CITIES
Centre for IT Intelligent Energy Systems

Load forecasts for Greenhouses

Objective

Collect data from Greenhouse consumers and weather observations. Derive an offline model structure for load forecasting in greenhouses. Establish an online setup for load forecasting in greenhouses. In the online setup the model parameters should be adapted to the actual dynamics.

Compare or formulate costs when load can be delayed or pushed forward in time. The energy price will influence on the distribution profile. Ultimative model based predictive control of supply temperatures will be derived with the purpose of reducing the heat loss and the pumping costs.

Partners

- Fjernvarme Fyn A/S
- DTU Compute
- DTU Byg
- Enfor
- Eurisco ?

Background

Pipes in the street are dimensioned after a certain demand and a payback time over 30 years. District heating network is a dynamic system that changes the characteristics over time. Consumers reduces their demand by insulating their buildings, or increase their demand by extending their building. Rather than changing the pipes in ground, a change in the distribution pattern or a control of the supply temperature is more reasonable. To find this distribution optimum it is important to know the load in a branched network ahead of time, to be able to optimize the flow temperature to reduce the heat loss and pump costs. If the payback time is acceptable additional components could be a part of the solution.

Connection with CITIES WP's

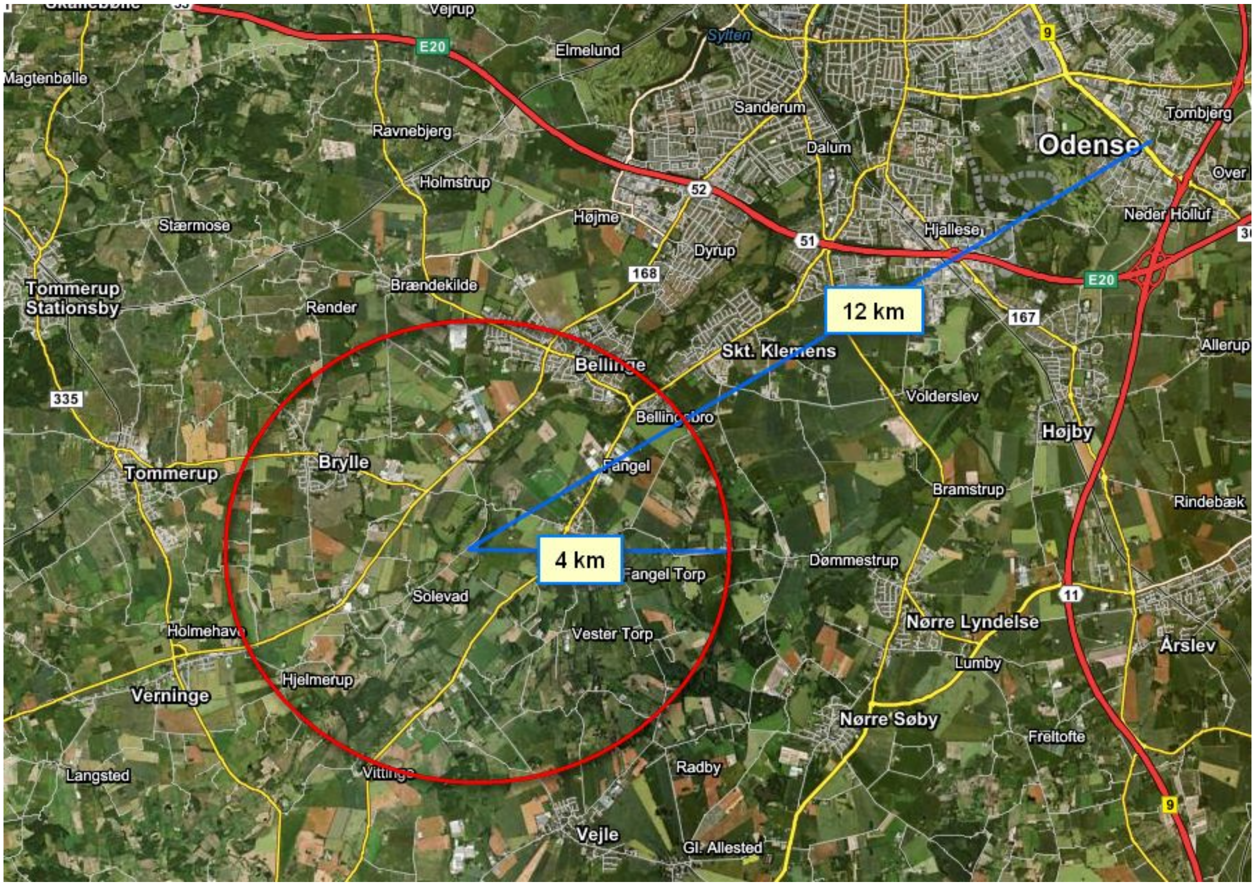
- WP1: User behavior, load profiles
- WP3: Models for heat dynamics of buildings
- WP5: Forecasts of electricity prices and load, methodologies for model predictive control.

