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The Upshot of Generation Mix Variation in Electricity Tariff via System Dynamics Approach: Malaysia Circumstances

Norlee Husnafeza Ahmad, Nofri Yenita Dahlan, and Nor Erne Nazira Bazin

***Abstract*— Generation mix for electricity literally denotes the mix of various energy used in order to generate electricity. No matter what type of market model one country is using, generation mix is the key in power generation especially when tariff and sustainablity are the main concerns. At present, the generation mix is undergoing significant changes in the world. In Malaysia, generation mix mostly is dominated by oil during early years up until the 5th Fuel Diversificiation Policy is introduced. From 85% of electricity generation of oil in early 1980s, it drops until 5% after the policy is established. Globally, the generation mix is continuously varying and the electricity market equilibrium analysis in this new circumstances is essential to the market regulator, operator, and partner. Therefore, this paper thoroughly investigate the impact of generation mix variation on electricity tariff in Malaysia by using System Dynamics as the approach for a 30 years span of time. A System Dynamics model is developed in order to look at the rapport between generation mix and electricity tariff. The result validates the significant effects on electricity tariff with the variation of generation mix.**

***Index Terms*— generation mix, tariff, System Dynamics, Malaysia electricity supply industry**

I. INTRODUCTION

MALAYSIA is more or less blessed with a decent generation mix of energy resources varying from conventional sources to renewable energy resources. In early 80's, roughly around 85% of electricity generation in Malaysia is generated by oil. But then, the world was facing with the global oil crisis during that decade in which resulted with the increased of oil price. This incident led to the commencement of the Four-Fuel Policy by Malaysian goverment [12]. The policy was made to reduce the overdependency on oil as the main energy source as well as aiming to have a more optimal fuel mix considering not only oil and coal, but also hydro and gas. More than 90% of electricity generated in Peninsular Malaysia was attained from fossil fuel during 1990 until 2016. In the early 80's, about 85% of electricity generation in Malaysia was generated by oil. Worldwide, generation mix is also undergoing a significant changes especially with the gradually increment of the proportion of renewable energy while the conventional fossil energy is started to decline in the primary inputs share to power generation [13].

Electricity modelling is not new among researchers especially in power generation sector. A lot of researchers had developed an electricity market model in order to cater their research objectives. Y.Smeers *et.al* in their paper, had developed an electricity model in order to observe how a different transmission market model can affect the generators' market power [26]. In the meantime, [27] also developed an electricity model in which they aimed that the model could be a help in analysing the evolution of electricity prices in deregulated markets. In addition, S. Meng *et.al* in their paper [28] used the new computable general equilibrium (CGE) in developing a model that will help them to gauge the effects of a national emission trading scheme on the Australian energy sector.

The same goes to the research on System Dynamics (SD) approach that has been utilised for many years in order to build a forecasting, strategic planning, assessing policy, assessing risk management, introducing new technology, and many more models [15 – 19]. The first SD method is developed by Forrester in 1958 [6] with the objective to understand on how the structure of a system determines its behaviour. It is developed as a decision support tool for a particular purpose, typically building understanding on the causal effects in a system structure that contributes to system results. This structure can then be changed if there is any way of improvement in the system. SD architecture includes the extensive use of diagrams, which are causal loop diagram and stock-flow diagram. SD has been an approach for a lot of researchers to develop a model that can be utilised by the utility; for instance, to look at the bigger view of a system. In [16], the authors used the architecture of SD to establish the significance of the development of renewable energy in order to evaluate the risk

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in investing in renewable energy project before a decision is made. Adelino *et.al* in their paper, developed an SD model in order to solve the generation expansion planning problem in a competitive market [18]. Throughout the model that they had developed using SD approach, they managed to capture the behaviour of electricity market as well as charactesing the evolution of electricity prices which then can be used by a generation agent to build a robust expansion plan. Meanwhile, researchers in [20] has presented a taxonomic analysis of SD approaches to energy modelling and simulation in which they had come into conclusion that energy systems are associated with complex uncertain behaviour. Besides that, a lot more researches have been made and it is proven that SD model is a reliable model when it comes to observe the causal and effects of each and every variables happened to be in a particular system.

The base market model of Malaysia electricity supply industry (MESI) has been put into a model using SD as the approach in order to look at a how the variation of generation mix can affects the electricity tariff. The motivation of this research is to study the effects on electricity tariff throughout the electricity modelling. This is aligned with MESI's transformation planning that is anticipated in improving the electricity market model from a regulated market into a deregulated market. During the course of the electricity modelling, the impact on the electricity tariff can be clearly seen with the changes of generation mix. It is well known that the changes in electricity tariff, like it or not, will affect the consumers. By taking all this factors and correlations, this electricity modelling can be a tool to determine which electricity market model that will benefit not only the utilities, but also the consumers. In addition, benefiting from the electricity market modelling it can not only used for a proper planning but also to determine the cause and effect of all the variables that occurs in the system. This will help the utilities to look at any improvement they can accomplish. This research has two main objectives which include: (i) to model the current upstream market of MESI, and (ii) to observe the effect on variation of generation mix in MESI market via SD models. In order to see the relationship, 30 years' time interval is chosen due to few variables that are very sensitive to time.

