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Forecasting Impact of Demand Side Management on Malaysia's Power Generation using System Dynamic Approach

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ABSTRACT

Rapid economic growth, increasing population, industrialization and high living standards have increased the electricity demand more than ever before. Efficient energy planning and management is always considered as the greatest challenge in all over the world. Among the other factors availability of electricity is the main bottleneck to the economic growth and industrial revolution. Considering this fact, it becomes necessary for academicians, government agencies and electricity companies to construct more efficient methodologies and procedures to predict long-term electricity demand. The objective of this article represents the initiative towards understanding and analyzing the importance of demand-side management (DSM) in forecasting electricity demand by using a system dynamics approach. This study examines the long term impact of demand-side management variables including HER (Home energy report), MEPS (Minimum Energy Performance Standards) and NEEAP (National Energy Efficiency Action Plan). The future installation capacity of Malaysia's power generation is evaluated considering the factors of population, per capita electricity consumption, efficiency, capacity margin and DSM. The forecasting horizon of the simulation model is 15 years from 2016 to 2030.

Keywords: Energy Forecasting, System Dynamics, Energy Efficiency, Energy Demand Side Management
JEL Classifications: O18; Q21

1. INTRODUCTION

An uninterrupted supply of electricity is considered as an essential component for human development in the 21st century. The fundamental requirement for effective government policies is to ensure affordable, acceptable and consistent supplies of electricity to all sectors (Tufail et al., 2018a; Dooyum et al, 2020; Geng, 2021). In this regard appropriate electricity demand forecasting is essential. The electricity demand forecasting can be implemented in generation capacity enhancement, uninterrupted availability of supplies, managing fuel prices and formulating diversification policies for optimum generation portfolio. Electricity demand forecasting can be classified into two categories, (1) Short-term forecasting usually utilizes for routine load balancing activities and (2) long-term forecasting adopted for the formulation of government policies. Energy planning has been recognized as a complex problem because of its critical role in the other sectors of society (Hook and Tang, 2013; Nelwan et al., 2021). Several studies have been conducted addressing different issues in the energy sector. Jebraj and Iniyan (2006) reviewed numerous models and categorized the energy sector as planning, forecasting, optimization, energy supply and demand, neural networks and fuzzy logic. Specifically, energy demand models can be classified in different ways including univariate versus multivariate, static versus dynamic, and from time series forecasting to hybrid modeling. The Malaysian energy sector has been reviewed by several researchers in the past (Ong et al., 2011; Ohetal, 2010; Jafareta, 2008). Studied carried out by Sukki et al. (2012) was focused on particular availability of resources; however, Ahmed and Tahir (2014) assessed the prioritization of renewable resources. Socovol and Drupady (2011) discuss the issues of power generation projects. Although these studies adopted both qualitative and quantitative methodologies still ignored some of the critical variables because of rigidness of tool and complexity of the model. The accurate forecasting is important for a sustainable future power generation mix. Several internal and external factors impact on the electricity demand such as population growth, consumption pattern and equipment efficiency, etc. Considering this fact, it is essential to adopt an efficient and reliable tool which has provision to integrate several variables impacting on the system. System dynamic (SD) is considered as the most appropriate tool which can be used to measure the impact of numerous variables on a particular system at a specific interval of time.

This study set to explores the intrinsic relationship among increasing population, per capita energy consumption and government initiatives in terms of Demand-side management. Considering Malaysia as a case study an integrated system dynamics model was developed coupled with a modeling structure based on the framework of IThink 9.0 software, which offered a realistic platform for predicting the trends of Malaysia's electricity demand by 2030 compliance with the Malaysian policies.

2. SYSTEM DYNAMICS

The efficient policy formulation is highly dependent upon the in-depth knowledge of decision-makers to understand the relationship of variables within a system. Considering the cause-and-effect of dynamic variables on a broad spectrum is a complex process. To analyze the domain of interconnecting complex variables, J. Forrester has introduced the methodology of system dynamics (SD) in 1960. SD is a firm approach that reveals the dynamic changes in a system considering the system holistically to understanding, visualize and analyzing feedback in a system (Forrester, 1969; Zhao et al., 2011; Lefaan et al., 2019).

The four fundamental components of System dynamic modeling are stock, flow, converters and connectors. The stock acts as an accumulator and shoes the increasing and decreasing trend of tangible and non-tangible variables of the system such as electricity demand or behavior. The value of a stock is depended upon the flows. The increase and decrease of stock can be controlled by in or out flows to and from the stock. Convertor contains information of variables, mathematic relationship and impact; however, connectors are used to formulate a relationship between convertors flow and stock (Mirchi et al., 2012; Rehan et al., 2011; Mayasari et al., 2019). Figure 1a shows the symbol of basic model building blocks. The concept of stock and flow can be easily understood from Figure 1b in which the stock is represented by a water tank which level is actually controlled by the inflow and out flow of water.