Description

Consumers in this demo case is Greenhouses which are characterized by having a large heating demand and being very sensitive to the solar radiation, that makes the heat load very fluctuating compared to ordinary family houses. It is expected that the model parameters needs to be adapted to the individual greenhouse, since the plants and the activity varies throughout the year. Instead of having a year long data history, that is not necessary compatible with the actual plants, it is maybe more convenient to try to have only a week of floating history, that generate a set of floating model parameters, in hope of a acceptable adoption model that doesn't need any manually adjustments, even when growth items are changed. Methods for automatic calibration of model parameters will have a high priority.

Available data

Greenhouses consumption are recorded hourly as accumulated energy, accumulated volume flow, temperature forward and return. Weather observations are recorded (approx. 12 km +/- 4 km, see picture below). More specifically temperature, wind speed, wind direction, and solar radiation (global radiation spectrum 380-1100 nm) radiation hourly (running average logged every hour, raw data sampled every 1 minute). The meteorological observations are available from a site placed rather far (approx. 12 km +/- 4 km, see picture below) from the greenhouse, so a time adjustment according to the wind speed and position of the greenhouse might be necessary.
Forecast are obtained at the same place as the observation, with the same parameters, so here it will be necessary to make the same time adjustment as for the observations.



Time correction for geographic displacement

To compensate for a geographic displacement between observation and a specific greenhouse, it will be necessary to calculate a time correction.

Stochastic model for greenhouse demand

A universal model should be developed for greenhouses, but for the individual house the parameters must be adapted. Model parameters should be generated from observation obtained over a time horizon of one week (this we don't know yet). It is important that the model is transparent, and defined by parameters, so it doesn't need to be a black box model, and secondly generate a load forecast time series form weather forecast time series (houer values, 124 hours ahead).

Scenario simulator

Different scenarios should be simulated to find the cost minimum of time depending prices, pushing or pulling the load in time. A financial overview will be indicating if an investment in a storage tank is a good idea.

Forecast services for optimal control of supply temperatures to greenhouses

Forecast services are crucial for optimal decision-making, production planning, trading of power and for control of district heating network. In this section we briefly describe the list of forecast services needed, discuss the statistical forecast characteristics, and illustrate how the forecasts can be used in optimal control and decision making.

It is clear that forecasts are needed both on a day-to-day basis, e.g., in order to provide input for the market clearing, and for the optimal production planning, as well as on a shorter horizon, e.g. in order to use the flexibility of the distributed energy resources to control the electricity load.

The predictive controllers considered are based on forecasts of load, prices, etc. The forecast services needed depend on whether Direct Control (DC) or Indirect Control (IC, also referred to as or control-by-price) is implemented:

- Load (demand or flexibility) forecasts (for both DC and IC)
- Price forecasts (only for IC)
- State forecasts (e.g. room temperature) (only for DC)

In all cases it is assumed the appropriate meteorological forecasts are available.

Deliverables

- Greenhouse observations (Fjernvarme Fyn)
- Weather observations (Fjernvarme Fyn)
- Weather forecasts (Fjernvarme Fyn / Enfor ?)
- Offline model structure for load forecasts (DTU Compute)
- Online and predictive model for load forecasting (DTU Compute / Enfor)
- Scenario simulator (Fjernvarme Fyn)
- Report (all)

Time schedule

March 2016 to March 2017