II. Overview of Electricity Supply Industry in Malaysia

Malaysia Electricity Supply Industry (MESI) aims to change its structure to a more competitve market. Until then, MESI has gone through various stages of change and has evolved from a largely single entity to a multiplayer industry, especially in the generation market. The case for MESI transformation is to improve governance, ensure sustainability of the industry, implement a clear, consistent tariff pass-through mechanism, offset risks to industry members, standardize gas price subsidies and establish fuel supply protection in creating a fair competitive bidding framework for greater efficiency [4]. The series of reform, known as MESI 1.0, has been ongoing since 2010. The goals are to guarantee a safe and stable supply of electricity, to provide commercially competitive tariffs, to be environmentally sustainable and to enhance consumer service or choice[5]. Then, the government has announced the start of the next MESI reform series, MESI 2.0. MESI 2.0 aims to increase the industry efficiency, to provide future evidence to industry, structure, regulations and key processes, and to empower consumers [2]. The MESI 2.0 aims to liberalize of electricity distribution components as well as to better promote the use of renewable energy in Malaysia [3]. The government is eliminating guaranteed capacity and energy payments in efforts to lower electricity tariffs. The latest practice for the issuance of PPAs is by means of tender, which is large-scale solar project, the potential PPAs could be issued by means of a power auction.

III. Methodology

In 1958, Forrester has developed the first SD model [6] with the objective to identifty how the structure of a system determines its behavior. It is developed as a decision support tool for a certain purpose in order to understand on the causal effects in a system structure that contributes to the system result. To make this model in SD model is unique, the model structure can be changed if there is any way of improvement needed in the system. SD architecture is broadly adapting an extensive use of diagrams which are named as causal loop diagram (CLD), and stock-flow diagram (SFD). The structure of a system and the correlation exist between its volatility works over time to acquire dynamic behaviour patterns of the system's volatility. Another context is also used to explicitly summarise the finding of changes to the system as the result of modelling process [11]. Figure 1 picturized the steps in order to design MESI market model with the approach of SD with the following steps below are being commenced;

- Understand market scenarios in MESI.
- Explore the structure and operation of the market model
- Obtain the exogenous and endogenous variables that are related and significant to generation mix of a market model.
- Design the market model with the distinguished components in generation mix using SD.
- Perform comparative analysis on the model with the real-world execution.

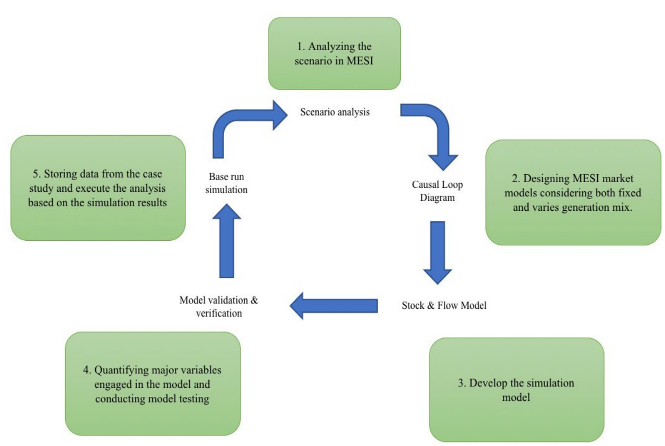

Figure 1: System Dynamics in practice

A. Analyzing the scenario in MESI

The modelling started with an analyzation of the scenario in MESI. This step is crucial since the model is grounded on MESI behavior. Analyzation includes the comprehending on what is happening is MESI and what is the plan that has been made by the government for MESI in the near future. It is essential to have a proper background study of the structure and operation of MESI market before progressing to its model development. The key variables that determine/change the behaviour of the system need to be identified and later established the dependencies of each variables toward each other. The establishment and indication are critical, and it relates back to group model building exercise which is to develop the CLD. Once the market model study has been deliberated, the list of all variables involved in MESI market is assembled. These variables is used in order to construct the CLD of the model which will be the basis utilized to develop the SFD in the next step.

B. Designing MESI market models (CLD Mental Model)

CLD in a model of SD is one of the fundamental tool to represent the feedback structure of the system. It acts as the mental model before a detail model is build. Via CLD, hypothesis about the cause of dynamics can be easily captured [11]. CLD is well suited to characterize the interdependencies and feedback making proceses making it convineient to start with in any modeling stage The cause- and effect-variables will be connected through a causal link with a positive and negative charge.The positive and negative signs decipher how each variables react with each others. Figure 2 shows the example of CLD model that is used to help identifying the causal relationship among important variables that has been identified through literature reviews. Variable with negative (-) relationship indicates that any changes in one variable will affect the other variable inversely. For instance, the *usage of electricity* has a negative relationship with the *electricity tarif*. It indicates that the the usage of electricity will decrease if the electricity tariff increases. Meanwhile for a positive (+) relationship it indicates that a change in a variable will produce a change of the same direction in the other variable. For example, *population* has a + relationship with the *electricity demand*. It illustrates that the higher the number of population, the higher the electricity demand will be.

