WeForming

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What is demand response and why do we need it?

The term “demand response”

To ensure the normal operation of the electric power system, generation and consumption must always remain balanced. Since the inception of power systems, generation has adjusted to changes in consumption to maintain this balance. This was relatively straightforward when thermal power plants, whose production could be precisely predicted based on fuel intake, dominated the energy mix. As a result, the demand side could remain passive, responding solely to its immediate needs. However, the shutdown of such power plants, due to their high greenhouse gas emissions, has reduced (and will reduce even further) the system's ability to maintain the generation-demand balance. This necessitates alternative sources of flexibility — actors in the power system capable of adjusting their production or consumption levels to maintain balance. In addition to commonly discussed solutions like battery storage and hydrogen technologies, a significant source of flexibility lies within the previously passive demand side. Activating this flexibility, by increasing or decreasing consumption, is known as **demand response**.

How do we achieve it?

System needs can be communicated through indirect signals, such as varying tariffs that encourage **implicit demand response**. The goal is to prompt rational end users to consume electricity during periods favourable for the power system.

This type of demand response is already implemented in several European countries. Another approach involves directly motivating end users to change their consumption patterns (e.g., by delaying device operation) using financial incentives, referred to as **explicit demand response**.

Explicit demand response is currently provided mainly by industrial consumers, who are well-suited for this role due to their large electricity demand, functional SCADA systems, and predefined demand schedules. However, a much larger number of potential providers exist in the residential and commercial sectors. Most households and offices own heating and cooling devices, which have been increasingly electrified in recent years. Many households also use traditionally electricity-powered appliances, such as dishwashers and washing machines.

With the advent of smart features that enable remote management, households and offices are becoming viable sources of flexibility. Yet, despite the large number of appliances in these sectors, their individual consumption remains negligible at the system level. Therefore, it is essential to aggregate a significant number of households and offices and manage their consumption in a coordinated way.

There are multiple barriers to full rollout

The aggregation of end-users in the residential and commercial sectors holds great potential, but this theoretical potential for demand response services remains largely untapped in practice. The reasons for this can be categorized into three main factors: technical, financial, and psychological.

Although most households and offices are equipped with a large number of devices and the process of electrification is progressing, the majority of these devices still lack features for smart control or are not fully electrified. This technical obstacle complicates active participation of these end users in flexibility provision. However, with the rise of smart devices and accelerated electrification, this challenge is expected to diminish.

From the financial side, investing in new smart appliances could be an aggravating circumstance for end users, particularly if they already own functional devices that lack necessary features for service provision. Additionally, even if the end users are open to participation in the service provision, financial incentives are often insufficient or unclear.

However, psychological reasons represent the biggest challenge for a complete take-off of the demand response in a non-industrial environment. Firstly, end users behave as they see fit at any given moment, and from their perspective, there is no reason for them to change. It is in human nature to resist changes, especially when it involves changing something that is already functional and satisfactory. Electricity costs are generally not high, so it would be difficult to get the end users to actively participate in the power system for only minimal savings. Furthermore, participating in explicit demand response often requires granting access and control over their appliances to a third party, such as a system operator or aggregator, which end users might be unwilling to do. They feel that they should retain control and ownership of their devices and find it difficult to give them up.

One of the key psychological reasons is a potential disruption of user comfort that arises from providing services to the system. Reducing the intensity of heating or cooling when the user wants to increase it, or postponing the dishwashing from the desired starting time, are examples of end-user consumption reduction that can lead to physical discomfort or disrupt their daily schedule.

To overcome these challenges, well-designed control models are needed to ensure that end-users feel no inconvenience, except for the reduction of their electricity costs, which would motivate more active participation in supporting system stability.

WeForming and demand response

The value of bringing demand response closer to end users is highlighted in WeForming **deliverable D2.1.** In this document, we discuss devices capable of actively participating in demand-side management, emphasizing both individual devices and structural elements (e.g., windows) that contribute to optimizing such strategies. Additionally, we explore the key characteristics a smart building must possess to fully embody the concept of Intelligent Grid Forming Buildings (IGFBs). For those starting their research on this topic, deliverable D2.1 can serve as an excellent starting point.

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Nikolina Čović joined the Faculty of Electrical Engineering and Computing (FER) at the University of Zagreb in 2020 as an assistant, concurrently starting her doctoral studies. Her research focuses on providing flexibility services with low-carbon technologies in the power system, specifically through modeling hybrid power plants and demand response of household appliances using linear programming and machine learning.

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