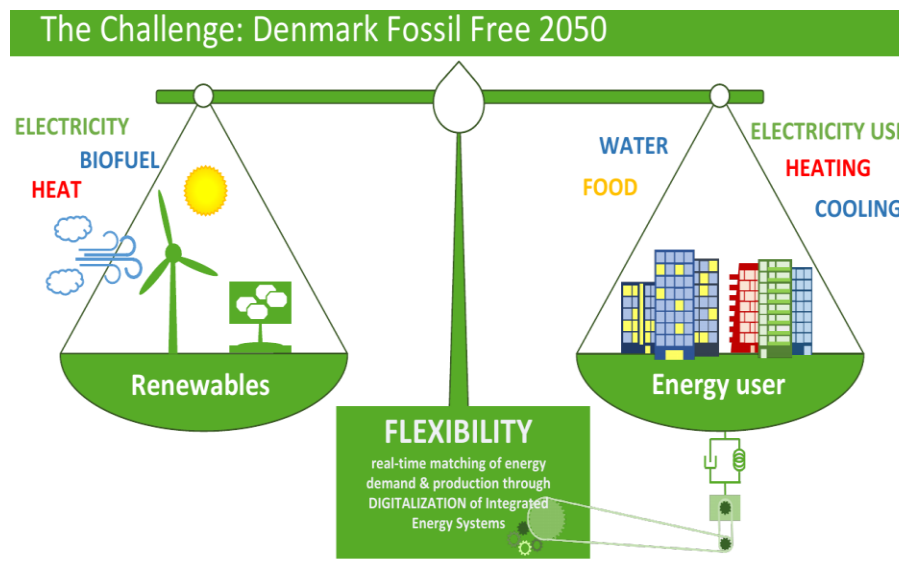# Project: Flexible Energy Denmark (FED)

Figure 1: Flexible Energy Denmark establish the tools and solutions for enabling the end-user flexibility for large-scale integration of wind and solar energy.

Summary of project

In the FED project we analyze large amounts of consumer data and consumer behavior. The ambition is to enable the development of digital solutions that are capable of adjusting the power consumption to fit the power production – among other things by use of Machine Learning and different tools for handling Big Data. In FED we develop methods for forecasting of wind and solar power production, as well as methods for an efficient integration of the renewable energy production by a next generation of controllers for heat pumps, supermarket cooling, wastewater treatment, district heating operation, and for using buildings as energy storage solutions in an integrated energy system.

A key focus of the FED project is to deliver a next generation of smart grid solutions, such that the flexibility in integrated energy and water systems can be used for providing grid services.

As a result, Denmark's new national research for green transition, Center Denmark, is also among the partners in the FED project. Their role will be to make the knowledge that the FED project creates available to the entire energy sector in Denmark. This will allow the solutions and results of the project to be applied as widely as possible.