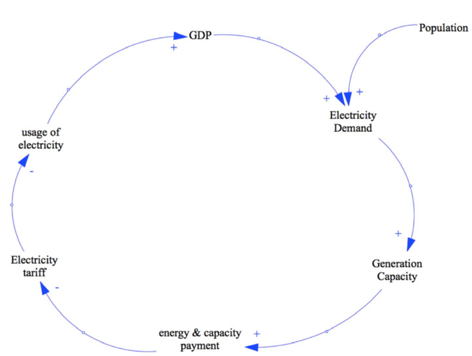

Figure 2 : CLD

Despite the handiness of CLD, it still experienced numbers of limitation and can be easily mistreated. Being a system that is known as its extensive usage of diagram, this limitation of CLD can be overcome with another diagram that is called the stock-flow diagram (SFD).

C. Develop the simulation model (SFD Model)

SFD is a building blocks for a quantitative analysis model in SD behavior. There are two kinds of variables that occur in this model namely as the stock- and flow-variable. Stocks are accumulations that characterise the system and generate the information upon which decision and actions are based upon. Stock creates delays and it is also the source of imbalanced dynamics in system. Meanwhile, flow variables represent the rates of changes of levels. Unlike CLD, SFD model contains more thorough information since it is dealt with levels, rate, and mathematical formulae. SFD also carried out the simulation in SD in order to regulate the numerical changes as well as the behaviour analysis with the influence of time.

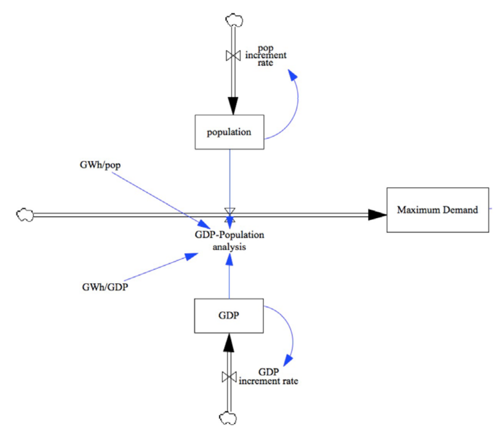

Figure 3: SFD

Figure 3 shows one of the example of SFD model exists in this whole model. *Maximum Demand* is chosen as the Stock meanwhile the regression analysis equation is made between the two variables – *GDP* and *population* – have become the Flow of the model. SFD model will becomes the simulation model and will be used through out the research in order to meet the objective of this research.

The simulation of SFD model is done by utilizing SFD while checking on the structural validity of the developed model. Once simulation is done, the comparison of model-generated data with historical data ascertains the behavior validity of the simulation model. Utilising SFD, a thorough analyses are made. Besides that, while running the simulation few testscan also be conducted in order to validate the model such as boundary adequacy, structure verification, as well the dimensional consistency test. The development of the simulation model is then followed by quantifying all major variables engaged in this model and a model testing is conducted. In SD there are several ways in validating and verifying the developed model. Many researchers opted to use structure verification as method to validate their model [23-25]. As for this research, the sensitivity analysis and structure verification are used in order to validate the accuracy of the model as proposed in [22].

IV. Results and Discussion

A 37-unit data as shown Appendix A is utilised with the purpose to acquire the base case model. The data is taken from Energy Commission 2017 Annual Report [7]. First before the results are presented and discuss, it is best to know that some of the most important variables in the model are validated with the historical data, where the time horizon is 2017. Later, a possible projection to the future, depending on the scenarios, is presented. Besides that, a sensitivity analysis also prepared in order to validate the model.

Given that this research is focusing on the generation mix of the power generation, an estimation of maximum demand is needed in order to plan for the power generation needed. In order to come out with the numerical values of maximum demand, the correlation between gross domestic product (GDP) and population are employed through a regression analysis. Table 1 depicts the regression results between the two variables – GDP and population – that yield 99% confidence. Using this correlation, it is convinced to say that the GDP and population are fit to be used as the variables in order to estimate the maximum demand of the system. The result for this correlation can be seen in Figure 4. From the figure, it shows that both GDP and population are in the same direction with the maximum demand. The increment of GDP and population is led to the increment of maximum demand in the system.

