and took into account the standpoint of different stakeholders (residential consumers, network operators, society as a whole, etc.).
Two levels of KPIs have been defined, one level which relates to final consumers in the residential sector (that is, householders), and another which relates to the national power system:

I — KPIs at residential consumer level:

a) Reduction of annual electricity consumption
b) Reduction of annual electricity consumption in system peak hours
c) Reduction of consumers' electricity bill

II — KPIs at national power system level:

a) Reduction of final energy consumption (electricity)
b) National peak load reduction
c) Reduction of primary energy consumption
d) Variation of import dependency
e) Variation of market marginal price (day-ahead)
f) Reduction of CO_2 emissions

To demonstrate the potential impact, these KPIs have then been calculated according to the characteristics of four different European countries: **Hungary, Italy, the UK** and **Denmark**.

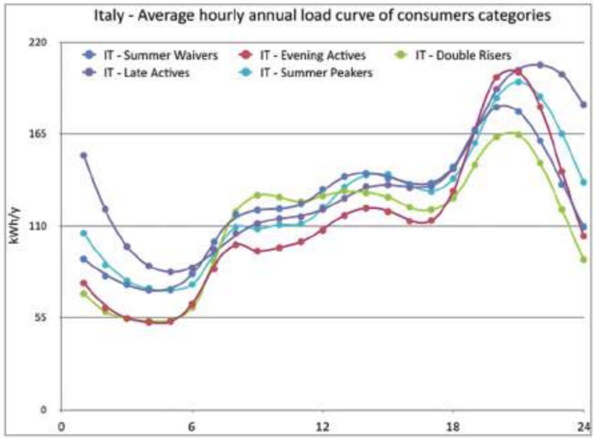
3.1.1.1 Impacts on consumers

The impacts of feedback mechanisms on individual household consumption were calculated for each of the load profile segments identified in the Chapter 2.1.2.2.2. In order to evaluate these impacts, we first quantified the achievable energy saving by consumers due to feedback programs. VaasaETT keeps an up-to-date database consisting of, at the time of writing, close to 140 demand response and feedback programs around the world, amounting to 569 samples and involving over 930,000 residential participants. We used this database to define the potential annual consumption reductions (in per cent), based on data extracted from European feedback pilots (68 pilots).

These potential savings were applied to the hourly load curves using a **time-dependent function** to distribute consumption reduction during the day, assuming that energy reduction is easier when the consumption is high and more difficult when the consumption is small. Different time-dependent functions were applied to different user categories and to each country. The KPIs are then calculated using the time-dependent function of each customer category.

As an example, the following figure shows the load curves of the different categories of users in Italy. The calculations have been done assuming total consumption reduction of 7.4%, which is the average reduction seen in the VaasaETT database.

Figure 30 Average hourly annual load curve of user categories in Italy



The methodology and assumptions for the calculation of each KPI are briefly discussed below:

- **KPI I-a) Reduction of annual electricity consumption:** This KPI focuses on the total energy saving achievable in a year. Data extracted from the database indicates that feedback pilots organised in Europe (68 pilots) have led to annual consumption reductions of 7.4% on average. Since different categories of users have different attitudes and different opportunities to reduce energy consumption, we have modelled three saving levels: a higher, an average and a lower level. The potential savings for each level, as extracted using the database, can be found in Table 1.

Table 1 Assumed reduction in electricity consumption

Small saving	Average saving	Large saving
% saving		
2.0%	7.4%	10.0%

- **KPI I-b) Reduction of annual electricity consumption in system peak hours:** This KPI looks at the potential for different categories of consumers to save energy during system peak hours, and thereby to help lower national peak load. System peak hours were defined as the three consecutive hours with the highest prices on the wholesale market. Reducing energy consumption during peaks will also help lower the marginal price of electricity, since expensive peak generation plants are needed to cover intermittent periods of high electricity demand. In Italy, Hungary and the UK the system peak hours were identified in the evening (18:00–21:00), while in Denmark they take place in the morning (08:00–11:00).

- **KPI I-c) Reduction of consumers' electricity bill:** The reduction of the electricity bill is a direct consequence of KPI I-a. For this last KPI, we evaluated the financial savings each category of consumer can achieve by lowering their energy consumption thanks to feedback. The retail price is made of a fixed component that does not change with the consumption, and a variable fee.

  This fact was taken into consideration for the calculations.

The average savings potential for each country, assuming average savings of 7.4%, is summarised in Table 2. Specific results for each category of consumers can be found in Annex II: Analytical results of impacts on residential consumers and national power systems.

Table 2 **Impacts of feedback on energy consumption — results at household level assuming 7.4% savings**

Savings potential	IT	HU	DK	UK
Annual reduction in electricity consumption (kWh)	208	154	228	327
Annual reduction in electricity consumption in system peak hours (kWh)	63	40	27	92
Annual reduction in electricity bill (€)	35	18	66	69

The absolute impacts on energy consumption are highest in the UK, since the current consumption volume is highest here [38]. As such, a 7.4% reduction in consumption could: decrease annual electricity use by 327kWh per household on average (43% higher than the second highest, Denmark), save 92kWh per household annually during system peak hours (46% higher than the second highest Italy), and save €69 per year from each household's energy bill.

It is interesting to note that Danish consumers could save almost as much as UK consumers in financial terms (66€/year vs. 69€/year) despite a much lower consumption level. This shows that the price structure (that is, the proportion of the fixed vs. the variable component of energy prices) and of course the level of prices (Danish households pay by far Europe's highest price for electricity, whilst prices in the UK are on the lower side [39]) are important criterion that influence the attractiveness of feedback mechanisms for individual households.

Another interesting observation is that Denmark shows the lowest savings potential during system peak hours. More specifically, savings during system peak hours are estimated to be 6.6% of annual consumption, whilst they represent between 10%–12% of annual consumption in other countries.

The Danish load's relative "flatness" is due to the fact that the penetration of electric heating and cooling systems is much lower than in the other countries (though the increasing penetration of heat pumps may soon start posing problems of peak load at the local level).

Table 3 shows the impacts of feedback mechanisms for the consumer **load profile** categories with the lowest and highest financial savings potential in each country, as well as the estimated savings range assuming the lowest (2%) and highest savings scenarios (10%).

Table 3 **Potential savings range in electricity bill (in €, assuming savings of 2% and 10%) for consumer categories with lowest and highest savings per country**

	Lowest Savings in €		Highest Savings in €	
	Consumer category	Savings range (2% savings – 10% savings)	Consumer category	Savings range (2% savings – 10% savings)
IT	Evening Actives	9–44	Late Actives	11–54
HU	Winter Spinners	4–20	Double Risers	6–27
DK	Double Risers	14–71	Winter Spinners	23–115
UK	Home Lunchers	16–79	Winter Spinners	28–138

Interestingly, we can notice that consumer categories with similar behaviours can achieve very different outcomes according to their level of consumption and each country's pricing structure and level. For instance, Winter Spinners have the lowest potential financial savings in Hungary, while they have the highest in Denmark and in the UK.

The wide savings range for all categories shows that consumer understanding and use of feedback is one of the most important factors in feedback programs. As we can see, engaged consumers that belong to user categories with the lowest monetary savings potential can still achieve significantly higher savings than poorly-motivated consumers from user categories with the highest monetary savings potential.

Using Italy as an example, engaged Evening Actives can save up to 44€ from their electricity bill (assuming 10% savings), while low-motivated Late Actives can save only 11€ (assuming 2% savings). This highlights the importance of a NATCONSUMERS-style advice mechanism, which aims to maximise user engagement by creating much more tailored messaging which is of interest to each specific user.

Overall, bill savings due to feedback can vary significantly depending on the consumption habits of each consumer category and the price structure of each country. According to our modelling and assumptions, the highest would be as high as 138€/year for Home Lunchers in the UK, while the lowest can be as small as 4€/year for Winter Spinners in Hungary. However, even consumers that belong to **load profile** categories identified having low monetary savings potentials can achieve significant reductions to their electricity bill if they are well engaged and motivated.