Example: Heat pumps in summer houses with a swimming pool

In 2020 in Denmark, approximately 10 % of the available wind power generation was lost, and in 2021 the fraction of lost green energy production will increase; for the last few months about 16 % of the available wind power was lost.
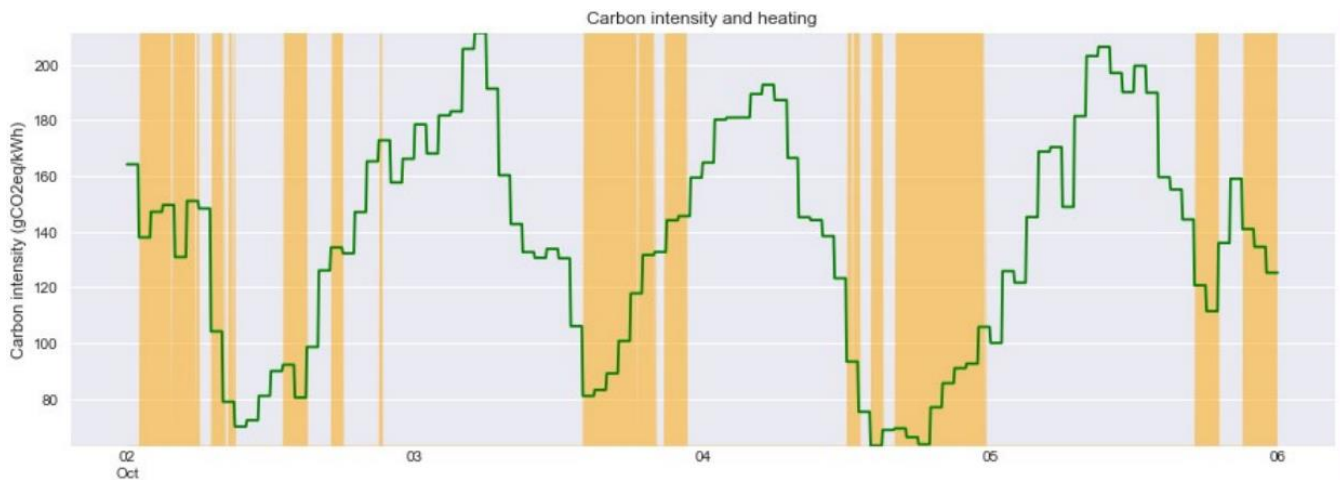
Figure 2: Predicted carbon intensity (green) and periods at which the heat pump is turned on (orange). The installation is located in Denmark.

Summer houses with a swimming pool consume substantial amounts of electricity for the heating and humidity control. In the FED project we are using the flexibility of summer houses to lower the carbon emission and for providing grid services.

The electricity demand from summer houses is particularly flexible. For example, swimming pools have a large thermal mass, thus, the load to heat pool water can be disconnected or shifted with little consequences on the comfort of the occupants. This makes them particularly well-suited to the provision of ancillary services and balancing. Field testing of the proposed setup involves a small but representative number of summer houses. For this living lab in FED it has been decided that 15 houses, located in Blåvand in Denmark, would be enough proof-of-concept.

Using the Smart-Energy OS (SE-OS) the CO_2 - or price-based indirect control provides a setup for storing excess wind and solar power, and at the same time the setup can provide services for the smart grids. Here the Distributed Energy Sources (DERs), i.e., swimming pools, after receiving the control signals, calculate: i) the optimal consumption profile within the forecast horizon, and

ii) the set-point for the thermostat of each individual summer house. The control signal is based on the grid load forecasts, electricity price or CO_2 forecasts, weather forecasts from ENFOR (forecast provider), and booking information from NOVASOL (summer house rental company).

The results show that, depending on the actual layout of the summer house, we are able to save 15-30 % CO_2 emission or similar cost savings with the smart control of the heat pump, and at the same time we can provide both balancing and grid services. Please see figure 2 for predicted carbon intensity and periods for heat pump operation.

The energy consumption may at the same time increase with 5 % - but in a low CO_2 emission or cost period.

A similar technology can be used to control heat pumps e.g. in district heating networks. Using forecasts and model predictive control the water is heated when the CO_2 emission or price is low.

The setup is a part of Uni-Lab.dk under Center Denmark, and a living lab under the Flexible Energy Denmark project.

FACTS ABOUT THE PROJECT

IoT catagory: Grid services, optimize heat pump operation, grid services, cloud-based solutions.

Goal: Minimize cost and emission while optimizing the comfort.

Beneficiary: Many options.

Data required: Weather forecasts, CO_2 emission, price and load forecasts.

Analysis method: Cloud based solution using forecasting and model predictive control.

Modelling requirements: Grey-box or data-driven digital twin models are needed.

Quality-of-services: Near real-time.

Project participants: Several network operators and balance responsible parties. Forecasting and control providers.

Time schedule: 2019-2023

Budget: 45 mio. DKK.

Technology availability: TRL 7

Link to webpage:

https://www.flexibleenergydenmark.com/

Contact information

Henrik Madsen
✉ hmad@dtu.dk
📞 +45 20 83 43 04