TABLE 1
REGRESSION ANALYSIS

Multiple R	0.996293681
R Square	0.992601098
Adjusted R Square	0.991121318
Standard Error	1374.002161
Observations	13

ANOVA

	Coefficient	*Standard Error*
Intercept	-166290.762101157	0.992601098
GDP (RM Milion)	-0.0151343162810914	0.991121318
Population ('000 people)	11.8869348074454	1374.002161

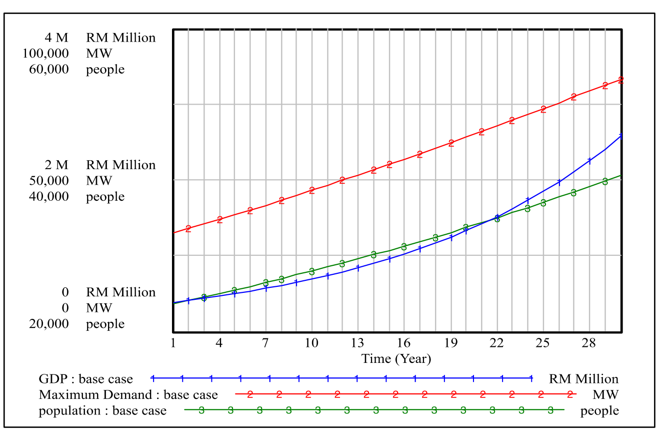

Figure 4:Correlation between GDP and population with maximum demand as the output

After estimating the maximum demand needed every year in the system, the generation mix decision is made. On top of that, during the development of the model, the type of technology for power plant involves in power generation are taken into consideration. There are five (5) technologies namely as, coal-, gas-, hydro-, oil-, and RE-power plant. The electricity generated by those technologies will then sum up in order to meet the demand for each year. In this research, there will be two models which is the model with fixed generation mix, and varies generation mix. Both models are having the same structure and variables except for the generation mix variables. Appendix B. 1 and Appendix B. 2 show the part of the model that is different between the fixed and varies generation mix, respectedly.

$$Capacity\ check = Reserve\ Margin + Maximum\ Demand \quad (1)$$

$$Total\ generation = Existing\ capacity + New\ capacity \quad (2)$$

$$if\ Capacity\ Check < Total\ generation\,; \quad Additional\ generation = 0 \quad (3)$$

$$if\ Capacity\ check > Total\ generation\,; \quad Additional\ generation = Capacity\ check - Total\ Generation \quad (4)$$

Figure 5 shows the cause tree of the additional generation that will be added into the system once the demand exceeds the existing capacity in the system. The figure explains on how the additional generation is obtained. Initially, the system will be having 0 MW of new installed capacity as well as 0 MW maximum demand. Therefore, the total installed capacity will consists only from the existing power plants. Subsequently, when there is maximum demand, the system will do a capacity check where the reserve margin will be taken into the matter. This capacity check will then be compares with the Total Installed Capacity in order to determine if the system needs additional generation for thet particular year. All these processes have been translated into mathematical equations as seen in Equation 1 – 4.

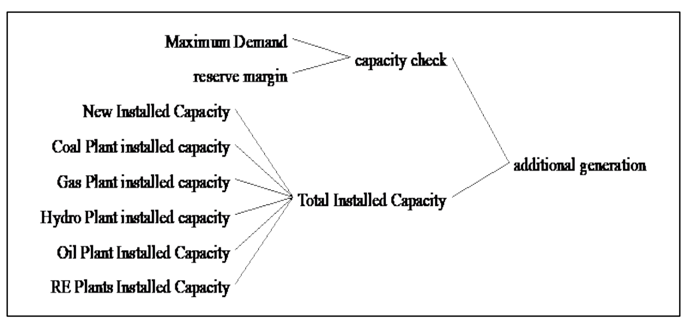

Figure 5: Cause tree of additional generation needed in the system

Commencing from this additional capacity needed in the system, the model will then distributed the capacity according the weightage of each technology. For the fixed generation mix model, the weightage of each technology is as shown in Table 2 below [8]. This is the base case model that will be the benchmark to the next model which is the varies generation mix model.

TABLE 2
FIXED GENERATION MIX REFERRED TO [8] (%)

Technology	%
Coal	44.3
Gas	37.4
Hydro	17.3
RE	0.05
Oil	0.05

For the model with varies generation mix, Figure 6 illustrates the variations of the generation mix in the 2nd model. The variants are based on the report by Suruhanjaya Tenaga (ST) [9] where in the latest generation development plan 2019, Malaysia is targeting to have more power generated by RE and gas. Hence for the 2nd model, the variation of the generation mix followed the pattern of the generation mix targeted by ST as shown in Table 3. In addition, this variation of generation mix can also be taken as the sensitivity analysis in order to validate the accuracy of the developed model. By looking closely at Figure 6 and Figure 9, it is clear that the model is sensitive to the changes of the generation mix and it reflects to electricity tarif as well. The behavior for both variables remain the same through out the simulation too.