The functionality of stock in a SD simulation model is expressed by an equation. Mathematically, a stock (S) can be represented as an integration of the difference between inflow and outflow over a specific period of time.

$$S_t = \int_{t=0}^{t=n} [Inflow(t) - Outflow(t)]dt + S(t_0) \qquad (1)$$

Similarly, the rate of change in stock can be represented as a derivative at a specific interval of time. The mathematical representation of flow (F) is shown in equation 2.

$$F = (Inflow - Outflow);\; F = \frac{ds}{dt} \qquad (2)$$

2.1. Overview of Malaysian Electricity Sector

Malaysia has experienced rapid economic growth along with social and environmental transformation since its inception (Hezri and Hasan, 2006;Tufail et al., 2018b; Jamaludin et al., 2019). To accomplish the target of being a developed nation by 2020; Malaysia is focusing more on sustainable growth and development (Tahir et al., 2015). In this regard, Malaysia has targeted to achieve 6% annual growth in its gross domestic product (GDP) compliance with the requirement of 11^{th} national action plan (EPU, 2015). To attain the desired level of growth rate it is imperative for Malaysia to deeply visualize its future electricity demand considering the factors of installed capacity as it is an integral component to support the nation's capacity succession planning over an intermediate to long term period in order to sustain the economy. An adequate supply of electricity is one of the fundamental components of production, along with labor, capital and material.

The power generation sector of Malaysia is highly dominated by fossil fuels which immensely contribute to exaggerated carbon in the environment causes serious health issues. Sustainable supplies of electricity are one of the key contemporary issues of global policymakers. According to 2016 Installed capacity data indicated that more than 70% capacity is based on fossil fuels followed by hydropower with 18.6% of the total share. However, with respect to available capacity 87.7% share is occupied by fossil fuel resources. To be distinct, the 87.7% accounts for 42.6% natural gas, 28.9% coal and 6.3% diesel/MFO (NEB, 2016). The transformation of the Malaysian economy from agriculture to industrial has raised the Malaysian living standards (Ahmed Majid and Zaidi, 2001). This trend will continue to grow and directly impacts on total power consumption. From 1995 to 2016 the demand for electricity has been increased from 38,820 GWh to 144,024 GWh (NEB, 2016) and is expected to increase 30% more by 2020 (MES, 2017; Tufail et al., 2018). As shown in Figure 2, the major transition can be observed in domestic and commercial sectors from 2004 to 2016 because of the rapid population growth. The share in electricity consumption is highest for the industrial sector at 47%, followed by the commercial sector at 30.8%, the domestic sector at 21.6%, agriculture 0.4% and 0.2% for transport and other sectors.

Figure 1: (a) Functional blocks of SD model. (b): Conceptual diagram of SD working principles

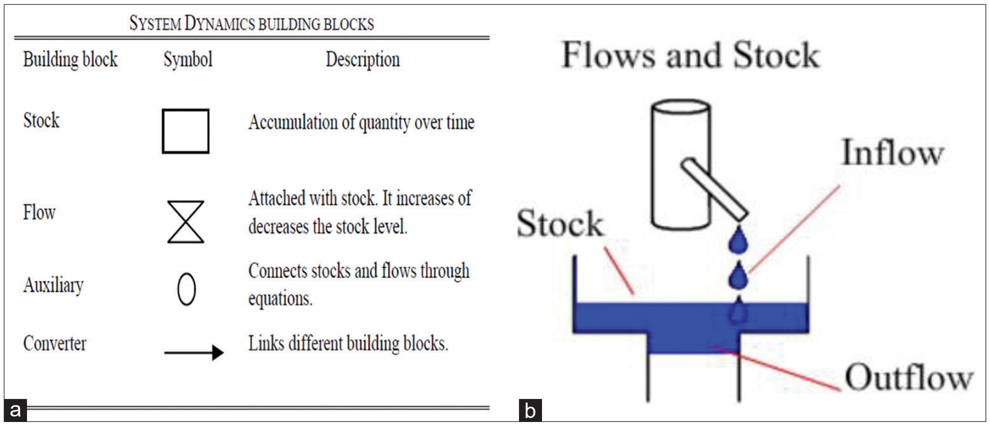
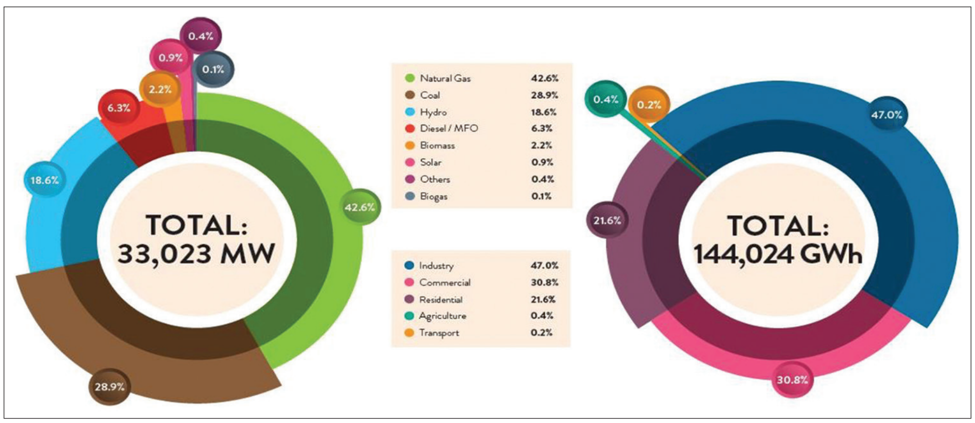