Given the large number of residential consumers in each country, the impact in national level is expected to be highly significant. The following subsection examines the impact of feedback mechanisms at national level.

3.1.1.2 Impacts on national power systems

The impacts on the national power systems of the four countries were determined by comparing different simulations of the electricity markets for the year 2020 with the electricity market simulator s-MTSIM developed by RSE.

First of all, we built **a baseline scenario for the year 2020** based on the null-hypothesis that residential consumers do not respond to any feedback mechanisms to save electricity. For the evolution of the power systems in terms of supply (net generating capacity) and demand (annual demand forecast) of the four countries, we relied on existing studies and in particular on the MAF 2016 study published by ENTSO-E.
The Mid-term Adequacy Forecast (MAF) is a Pan-European assessment of the risks to security of supply and the need for flexibility over the next decade. The methodology used by ENTSO-E takes into account the transformation of the power system with increasing variable generation from renewable energy sources. The scenario analysed in MAF 2016 for 2020 is based on a best estimate of the evolution of the generation mix (thermal and renewable park) and transmission capacity as well as demand forecast of each country. This scenario is referred as the "Best Estimate/ Expected Progress" for the year 2020.

Starting from this baseline scenario we then defined **three saving scenarios** based on a different percentage of users' acceptance (response) to feedback mechanisms:

- 25% user acceptance
- 50% user acceptance
- 75% user acceptance

For all these saving scenarios we also assumed the **success of smart-meter roll-out** for the year 2020. In Italy, and Denmark the roll-out of **smart-meter** is already close to 100%, so we assumed that all residential consumers will have a **smart-meter** in their homes by 2020. We assumed the 100% penetration also in the case of U.K. In Hungary there is no a national roll-out plan for **smart-meters**, so we have chosen 80% as a **smart-meter** roll-out target, matching that set by European Commission for all European consumers by 2020.

For each of the three savings scenarios we have used the same data for the baseline scenario, with the exception of the annual load of the residential sector (variable data). We then compared the results of the simulation of the baseline scenario with that of the three saving scenarios (25%, 50% and75% user acceptance).

Table 4 shows the annual reduction in electricity consumption achievable in the four countries thanks to feedback. On average, in the first scenario (user acceptance: 25%) the demand for electricity in the residential sector decreases by around 2.5% compared to the baseline. This reduction reaches 5% and 7.5% in the mid and high user acceptance scenarios respectively. In Hungary, the reduction is limited compared to the other countries, because we assumed a reduced success of **smart-meter** roll-out and, as a consequence, a reduced number of consumers able to monitor their consumption and respond to feedback mechanisms.

Table 4 **Reduction in electricity consumption (data in TWh and % variation)**

Country	Baseline 2020 (TWh)	Reduction in electricity consumption compared to baseline TWh (and %)		
		User Acceptance 25%	User Acceptance 50%	User Acceptance 75%
IT	72.6	70.8 (2.5%)	68.9 (5.0%)	67.1 (7.4%)
HU	8.6	8.5 (2.3%)	8.3 (3.5%)	8.1 (5.8%)
DK	7.3	7.2 (2.7%)	7.0 (5.5%)	6.8 (8.2%)
UK	124.8	121.7 (2.4%)	118.6 (5.0%)	115.5 (7.5%)

It is important to note that consumption feedback alone (without dynamic pricing or appliance automation) does not specifically target reductions in consumption during peak hours, and is therefore not the best tool for demand management and network operators. However the consumption reductions modelled above also take place during system peak hours [40]. The reduction in annual national **peak consumption** achievable in the four countries is reported in Table 5. In Italy and Hungary, in the first saving scenario (user acceptance: 25%) the national peak decreases by around 0.5% compared to the baseline. This reduction increases to 1% and 1.5% in the other scenarios. Denmark and the UK can achieve greater reductions because the national peak and residential daily peak coincide.

Table 5 National peak load reduction (data in GW and % variation)

Country	Baseline 2020 (TWh)	National peak load reduction (%)		
		User Acceptance 25%	User Acceptance 50%	User Acceptance 75%
IT	61.4	0.5%	0.9%	1.4%
HU	6.4	0.4%	0.8%	1.2%
DK	6.4	0.7%	1.4%	2.1%
UK	58.5	1.2%	2.3%	3.5%

Lower national electricity consumption means both a reduced need to generate electricity (thereby reducing fuel consumption) and a lower need to import electricity. The reduction of these two KPIs is reported in Table 6 and Table 7. Italy, Hungary and the UK are net importers of electricity , which means that they need to import electricity as well as to produce it to satisfy national demand.

As a consequence, in these countries, the reduction in national demand means both a reduction in the production of electricity (reduction of fuel consumption) and a reduction in imports.

In Denmark the situation is different because the country is a net exporter. In the three saving scenarios, with a lower demand, the simulator found it to be cost-effective to maintain the same level of national production in Denmark and to increase the export. The negative variations of net import for Denmark must be seen as an increase of the amount of electricity exported.

Table 6 **Reduction of fossil fuel consumption for generation plants (data in Mtoe and % variation)**

Country	Baseline 2020 (TWh)	Reduction of fossil fuel consumption for generation plants (%)		
		User Acceptance 25%	User Acceptance 50%	User Acceptance 75%
IT	43.2	0.5%	0.9%	1.2%
HU	3.6	0.2%	0.2%	0.2%
DK	3.8	0.0%	0.0%	0.0%
UK	37.4	1.1%	2.1%	3.2%

Table 7 **Reduction of the net import of electricity (data in TWh and % variation)**

Country	Baseline 2020 (TWh)	Reduction of the net import of electricity (%)		
		User Acceptance 25%	User Acceptance 50%	User Acceptance 75%
IT	57.6	0.7%	2.6%	4.7%
HU	13.9	0.7%	1.4%	2.9%
DK	−6.1	3.3%	4.9%	8.2%
UK	35.3	0.8%	1.4%	2.5%

The impacts on the average annual marginal price of the day-ahead electricity markets are positive in all countries. The reduction is most significant in Italy and in the UK where the consumption of electricity is higher. The reduction in the market marginal price achievable in the four countries is reported in Table 8.

Table 8 **Reduction of market marginal price (data in €/MWh and % variation)**

Country	Baseline 2020 (TWh)	Reduction of market marginal price (%)		
		User Acceptance 25%	User Acceptance 50%	User Acceptance 75%
IT	48.8	0.3%	2.3%	3.3%
HU	47.6	0.1%	0.2%	0.6%
DK	44.3	0.1%	0.5%	0.7%
UK	55.4	0.5%	0.9%	1.4%

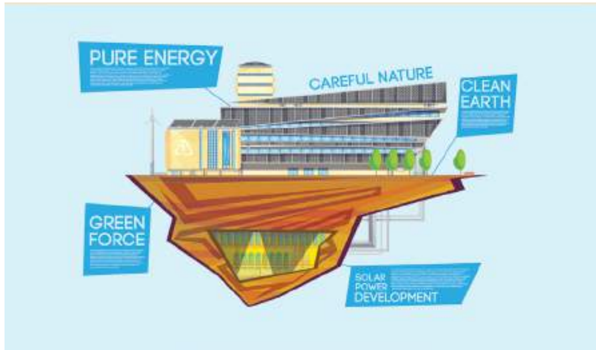


Table 9 Reduction of CO_2 emissions (data in $MtCO_2$ and % variation)

Country	Baseline 2020 (TWh)	Reduction of CO2 emissions (%)		
		User Acceptance 25%	User Acceptance 50%	User Acceptance 75%
IT	121.6	0.5%	0.9%	1.2%
HU	10.7	1.3%	1.3%	1.4%
DK	7.2	0.3%	0.5%	0.8%
UK	75.8	1.5%	3.0%	4.5%

Finally, as a consequence of the reduction in fuel consumption shown in Table 6, energy saving will lead to a reduction of CO_2 emissions from generation plants which rise with the level of user acceptance (Table 9). In Denmark, as shown before, the consumption of fossil fuels remains stable in all scenarios, but feedback can lead to a reduction in CO_2 emission thanks to an increase in gas generation and a decrease in coal generation.

