ENERGY FORECAST USING LINEAR REGRESSION METHODS

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This thesis is submitted as partial fulfilment of the requirements for the award of the Master Degree of Electrical Engineering

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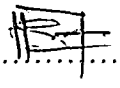
Signature : 

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ABSTRACT

Energy analysis and forecasting have always been the essential part of an efficient energy system planning and operation. This thesis presents the mathematical methods based on regression analysis and energy profiling for energy modelling and forecasting. Two applications of energy were analyzed such as energy heating demands and electricity demands. The methods are applied for the Energieversorgung Offenbach AG (EVO) in Gravenbruch and Offenbach at Germany, using 1995 and 2003 data. The models of energy heating demands were developed based on simple linear and multiple regression methods. The Mean Absolute Percentage Errors (MAPE) are compared between two models. Two approaches to determine the typical energy profile are proposed. The two approaches use similar outdoor temperature for energy heating demand profiles and for electricity demands using similar electricity profile. The proposed approaches were able to determine the typical profiles of different type of day.

CONTENT

LIST OF TABLE

LIST OF FIGURE

LIST OF SYMBOL

^{o}C	Degree Celcius
EHD	Energy Heating Demand
T	Outdoor Temperature
ΔT	Temperature Difference
β_o	Regression coefficient
β_1	Regression coefficient
β_2	Regression coefficient
R^2	Coefficient of Determinations

CHAPTER I

INTRODUCTION

1.1 Overview

Over the last several decades, there has been an increase of activity in the field of energy management. Strategic energy management include modelling and forecasting, benchmarking, energy use and cost analysis, and measurement and verification [1]. These applications allow organisations to gain a comprehensive understanding of current energy performance, plan and select cost effective energy conversation measures, track performance of measures that have been implemented, and verify the savings realised. Energy management is the judicious and effective use of energy to maximize profits (minimize costs) and enhance competitive position [2]. Energy management practice has traditionally focused exclusively on technologies that increase the energy efficiently of key energy consuming process and equipment. Modelling, forecasting and profiling of energy are part of energy management strategic.

Modelling building or process energy usage normally involves gathering energy demand data and plotting this against some variable (such as outdoor temperature or humidity) that represents the primary driver of that energy consumption. As an example, consider the scatter plot in Figure 1.1 showing the energy heating consumption versus outdoor temperature.