Figure 2: Malaysia Electricity installed capacity and final consumption



Source: National Energy Balance, (2016)

The electricity consumption of domestic sector can be evaluated by several factors including the number of households, household income, and average consumption level of per household (Othman and Ong, 1996; Kamarudin and Ponniran, 2008). However, in commercial sector, Numbers of new buildings, office operational hours, number of employees can be used as an indicator for measuring electricity consumption (Aun, 2004; Cheng, 2005; Masjuki et al., 2006). The consumption pattern of electricity is directly proportional to economic growth and the increasing population. To cater the increasing demand government of Malaysia has shifted focus from increasing supply to meet demand for reducing consumption by introducing Energy efficiency (EE) and Demand Side management (DSM) measures. This makes provision for DSM to serve as a countervailing force to the traditional supply-side framework or supply centric. DSM will be a very useful mechanism to trim away the demand spikes, which eventually helps in the reduction of CO2 and deferment of generation planting up. The target has been set to achieve at least a 10% reduction in electricity consumption by the end of 2025 and 15% by the end of 2030 respectively (Green Energy Report, 2017). In order to accomplish the desired objects, Government of Malaysia has introduced several energy efficiency measures including Green Energy Master Plan (2017).

1. Home Energy Report (HER)
2. Minimum Energy Performance Standards (MEPS)
3. National Energy Efficiency Action Plan (NEEAP)

2.2. Demand Side Management Measures

DSM refers to a technique to manage the demand for electricity by introducing efficient measures i.e. (reducing use of electricity, changing the timing of usage during peak hour demand). The adoption of DSM will reduce the demand for electricity generation and also reduce loads on transmission and distribution systems. Some of the effective DSM measures are discussed below.

2.2.1. Informative policy for efficient utilization of electricity

One class of options is to provide information to electricity consumers on how to use energy wisely and efficiently and to provide pricing structures that help spur customers to change the amount and timing of energy use, so consumers have informed choices and control utility bills (TNB, 2017). In 2015 TNB initiated a program Home Energy Report (HER) to examine the consumption behavior of electricity among its consumers. A pilot study is conducted on 200,000 consumers in Klang Valley, state of Melacca and Putrajaya which aims to provide the monthly consumption pattern of electricity to its consumer thought advanced automated digital system. The aim is to provide detailed information, including analysis of their energy consumption patterns with comparisons to similar houses in the neighborhood; Year-on-year tracking of energy consumption patterns, with monthly household efficiency rankings; and Energy saving tips and EE measures. The pilot study has managed to save 13,979 MWh of electricity from July 2015 to June 2016 which is accountable to save 5,386,000 RM of billing amount. TNB is planning to implement this program to the whole nation through web portals in the near term. With the current standards, HER can manage to save 70 kWh of per capita electricity consumption which is approximately 1.5% of total electricity demand (TNB, 2017).

2.2.2. Higher-efficiency technologies and energy labeling

Energy-efficiency measures reduce energy consumption (and peak loads) by substituting more efficient appliances and equipment for less efficient units or systems. As shows in the Figure 3, GOM introduces the 5-star efficiency program in 2013 with the collaboration of Suruhanjaya Tenaga (ST) under the name of Minimum Energy Performance Standard (MEPS). Initially, the program is limited to a few high domestic energy consumption appliances such as refrigerators, air-conditioners, televisions, fans as well as lighting. ST issued a certificate rated from 1 to 5 stars as per their Energy efficiency features. MEPS strictly monitors the said electric appliances in the Malaysian market to meet the maximum efficiency standard as per regulation. Table 1 discusses the amount of electricity saved under the NEEAP policy in the last 10 years, which is approximately 50,600 GWh. In terms of energy-saving up till now NEEAP contributes 3.50 present of electricity per year.

