WHY

CLIMBING THE CAUSALITY LADDER TO UNDERSTAND THE ENERGY DEMAND ON THE RESIDENTIAL SECTOR

Local Policy Brief
Better energy planning for urban neighbourhoods

1. Introduction and Context

Energy system models (ESMs) are a set of mathematical equations that describe the energy system. Experts use these models to describe how changes in energy systems impact on society. Nevertheless, current ESMs lack accuracy simulating the residential sector due to the large diversity of buildings. The European research project called "WHY", financed by the European Union's Horizon 2020 programme, developed a causal model to analyse people's day-to-day decisions when using energy at home. The European research team uses this causal model to understand people's reactions to changes introduced in the energy market such as tariff changes, new taxes, rebates, changes in building codes, etc. These developed tools have been used to improve:

- the assessment of household electricity consumption trends,
- the knowledge of user behaviour in the modelling community and
- the operation and planning of the energy distribution system.

The project's use cases assess the Fitfor55 and REPowerEU strategies, the global energy system and the creation and management of energy cooperatives and energy communities. In particular, the local use case of Maintal addresses the challenge of transforming a municipality's residential energy system to an environmentally conscious, sustainable energy system. To be able to set up the relevant strategies and implementation plans, WHY support the Maintal municipality providing very detailed simulation of the household energy and water consumption for each house of an entire district already before setting up an investment.

On the other hand, the use case of energy cooperatives addresses the challenge of foreseeing the short, medium and long changes in the energy consumption when implementing a change on the electric tariff. Taking advantage of two changes on the electric tariff that were implemented in Spain the 1st of June of 2021 and in May of 2022 (the gas cap mechanism), a behavioural model was built which allows to forecast both the reduction on energy consumption and the flexibility potential triggered by the change of tariff. This information is now used to design a new tariff for the clients of the energy cooperative Goiener.

2.

Embrace diversity! Standardised load profiles are not representing the real people

Source: AlphaIC

We need to transition our energy system from an oligopolistic and fossil fuel based one to a decentralised and renewable one. In this scenario, people's homes have to be part of the system producing and consuming energy in a variety of ways. This variety is becoming more and more diverse as new technologies, like PV panels, storage systems, heat pumps or electric charging points, enter the home ecosystem. Nevertheless, these new technologies generate interesting effects:

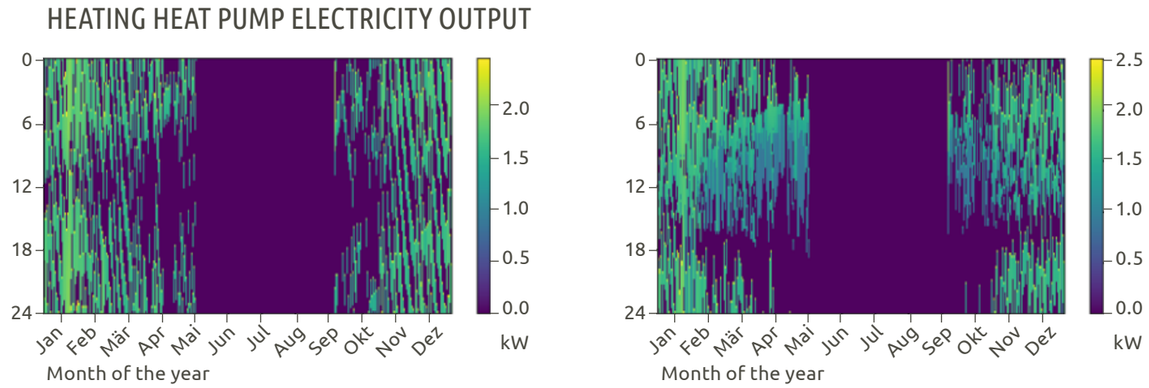
- Residential consumption behaviour becomes more diverse as the technical setup can differ vastly from one household to the next.
- The role of residential consumers is changing substantially from formerly passive consumers to prosumers.