3.1.1.3 Conclusions

The study showed that the NATCONSUMERS-style feedback can bring about multiple advantages to all consumer **load profile** categories in all countries studied. First of all, feedback mechanisms lead to a decrease in overall electricity consumption. The modelling shows that these benefits are more substantial for certain profiles of users, generally the most energy-intensive users. The second aspect we investigated is the impact of feedback on consumption during system peak hours.

A reduction in electricity consumption in the residential sector during system peak hours helps to reduce national peak load.
This effect is higher when peak consumption of the residential sector and the national peak coincide.

Finally, reductions in electricity consumption lead to a reduction in electricity bills. Retail prices for household consumers are typically composed of a fixed and a variable component, so the impact on the electricity bill is higher in countries with a lower fixed component such as Hungary.

Aggregated individual savings arising from feedback also have an impact on the power system at national level. A lower national demand for electricity (both throughout the day and during system peak hours) leads both to a lower request to generate electricity (reduction in fuel consumption) and a lower need to import electricity. The impacts on the average annual marginal price of the day-ahead markets are positive in all countries, but the reduction is more significant in Italy and in the UK, where the overall consumption of electricity is higher than in Hungary and Denmark. Finally, from the environmental point of view a reduction in fuel consumption for generation plants means a reduction in CO_2 emissions. Logically, the more household participate in feedback programs the greater the impact, hence the importance for market actors to focus very much on customer acceptability of feedback offerings.

3.2 How the NATCONSUMERS tool could be used by different market actors

The NATCONSUMERS tool is, by its nature, directed towards the end-consumers of energy. But it is also by design an engagement tool, and as such has potential value for many different market actors.

This part of the handbook elaborates on and investigates a selection of use cases for the NATCONSUMERS tool among parties in the value chain of energy; namely, the market actors.

The list of market actors in the energy sector includes a wide range of related organisations: energy providers, electricity companies, telecommunications companies, etc. Involving these market actors is paramount for any distribution of the tool to be technologically, economically and politically feasible. As such, the market actors are the final gate-keepers when it comes to the stage of distribution of the tool and implementation of the proposed methodologies of NATCONSUMERS.

3.2.1 What's the value?

The aims of the electricity industry are rapidly changing. Only 20 years ago security of supply was the one primary measure of the industry; amongst engineers employed in the sector it was common to speak about customers simply as 'imbalances in the grid'. This changed dramatically, and almost overnight, with the liberalisation of the industry. With liberalisation came political and popular demands. Such demands were initially related to efficiency and price, and latterly are increasingly related to the handling of a large influx of renewable and intermittent energy. With this, the whole structure and dynamic of the industry has changed; energy has transformed from a simple, state-owned commodity to a market player and economic power.

For the end-customer however, not a lot has changed. Well, not at first glance. However, on deeper inspection emerges the growing disquiet with spiralling energy prices and bills which have become increasingly difficult to understand. Even security of supply has re-emerged as an issue, with the growth of small-scale renewables and distributed generation challenging the grid's ability to balance supply and demand. Combined, this has resulted in an industry with a rapidly declining customer satisfaction, as reported by the customer watchdog organization "Which?" and "this is money" in 2014: *"The failings of a broken energy market: Customer satisfaction with gas and electricity firms plummets to a measly 41%"* [41].

In other words, the industry needed more than ever to encourage people to engage and understand their role as energy users. In the decade from the early 2000's to the financial crisis, this meant a golden age for the advertising industry, since a whole new business with a huge need for communication was born. It changed, however, very little; after all, the product was not really a product, the price was heavily regulated, and there was no difference between different suppliers in terms of the electricity which comes out of the plug. In the end, the communication game has become primarily a game of branding.

This has changed only very subtly as the industry begins to understand that not only the customers needed to change — but also the industry in itself. It has become clear that encouraging the uptake of the most effective measures to save energy, and earning consumers' trust and engagement, demands an understanding of how people behave and use energy in their homes —

and why they do not necessarily perform rational practices.
Within this context, the NATCONSUMERS tool brings value to both the customer and the supplier; it is a tool to establishing dialogue and to bring the parties together on an equal level. It is both a means and a solution for the future energy market.

3.2.2 Natconsumer — Use cases for the future

3.2.2.1 Energy Advice Centres

Within Europe, a growing network of local or national advice centres on energy saving are gaining more and more importance. These centres provide free, impartial advice on energy savings, renewable energy, sustainable transport, waste prevention and more. For a provider offering this kind of service, the NATCONSUMERS tool can enhance the impact and engagement with users. For example, by delivering insights derived from smart-meter data and complementing it with behavioural and individual factors (building characteristics, socio-demographics, weather forecasts etc.), a NATCONSUMERS tool can both provide a household with energy saving advice whilst simultaneously reducing costs for the advice centres.

By creating a tool which identifies suitable, tailored, relevant advice for householders, advice centres reduce time diagnosing each household's energy problems, thereby enabling them to reach many more customers and thus reduce consumption across a larger number of households.

Design example

The current approach used by many advice centres is to provide advice by phone, based on the advisor's expertise. The capabilities provided by a NATCONSUMERS tool provide opportunities for different channels of advice provision as well as enhancing outreach.

As an example, the use of a NATCONSUMERS tool means that it is possible to establish a baseline to benchmark the consumption of a user before the intervention begins. This is achieved byobtainingload profile segments and understanding peoples' attitudinal segment before the engagement begins. Within this handbook we have established already models for a number of different countries, and the more users are using the tool, the more precise and valuable the output will be.

The self-learning mechanisms of the tool enables more and more advanced feedback services — thus the feedback grows in complexity and value with the changes the customer implements. The interaction works individually and according to milestones or triggers in the system. At the right time during user activity (different for each consumer segment or profile), pop-up messages will appear asking simple questions. These questions will either be useful for user energy profiling, for identifying a change in behaviour, for evaluating the impact of advice, or for evaluating satisfaction with the service or the organization providing the feedback. In this way, the tool will gradually extract more information about the user in an efficient and non-intrusive way.

Questions can include explicit quantitative questions about relevant behaviours (for example, how often do you do behaviour X, from always to never) and quasi-explicit quantitative questions about attitudes, subjective norms and their perceived behavioural control towards saving energy (for example, saving energy at home is a good thing; from strongly agree to strongly disagree). Quantitative questions about behaviour and attitude will be followed up with qualitative questions that will probe why respondents gave their quantitative answers (for example, You said that you strongly agreed that saving energy at home is a good thing. Can you please tell us why you think that?).

Moreover, the tool will become more and more advanced with the answers from the questions, building individual customer profiles — and thus at a later state enable profile designed semi-structured, qualitative interviews, which will bring a further dimension of insight and knowledge about behaviour change and interaction with the tool.

For the Energy Advice centre it is easy to measure the impact of the tool. The amount and type of

advice given can, for example, be compared to a baseline scenario from the number of phone calls (CRM system) and number of log-ins to the website / app as well as web user activity.
The NATCONSUMERS tool also provides a very easy way to calculate impact, as user interaction can easily be correlated to actual savings.

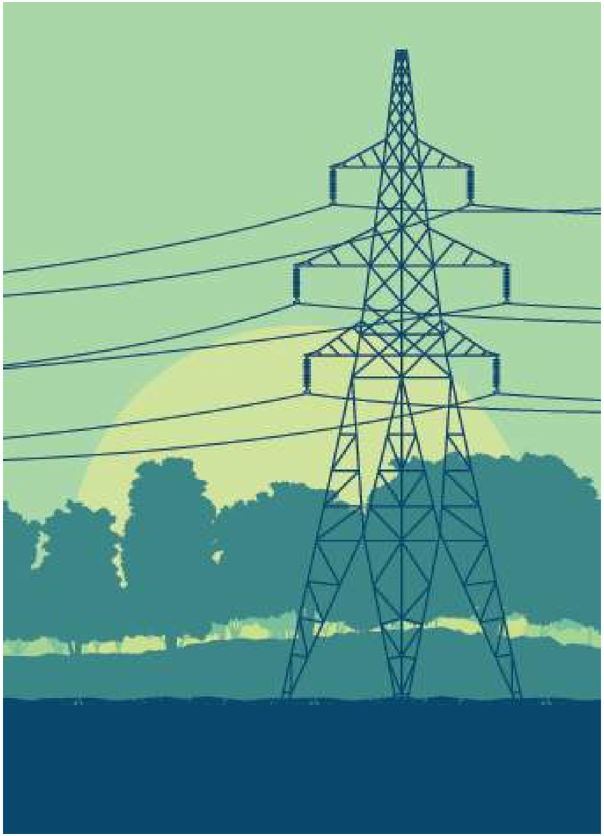
The NATCONSUMERS tool is, in this respect, a perfect tool helping DSOs to engage with consumers in a positive way, increasing their levels of interaction and, subsequently, building trust. This will both aid the smart-meter roll-out process itself, and also establish an ongoing relationship with consumers beyond smart-meter installation.

