PREDICTION MODELING FOR FUTURE ELECTRICAL ENERGY DEMAND IN MALAYSIA

By

IMTIAZ AHMAD KHAN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

September 2006

DEDICATION

To my family & friends

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman: Associate Professor Ir. Norman Mariun, PhD

Faculty: Engineering

Accurate forecasting of energy requirement for future development of the country is one of the most important factors of energy management. Adequacy of energy is the main factor for the development of a country. Electricity producing natural resources are depleting very fast, all over the world, since their quantity is limited and their use is increasing very rapidly. But the pace of development can not be compromised. Financial limitations do not permit to, increase the generation capacity to meet the peak demand and produce surplus electricity after peak hours, and obtain new technologies of electricity generation. For installation and maintenance of generation capacity, transmission and distribution infrastructure long term forecasting is very important. Energy requirement depends on number of variables, some of them which are cardinal to the energy consumption and addressed here are population, number of electricity consumers, per capita electricity consumption, peak electricity demand, gross domestic product and annual electricity consumption of the country. Data for these variables are available annually and have very firm relation with time. These data were analyzed in this work. Annual electricity consumption has been taken as dependent and rest as

independent variables. All the variables have been evaluated for first, second and third order polynomial with time and mathematical relation was found. This mathematical relation was then extrapolated into future for next ten years, the forecast horizon. Out of these, evaluated values of independent variables having minimum standard deviation from the past data trend, were used in developing multi variable model. All the evaluation work was performed on MATLAB software. The chance of error is low in this model since it takes the variation of data into consideration and follows the previous trend by checking standard deviation. Once the data are keyed in the program it takes less than a minute in giving the forecasted values and its corresponding graph. The achievement of this work is that by just updating the data of the variables for recent year in the program the current updated forecast for next ten years can be obtained. This forecast may be of great use for energy managers. Since it is sensitive to six independent variables, it gives more reliable forecast. This program can be used for any country for the same forecast horizon with the assumption that the previous trend will persist.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

RAMALAN PEMODELAN PERMINTAAN ELEKTRIK MASA DEPAN DI MALAYSIA

Oleh

IMTIAZ AHMAD KHAN

September 2006

Pengerusi: **Profesor Madya Ir. Norman Bin Mariun, PhD**

Fakulti: **Kejuruteraan**

Ramalan keperluan tenaga yang tepat untuk pembangunan masa depan negara adalah salah satu daripada faktor-faktor penting bagi pengurusan tenaga. Tenaga yang mencukupi adalah faktor utama untuk pembangunan sesebuah negara. Sumber-sumber asli tenaga di seluruh dunia yang menghasilkan bekalan elektrik sedang berkurangan dengan cepat disebabkan oleh kuantitinya yang terhad dan penggunaannya yang sedang meningkat dengan mendadak. Namun demikian kepesatan pembangunan tidak boleh dikompromi. Pembatasan kewangan tidak membenarkan peningkatan kapasiti penjanaan bagi memenuhi kehendak puncak, penghasilan bekalan elektrik lebihan selepas waktu puncak dan pemilikan teknologi-teknologi penjanaan bekalan elektrik yang baru. Bagi pemasangan dan penyelengaraan kapasiti penjanaan, ramalan jangka masa panjang terhadap infrastruktur penghantaran dan pengagihan adalah sangat penting. Keperluan tenaga bergantung kepada beberapa pembolehubah yang mana ada di antaranya adalah yang utama bagi penggunaan tenaga seperti yang ditumpukan di sini iaitu jumlah penduduk, bilangan pengguna bekalan elektrik, penggunaan bekalan elektrik per kapita, kehendak bekalan elekrtrik puncak, keluaran dalam negeri kasar, dan penggunaan

bekalan elektrik tahunan negara. Data-data bagi pembolehubah-pembolehubah ini boleh diperolehi setiap tahun dan mempunyai perhubungan yang kukuh dengan masa. Data-data ini telah dianalisakan di dalam kerja ini. Penggunaan bekalan elektrik tahunan telah diambil sebagai pembolehubah bersandar dan yang lainnya sebagai pembolehubah tidak bersandar. Kesemua pembolehubah-pembolehubah tersebut telah dinilai untuk polinomial dengan masa order pertama, kedua dan ketiga and hubungan matematik telah dapat dijumpai. Hubungan matematik ini telah diekstrapolasikan untuk sepuluh tahun akan datang iaitu sebagai ruang lingkup ramalan. Dari kesemua ini, nilai pembolehubah-pembolehubah bersandar yang telah dinilaikan sebagai mempunyai pelencongan piawai dari arah aliran data yang lampau yang minima telah digunakan di dalam membangunkan model pembolehubah rantaian. Kesemua kerja penganalisaan telah dilaksanakan dengan menggunakan perisian MATLAB. Kebarangkalian kesilapan di dalam model ini adalah rendah kerana ia mengambil kira perubahan ke atas data dan mengikuti arah aliran terdahulu secara pemeriksaan terhadap pelencongan piawai. Sejurus data-data tersebut dimasukan ke dalam perisian ini, ia mengambil masa selama kurang dari satu minit untuk memberi nilai-nilai ramalan dan graf sepadan. Pencapaian dari kerja ini ialah bahawa dengan hanya mengemaskini data-data pembolehubah bagi tahun lalu di dalam perisian tersebut, ramalan terkini yang terkemaskini untuk sepuluh tahun akan datang boleh diperolehi. Ramalan ini mungkin bermanfaat untuk pengurus-pengurus tenaga. Oleh kerana ianya sensitif terhadap enam pembolehubah tidak bersandar, ia menghasilkan ramalan yang lebih dipercayai. Perisian ini boleh digunakan untuk mana-mana negara bagi ruang lingkup ramalan yang sama dengan andaian bahawa arah aliran terdahulu akan berterusan.