TABLE 3
VARIATION OF GENERATION MIX REFERRED TO [9] (%)

Technology	2022	2023	2024	2025	2026	2027	2028
Coal	12	16	19	23	23	23	24
Gas	44	40	39	36	37	36	34
Hydro	7	7	6	6	6	7	7
RE	12	16	19	23	23	24	23

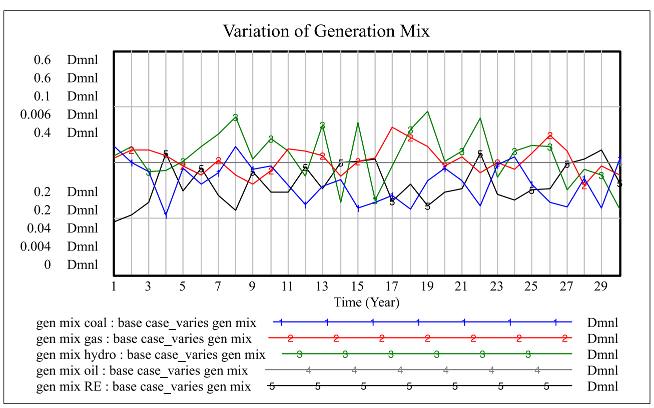

Figure 6: Variation of generation mix for each technology

These two conditions of generation mix have presented a significant changes in the additional generation in the system. Figure 7 shows the difference between two models reflected to the additional generation needed in the system. As the figure depicts, the model with fixed generation mix gives a slightly higher additional capacity as compared to when the variation of generation mix is applied to the model.

Eventhough both cases give the same maximum demand as shown in Figure 8, but when it comes to additional generation, the model with variation of generation mix shows a lower capacity is needed in the system.

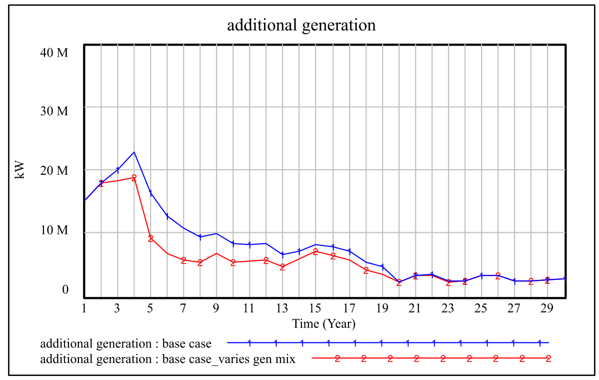

Figure 7: Graph of additional generation needed in the system

The rise in additional generation in base case model is believed to have relationship with the construction time of one power plant. For a fixed generation mix, the additional generation is higher due to the allocation of power generated by coal and gas contributed almost 80% of the generation.

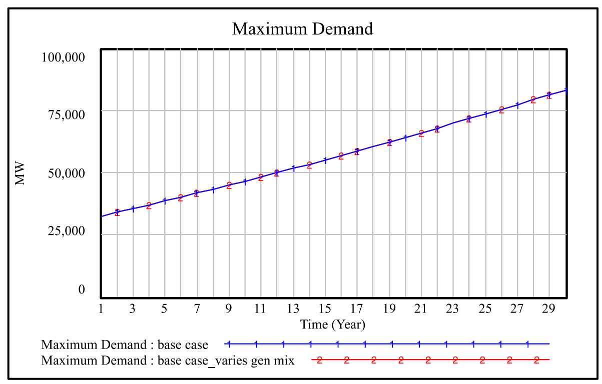

Figure 8: Graph of maximum demand in the system

Taking into consideration the construction time for each plant, this has made the additional generation for the base case model lead to higher MW as compared to the model with varies generation mix.

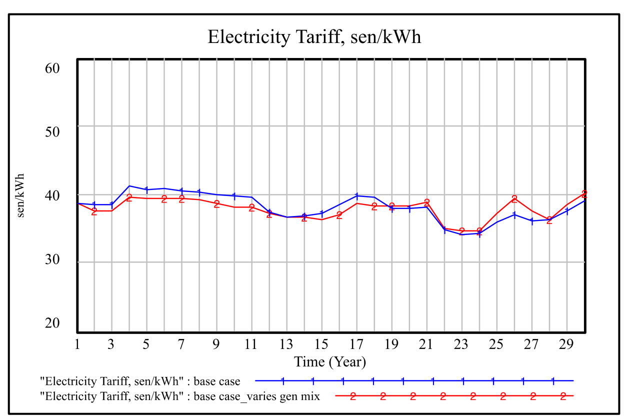

Figure 9 Electricity Tariff

Moving forward to the highlight of this research where in Figure 9, the upshot of generation mix variation in electricity tariff is observed. Taking electricity tariff as the variable that is going to be observed, the graph shows that the 1st model, (fixed generation mix), gave a slightly higher electricity tariff as compare to when the 2nd model (varies generation mix). This result is contributed by the distribution of generation mix percentage for all technology in the 2nd model is much more balance. For the 1st model, the coal and gas plant are set to be the highest contributors to the power generation makes the electricity tariff a bit higher as compared to the 2nd model. However, for the 2nd model, with RE-plants contributed as high as 24% of the generation, the tariff is expected to be lower compared to having 0.05% of RE-plant power generation is the 1st model since it is known that RE is among the cheapest power generator. The variation of generation mix with RE generation allocated with a much promising percentage contributes to lower electricity tariff.