3.2.2.2 Distribution companies

Distribution System Operators (DSOs) are in charge of the **smart-meter** roll-out in many countries across Europe. EU member states have committed that 100% of households will have a **smart-meter** properly integrated into their systems by the end of 2020. In general, however, DSOs are poorly known and recognised by householders. This has proven a barrier to **smart-meter** roll-outs, since public opinion of (and trust in) DSOs is very low.

Over time, this could allow consumers to become more energy-literate and more willing participants in demand response programmes and peak-demand shaving exercises.

Design example
DSOs can start building profiles within the NATCONSUMERS tool before — or immediately after — the installation of **smart-meters** in each household. The tool will provide the DSO with a direct link to their customers, which can be



used to answer questions from worried citizens and solve problems and anxieties before they become a real problem. In this way, the tool is constantly monitoring the mood of the end-users and, in addition, it will provide the end-user with an immediate understanding and benefit of the newly installed **smart-meter**.

The value of the tool can be easily monitored by creating a small control group, which is not receiving feedback from the tool. In this way, possible savings in roll-out costs to handle problems related to obstructive citizens can be calculated. Afterwards, the tool can continue to be used also as an energy savings tool, and to prepare customers for demand response initiatives.

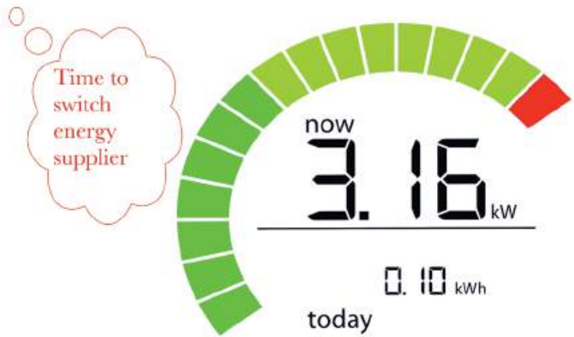
3.2.2.3 Energy retailers

Energy retailers are among those who have felt the greatest impact of changes in the energy sector. Energy is an invisible product, and as such all retailers have had to invent new ways of selling their services to the end-customer. The NATCONSUMERS tool can therefore be of high value, either to help prepare the sector for future liberalisation, or where the market is already fully liberalised, to help retailers distinguish themselves from competitors.

Most importantly for retailers, the tool provides a means to shift the focus of consumers away from price, instead offering a more holistic outlook which enables customers to use their energy in the most comprehensive way. In this way, retailers can build trust and loyalty amongst their customer base.

Design example

One application for a NATCONSUMERS tool would be for use in a mass-educational program that increases consumer awareness and knowledge of energy. The approach could simply be to contact households with an invitation letter in which the aim of the educational programme is described and the benefits and added value services to participants are outlined. Those households which consent to participate will register with the tool and complete the initial profiling questionnaire comprising demographics, building characteristics, and **golden questions** on attitudes and behaviours (pre-questionnaire).Based on these simple measures, a dialogue based on the NATCONSUMERS tool will be established.



Measuring the success of the tool to the retailers themselves could be complex, since the benefits to the company are indirect (through customer retention and improved brand image). Nonetheless, proving the value of their services and distinguishing their offering from competitors are important factors with in any competitive industry.

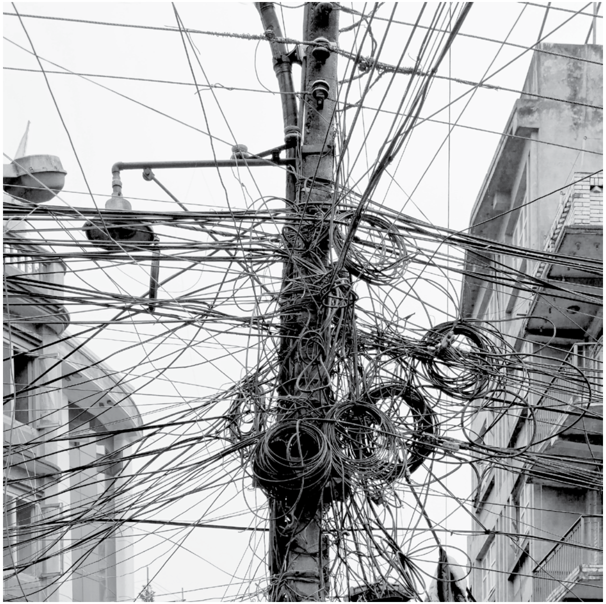
3.2.2.4 Charity organisations

Charity organisations focusing on, for example, energy poor households can also benefit from the tool. Whilst **energy poverty** has no universally accepted definition, it is commonly applied to people who spend more than 10% of their income on energy. Such people could gain considerable value from reducing their energy costs; lifting people out of **energy poverty** not only has financial benefits for the household in question, but also health and social benefits.

Any organisations working directly to help those in energy poverty could use the tool within their operations to assist in identifying households struggling with energy poverty and to provide assistance. It has the potential to substantially change the situation of many energy poor households — helping to release people from the vicious circle of debt and punishment, and instead helping to create a positive spiral.

Design example

The charity organisation has the direct contact with people in **energy poverty**, and the tool could be introduced as an investigative tool to analyse how to save money on energy. Essentially, the charity could use the tool and provide their clients with tailored advice and feedback, whilst also monitoring to assess whether this leads to any changes in energy use.



3.2.3 Conclusion

The NATCONSUMERS tool is useful for both the energy industry and any organisations working with end-customers — whether their aim is to save energy, to reduce fuel poverty, to prepare customers for the roll-out of **smart-meters**, or even to strengthen the relationship with consumers and reduce churn in the retail market.

Most importantly, the approach should always be designed with clear goals in mind. The NATCONSUMERS tool is not a magic wand — but it is a useful tool, which in itself requires training and careful implementation to function most effectively. With appropriate use however, a NATCONSUMERS tool could bring multiple benefits throughout the energy industry.

4. How to get Started — Recommendations and key takeaway messages

4.1 About consumer feedback

An integrated approach, including the variety of different factors affecting individual and collective behaviour, needs to address all aspects of energy supply and demand.

The consumer feedback is an essential element for effective learning, and to raise social awareness and change consumers' attitudes. Making energy more visible and controllable to the customer is therefore essential.

Data extracted from Vaasaeet database indicates that feedback pilots organised in Europe (68 pilots) have led to consumption reductions of 7.38% on average.

Consumers need appropriate frames of reference in order to determine whether their energy consumption is excessive or not. Currently, most people can only make comparisons with their own historical consumption, rather than comparisons with other, similar households to determine what level of consumption should be considered 'normal' (normative feedback).

4.2 About smart energy advice

To create energy efficiency advice, both contextual and psychological factors must be considered. We must develop advice which is relevant to the wider and household context each individual is living in, but must also consider their individual context to understand what would motivate them to take note of the advice.

The first stage of any advice provision must therefore be to build up people's knowledge around the consequences of their behaviours, either the direct consequences on an individual's energy bill or levels of comfort, or the broader consequences on the environment and natural systems. The second stage of advice provision must be to build up knowledge on how they can change behaviour, that is, developing their action-based knowledge.

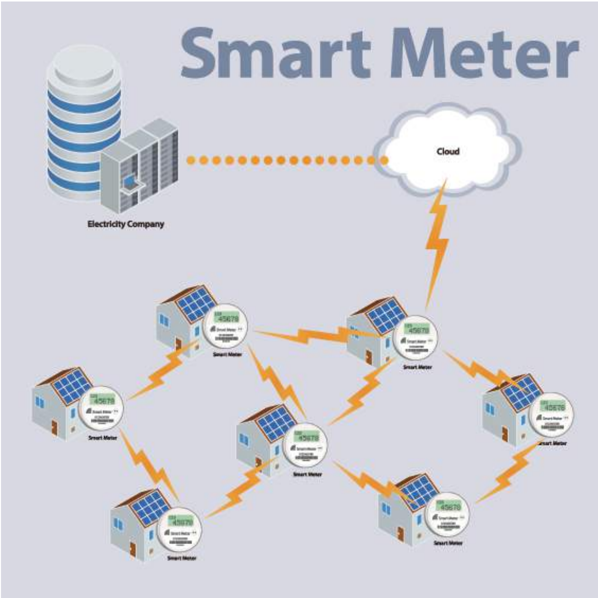
NATCONSUMERS messaging must therefore act to educate and inform, building up consumer knowledge both in terms of what they can do and why they should do it.

There are two main aspects to the tailoring of messages:

- What should the message say — what content is relevant to that individual, at that point in time
- How should the message be said — how should the advice be framed to make it resonate with that consumer, at that point in time

Many of the factors which influence energy use, such as demographics or building characteristics, are not changeable — our advice should account for these as contextual factors, but cannot change them.

Other factors are actionable, for example, 'lack of knowledge' is a factor which influences energy consumption and can be tackled by providing useful information on the consequences of energy using activities through NATCONSUMERS messaging.



One of the first objectives of NATCONSUMERS feedback must therefore be to build trust and reduce consumer fear. Consumers must be made aware of how their **smart-meter** data is being used, how this can help them, and why they are being given this advice before they will trust in and respond to it.

Messaging style must be aligned with the consumer's perceived image of the sender of the message.

Initially messages should be quite factual and informative; over time this could develop into a more conversational style, and ultimately offer more challenging statements which push people to consider their actions more closely. As trust in the service and the effectiveness of the advice increases, the tone of the advice itself must develop.

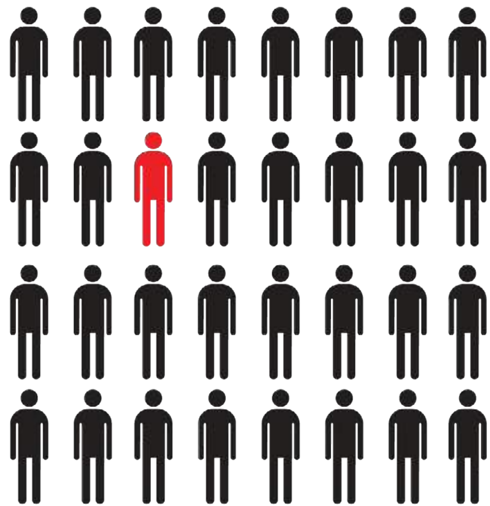
4.3 About classifying consumers

The segmentation engine has to build upon two pillars, one of which defines 'what' we should tell the consumers, while the other defines 'how', on the basis of the argumentation, we should say it.

In all of the messages, it is not enough to know only the user's own consumption; we also need a **benchmark segment** for comparison

- The consumption curve of the given household has to be similar
- The consumption volume of the given household has to be similar

In order to calculate the correct **benchmark segment**, a special mix of **load profile** and socio-demographic segmentation was suggested. The **load profile** segments identify the typical consumption curve of the households on daily, weekly and yearly bases. The socio-demographic classification built under the load profile segmentation helps differentiate the consumption volume of households within the same **load profile** segment. The output of this joint classification is the benchmark segmentation.
We suggest to subordinate socio-demographic segmentation to load profile segments, and find



socio-demographic groups inside load profile segments which have a similar consumption size. This method ensured that the consumers who were grouped together in the final classification were similar not only in their consumption volume but also in their load curves, which makes a much more valid and reliable comparison.

The basic logic of attitudinal segmentation is to find the attitudes which may work as arguments to change energy consumption, then segment the consumers with the help of these attitudes, classifying them into groups which divide, as clearly as possible, the energy consumers into groups based on their behaviour and habits.

Our analyses clearly showed that the three most distinct attitude dimensions relate to technological innovation, environmental preservation, and economic rationality. In the design of our messages we consider these as primary factors, which form the basis for out attitudinal segmentation. The argumentation logic in the NATCONSUMERS engine will mainly rely on the primary drivers.

The segmentation could be reproduced with a smaller number well-directed questions (we will call these the "**golden questions**"). These **golden questions** can therefore be used to place consumers into their appropriate segmentation group without the need for a lengthy questionnaire.

4.4 About Natural language communication

In **Natural Language** processes, the numerical data has to be transformed into easily interpretable linguistic content, extracting relevant information that will then be presented to the user in an easy to read, conversational format.

The **Natural Language** of Energy communicates on many levels and through many means. It is not necessarily a language of words — it could be nudging, pictures, hardware, a light, a sound — and even more. It seeks to meet the customer in the most engaging manner. This means that lasting engagement is more important than instant reactions, which soon wear off.

To build up a **Natural Language** communication, follow these steps:

1. Think about what you want to communicate to the residential energy consumer. To do this, we must consider the specific energy context of the individuals; we must consider what advice is relevant for the user..
2. Write **narratives** to communicate with the final user. As such, at this point we must consider "the tone", "colour" and any other subjective aspects of communication.
3. Map the **template** of each **narrative** with keywords.
4. In the case of higher complexity **narratives**, design the **logic rules** to combine two or more **computational perceptions**.
5. Choose or create the **indicator variables** and include them in the consumer dataset.

Whilst the attitudinal segmentation should be the primary focus when developing the **corpus**, it is also important to cover the different possible **load profile** situations (that is, "your consumption is decreasing", "your consumption peaks at..." etc.). These should be taken into account as they provide valuable information about consumers' consumption habits.

A good **corpus** balance must be taken into account. The **corpus** must have a wide range of text categories well-balanced between data categories. A **corpus** should be able to change over time in order to include new terms needed or exclude terms which do not have success.

4.5 About Developing/selecting an engagement concept

The different engagement patterns emerged in our project can be organized along an axis according to the balance of effort vs. benefit for users. This scale ranges from "fixing accidental overconsumption" (achieving benefits with minimal effort) to "informing on occasional opportunities" (requiring more, but temporary, effort and providing relatively strong benefits) to "inducing changes in comfort expectations" (more demanding efforts over longer time periods).

Working through the concepts one-by-one, a number of themes emerged around the different concepts

- the necessity of internet access for several of the concepts to work quickly emerged as potentially problematic
- not everybody like the idea that children would be encouraged to dictate how the household consumes energy, whilst others were concerned that, given the limited influence a child may be able to enact over the household
- people like concepts which followed a simplification pattern. Such concepts, which have a good visual impact and a simple, easy to understand design, were seen as more intuitive to use
- where a concept is similar to a product or service the user already knows, it was viewed more favourably

We must be cautious when choosing an appropriate engagement strategy; not all concepts can be effectively 'stretched' to all demographics, and so a single concept is unlikely to appeal to all. Energy is a low engagement topic, people therefore do not want to engage with it continuously. This means timing is very important; consumers want feedback when it is necessary, not constantly. Sometimes feedback could be frustrating. If a household cannot afford to, for example, change their washing machine, it could be quite demoralising and frustrating to receive regular advice that the device needs replacing.

4.6 About the Impacts

Consumer understanding and use of feedback is one of the most important factors in feedback programs. Engaged consumers that belong to user categories with the lowest monetary savings potential can still achieve significantly higher savings than poorly-motivated consumers from user categories with the highest monetary savings potential.

A reduction in electricity consumption in the residential sector during system peak hours helps to reduce national peak load. This effect is higher when **peak consumption** of the residential sector and the national peak coincide.

Aggregated individual savings arising from feedback also have an impact on the power system at national level. A lower national demand for electricity (both throughout the day and during system peak hours) leads both to a lower request to generate electricity (reduction in fuel consumption) and a lower need to import electricity.
From the environmental point of view a reduction in fuel consumption for generation plants means a reduction in CO2 emissions.

4.7 About advantage for different market actors

Energy Advice Centres

- By creating a tool which identifies suitable, tailored, relevant advice for householders, advice centres reduce time diagnosing each household's energy problems, thereby enabling them to reach many more customers and thus reduce consumption across a larger number of households.

Distribution companies

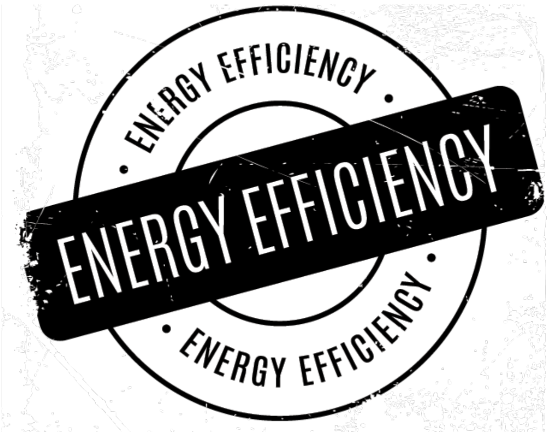
- The NATCONSUMERS tool is helping DSOs to engage with consumers in a positive way, increasing their levels of interaction and, subsequently, building trust. This will both aid the smart-meter roll-out process itself, and also establish an ongoing relationship with consumers beyond smart-meter installation.

Energy retailers

- The tool provides a means to shift the focus of consumers away from price, instead offering a more holistic outlook which enables customers to use their energy in the most comprehensive way. In this way, retailers can build trust and loyalty amongst their customer base.

Charity Organizations

- Any organisations working directly to help those in **energy poverty** could use the tool within their operations to assist in identifying households struggling with **energy poverty** and to provide assistance. It has the potential to substantially change the situation of many energy poor households — helping to release people from the vicious circle of debt and punishment, and instead helping to create a positive spiral.



Annex I: Web tool development

This Appendix provides detail on the calculations driving the proof-of-concept web tool described in Chapter 2.4.

Calculation of the load profile

Once the user has uploaded their **smart-meter** data into the tool, the users **load profile** must be calculated. The different **load profiles** identified within this project (in the five countries studies: Hungary, Italy, the UK, Ireland Denmark) and the procedure used to identify the profiles is discussed in Chapter 2.1.

Each of the identified profiles were defined with a curve of 432 points or dimensions:

- Each hour of the day equates to one data-point, that is, 24 points per day
- Daily profiles were assessed over 3 short-term timescales: weekday, Saturday and Sunday. This gives 24 x 3 = 72 data points
- Each profile was also assessed every 2 months (that is, six times a year) to give an annual perspective. This gives 24 x 3 x 6 = 432 data points per profile

For simplicity within this tool, rather than the 432 data points in the **load profiles** calculated, we have used only 48 points: 24 for winter and 24 for summer.

To assign the user to a **load profile**, first the **smart-meter** data is transformed into a 48-point curve, with 24 points for winter and 24 points for summer. To do so, the **smart-meter** data is aggregated and averaged. Raw values for consumption are converted to percentage consumption relative to the total volume of energy use for that curve;

this means the sum of all points on the curve is equal to one, thereby eliminating the effect of consumption volume. As such, the load profiles account only for the shape of the consumption curve, rather than the magnitude; that is, the curve represents patterns of energy use over time, but provides no information on the quantity of energy used. Two households with very different total consumption may therefore be in the same load profile segment if their pattern of energy use over time is the same.

Depending on time period covered by the uploaded smart-meter data, it may not be possible to calculate aggregates for both winter and summer consumption. In this case, only one can be calculated, meaning the load profile comparison is done using only a 24-point curve (winter or summer).

Once the user's load profile curve has been calculated, it is compared with the load profiles identified (for each country) during the load profile segmentation (see Chapter2.1.2.2). First, the user is assigned to a country; if the user's country is not available it is assigned to the nearest country available (geographically). The user's load profile is then compared with the 4 or 5 load profile segments of the reference country, and assigned to the most similar one. This calculation is based on minimising the Euclidean distance between the curves.

Through this process the user is therefore assigned to one of the reference load profile segments.

Calculation of the 'benchmark' segment

The benchmark segment is formed from the relation between the load profile and socio-demographic data of the user. These two parameters are calculated within the tool, thus the user can be assigned to a benchmark segment. The benchmark segment can then be used to create comparative messages — for a particular energy usage trait (for example, total consumption, **peak consumption**, etc.) the user can be compared against that trait for a 'similar household'. This 'similar household' will be the **benchmark** — a household with a similar electricity **load profile** and similar socio-demographic characteristics (for example, same size home, same type of house etc.).

Calculating indicator variables

An '**indicator variable**' is a variable calculated from the **smart-meter** data (or other input data) which is used to determine the output message content. As a simplified example, for the message "your consumption has been very high this month", the **indicator variable** would be monthly energy consumption. In this example, the numeric value for total monthly consumption has been translated, through **perception mapping**, to the linguistic descriptor 'very high'.

The calculation of these **indicator variables** is a mathematical procedure, which will vary in complexity depending on the variable in question. To create a full NATCONSUMERS tool, a range of different **indicator variables** would need to be calculated, allowing a range of different message types to be constructed. However, for the purposes of this web tool we have simplified the process to look at only one **indicator variable**: monthly energy consumption. This is extracted from the **smart-meter** data by aggregating all energy consumption throughout a particular month.

When generating messages, we will sometimes wish to compare the value of the user's **indicator variable** with that of their **benchmark segment**. Take, for example, the message: "This month your electricity consumption is 12% higher than that of people similar to you". To generate this message, we need to know the value of the **indicator variable** (monthly consumption) of the user, and the value of the **indicator variable** for 'people similar to you', that is, that user's **benchmark segment**. As such, the web tool must calculate **indicator variables** for every user, based on their **smart-meter** data, and indicator variables for every **benchmark segment**.

Calculation of the attitudinal profile

As discussed in Chapter 2.1.3.2, the attitudinal segment for each individual can be generated from responses to 6 **Golden Questions** (which have been distilled from our original, much larger survey). The responses to these questions allow the user to be assigned to one of 7 attitudinal segments. These questions are asked during the sign-up stage of the tool. The questions are:

To what extent do you agree or disagree with the following statements?

- *I always like to have the latest technologies, like the newest phone or tablet.*
- *I think it's fun to try new thing.*
- *What friends or neighbours think of my home is important to me?*
- *I'm always looking for ways to save money in my day-to-day life.*
- *I'm happy to spend money on things which make my life more convenient, like household gadgets or car travel.*
- *I am concerned about climate change, and always try to reduce my carbon emissions in day-to-day life.*

For each statement, respondents can select from a scale of:

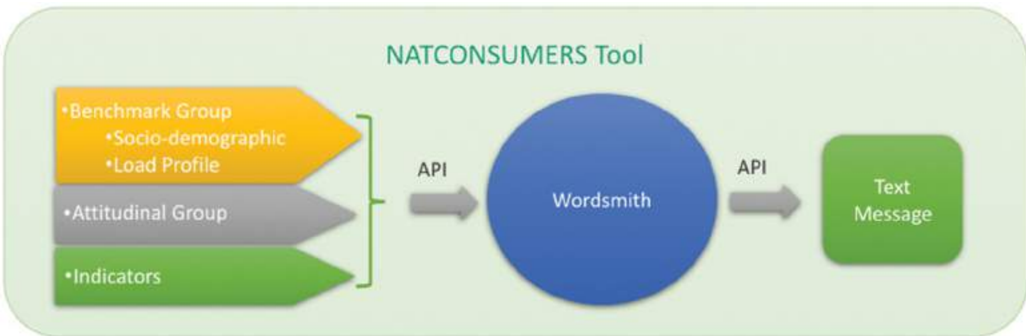
- *Strongly agree* (5)
- *Somewhat agree* (4)
- *Neither agree nor disagree* (3)
- *Somewhat disagree* (2)
- *Strongly disagree* (1)

Based on these responses, the user's attitudinal segment is calculated by measuring the Euclidean distance between their answers and the cluster centres of the different segments. The user is assigned to the profile with the shortest distance from their own answers.