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I certify that an Examination Committee has met on 18th September 2006 to conduct the final examination of Imtiaz Ahmad Khan on his Master of Science thesis entitled "Prediction Modeling for Future Electrical Energy Demand in Malaysia" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Senan Mahmod Abdullah, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Ishak Aris, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Norhisam Misron, PhD
Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Abdullah Asuhaimi Mohd Zin, PhD
Professor
Faculty of Electrical Engineering
Universiti Technology Malaysia
(External Examiner)

HASANAH MOHD GHAZALI, PhD
Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

Norman Mariun, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Mohammad Saleem, PhD
Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Mohd Amran Mohd Radzi
Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Member)

_____
AINI IDERIS, PhD
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

_____

IMTIAZ AHMAD KHAN

Date:

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LIST OF ABREVIATIONS

Exp	Exponential
POP	Population
PCEC	Per Capita Electricity Consumption
NC	Number of Consumers
PDE	Peak Demand of Electricity
GDP	Gross Domestic Product 1995 Price and 1995 US$
AEC	Annual Electricity Consumption
X1	Time period (eleven years; 1993 to 2003)
X11	Time period (twenty one years; 1993 to 2013)
X111	Time period (36 years; 1978 to 2013)
X2	Population data in Millions for time period X1
X3	Per capita electricity consumption in multiple of 100kWh for time period X1
X4	Number of consumers in multiple of 0.1Millions for time period X1
X5	Peak Demand of Electricity in multiple of 1000MW for time period X1
X6	GDP in multiple of US$ Billions for time period X1
X7	Electricity Consumption in multiple of 1000GWh for time period X1
t1	Time period of eleven years X1 represented by 0,1,2,…….., 10
t2	Time period of twenty one years X11 represented by 0,1,2,…….., 20
FOP	First Order Polynomial
SOP	Second Order Polynomial
TOP	Third Order Polynomial
Xi1	Matrix for calculating coefficients b for all variables, for X1 time period
Xi2	Matrix for calculating coefficients b for all variables, for X11 time period
b21	Coefficient for first order polynomial data for POP
b22	Coefficient for second order polynomial data for POP
b23	Coefficient for third order polynomial data for POP
X211	Population data for X1 time period for FOP

X212 Population data for X11 time period for FOP

X221 Population data for X1 time period SOP

X222 Population data for X11 time period for SOP

X231 Population data for X1 time period for TOP

X232 Population data for X11 time period for TOP

b31 Coefficient for PCEC for FOP data

b32 Coefficient for PCEC for SOP data

b33 Coefficient for PCEC for TOP data

X311 PCEC data for time period X1 for FOP

X312 PCEC data for time period X11 for FOP

X321 PCEC data for time period X1 for SOP

X322 PCEC data for time period X11 for SOP

X331 PCEC data for time period X1 for TOP

X332 PCEC data for time period X11 for TOP

b41 Coefficient for NC for FOP data

b42 Coefficient for NC for SOP data

b43 Coefficient for NC for TOP data

X411 NC data for time period X1 for FOP

X412 NC data for time period X11 for FOP

X421 NC data for time period X1 for SOP

X422 NC data for time period X11 for SOP

X431 NC data for time period X1 for TOP

X432 NC data for time period X11 for TOP

b51 Coefficient for PDE for FOP data

b52 Coefficient for PDE for SOP data

b53 Coefficient for PDE for TOP data

X511 PDE data for time period X1 for FOP

X512 PDE data for time period X11 for FOP

X521 PDE data for time period X1 for SOP

X522 PDE data for time period X11 for SOP

X531 PDE data for time period X1 for TOP

X532 PDE data for time period X11 for TOP

b61 Coefficient for GDP for FOP data

b62 Coefficient for GDP for SOP data

b63 Coefficient for GDP for TOP data

X611 GDP data for time period X1 for FOP

X612 GDP data for time period X11 for FOP

X621 GDP data for time period X1 for SOP

X622 GDP data for time period X11 for SOP

X631 GDP data for time period X1 for TOP

X632 GDP data for time period X11 for TOP

b71 Coefficient for AEC for FOP data

b72 Coefficient for AEC for SOP data

b73 Coefficient for AEC for TOP data

X711 AEC data for time period X1 for FOP

X712 AEC data for time period X11 for FOP

X721 AEC data for time period X1 for SOP

X722 AEC data for time period X11 for SOP

X731 AEC data for time period X1 for TOP

X732 AEC data for time period X11 for TOP

bp Coefficient for AEC with multi variables

X7f Final forecast values of AEC