Up until now, residential consumers were represented by standardised aggregated consumption parameters. This has worked so far as, given a large enough number of residential consumers (for example, all the consumers in a country), the diversity of behaviours will be smoothed and a standardised profile will correctly represent the aggregated consumption. The argument also holds in urban infrastructure planning in cities and communities. In this case it is not the aggregation that was smoothing the behaviours, but the fact that the technical equipment and living situations of residential consumers were quite similar. Nowadays, this approach is not realistic anymore as the way of life, work and how people move around have changed at a rapid pace. Home office, online services, electric cars and more transformed our lifestyle and with it, the way we consume energy. This changes the way residential consumers need to be perceived by the system planners and in simulations.

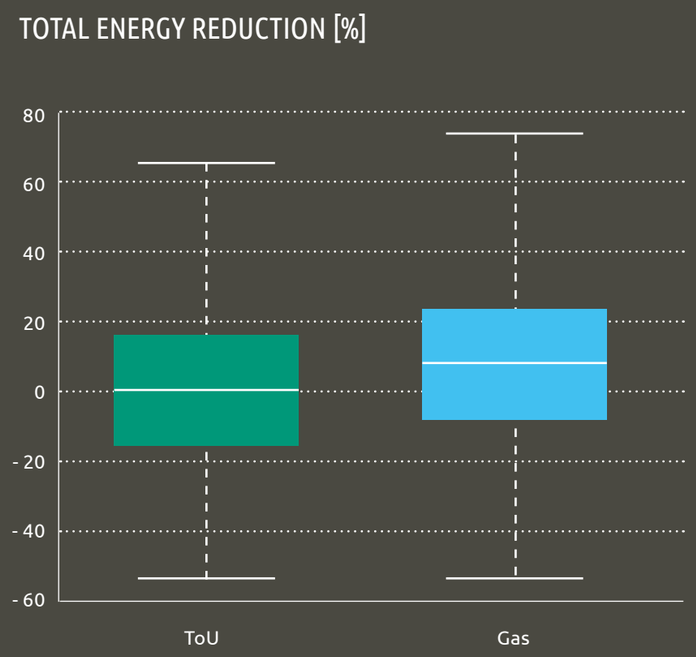
The WHY-Consortium recommends changing planning routines from using standardised consumption values for residential consumers when assessing cities or municipalities. To highlight this issue the WHY-Toolkit was designed and used to provide more detailed data for a technical bureau for the planning of a neighbourhood in the German city of Maintal. **The results indicated that the use of standardised consumption behaviour overestimated the thermal energy demand for heating on average by 7.5% over the entire positive energy district considered in the corresponding use case.**

3.

Time to unlock flexibility easily



The figures show how much of the heating energy demand can be moved with an appropriate control algorithm, in this case optimising photovoltaic self consumption. The right panel shows the results with the control algorithms enabled and the left panel without it. Source: WHY Project.



Comparison of the distribution of the total electrical energy demand during Time of Use (ToU) and Price Signal (Gas) tariffs. Positive values means total energy reduction. Source: WHY Project.

We need large-scale integration of non-controllable renewable energy generation to decarbonize the European economy. This undertaking requires large amounts of storage capacity and flexibility from the energy demand side. To date, solutions tackle this issue by the use of reversible hydroelectric power stations, large battery banks and markets to reduce the energy consumption from industrial sectors. These approaches have their own set of problems:

- The lack of suitable geographical locations,
- They are very expensive, and
- They only solve some of the situations.

Under the current pathway defined for the energy system, the provision of flexibility from buildings and the residential sector is expected to contribute significantly in the near future.

The flexibility potential from buildings and the residential sector come from the use of residential energy equipment (such as heat pumps, energy storage and bidirectional electric vehicles charging points, etc.) or human behavioural changes. Our research shows that the potential flexibility that can be extracted from behavioural changes is small (between 1 and 9 %) and leads mostly to behaviour changes in people at risk of poverty. Nevertheless, interventions to influence energy consumption patterns of people are very cheap and fast to deploy by simply implementing a time of use or a dynamic tariff.

