CITIES
Centre for IT Intelligent Energy Systems

Dynamic CO2-based control of summerhouse swimming pool heating

Objective

The task in this demo project is to demonstrate the feasibility of controlling electricity-based heating of summerhouse swimming pools, in order to minimise total emissions. Swimming pools are flexible in the sense that due to their thermal inertia, it takes a rather long time for them to heat and cool, meaning that the time at which they are heated, can be chosen such as to minimize emissions while still respecting comfort requirements.

Partners

- NOVASOL (http://www.novasol.dk)
- DTU Compute (www.compute.dtu.dk)
- ENFOR (http://www.enfor.dk)
- Tomorrow (http://www.tmrow.co)
- SE (http://www.se.dk)

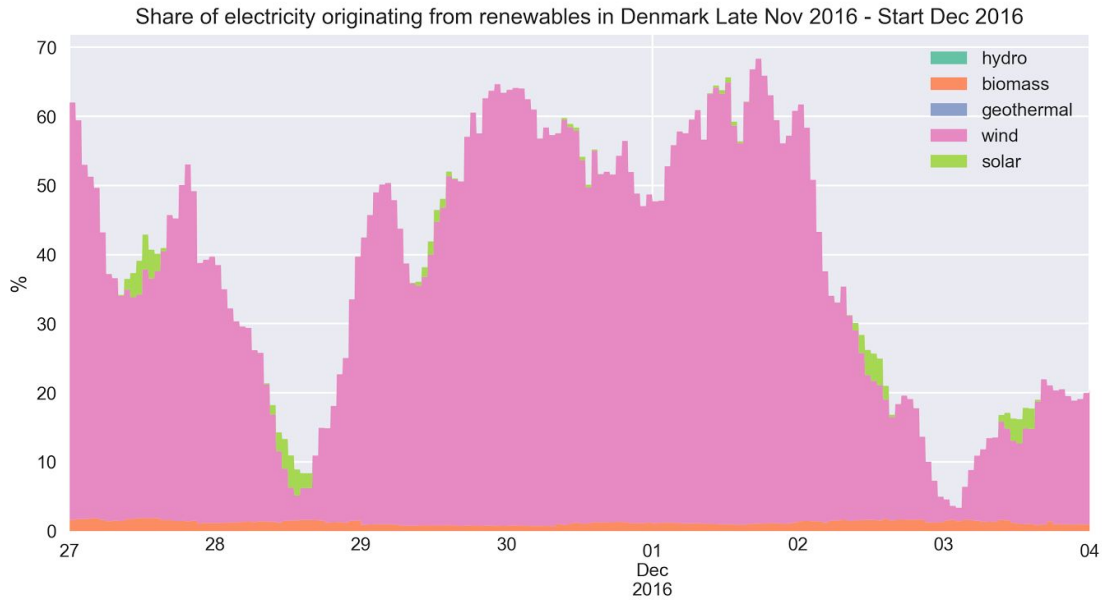
Background

This project will first of all demonstrate the use of CITIES developed controllers and forecast systems for heating the pools in a way which minimises the total CO2 emission. As a secondary objective the same setup can be used to do price-based control. This also gives the opportunity to solve some ancillary service problems in low voltage grids (DSO grids). This is, however, not the focus of this demo project, but these possibilities will be studied in the related H2020 SmartNet project, and the same setup and hardware will be used for both CO2-based and price-based control.

In the future electric energy system one of the main challenges will be to keep the voltage level in weak DSO (low voltage grids) areas close to the reference. This challenge is even more pronounced in areas with a lot of summerhouses, since the use of the houses are less predictable, and because the electricity grid here is often rather weak. However, summerhouses with swimming pools constitutes large energy storages which can be used for solving some of the issues related to the electricity grid. SE has recognized the need for being active in studying solutions of the future for DSO operators, and trying to provide solutions which minimizes the carbon footprint, and hence SE participates in this project.