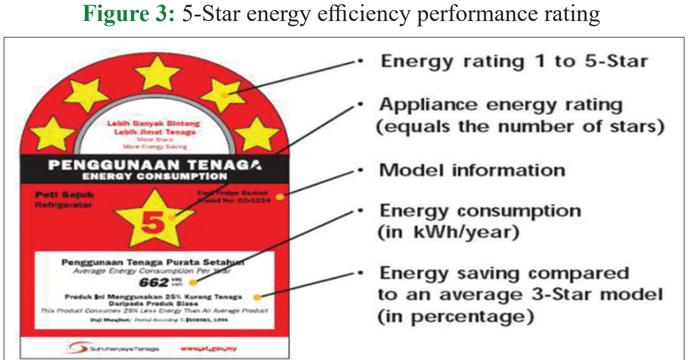
2.2.3. Electricity Tariff

The cost of electricity from generation to distribution before reaching the end-user will be translated into a tariff. The current tariff for domestic consumers is shown in Table 2. The monthly electricity usage was based on actual meter readings performed at the households. The average consumption was then multiplied by the billing period and the applicable tariff rates to determine the total bill amount. Multiply the rate depends on the unit of energy use.

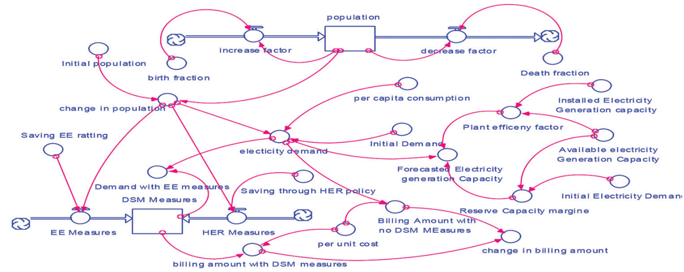
3. THE MODEL

System Dynamic Modeling (SDM) technique is a mechanism of studying relations between complex feedback systems, usually used in the absence of formal analytical models, however, the simulation model can be developed by formulating linkage between several feedback components. To demonstrate the importance of feedback relationships in determining the behavior of complex electricity demand forecasting system, our model considers population rising trend, per capita electricity consumption and also evaluate the impact of demand-side management on installation capacity of Malaysia's power generation.

Figure 3: 5-Star energy efficiency performance rating



Source: Oh et al. (2014)



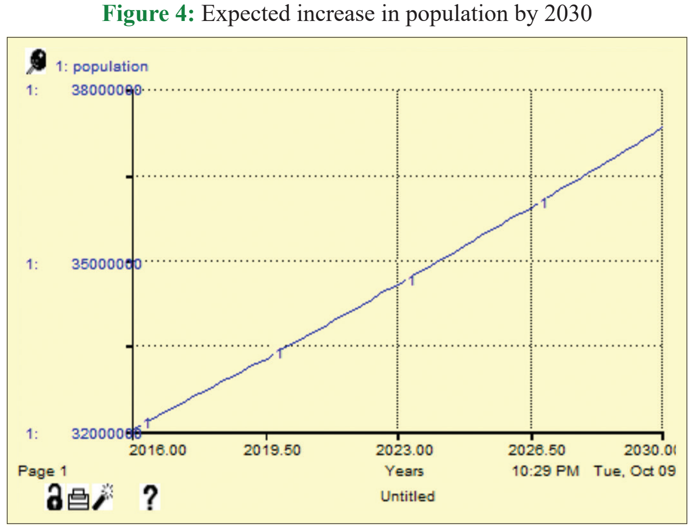
The above model is designed to evaluate the relationship between rising population and electricity demand. The per capita consumption is used as an intermediately variable to forecast the total electricity demand by the year 2030. The installation capacity will be evaluated by considering the factors of plant efficiency and reserve capacity margin. Finally, as per Malaysia's green energy master plan 2017 the impact of DSM is evaluated on electricity demand and total installed capacity with the ongoing policies of the National energy efficiency action plan of Malaysia. Table 3 shows the variables and equations of the designed dynamic model of forecasting population, electricity demand and installed capacity.

4. RESULTS

It has been acknowledged that the rising population is the main driving factor of increasing electricity demand. Figure 4 depicts the expected rising trend of the population from 2016 to 2030. It is estimated that by the end of the year 2030 the Malaysian population will reach around 36,508,851 people.