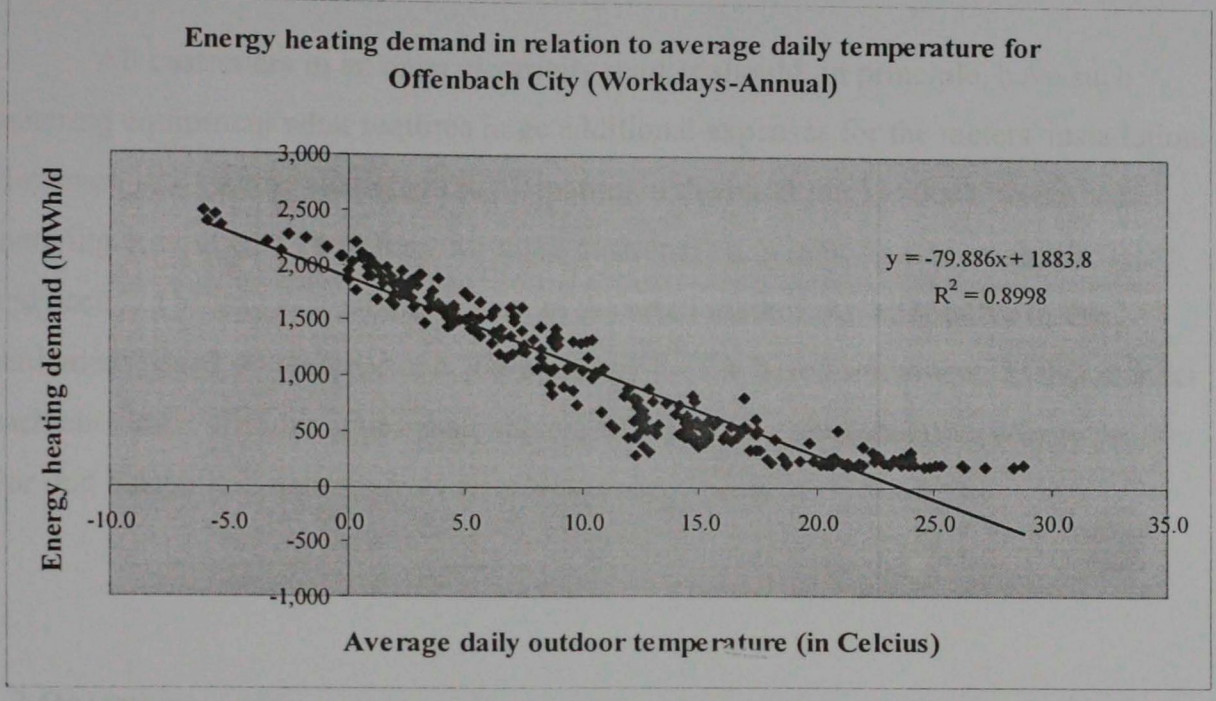

Figure 1.1: The energy heating demand versus outdoor temperature.

This model can be used to forecast the energy demand. The property has a number of useful applications, ranging predicting energy heating consumption for scheduled generation run to predicting the energy savings possible if proposed energy efficiency measures are taken. Accuracy of the energy forecasting has influence on security and efficiency in energy supply.

Energy profiles in the deregulated power systems are becoming critical for distribution companies or supplier. While in the regulated environment such information has been used for financial planning [3], demand-side management [4], system planning [5] or better tariff design, in the deregulated systems this information has considerable impact on the settlement price between customers and their suppliers. By knowing customer's energy profile, distribution companies or other suppliers can simply determine the price of the customer's demand. Thus they can provide better marketing strategies and improve efficiency. The problem is easily solved for the large eligible customers participating at the wholesale market since they have appropriate meters installed.

All customers in an open electricity market should, in principle, have such metering equipment what requires huge additional expenses for the meters' installation. However, most of the customers participating in the retail market don't posses such metering equipment. Therefore, for these customers it is important to establish "fair" and accurate billing system and access to the retail market. An alternative to the settlement based on metered demand is energy profile based settlement. In this manner each customer, without appropriate meters, is assigned a representative energy profile. For that reason it is necessary to determine energy profiles.

1.2 Objectives

The main objectives of this study are to model and forecast the energy demand using mathematical method and energy profiles determination.
The following studies to achieve the objectives proposed are:

- To develop a simple model to predict the energy heating demand of building and industrial enterprise by regression analysis.
- To study a relationship between energy heating demand and outdoor temperature using regression analysis.
- To present a method for energy heating forecasting.
- To determine the typical energy heating profile

Two applications of energy forecast were analyzed:

- Energy heating demand based on influence factor (etc: Outdoor temperature)
- Electricity demand based on time series

1.3 Organisation of this thesis

This thesis is divided into 6 chapters.
Chapter 2 described the literature for model of energy and forecasting. Within the literature review, the model of energy analysis and forecasting in previous work were presented.

Chapter 3 consists of two parts discussing the economic of energy and mathematical method for energy analysis and forecasting. Part 1 starts with the overview of liberalization of energy, the impact of liberalization of energy market and solution for liberalization of energy. The mathematical methods for energy analysis and forecasting are described in Part 2.

In Chapter 4, the research methodologies were presented. The methodology describes the steps taken to answer the research questions. Presentation of data collected compiles pertinent tables and charts collected during the research.

Data analysis follows with a statistical and graphical review of the information presented. All the results are presented in Chapter 5.

Chapter 6 discusses all the result for energy analysis and forecasting.
The thesis closes with the conclusions and recommendations in Chapter 7.

CHAPTER II

LITERATURE REVIEW

2.1 Review of methods or technique in published literature

A survey of the published literature dealing with the modelling, forecasting and profiling of energy demand was performed. The emphasis of the survey was on methods that would be useful to consider for modelling, forecasting and profiling. Methods used to analyze energy demand data were also examined for applicability to the buildings of interest for this study. From the sources reviewed, 11 reports of interest to this survey were identified in the literature. There were two principal sources for these reports: the thesis and IEEE Transactions for the years 1985 to 2004.

Five general approaches were developed to define the modelling, forecasting and profiling methods found in the literature. These approaches are using:

- Statistical approaches like the Box and Jenkin's model, exponential smoothing, linear and multiple regressions, adaptive and weather models
- Expert system
- Artificial neural network
- Fuzzy Logic

Several review based on regression analysis will be below: