

# UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF ELECTRIC LOAD FACTOR OPTIMIZATION TECHNIQUE WITH MULTI CRITERIA DECISION MAKING

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# DEVELOPMENT OF ELECTRIC LOAD FACTOR OPTIMIZATION TECHNIQUE WITH MULTI CRITERIA DECISION MAKING



SEYED AMIR HOSSEIN KHOSHSOLAT

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

January 2014

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# DEDICATION

ТО

My beloved family



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

# DEVELOPMENT OF ELECTRIC LOAD FACTOR OPTIMIZATION TECHNIQUE WITH MULTI CRITERIA DECISION MAKING

By

## SEYED AMIR HOSSEIN KHOSHSOLAT

#### January 2014

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Electric energy has an important role in daily human life. This energy, is the infrastructure for the electric energy industry. It is conveyed by three stages, namely generation, transmission and distribution systems for use by consumers. Consumers do not have a constant energy consumption over a daily hour and yearly days. The average and peak load of electric energy will be different. Load factor is defined as an average load divided by peak load. This study is concerned to modify this factor so that it could come close to unity (1) and the closer the better. Therefore the capacity and investment in electric infrastructures must be evaluated in coordination with peak load.

In order to optimize the load factor different potential alternatives usage on the demand side like renewable energy, combined cooling, heat and power (CCHP) systems, fuel cell, tariff management and other will be analyzed. However, some criteria for each alternative must be considered under the process of substitution. In order to select the suitable alternatives, this research used Fuzzy Multi Criteria Decision Making technique to develop the load factor optimization method. This method was used to evaluate data for local area of Tenaga National Berhad in Malaysia and West Mazandaran Regional Electric Company in Iran. Among the Multi Criteria Decision Making (MCDM) techniques, Topsis method was selected to develop the coding using MATLAB software. Furthermore, sensitivity analysis was used to analyze and verify the out put data and the logic of the optimization methodology through graphic user interface (GUI). The results of three specific case study show that the 10%, 15% and 20% aimed in the improvement of load factor gives us a sort of priorities from the best to the worst one. Depending on the condition of alternatives and those criteria, the output could be different. This shows the flexibility and compatibility of the optimization method which have been developed in this study. Other studies and demand side management (DSM) methods just were able to consider limited alternatives or criteria in load mitigation. However, the proposed method is able to make solution for any dimensions of decision making matrix in load factor optimization (LFO) course. It can be concluded that this method, by the first time, made a direct bridge between electric LFO and decision making in demand side management.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah.

# PEMBANGUNAN TEKNIK PENGOPTIMUMAN FAKTOR BEBAN ELEKTRIK MENGGUNAKAN PELBAGAI KRITERIA MEMBUAT KEPUTUSAN

Oleh

## SEYED AMIR HOSSEIN KHOSHSOLAT

#### Januari 2014

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Tenaga elektrik memainkan peranan penting dalam kehidupan manusia: Tenaga ini merupakan. infrastruktur bagi industri tenaga elektrik, Ia disalirkan kepada pengguna melalui tiga peringkat, iaitu sistem penjanaan, penghantaran dan pengagihan. Pengguna tidak menggunakannya berterusan sepanjang hari atau sepanjang tahun. Ini bermakna, beban purata dan beban puncak penggunaan tenaga elektrik akan berbeza. Secara defininya, faktor beban ditentukan dengan membahagikan beban purata dengan beban puncak. Kajian ini berkecenderungan untuk mengubahsuai faktor ini supaya hampir dengan 1. Oleh itu, keupayaan dan pelaburan dalam infrastruktur elektrik perlu dinilai dan diselaras dengan beban puncak basi mendapatkan beban puncak yang optimum, perbezaan potensi alternatif terhadap permintaan seperti tenaga boleh diperbaharui, sistem CCHP (Combined Cooling, Heat and Power), sel bahan api, pengurusan tarif dan lain-lain akon di analisis. Walau bagaimanapun, terdapat beberapa kriteria bagi mana-mana alternatif yang perlu dipertimbangkan dalam proses penggantian, bagi memilih alternatif yang sesuai, kajian ini menggunakan teknik, pelbagai kriteria membuat keputusan fuzzy untuk membangunkan kaedah pengoptimum faktor beban. Kaedah ini digunakan bagi menilai bagi. data daripada Tenaga Nasional Berhad bagi kawasan di Malaysia dan juga data daripada West Mazandaran Regional Electric Company di Iran. Antara teknik dalam pelbagai kriteria membuat keputusan, kaedah TOPSIS telah dipilih untuk dikodkan dalam perisian MATLAB. Selain itu, sensitiviti analisis digunakan telah dipilih bagi menganalisis dan mensahihkan data keluaran dan kelogikan methodologi peng optimuman melalui muka pengguna grafik.

Keputusan dari tiga kajian spesifik menumjukkan 10%, 15% dan 20% dalan penambahbaikan faktor beban memberikan jenis keutamaan dari yang terbaik hingga yang paling teruk. Ianya bergantung pada kondisi alternatif dan kriteria data keluaran juga akan berbeza.

Ini menunjukkan fleksibiliti dan keserasian kaedah pengoptimumam yang dibentuk dalam kajian ini. Kajian lain dan kaedah pengurusan permintaan sampingan hanya dapat pertimbangkan alternatif yang terhad atau kriteria dalam beban mitigasi.

Kaedah baru ini berupaya membuat penyelesaian pada setiap dimensi matrik pembuat keputusan dalam pengoptimuman factor beban. Kesimpulannya, kaedah ini,

untuk pertama kalinya menjadi penghubung antara pengoptimuman factor beban dan pembuat keputusan dalam pengurusan permintaan sampingan.



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Seyed Amir Hossein Khoshsolat January 2014 I certify that a Thesis Examination Committee has met on 15 January 2014 to conduct the final examination of Seyed Amir Hossein Khosh Solat on his thesis entitled "Development of Electric Load Factor Optimization Technique with Multi Criteria Decision Making" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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# **DECLARATION**

## **Declaration by the student**

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# **Declaration by Members of Supervisory committee**

This is to confirm that:

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- the research conducted and the writing of this thesis was under our supervision;
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