Generation of the Messages

For the purposes of this web tool, we have not created an entirely new **Natural Language Generator** from scratch. Instead, we have used the Wordsmith service [42] to provide the basis for our **Natural Language Generator**, and populated this with our own **narratives** and **logic rules,** to create a bespoke NATCONSUMERS **corpus**.
The figure below shows the interactions between Wordsmith and the NATCONSUMERS web

Figure 31 **Interaction between the Tool and the Wordsmith service**



tool. Wordsmith uses a public API (Application Processing Interface) to access the data required to generate the messages, and again to return the message to the tool once it has been generated. Within Wordsmith, the **corpus** and **logic rules** (the development of which is described in Chapter 2.2.2) are programmed.

The Wordsmith service requires the following inputs in order to generate messages:

- The **corpus** and **logic rules** to generate the message. A basic **corpus**, as developed in Chapter 2.2.3, has been programmed in the service for this tool.
- The parameters of the particular user and particular message. These are provided by the tool:
    - The user's **benchmark segment**, which includes the socio-demographic and **load profile** data
    - The user's attitudinal segment
    - The **indicator variables**. These are relevant to a particular message, and may change between messages.

Once the message has been generated within Wordsmith, it is sent back to the web tool where it can be viewed by the user.

Annex II: Analytical results of impacts on residential consumers and national power systems

Table 10 KPI I-a: Total annual electricity reduction in Italy

Scenarios	Baseline	Small saving	Average saving	Large saving	Small saving	Average saving	Large saving
Categories	Annual electricity consumption (kWh)				% variation		
IT – Summer Waivers	2945	2886	2728	2651	−2.0%	−7.4%	−10.0%
IT – Evening Actives	2647	2594	2452	2383	−2.0%	−7.4%	−10.0%
IT – Double Risers	2649	2596	2453	2384	−2.0%	−7.4%	−10.0%
IT – Late Actives	3239	3174	3000	2915	−2.0%	−7.4%	−10.0%
IT – Summer Peakers	2987	2927	2767	2688	−2.0%	−7.4%	−10.0%

Table 11 KPI I-a: Total annual electricity reduction in Hungary

Scenarios	Baseline	Small saving	Average saving	Large saving	Small saving	Average saving	Large saving
Categories	Annual electricity consumption (kWh)				% variation		
HU – Home Lunchers	2091	2049	1937	1882	−2.0%	−7.4%	−10.0%
HU – Afternoon Actives	1974	1934	1828	1776	−2.0%	−7.4%	−10.0%
HU – Double Risers	2285	2239	2116	2056	−2.0%	−7.4%	−10.0%
HU – Winter Spinners	1732	1697	1604	1559	−2.0%	−7.4%	−10.0%

Table 12 KPI I-a: Total annual electricity reduction in Denmark

Scenarios	Baseline	Small saving	Average saving	Large saving	Small saving	Average saving	Large saving
Categories	Annual electricity consumption (kWh)				% variation		
DK – Summer Waivers	3714	3640	3440	3342	−2.0%	−7.4%	−10.0%
DK – Double Risers	2451	2401	2270	2205	−2.0%	−7.4%	−10.0%
DK – Afternoon Actives	3214	3150	2977	2893	−2.0%	−7.4%	−10.0%
DK – Winter Spinners	3966	3886	3673	3569	−2.0%	−7.4%	−10.0%

Table 13 KPI I-a: Total annual electricity reduction in United Kingdom

Scenarios	Baseline	Small saving	Average saving	Large saving	Small saving	Average saving	Large saving
Categories	Annual electricity consumption (kWh)				% variation		
UK – Double Risers	4214	4130	3903	3793	−2.0%	−7.4%	−10.0%
UK – Home Lunchers	3738	3663	3462	3364	−2.0%	−7.4%	−10.0%
UK – Afternoon Actives	4468	4379	4138	4021	−2.0%	−7.4%	−10.0%
UK – Winter Spinners	6474	6334	5996	5826	−2.0%	−7.4%	−10.0%

Table 14 KPI I-b: Reduction of annual electricity consumption in system peak hours in Italy

Scenarios	Baseline	Small saving	Average saving	Large saving	Small saving	Average saving	Large saving
Categories	Annual electricity consumption in system peak hours (kWh)				% variation		
IT – Summer Waivers	526	510	466	444	−3.0%	−11.4%	−15.6%
IT – Evening Actives	568	549	499	475	−3.3%	−12.1%	−16.4%
IT – Double Risers	474	459	420	400	−3.2%	−11.4%	−15.6%
IT – Late Actives	561	544	497	475	−3.0%	−11.4%	−15.3%
IT – Summer Peakers	542	525	481	459	−3.1%	−11.3%	−15.3%

Table 15 KPI I-b: Reduction of annual electricity consumption in system peak hours in Hungary

Scenarios	Baseline	Small saving	Average saving	Large saving
Categories	Annual electricity consumption in system peak hours (kWh)			
HU – Home Lunchers	297	291	275	267
HU – Afternoon Actives	379	367	335	319
HU – Double Risers	428	415	380	362
HU – Winter Spinners	267	260	240	230

Small saving	Average saving	Large saving
% variation		
−2.0%	−7.4%	−10.1%
−3.2%	−11.6%	−15.8%
−3.0%	−11.2%	−15.4%
−2.6%	−10.1%	−13.9%

Table 16 KPI I-b: Reduction of annual electricity consumption in system peak hours in Denmark

Scenarios	Baseline	Small saving	Average saving	Large saving
Categories	Annual electricity consumption in system peak hours (kWh)			
DK – Summer Waivers	500	490	463	450
DK – Double Risers	352	345	326	317
DK – Afternoon Actives	386	380	365	357
DK – Winter Spinners	516	507	482	470

Small saving	Average saving	Large saving
% variation		
−2.0%	−7.4%	−10.0%
−2.0%	−7.4%	−9.9%
−1.6%	−5.4%	−7.5%
−1.7%	−6.6%	−8.9%

Table 17 KPI I-b: Reduction of annual electricity consumption in system peak hours in United Kingdom

Scenarios	Baseline	Small saving	Average saving	Large saving	Small saving	Average saving	Large saving
Categories	Annual electricity consumption in system peak hours (kWh)				% variation		
UK – Double Risers	742	719	656	625	−3.1%	−11.6%	−15.8%
UK – Home Lunchers	621	608	574	557	−2.1%	−7.6%	−10.3%
UK – Afternoon Actives	961	932	854	817	−3.0%	−11.1%	−15.0%
UK – Winter Spinners	1076	1036	930	878	−3.7%	−13.6%	−18.4%

Table 18 KPI I-c: Reduction of consumers´ electricity bill in Italy

Scenarios	Baseline	Small saving	Average saving	Large saving	Small saving	Average saving	Large saving
Categories	Annual electricity bill (€)				% variation		
IT – Summer Waivers	546	536	509	496	−1.8%	−6.8%	−9.2%
IT – Evening Actives	495	486	462	451	−1.8%	−6.7%	−8.9%
IT – Double Risers	496	487	462	451	−1.8%	−6.9%	−9.1%
IT – Late Actives	595	584	555	541	−1.8%	−6.7%	−9.1%
IT – Summer Peakers	553	543	515	502	−1.8%	−6.9%	−9.2%

Table 19 KPI I-c: Reduction of consumers´ electricity bill in Hungary

Scenarios	Baseline	Small saving	Average saving	Large saving	Small saving	Average saving	Large saving
Categories	Annual electricity bill (€)				% variation		
HU – Home Lunchers	254	249	236	229	−2.0%	−7.1%	−9.8%
HU – Afternoon Actives	240	235	223	217	−2.1%	−7.1%	−9.6%
HU – Double Risers	277	271	257	250	−2.2%	−7.2%	−9.7%
HU – Winter Spinners	211	207	196	191	−1.9%	−7.1%	−9.5%