V. Conclusion

In conclusion, this paper has developed a framework that correlate between the generation mix and electricity tariff in Malaysia electricity scenario. The model and simulations highlighted the dependence and interaction of each variables with regards to electricity tariff. A lower electricity tariff recorded for the 2nd model – the varies generation mix – can be used for future research especially in formulating a proper policy for the generation mix. Besides that, since this research is using the existing market model of MESI, a future works on a different market model can be proposed in order to observe what market model is suitable for MESI in order to to improve governance, ensure sustainability of the industry, implement a clear, consistent tariff pass-through mechanism, offset risks to industry members, standardize gas price subsidies and establish fuel supply protection in creating a fair competitive bidding framework for greater efficiency.

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References

[1] Z. Ngadiron, N. H. Radzi, Z. Yassin, and I. Amin, “Review on Restructuring of Malaysia Electricity Supply Industry,” *Appl. Mech. Mater.*, vol. 773–774, pp. 476–480, 2015.

[2] S. N. M. E. A. Hazwan Faisal Mohamad, “Electricity industry to undergo transformation with MESI 2.0,” 2018.

[3] Mckenzie Baker, “Malaysia Electricity Supply Industry 2.0,” 2019.

[4] T. Energy, “Energy industry,” *Chem. Eng. News*, vol. 80, no. 12, p. 55, 2002.

[5] H. Aris, B. N. Jørgensen, and I. S. Hussain, “Electricity supply industry reform in Malaysia : Current state and way forward Electricity supply industry reform in Malaysia : Current state and way forward,” no. October, 2019.

[6] J. W. Forrester, *Industrial Dynamics*. The MIT Press, 1961.

[7] Energy Commission, “National Energy Balance 2017,” 2017.

[8] Energy Commission Malaysia, “National Energy Balance 2018,” 2018.

[9] Energy Commission Malaysia, “Report on Peninsular Generation Development Plan 2019,” 2020.

[10] BP Energy Outlook, www.bp.com/

[11] R.G. Coyle, Management SD

[12] Energy Policies in Malaysia, 2013. Malaysia Structural Steel Association

[13] https://www.bp.com

[14] multi-criteria analysis of electricity gen mix scenarios in Tunisia

[15] H Lyu, H Li, F Wallin and B Xv, *Research on Chinese Solar photovoltaic development based on green-trading mechanisms in power system using as system dynamics model,* Energy Procedia, 105, 2017, pp.3960-3965.

[16] X Liu and M Zeng, *Renewable energy investment risk evaluation model based on system dynamics,* Renewable and Sustainable Energy Reviews, 73, 2017, pp.782-788.

[17] T.S Jalal, P.Bodger, *The Development of a System Dynamics Model to Evaluate Electricity Generation Expansion in New Zealand,* 20th Australasian Universities Power Engineering Conference, 2010, pp. 1–6.

[18] Adelino J.C. Pereiraa, João Tomé Saraiva, *Generation Expansion Planning (GEP) – A Long Term Approach Using System Dynamics and Genetic Algorithms (Gas),* Energy 36 Journal, 2011, pp. 5180–5199.

[19] Xiaodan G and Xiaopeng G, *China’s photovoltaic power development under policy incentives: A system dynamics analysis,* Energy, 93, 2015, pp.589-598.

[20] Mutingi M, Mbohwa C and Kommula V, *System dynamics approaches to energy policy modelling and simulation,* 4th International Conference on Power and Energy System Engineering, 141, 2017, pp.532-539.

[21]http://www.powerengineeringint.com/articles/print/volume-22/issue-7/regional-profile/malaysia-s-changing-power-sector.html

[22] H. Qudrat-Ullah, "On the validation of system dynamics type simulation models", *Telecommunication System,* vol.51, pp.159–166, 2012.

[23] S. Movilla, L.J Miguel, L.F Blazquez, "A system dynamics approach for the photovoltaic energy market in Spain", *Energy Policy,* vol. 60, pp. 142 - 154, 2013.

[24] S.Ahmad, R.M Tahar, "Using system dynamics to evaluate renewable electricity development in Malaysia", *Kybernetes Journal,* vol.43, pp. 24-39, 2014.

[25] C.W Hsu, "Using a system dynamics model to assess the effects of the capital subsidies and feed-in tariffs on solar PV installation", *Applied Energy Journal,* vol.100, pp. 205-217, 2012.

[26] Y.Smeers, A.Ehrenmann, M. Castelnouvo, "Electricity Modelling: Market power and the relevant market", *INFRATRAIN 2015,* pp. 1-24, 2015.

[27] A. Escribano, J. Pena, P. Villaplana, "Modelling Electricity Prices: International Evidence", *Working Paper 02-27, Economic Series 08,* Isssue 2, pp. 193-210, 2002.