Concerning the base scenario, it is estimated that by the years 2030 the total electricity demand expected to reach at 156,507 GWh on the other hand the increased in generation capacity should be planned for 246,489 GWh considering 40% demand to reserve margin (refer Figure 5). However, in the recent official report of a green energy master plan (2017), GOM has proposed a reduction in total demand by introducing the demand-side management strategy discussed in Figure 6. In this regards the government has adopted several measures including HER and MEPS under the National energy efficiency action plan. Figure 6 illustrates the

Figure 4: Expected increase in population by 2030



impact of these initiatives in the long-term i.e. 2030. It has been predicted that with the current measures government of Malaysia will be managed to save 20000 GWh of energy in 15 years. However, with modification in these values will help to achieve more positive results.

Table 1: Summary of key initiatives under NEEAP over 10 years

Key Initiative	Description	Program	Savings in 10 years (GWh)
Rating and labeling of Energy	Labeling of appliances in the form of star rating as per performance	Refrigeration	2079
	Announces special promotion on 5-Star rating equipment	Air-conditioning	5983
	Introduces rebate on 5-star rating equipment	Ceiling fans	645
MEPF (Minimum energy performance Standard)	Endorsement of MEPF standards	Compact fluorescent lamps	3056
		Efficient motors	934
Energy audit of the commercial sector and industries.	Maintain energy audits on government, commercial and industrial sectors	Large commercial services	1565
		Large industrial services	8384
	Endorsement of adopting optimization and low-cost measures	Large government services	927
		intermediate commercial services	306
		intermediate industrial services	539
Management of energy utilization in buildings and industries.	Obligatory management of energy system and audit on government, commercial and industrial sectors	Large commercial services	1363
		Large industrial services	15,937
		Large government services	1112
	Endorsement of adopting optimization and low-cost measures	intermediate commercial services	681
		intermediate industrial services	1201
Reimbursement scheme on efficient standard measures	Reimbursement on the adoption of standardized technology and quality	Chillers, HVAC, pumps, lighting, etc.	4950
Implementation of energy-efficient construction design	Propose a plan for the implementation of energy-efficient buildings	New Commercial buildings	932

Source: KeTTHA, (2014)

Table 2: TNB's electricity tariff for domestic households

Tariff category	Unit	Current rate (1 January 2018)
Tariff A - Domestic Tariff		
For the first 200 kWh (1-200 kWh) per month	Cent/kWh	21.8
For the next 100 kWh (201-300 kWh) per month	Cent/kWh	33.4
For the next 300 kWh (301-600 kWh) per month	Cent/kWh	51.6
For the next 300 kWh (601-900 kWh) per month	Cent/kWh	54.6
For the next kWh (901 kWh onwards) per month	Cent/kWh	57.1
The minimum monthly charge is RM3.00		

(Tenaga National Berhad, 2018)

Table 3: Data and boundaries of model

Variables	Value	Equation
Population	32 Million	STOCK: Population(t)=population (t - dt)+(increase factor - decrease factor) * dt
Birth rate	19.1	INFLOW: Increase factor=birth fraction*population/1000
Death rate	5.1	OUTFLOW: Decrease factor=Death fraction*population/1000
Per Capita consumption	4553 KWh	STOCK: Change in electricity demand=(change in population*per capita consumption)*(Energy efficiency and Demand side management)
Electricity Generation Capacity	289281 GWh	Forecasted Electricity generation Capacity=Electricity demand + Reserve Capacity margin*Plant efficiency factor
Electricity Available Capacity	249870 GWh	
DSM WRT EE measure	0.35%	STOCK: DSM Measures(t)=DSM Measures (t - dt) + (HER Measures + EE Measures) * dt INIT DSM Measures=7300
DSM WRT HER measures	0.15%	INFLOWS: EE Measures=Saving EE ratting*change in population HER Measures=Saving through HER policy*change in population
Plant Efficiency	Available capacity/ Generation capacity×100	Plant efficiency factor=Available Electricity Generation Capacity/Installed Electricity Generation capacity
Capacity Reserve Margin	Available Capacity - Electricity Demand/Available capacity×100	Reserve Capacity margin=Available electricity Generation Capacity-Initial Electricity Demand

Source: (DOSM, 2017; NEB, 2017; Kettha, 2017)

Figure 5: The expected increase in electricity demand and required generation capacity By 2030