Taking this into account, if a change of the tariff is an action to be implemented in an area were an small number of households do not own devices able to provide flexibilities, this tariff should:

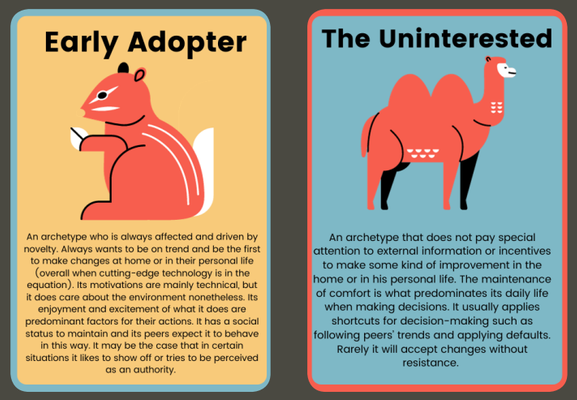
- **Be simple.** Time of use tariffs are easier to follow by humans and allow reorganising tasks at home helping to reduce its impact.
- **Be clear.** The difference between the price of the energy in each period of the tariff have to be large enough to provide a clear incentive to change behaviour.
- **Help people that cannot change habits.** Add special provisions in the tariff system for large families and people at risk of poverty in order to reduce the impact. Prioritise providing large incentives to invest in special equipment that could solve this problem long term (like large rebates on the installation of PV panels or insulation).

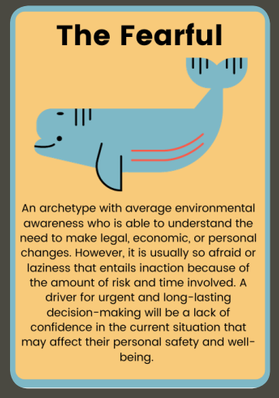
In case a dynamic tariff is implemented with an appropriate machine readable signal, it could be used by battery storages, heat pumps, air conditioners and electric vehicle chargers, to provide larger sources of flexibility to the system. Therefore, the long term solution will be the electrification of the heating and transport sectors with the inclusion of smart devices that can follow a price signal (or congestion signal in local flexibility markets).

WHY research shows that once dynamic energy tariffs are introduced, the flexibility potential from the residential sector greatly increases. Nevertheless, this solution requires an effort in the creation of local flexibility markets and the standardisation of communication protocols between home devices and Distribution System Operators (DSOs) in order to properly work. **While the Smart Grid Ready standard is a good first step**, using for example the mass of the building stock as flexibility potential requires not just a smart control of the heat pump itself, but also of every single thermostat in the building. **The next step should be the creation and enforcement of a unified standard and mandatory interoperability.**

4.

People are diverse so you need to take that into consideration when planning an intervention





Final set of investment archetypes found. Source: WHY Project

Research has shown that people's decision making is not only based on a cost-efficient approach (Rational choice theory). Other dimensions, like previous knowledge, the self-competences, or trust on the technology, play an important role when adopting new technologies. For example, experience has shown that when certain types of people (early adopters) are present in a neighbourhood, the adoption of technologies is accelerated.

Until now, most of the policy interventions to foster the adoption of certain technologies have been based on improving the cost-efficiency of the technology (namely, fiscal incentives or grants) and other aspects have been neglected.

In WHY, an extensive research activity showed that decision-making aspects related to competence and relatedness are as important need as the financial motivation when it comes to taking an investment decision related to the energy transition. This is why **it is important to contemplate actions to increase the competencies of all the stakeholders** (including sellers, installers and citizens) **when designing policy measures to foster the adoption of certain technologies**. Our results also prove that **providing messages that relate the technologies with social values** like the support to the community will lead to the improvement of living conditions and community engagement. Taking this into consideration, we recommend policy makers to:

- **Understand:** assess your target group trying to understand its motivations beyond the financial incentives. In WHY we have prepared a toolkit for this.
- **Engage Champions:** foster the emergence of early adopters in the community that will help you naturally to diffuse the knowledge of the technology. In fact, local authorities are usually among the most relevant champions.
- **Build Competences:** help all stakeholders to acquire competences on technology. Citizens need to understand the pros and cons of the technology from reliable and trusted sources, installers need to be confident on how to proceed with them and sellers need to provide relevant and unbiased information.
- **Nudge:** provide financial incentives and carry out marketing campaigns to increase the visibility of the technology and help to increase the cost-efficiency of the technology.

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