Table 20 KPI I-c: Reduction of consumers´ electricity bill in Denmark

Scenarios	Baseline	Small saving	Average saving	Large saving	Small saving	Average saving	Large saving
Categories	Annual electricity bill (€)				% variation		
DK – Summer Waivers	1126	1105	1047	1019	−1.9%	−7.0%	−9.5%
DK – Double Risers	760	746	708	689	−1.8%	−6.8%	−9.3%
DK – Afternoon Actives	981	963	913	888	−1.8%	−6.9%	−9.5%
DK – Winter Spinners	1199	1176	1114	1084	−1.9%	−7.1%	−9.6%

Table 21 KPI I-c: Reduction of consumers´ electricity bill in United Kingdom

Scenarios	Baseline	Small saving	Average saving	Large saving	Small saving	Average saving	Large saving
Categories	Annual electricity consumption (kWh)				% variation		
UK – Double Risers	994	976	927	904	−1.8%	−6.7%	−9.1%
UK – Home Lunchers	892	876	834	813	−1.8%	−6.5%	−8.9%
UK – Afternoon Actives	1047	1028	977	953	−1.8%	−6.7%	−9.0%
UK – Winter Spinners	1474	1446	1372	1336	−1.9%	−6.9%	−9.4%

Terminology

Additional Data: Data calculated within the Natural Language Generator through functions, lists or yes / no interactions.

Benchmark segment: a group to whom it would be meaningful for Households to be compared to when making comparisons.

Branches: These are used to establish relationships based upon the value of the data. This entails logic rules which determine what words are used under particular circumstances; for example, a branch could be: if this month's consumption is less than last month, include the word "cool".

CHAID: Chi-squared Automatic Interaction Detection — The output of CHAID analysis is a graphic model, a decision tree. In the structure of the decision tree, every top signifies a control variable referring to a concrete value, and every downward branch corresponds to an output of the control.

Computational Perception: Any variable, numeric or categorical, can be mapped into a linguistic description. This linguistic description of the variable is called Computational Perception.

Corpus: Collection of narratives that serves as a background for message composition.

Energy Poverty: Energy poverty has no universally accepted definition. It is commonly applied to people who spend more than 10% of their income on energy.

Engagement concept: Also known as an "*engagement framework*", is a concrete interface through which NATCONSUMERS messaging can be to interact with the consumer. This interface must be selected or created as part of the process of constructing a NATCONSUMERS tool.

Essential Data: Data obtained from a consumer's **load profile** data (**smart-meter** data) and their answers to the **"golden questions"**.

Functions: Functions generate new data from essential data, for example, by transforming the data into different units which are of more interest to the consumer. For example, data on kWh consumption within the essential data is transformed into the equivalent cost (€) or equivalent CO_2 emissions ($kgCO_2$). Functions can also generate new data by combining previous data, for example, energy consumption (kWh) can be converted into energy use per person (kWh/person).

Fuzzy logic: Using not fixed but groups of values to represent an important characteristic

Golden questions: A small number well-directed questions. The golden questions can be used to place consumers into their appropriate segmentation group without the need for a lengthy questionnaire.

Indicator variables: Indicator variables are obtained from the processing of consumer data. They are generated from the raw smart-meter data, before it enters the Natural Language Generator. They are used as data in the Natural Language tool to inform the 'logic rules' which personalise the message.

Load curve: A graphical plot showing the variation in demand for energy of the consumers with respect to time.

Load profile: see Load curve

Logic (business) rules: These rules establish the ways in which Natural Language expressions combine to construct the final narrative.

Narrative: 'Templates' — whether in the form of text, images or applications — included within the corpus and which form the basic structure of an advice message.

Natural Language: a communication form which is friendly, emotionally intelligent, relevant and simple.

Natural Language Generator: Computational software which creates messages using Natural Language.

Natural Language Granular Model: It is a traditional model for Natural Language generation. The Natural Language Granular Model is based on the idea that any variable, numeric or categorical, can be mapped into a linguistic description of this variable.

Peak consumption: That time segment where the energy consumption is the highest, usually on daily base

Perception Mapping: The process to build Computational Perception

Personas: A brief summary that together characterizes a consumer profile, incorporating detail on their attitudes, socio-demographics and **load profile**.

Reference groups: see Benchmark Groups

Smart-meter: It is a new kind of energy meter that can digitally send meter readings to data operators. They enable two-way communication between the device and data operator.

Synonyms: These are used to enrich the text, ensuring that the messages produced are always different. They allow for a diversity in phrasing despite the overall message (and template) remaining the same.

Templates: The templates are narratives or sentences which must be designed by someone who has a good understanding of residential energy use.

List of figures

List of tables

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27 Bergman (1998) A Theoretical Note on the Differences Between Attitudes, Opinions, and Values. *Swiss Political Science Review*, 4: 81–93.

28 Mirosa, Lawson and Gnoth (2011) Linking personal values to energy-efficient behaviours in the home *Environment and Behaviours* 45(**4**), pp. 455–475

29 In a finite mixture Gaussian model, we assume that the data is generated by mixtures of normal densities. Each component of this multivariate mixture distribution corresponds to a cluster. The clustering processes try to identify these different distributions behind the data structure.

30 We received the Danish data after the finalising the project reportD4.1, and so the report does not contain the Danish results. However, at a later stage of the project we reproduced all of the calculations for Denmark

31 These are the countries where we have consumption data based on intelligent measurement. The databases are described in detail in report D4.1. We did not have any additional information about Danish households above their energy usage data, so we have omitted them from this analysis.

32 In the case of Irish households, the decision tree of the **CHAID** model developed for the 'Double Risers' load curve-based segment, which was the most numerous, resulted in twelve subgroups by Standard Yearly Consumption. The first level of the decision tree is the household size (Household size) variant. This means that the first and most important criterion for the differentiation based on yearly consumption for the members of the 'Double Risers' segment is the number of people living in a household. Interpreting the structure of the decision tree, we see that the more people that live in a household, the greater the yearly energy consumption in the 'Double Risers' segment. The second level of the decision tree is the number

of bedrooms (Bedrooms) in the dwelling. In the group of one-person households, there is a significant difference between households with three or fewer and more than three bedrooms. Within the 'Double Risers' segment, the households are differentiated regarding the degree of yearly energy consumption first by the number of people living in the household, then by the number of bedrooms in a household. Reversing the relation, we can fairly accurately assess the yearly energy consumption of a 'Double Risers' segment household merely by the size of the household and the number of bedrooms. At the third level of the decision tree, one-person households with three or fewer bedrooms can be further divided into two distinct groups of energy consumption based on the type of the dwelling (Dwelling type). The yearly average consumption and the number of households are indicated on the subgroups of the decision tree ('parent' and 'child' nodes).

33 Xiao (2010) Corpus creation.In *Handbook of Natural Language Processing*, Second Edition (pp. 146–165). Chapman and Hall/CRC.

34 In this case the consumption data need to be controlled by weather

35 Which basically is a three day work shop with people outside the project to get new ideas and fresh input.

36 Originally the concept comes from music practice and describes an "informal performance of jazz (or rock) music that the musicians have not planned or practiced" (Cambridge Dictionary). This collective and intense creative process has been reused in the creative and tech industries and is now often referred to as "Jam", "hackathon" or "barcamp".

37 The recruited designers were from the UK, Belgium, France, Spain, Italy and Finland

38 UK has by far the highest average annual consumption amongst the selected countries: an average household in UK consumes about 4,425 kWh annually, which is 43% higher from the next highest (Denmark: 3,094kWh/year).

39 Household Energy Price Index by Energie Control Austria, MEKH and VaasaETT, 2017.

40 As explained above, system peak hours are defined as the three consecutive hours with the highest prices on the wholesale market which may be different from the peak consumption of the different segments of household consumers.

41 A country or territory whose value of imported goods is higher than its value of exported goods over a given period of time. A net importer is the opposite of a net exporter.

42 https://automatedinsights.com/wordsmith

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