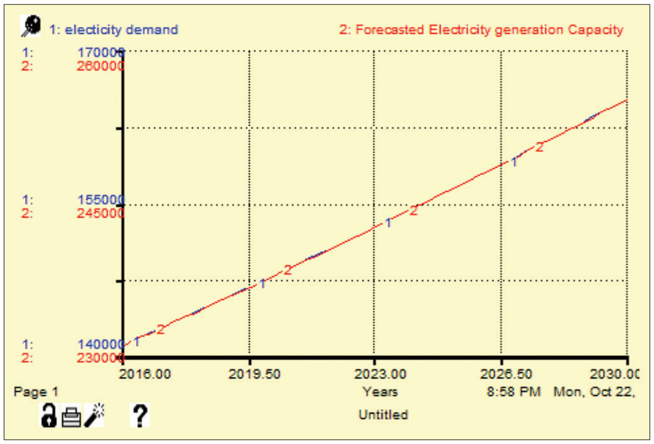


Figure 6: Change in electricity demand W.R.T. DSM

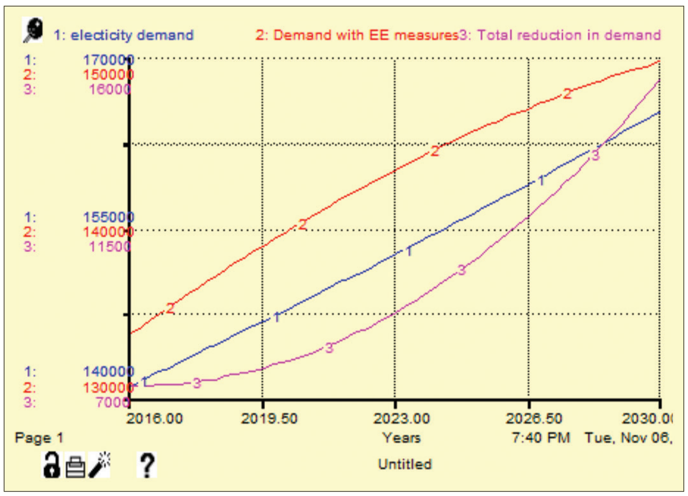


Figure 7: Change in billing cost

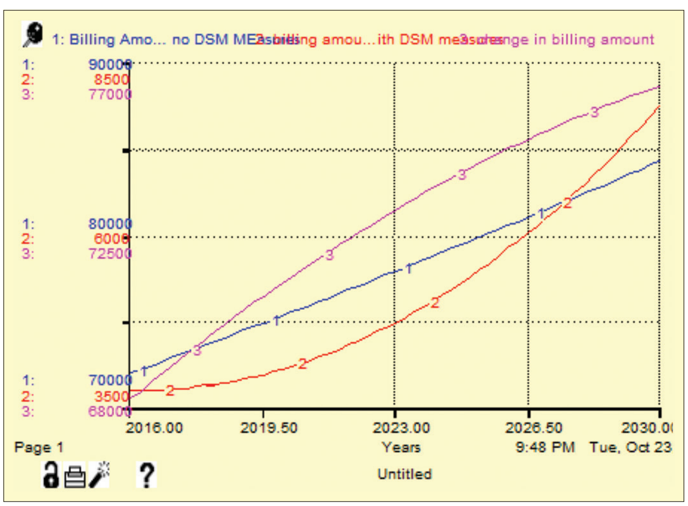


Figure 7 illustrates the comparison of electricity billing amount at the rate of 0.51 cent/kWh. It shows the comparison of electricity billing with and without adopting DSM measures. The third line on the graph represents the total amount of saving in billing per year; however, the policy boundaries have been set to the current implemented factors i.e. 5% approximately.