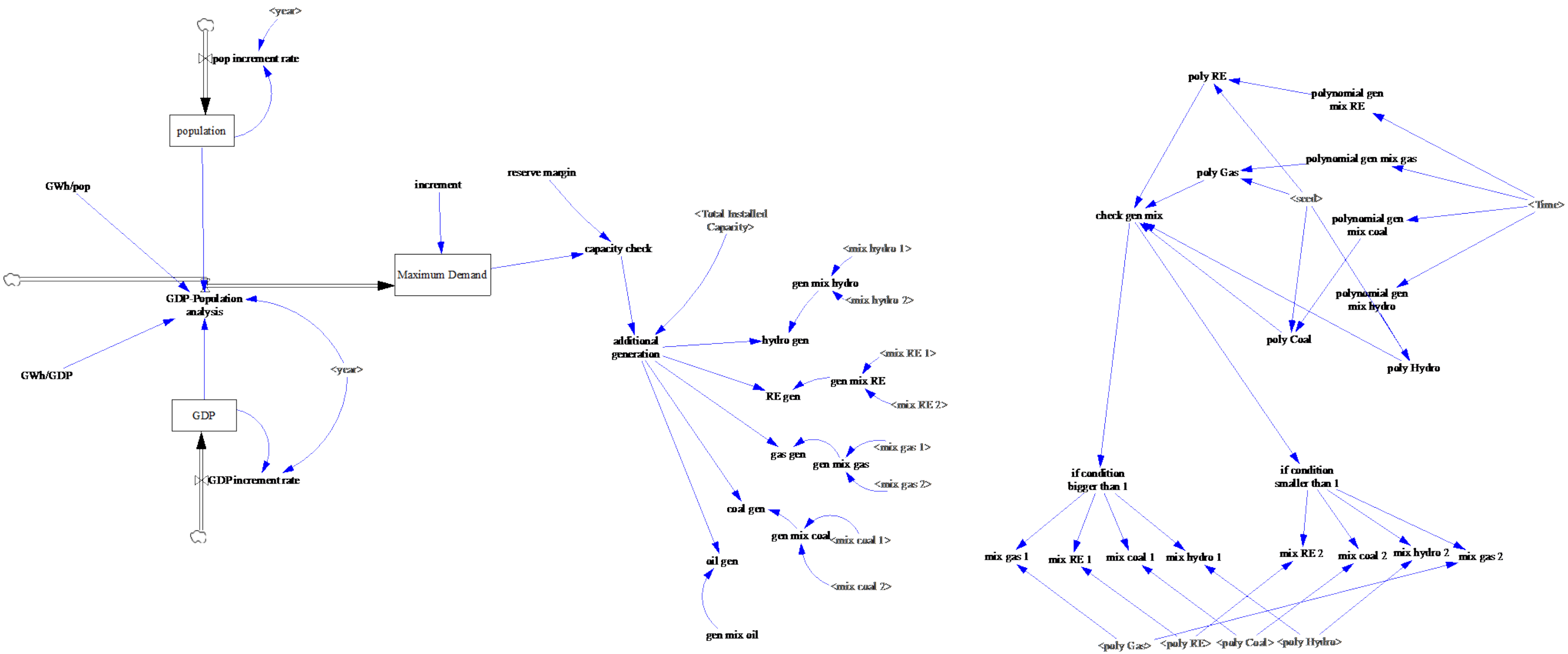
[28] S. Meng, M.Siriwardana, J.McNeill, T.Nelson. "The impact of an ETS on the Australian energy sector: An integrated CGE and electricity modelling approach", *Energy Economics,* vol. 69, pp. 213-224, 2018.