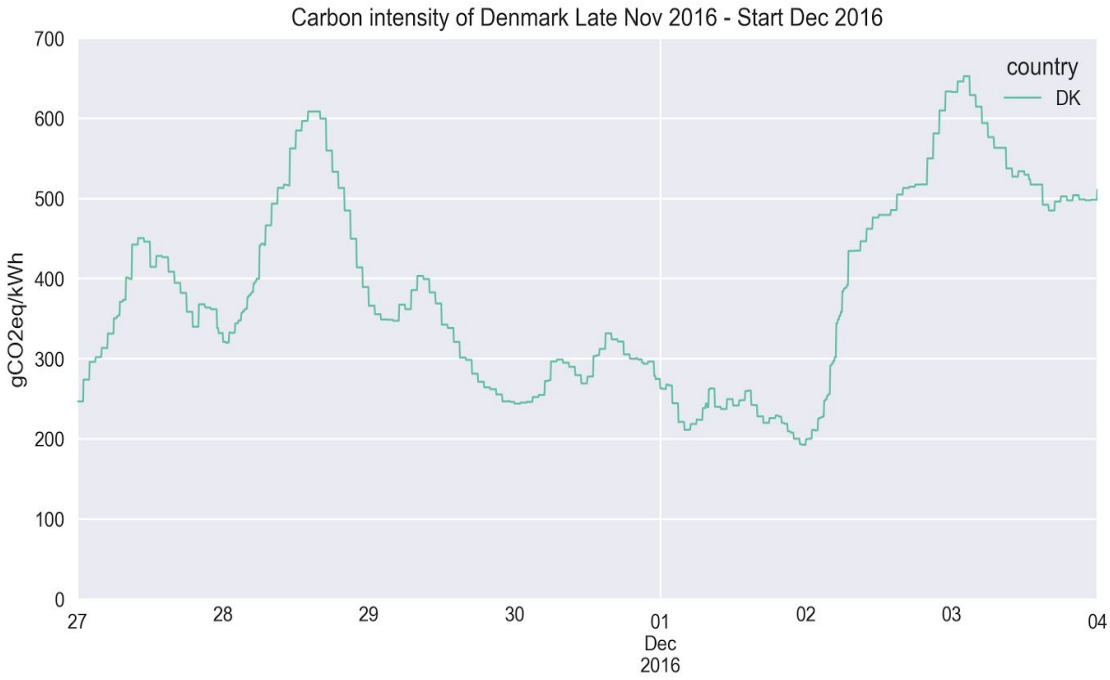
The purpose of this demo project is, however, to demonstrate a setup of model predictive control of the heating of the swimming pools which aims at minimising the CO2 emission. The houses considered here are using a heat pump.

The share of renewable-based electricity varies significantly and rapidly, as seen below:

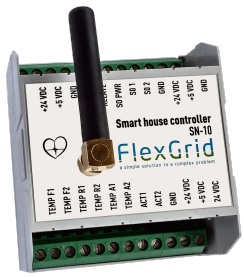


(data computed based on historical data from http://www.electricitymap.org). This translates into a very volatile **carbon intensity** (i.e. the overall emissions required to produce 1 kWh of electricity):

It therefore makes sense to optimise with respect to total emissions, by incentivising flexible devices to consume when the carbon intensity is low. Tomorrow will provide the CO2 signals and assist in a development of CO2 forecasts.

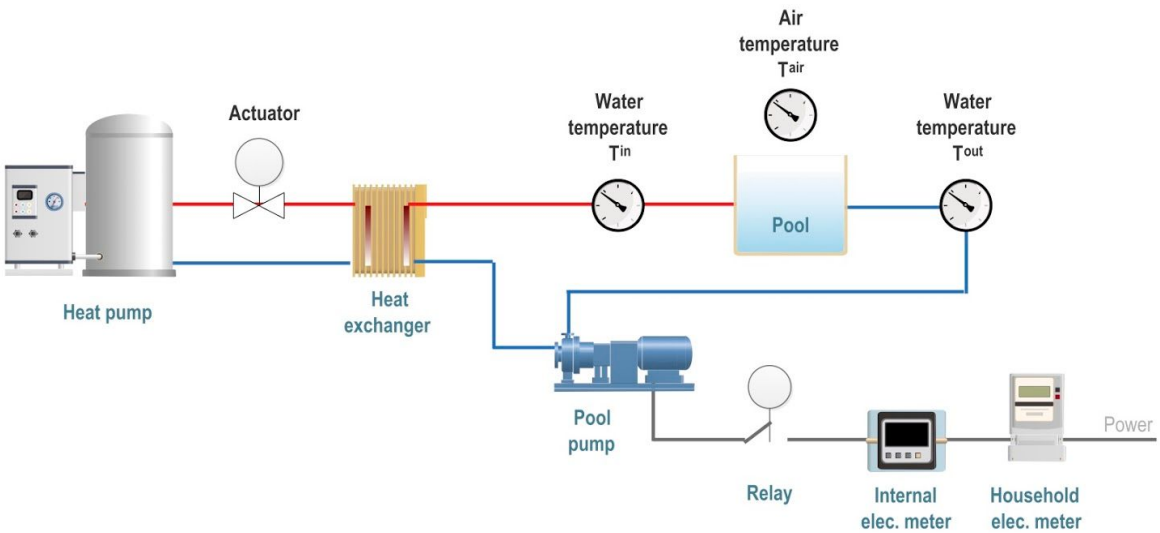


Description



Test setup

In this test setup, the *actuator* hereunder is a controllable thermostat listening to a signal from the local controller (called SN-10). The SN-10 unit controls the actuator in order to keep the controlled pool temperature (outgoing water temperature) close to a setpoint.