Figure 8: Amount of electricity saved with the adoption of DSM

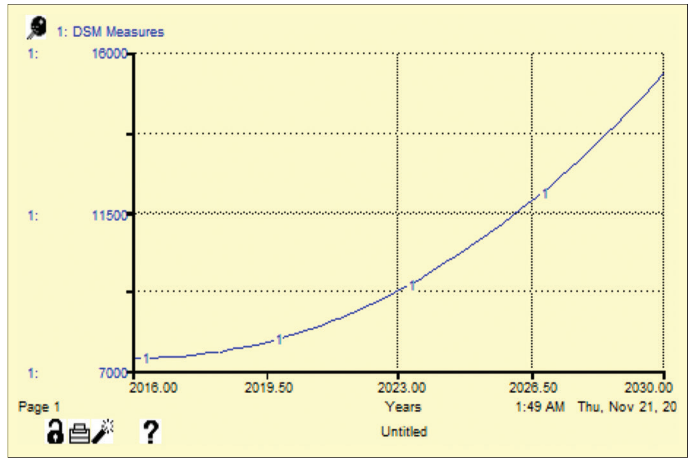


Figure 9: Impact of DSM on forecasted long term electricity

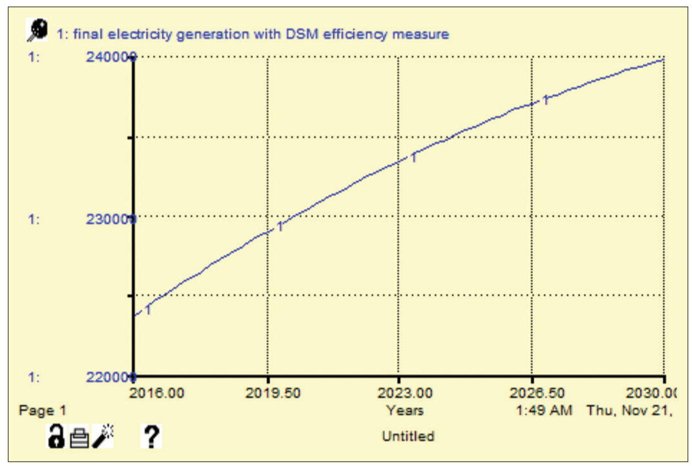


Figure 8 is a graphical illustration of the DSM measure's impact on overall electricity demand. The model suggests that in long run DSM measures may save around 16000Gwh of electricity. Figure 9 depicts the reduction in overall capacity requirements due to DSM measures by the end of 2030.

5. CONCLUSION

This study attempts to analyses the energy-growth nexus in Malaysia using a system dynamic modeling approach. System dynamics is a valuable approach used for the estimation of long- term electricity demand. SD provides in-depth vision to analyze the various variables' effects on final energy demand and consumption. The study set to explore the dynamic relationship among population, electricity demand and per capita consumption and also measures the impact of demand-side management on total electricity expansion capacity. The simulation model estimates that at the current rate of consumption and population growth there will be a need of 156 terawatt-hours of electric energy in the year 2030. However, the install capacity should stand 246 terawatt-hours. It is found that by using simulation, a fairly accurate forecast can be obtained. It also discusses that demand-side management can be used as an efficient technique to reduce the total electricity demand with significant value.

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REFERENCES

Ahmad, N.Z., Majid, M.A., Zaidi, M.A.S. (2001), Agricultural and industrial development in Malaysia: Policy bias? Humanomics, 17(1-2), 61-76.

Ahmad, S., Tahar, R.M. (2014), Selection of renewable energy sources for sustainable development of electricity generation system using analytic hierarchy process: A case of Malaysia. Renewable Energy, 63(1), 458-466.

Aun, C.S. (2004), Energy Efficiency: Designing Low Energy Buildings Using Energy 10. Vol. 7. CPD Seminar. p1-18.

Cheng, C.C. (2005), Electricity Demand-side Management for an Energy-efficient Future in China: Technology Options and Policy Priorities (Doctoral Dissertation, Massachusetts Institute of Technology).

Dooyum, U.D., Mikhaylov, A., Varyash, I. (2020), Energy security concept in Russia and South Korea. International Journal of Energy Economics and Policy, 10(4), 102-107.

DOSM. (2017), Department of Statistics Malaysia: Available from: https://www.dosm.gov.my/v1/index.php?r=column/ctwoByCat&parent_id=115&menu_id=L0pheU43NWJwRWVSZklWdzQ4TlhUUT09. [Last accessed on 2018 Jul 28].

Economic Planning Unit. (2015) Malaysia, the 11th Malaysia Plan 2016-2020, Percetakan Nasional Malaysia Berhad, Kuala Lumpur; 2015. Available from: http://www.epu.gov.my. [Last accessed on 2018 Jul 25].

Forrester, J.W. (1969), Urban Dynamics. Cambridge: The MIT Press.

Forrester, J.W., Forrester, J.W. (1971), World Dynamics. Cambridge, MA: Wright-Allen Press.

Geng, Z. (2021), Russian energy strategies in the natural gas market for energy security. International Journal of Energy Economics and Policy, 11(2), 62-66.

Hezri, A.A., Hasan, M.N. (2006), Towards sustainable development? The evolution of environmental policy in Malaysia. Natural Resources Forum, 30(1), 37-50.

Höök, M., Tang, X. (2013), Depletion of fossil fuels and anthropogenic climate change a review. Energy Policy, 52, 797-809.

Jafar, A.H., Al-Amin, A.Q., Siwar, C. (2008), Environmental impact of alternative fuel mix in electricity generation in Malaysia. Renewable Energy, 33(10), 2229-2235.

Jamaludin, R., Nawi, M.N.M., Bahaudin, A.Y., Mohtar, S., Tahir, M.Z. (2019), Energy efficiency of chancellery building at Universiti Utara Malaysia. Journal of Advanced Research in Fluid Mechanics and Thermal Sciences, 58(2), 144-152.

Jebaraj, S., Iniyan, S. (2006), A review of energy models. Renewable and Sustainable Energy Reviews, 10(4), 281-311.

