System Identification Competition No. III
JB,PB,MJ,HM
SIC III – 2007-8

SIC III

CASE 3:
Modelling the Heat Consumption in a District Heating System

This case consider the modelling of the heat consumption in a large district heating systems, called VEKS (Vest-Egnens KraftvarmeSelskab). This system actually covers about half of the Copenhagen area.

VEKS is a transmission company supplying heat to 19 local district heating companies at Western part of Copenhagen. The local district heating companies then resell the heat to private consumers, business customers and institutions. VEKS was established in 1984 with the aim of utilizing surplus heat generated from combined heat and power (CHP) plants as well as from waste incineration plants and major industrial enterprises. A further description is found here:

`http://www.veks.dk/Om%20VEKS/Varmeproduktion/Fjernvarme.aspx`

The purpose of this study is twofold: First we should characterise the heatload in the system, and try to describe how the heatload depends on changes in the weather. Secondly, we should consider the forecast of the heatload which is needed for an optimal control of the produced heat.

Due to the transportation time in the pipes, time delays exist between the control variable (the supply temperature at a plant) and the temperatures at the consumers. Therefore, in order to be able to control the supply temperature, a prediction of the heat consumption for the next hours is needed. Furthermore, the heat load depends on the heat dynamics of the buildings attached to the district heating network.

Purpose of this case

The purpose of the project is to investigate time series of measured heat production in the VEKS (Vest-Egnens Kraftvarme System) district heating system, and to establish models for predicting the heat consumption one to several hours ahead.

Furthermore, the dynamical characteristics of how the heat load depends on the climate variables should be described.

The results also provide us the background for building optimized controllers for the district heating system.

The data

The data and a description hereof is found on the WEB.

One year of hourly measurements of the heat consumption, climate variables, etc. are found in the file

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veks.csv
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A description of the data and the data format is found in the file:

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veks.exp.variables
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The meteorological data originates from a climate measurement station called Højbakkegaard in Tåstrup. The meteorological data can be assumed to be representative for the climate data in the entire VEKS area. Also the meteorological data are further described in the above mentioned file. The climate data must be used only to solve the problems related to the following projects.

The file

```
veks.csv
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contains the most important values only, namely the **Obs number, Ambient air temperature (T_a), Wind speed (W), Global radiation (GR)**

As a first part of this study you should considered models, where only the observations of the heat load have been used to set up a model.

Later on you should identify a model which takes into account the variations of the meteorological variables. The purpose is to set up at model which describes the dynamical relations between the meteorological variables and the heat load.

Task No. 1

Make an analysis of the data. This should include a time series plot of the data.

Do we expect a stationary model? Do we expect a linear model?

Task No. 2

Estimate the autocorrelation functions and the relevant cross correlation functions.

Task No. 3

Try to formulate a model for predicting the heat load without considering the meteorological variables. The performance for a one-hour and six-hour prediction should be illustrated. Elaborate on your choice of model.

Task No. 4

In this task the best possible prediction model should be formulated using the met variables as well. The prediction performance for a one hour and a six hour prediction shall be described. Elaborate on your choice of model.

Task No. 5

Study in detail the dynamic response from the ambient air temperature to the heat load. Find the stationary gain from the temperature to the heat load. Plot the step response function from the air temperature to the heat load.

Task No. 6

Similarly you should also describe how the wind speed and the solar radiation influence the heat load.