

## **Modelling and Predicting the Heat Consumption<sup>1</sup>. Related to Chapter 6, 7 and 8 of the book**

### **Background**

In Denmark a considerable number of houses are connected to a district heating system. In a district heating system several production units may exist, and for the considered district heating system this is indeed the case. The production cost varies from production unit to production unit – the cheapest is often a waste incinerator plant. The varying consumption of heat means that some units need to be started or stopped. A startup of a larger heat production unit may take several hours. Hence it is beneficial to be able to predict the heat consumption several hours in advance.

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 in the next hours is needed.

### **Purpose of the assignment**

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

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<sup>1</sup>The assignment is found at [www.imm.dtu.dk/~hm/time.series.analysis](http://www.imm.dtu.dk/~hm/time.series.analysis)

## The data

The data originates from VEKS (Vest-Egnens Kraftvarme System), which delivers the heat to a large part of Copenhagen. A description of the VEKS setup is found at

<http://www.veks.dk/0m%20VEKS/Varmeproduktion/Fjernvarme.aspx>

One year of hourly measurements of the heat consumption, climate variables, etc. are found in the file<sup>2</sup>

`veks.csv`

A further description of the data and the data format is found in the file

`veks.exp.variables`

The meteorological data, which are needed in Task No. 3 and 4, originates from a climate measurement station called Højbakkegaard in Tåstrup near Copenhagen. 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.

In Task No. 1 and 2 only the measured heat consumption (and possibly the time) is considered, whereas in Task No. 3 and 4 various explanatory variables should be considered as well.

## Task No. 1

Consider the time series of heat consumption. Estimate the autocovariance, autocorrelation and partial autocorrelation functions for the heat consumption. Estimate the spectrum for the variations of the heat consumption. You should comment on the estimated correlation functions and spectrum.

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## **Task No. 2**

A model for predicting the heat consumption several hours ahead should be formulated, and the prediction performance should be analysed. In particular the prediction performance for a one hour and a six hour prediction shall be described. Elaborate on your choice of model.

In this task only the measured heat consumption (and possibly the time) should be used in the model.

## **Task No. 3**

From now on all the available data can be used. Estimate the cross correlation function between the heat consumption, the air temperature, solar radiation (global radiation) and wind speed. You should comment on the estimated functions.

## **Task No. 4**

The heat consumption depends obviously on, for instance, the (ambient) air temperature.

In this task the best possible prediction model should be formulated, and the prediction performance for a one hour and a six hour prediction shall be described. Elaborate on your choice of model.