Kamarudin, Y. (2008), Feasibility Study of Implementing Demand-side Management (DSM) for Domestic Sector in Batu Pahat. (Doctoral Dissertation, Universiti Tun Hussein Onn Malaysia).

KeTTHA. (2014), National Energy Efficiency Action Plan. Draft Final Report. Available from: http://www.kettha.gov.my/kettha/portal/document/files/NEEAP%20For %20Comments%20Final%20January%202014.pdf.

KeTTHA. (2017), Green Technology Master Plan Malaysia 2017-2030 (GTMP). Putrajaya, Malaysia: Ministry of Energy, Green Technology and Water (KeTTHA).

Lefaan, Y. (2019), Human development concept and electrical system simulation using system dynamics model for Papua Province, Indonesia. International Journal of Energy Economics and Policy, 9(6), 199-209.

Mayasari, F., Dalimi, R., Purwanto, W.W. (2019), Projection of biodiesel production in Indonesia to achieve national mandatory blending in 2025 using system dynamics modeling. International Journal of Energy Economics and Policy, 9(6), 421-429.

MES. (2017), Energy Statistics Handbook. Malaysia Energy Statistics. Available from: http://meih.st.gov.my.

Mirchi, A., Madani, K., Watkins, D., Ahmad, S. (2012), Synthesis of system dynamics tools for holistic conceptualization of water resources problems. Water Resources Management, 26(9), 2421-2442.

Muhammad-Sukki, F., Munir, A.B., Ramirez-Iniguez, R., Abu-Bakar, S.H., Yasin, S.H.M., McMeekin, S.G., Stewart, B.G. (2012), Solar photovoltaic in Malaysia: The way forward. Renewable and Sustainable Energy Reviews, 16(7), 5232-5244.

National Energy Balance. (2016), Energy Commission of Malaysia. Available from: http://www.meih.st.gov.my. [Last accessed on 2017 Dec 26].

Nelwan, A.F., Dalimi, R., Hudaya, C. (2021), A new formula to quantify the national energy security of the world's top ten most populous nations. International Journal of Energy Economics and Policy, 11(1), 394.

Oh, T.H., Lalchand, G., Chua, S.C. (2014), Juggling act of electricity demand and supply in Peninsular Malaysia: Energy efficiency, renewable energy or nuclear? Renewable and Sustainable Energy Reviews, 37(9), 809-821.

Oh, T.H., Pang, S.Y., Chua, S.C. (2010), Energy policy and alternative energy in Malaysia: Issues and challenges for sustainable growth. Renewable and Sustainable Energy Reviews, 14(4), 1241-1252.

Ong, H.C., Mahlia, T.M.I., Masjuki, H.H. (2011), A review on energy scenario and sustainable energy in Malaysia. Renewable and Sustainable Energy Reviews, 15(1), 639-647.

Rehan, R., Knight, M.A., Haas, C.T., Unger, A.J. (2011), Application of system dynamics for developing financially self-sustaining management policies for water and wastewater systems. Water Research, 45(16), 4737-4750.

Saidur, R., Husnawan, M., Masjuki, H.H., Jahirul, M.I., Mahlia, T.M.I., Nasruddin, A.R., Zamaluddin, M.F. (2009), Energy and Electricity Consumption Analysis of Malaysian Industrial Sector. Proceedings of 4th International Conference on Thermal Engineering: Theory and Applications.

Sovacool, B.K., Drupady, I.M. (2011), Examining the small renewable energy power (SREP) program in Malaysia. Energy Policy, 39(11), 7244-7256.

Tahir, M.Z., Nawi, M.N.M., Rajemi, M.F. (2015), Building energy index: A case study of three government office buildings in Malaysia. Advanced Science Letters, 21(6), 1798-1801.

TNB. (2017) Electricity Tariff. Tenaga Nasional Berhad. Available from: https://www.tnb.com.my/residential/pricing-tariffs. [Last accessed on 2018 Oct 22].

Tufail, M.M.B., Ibrahim, J.A., Melan, M. (2018a), The financial impact of adopting carbon-tax as policy on electricity generation system: A case study of Malaysia's power generation mix. International Journal of Development and Sustainability, 7(4), 1428-1440.

Tufail, M.M.B., Ibrahim, J.A., Melan, M. (2018b) Conceptualizing energy security and the role of diversification as the key indicator against energy supply disruption. Journal of Advanced Research in Business and Management Studies, 11(1), 1-9.

Zhao, W., Ren, H., Rotter, V.S. (2011), A system dynamics model for evaluating the alternative of type in construction and demolition waste recycling center the case of Chongqing, China. Resources, Conservation and Recycling, 55(11), 933-944.