APPENDIX A

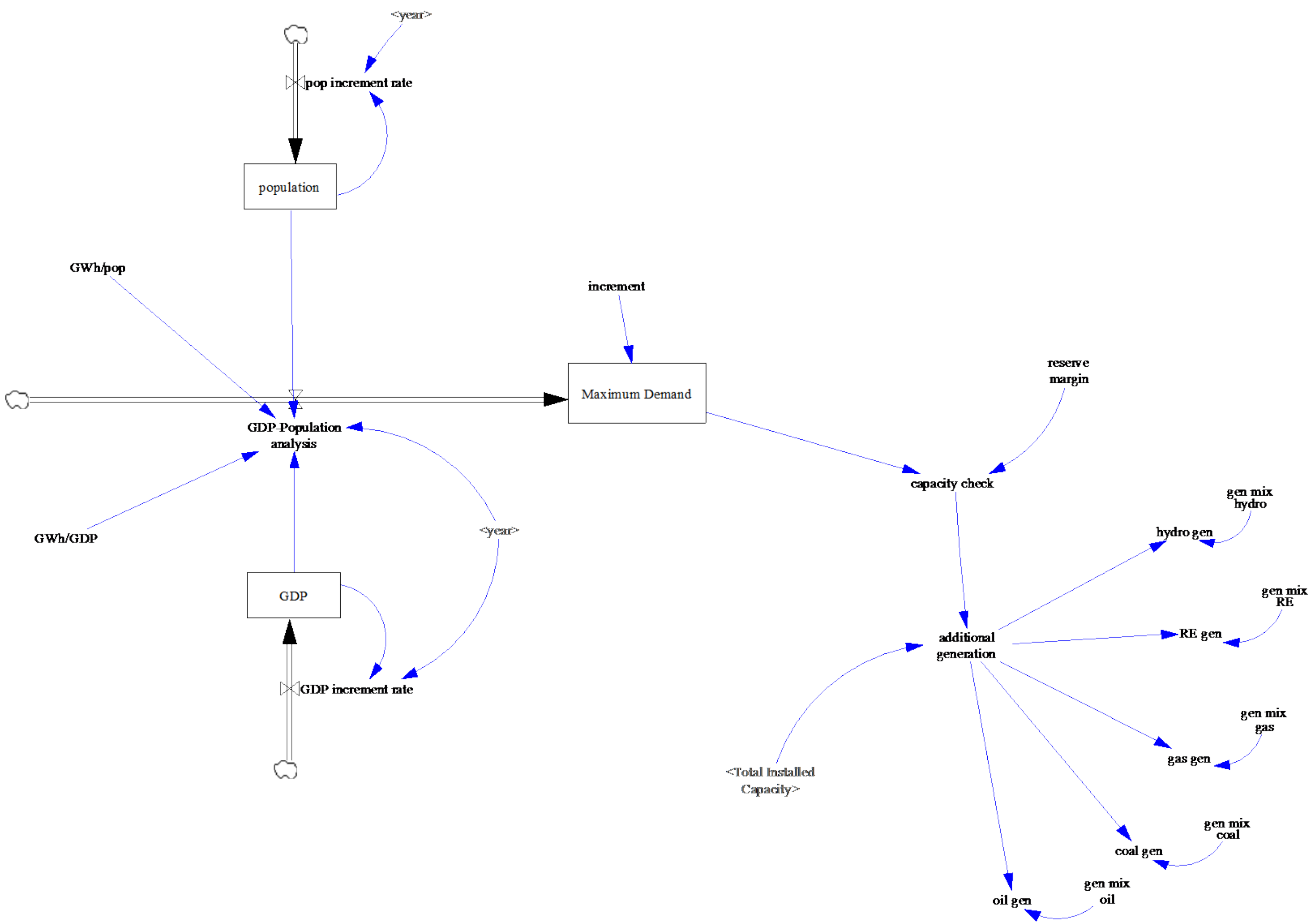
Power Plant	Unit Type	Size (MW)	PPA Expiry (Years)
SJ Sultan Ismail, Paka	Gas	1,029	2
SJ Jambatan Connaught, Klang	Gas	300	2
Kapar Energy Ventures Sdn Bhd	Gas	205	2
Port Dickson Power Bhd	Gas	436.4	2
Powertek Bhd	Gas	434	2
Pahlawan Power Sdn Bhd	Gas	322	2
TNB Pasir Gudang Energy Sdn Bhd	Gas	275	3
Stesen stesen Janakuasa Sg Perak	Hydro	649.1	3
GB3 Sdn Bhd	Gas	640	3
Panglima Power Sdn Bhd	Gas	720	3
Teknologi Tenaga Perlis Consortium Sdn Bhd	Gas	650	4
Prai Power Sdn Bhd	Gas	350	4
SJ Gelugor	Gas	310	4
SJ Putrajaya	Gas	253	5
SJ Sultan Mahmud Kenyir	Hydro	400	5
Kuala Langat Power Plant Sdn Bhd	Gas	675	6
Segari Energy Ventures Sdn Bhd	Gas	1,303	7
SJ Cameron Highlands	Hydro	250	7
SJ Tuanku Jaafar, Port Dickson	Gas	703	8
Kapar Energy Ventures Sdn Bhd	Gas	564	9
Kapar Energy Ventures Sdn Bhd	Coal	1,486	9
SJ Tuanku Jaafar, Port Dickson	Gas	708	10
TNB Janamanjung Sdn Bhd	Coal	2,070	10
Tanjung Bin Power Sdn Bhd	Coal	2,100	11
Jimah Energy Ventures Sdn Bhd	Coal	1,400	13
TNB Connaught Bridge Sdn Bhd	Gas	375	17
TNB Prai Sdn Bhd	Gas	1,071.43	17
SJ Pergau	Hydro	600	17

TNB Janamanjung Sdn Bhd	Coal	1,010	20
Tanjung Bin Energy Sdn Bhd	Coal	1,000	21
SJ Hulu Terengganu	Hydro	250	25
SJ Tembat	Hydro	7.5	25
SJ Ulu Jelai	Hydro	372	26
Bumipower Sdn Bhd, Jana Landfill Sdn Bhd, Naluri Ventures Sdn Bhd, Recycle Energy Sdn Bhd	RE	24.2	

APPENDIX B



Appendix B. 1: Sub-model for model with variation of generation mix



Appendix B. 2: Sub model for model with fixed generation mix