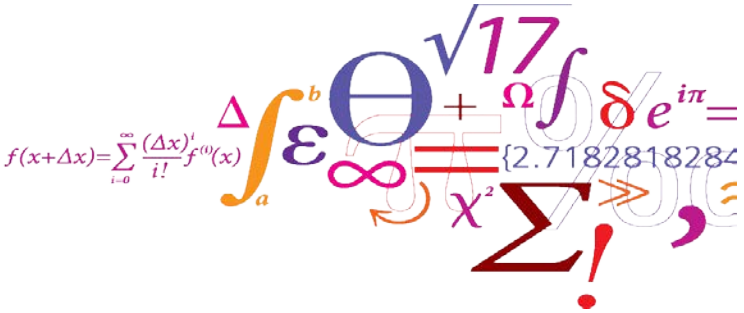
Modeling of electricity consumption in one of the world's most populous cities – Jakarta, Indonesia



Angreine Kewo

Supervisors:
Per Sieverts Nielsen, Xiufeng Liu

Agenda

- About my PhD project
- The 1st paper's Abstract
- Introduction
- Methodology
- Analysis and result
- Conclusions

My PhD project

DTU Management Engineering
Department of Management Engineering

DTU

Benchmarking Residential Energy Consumption in Indonesia

Angreine Kewo, PhD Student

Relevance – challenges, problem or opportunity?

As an emerging economic developing country, Indonesia shows the growing energy consumption and demand that has resulted in the need for an improved energy system. The power utility then has initiated an aggressive meter replacement program for 2011 where residential electromechanical meters are being replaced by electronic smart meters. However, the introduction of smart metering technologies in Indonesia, is only recent and mainly only in electricity energy sector. Indonesian consumers are expecting the smart meter to be more on the usefulness, ease of and perceiving risk. Extensive studies have been conducted in the developed countries where smart meters have widely been installed.

Most of the studies are using the data from countries locating in the northern hemisphere of the earth, where the weather temperature is low, and daytime is short in winter. Indonesia locates at the tropical region where the air conditioners are widely used. **People's** consumption behaviors are different, which may indicate the difference in consumption patterns. Therefore, it would be interesting to benchmark the residential energy consumption using the data from Indonesia, and compare with country such as Denmark, in order to develop new models specific to the use of Indonesian energy market.

Research question?

1. Demand response: How electricity consumer could be responsive based on Demand Response programs in Indonesia?
2. Residential electricity consumption pattern: What are the factors that influencing urban electricity consumption?
3. Building dynamic thermal profiles: How to characterize household building electricity consumption?
4. Short term demand forecasting: How to model the short term demand consumption?

Method

The research will be conducted within a number of case cities in Indonesia through the literature review, by investigating existing algorithms, models and tools for smart meter data analytics, and employing mix methods research of qualitative (interview, onsite visit) and quantitative (Questionnaire, time series analysis).

Expected Results

Energy demand modelling of Indonesian energy market to support energy efficiency.

Contact:
Angreine Kewo, PhD student
Produktionstorvet, building 426, room 117
DK-2800 Kgs. Lyngby
+ 45 61 35 31 77
ankewo@dtu.dk
www.man.dtu.dk

Supervisor/co-supervisor:
Per Sieverts Nielsen
Xiufeng Liu

Collaborating partners:
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Transport Modeling
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Management Science
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Systems Analysis
Engineering Systems
Technology and Innovation Management

The Abstract

Modeling of electricity consumption in one of the world's most populous cities – Jakarta, Indonesia

This paper presents insight into Jakarta's electricity consumption. It was identified that air temperature, day of rain, hotel room occupancy and rainfall could be used to characterize Jakarta's monthly electricity consumption. Monthly seasonal variation index (MSVI) is used to analyse the monthly cycle of electricity consumption. Furthermore, two selected approaches including multiple linear regression and artificial neural network (ANN) were employed to derive a model of the monthly electricity consumption. The ANN approach is conducted in four algorithms namely resilient backpropagation with backtrack, resilient backpropagation without backtrack, traditional backpropagation and globally convergent. The accuracy of these models was assessed by using root mean square error (RMSE), the mean absolute error (MAE), and the mean absolute percentage error (MAPE). The result indicates that the proposed ANN models perform better than multiple linear regressions in Jakarta's electricity consumption.