That setpoint can be lowered or increased temporarily in order to save energy or to preheat, depending on the expected CO2 intensity of electricity consumed.

Forecasting and Control

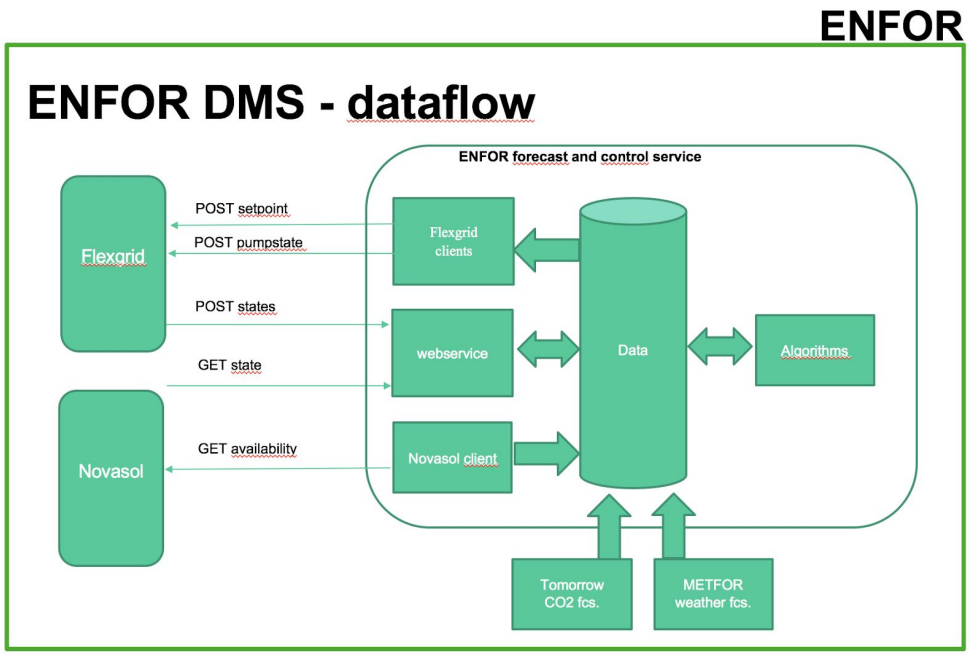
DTU will (assisted by Tomorrow and ENFOR) develop the methods and algorithms for forecasting and model predictive control. DTU is also responsible for finding the most suitable models for the controllers. The initial models might be ARX type of models whereas regime switching models will be considered at a later stage. The need for the regime based models arrives due to the fact that the dynamics of the house and the pool will depend on the use of the summerhouse and maybe also on the number of people and/or the activity levels. The algorithms for control will be implemented at the DMS and cloud computing facility operated by ENFOR. The algorithms for CO2 forecasting will be implemented by Tomorrow.

Data Management System and Cloud Computing

The Data Management System is hosted by ENFOR, so all the data is hosted here, and the interaction with the system takes place via this setup. The Cloud Computing facility at ENFOR also hosts the controllers.

The ENFOR services, which is illustrated on the figure below, consists roughly of the following 6 parts:

1. **Web-service:** Supports requests for data upload from FlexGrid, ie. the house data, and requests latest house state from Novasol.
2. **Tomorrow client:** Fetches CO2 forecasts made by Tomorrow
3. **FlexGrid client:** Uploads water temperature setpoints and pump status to FlexGrid
4. **Novasol client:** Fetches availability schedules from Novasol web-service
5. **Weather forecasts:** Provides local weather forecasts
6. **Algorithms:** Forecasts and control based on house data and the weather forecasts
7. **Data storage and management:** Includes a graphical user interface



Connection with CITIES WP's:

- WP1: User behavior, load profiles
- WP3: Assistance on model for the summerhouses
- WP5: Forecasting of load and CO2 emissions AND model predictive control

Deliverables

- Setup for CO2 based control of heat pumps
- CO2 signals and forecasts
- Predictive controllers for heat pumps
- Data management system
- Models for the thermal dynamics of summerhouses with a swimming pool

Time schedule

April 2017 to December 2017