Introduction

Impressive economic growth

7.75 per year GDP

74 million New middle class people

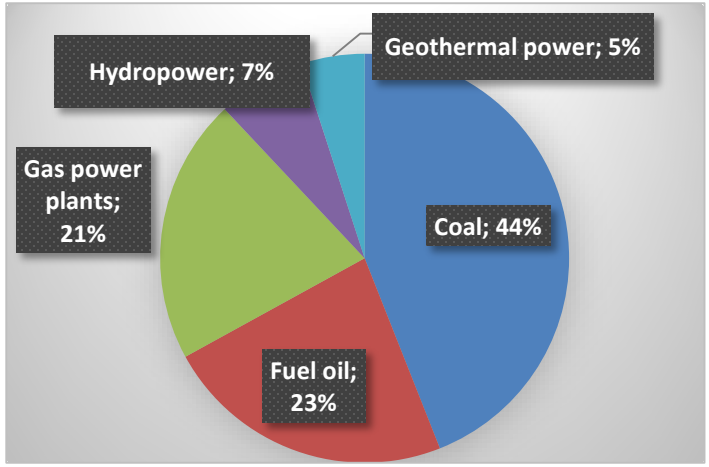
Energy Supply and Demand side

2.8 times ↑ Energy production 1980-2010

Nearly **5** times ↑ Energy consumption

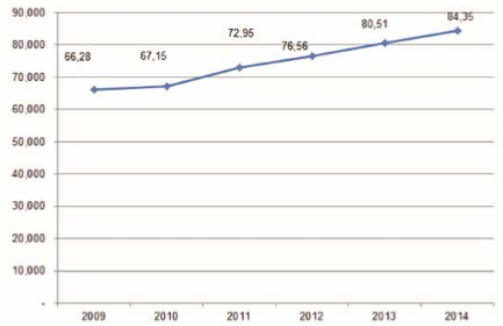
7.4% annually Electricity demand growth

Electricity sources



Electrification Rate

84% Indonesia **100%** Jakarta



Introduction

Jakarta

- Economic development center
- Fast growing population
- Less studied of research

Population

Objectives

- Conduct an in depth literature review on **modelling of electricity consumption**
- Present **the characteristics of Jakarta's electricity consumption**
- Identify **key climate and non-climate factors**
- Analyse **the relationship between the factors**

Methodology

MSVI: The seasonal variation index method

To derive the model:

1. Multiple linear regression and
2. Artificial Neural Network (ANN)

ANN algorithms:

1. Resilient backpropagation with backtrack,
2. Resilient backpropagation without backtrack,
3. Traditional backpropagation
4. Globally convergent

Accuracy:

1. Root mean square error (RMSE),
2. The mean absolute error (MAE), and
3. The mean absolute percentage error (MAPE)

Data analysis and result

Multivariate

- Climate: Air temperature and day of rain
- Non climate: Hotel room occupancy

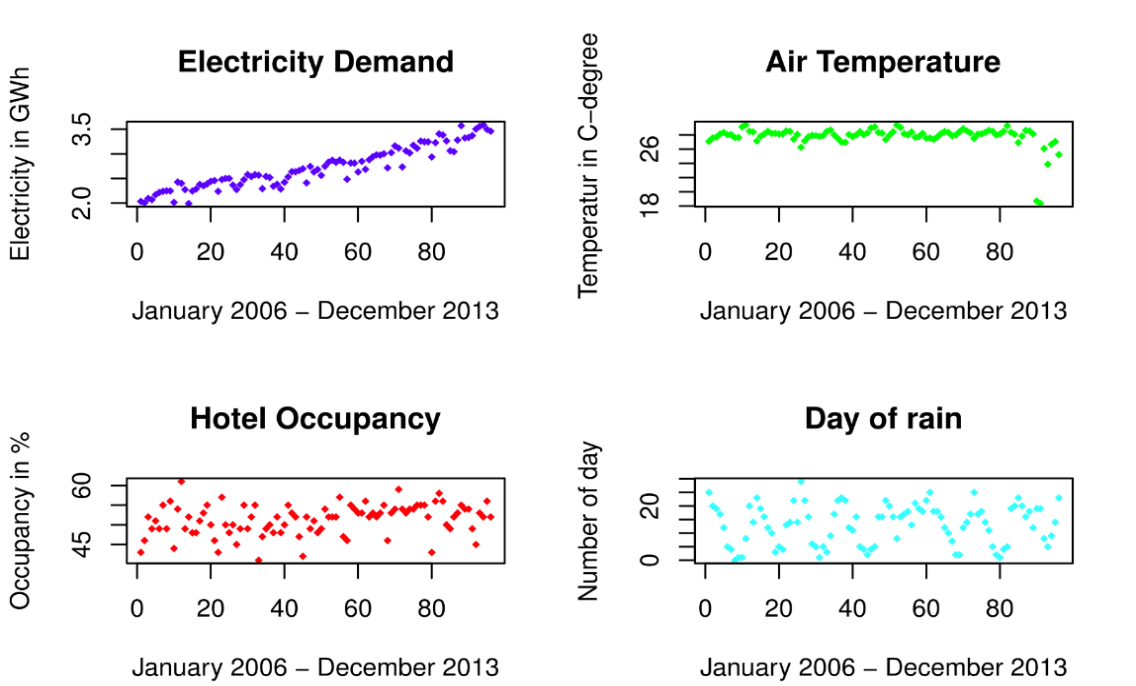
Data

- Monthly time series data 2006-2013

Data Sources:

- Jakarta's Central Bureau of Statistics
- Indonesia Agency for Meteorology

Data analysis and result



For Jakarta, the behaviour of MSVI shows an increased demand of electricity in November, followed by a gradual decrease until February, which is associated with the decrease of air temperature. The electricity demand is then continue with a gradual increase until September, and a slightly decrease in October.

Data analysis and result

Models	Training				Testing		
	RMSE	MAE	MAPE		RMSE	MAE	MAPE
Model 1	0.3030	0.2457	0.0953		1.3436	1.1752	0.3449
Model 2	0.3041	0.2466	0.0955		1.2969	1.1460	0.3364

Multiple Regression Model analyses show that there is no significant different between the result of modelling with training data set of RMSE, MAE and MAPE analysis.

The different amount of independent variable between model 1 and model 2 does not have a significant influence to the modelling of electricity consumption in Jakarta.

Data analysis and result

Models	Training				Testing		
	RMSE	MAE	MAPE		RMSE	MAE	MAPE
Model 1 of MLR	0.3030	0.2457	0.0953		1.3436	1.1752	0.3449
Resilient M	0.0003	0.0002	0.0001		-	-	-
Globally Convergent	-	-	-		0.7600	0.7356	0.2152

Training

The modelling result of four algorithms in the training process indicates that ANN resilient backpropagation with backtracking and resilient backpropagation without backtracking are better than traditional backpropagation and globally convergent.

Testing

In the testing process, the modelling result of four algorithms shows that traditional backpropagation provides the best out-of-testing sample model in the combination of hidden layer 1=50 and hidden layer 2=50, based on RMSE, MAE and MAPE.

Conclusions

- The annual electricity shows an increasing demand as a result of the expanding middle class living in urban areas
- Hotel room occupancy and day of rain have been found as the most significant driven factors in controlling the electricity load demand of Jakarta
- ANN performs better modelling than multiple linear regressions in Jakarta's electricity consumption
- Our approaches can be applied to other cities especially the capital of the country, tourism city and most populous city

Recommendation: to enclose more non climate factors: socioeconomic and demographic to the models and employ other modelling approaches

Thank you