Analysis of the Impact of Nuclear Power Plant on Malaysia's Power Systems: Costs, CO_2 Emission and System Reliability

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Abstract—**Although Malaysia is blessed with plenty of fossil fuel and natural resources, but the amount of fossil fuels is now depleting. This has led Malaysia to find other alternative resources to generate electricity to meet the demand. Some possible options are: 1) Coal, however this leads to the dependency on imported coal and increases gas carbon emission, 2) Renewable energy (RE), however, the resources are interruptible and expensive, 3) Nuclear power plant, however the recent Fukushima incident and the public acceptance are the major consideration. Despite the nuclear safety that should not be compromised, nuclear power plant has many advantages over fossil fuel power plants. Nuclear power plant produces less CO_2 emission, cheaper levelized cost than coal and gas power plants and can operate continuously for long hours. Ministry of Energy, Green Technology and Water Malaysia (KETTHA) targets the energy from nuclear in Malaysia will be 17.8% of total generation mix in 2030. This paper studies the impact of nuclear power plant on Malaysia's power system in 2030, in term of cost, CO_2 emission and power system reliability. Two scenarios have been considered and compared; 1) Existing generation mix as in 2013, 2) Generation mix with nuclear as targeted by KETTHA in 2030. Results show that the generation mix with nuclear power plants has lower operation and investment cost, lower CO_2 emission and higher system reliability.**

***Index Terms*—Nuclear, generation cost, reliability, CO_2 emission**

I. INTRODUCTION

Malaysia has been highly dependent on fossil fuel for electricity generation. In 2012, about 90.26% of electricity generation in Peninsular Malaysia was generated using fossil fuel and 8.69% from hydropower and other is from renewable energy (RE) [1]. Electricity generated from RE is still very small due to its high cost. Furthermore, the crisis of oil and gas price, depleting resources and inescapable global warming of the greenhouse gases from fossil fuel combustion are the main global issues. In concern with the issues, Malaysia's Prime Minister announced that Malaysia is willing to reduce 40% of its carbon intensity emission per GDP by 2020 from the 2005 baseline [2]. On the other hand, from the energy security point of view, highly dependent on one type of fuel is not a viable solution. Alternative energy sources must be considered for future generations to reduce the dependency on fossil fuels and to search for greener resources to generate electricity. With the constraints on the prices and the availability of fossil fuels and RE, nuclear perhaps is the prominent solution that could solve Malaysia's energy crisis.

Ministry of Energy, Green Technology and Water Malaysia (KETTHA) in its plan, targets Malaysia will have a more balance generation mix in 2030 with 41.3% generation is from gas, 28.9% from coal, 7.4% from RE, 17.8% from nuclear and 4.6% from hydro [3]. In October 2010, Malaysia's Prime Minister launched nuclear energy as one of the Entry Point Project (EPP) in Malaysia Economic Transformation Program (ETP). Malaysia is looking into the possibility of building 2GW capacity of nuclear power plant with the first 1GW is expected to be ready by 2021.

Malaysia is not alone in considering nuclear power option. There are some other countries such as Indonesia, Thailand, and Vietnam [6]. However, Thailand deferred the nuclear plan after Fukushima nuclear disaster. As for Singapore, Fukushima crisis would not derail their pre-feasibility study on nuclear energy, as it is needed to assess safety risks associated with the technology. However any further decision on the nuclear program remains far away [7]. As for Vietnam, Pre-FS for the 1st Nuclear Power Program (NPP) in Vietnam and power sector development master plan up to 2025 has been approved by the government. The master plan shows that nuclear power capacity will reach 4000 MW in 2025 with the first unit comes on line in 2020 [6].

Nuclear power plant produce less gas emission for each unit of electricity it produces, compare to those produced by fossil fuel. Nuclear plant will reduce the heavy reliance on fossil fuel in the country's energy mix and can be used as alternative resources to generate electricity in the situation where the country is facing depletion of oil and gas resources. Furthermore, nuclear plant has a lower operating cost although it has the highest investment cost [5].

In developing nuclear power plant, safety measure is the most important aspect. According to [8], site selection is compulsory for nuclear safety. The site selection has four weighting factors; 1) public safety and health is 50%, 2) environment (ecology and water quality) is 20%, 3) Socio-economic is 15% and 4) engineering costs is 15%.

As for Malaysia, the biggest concern of building nuclear power plant is the safety of nuclear power reactors, the radioactive waste disposal and public acceptance. To consider building nuclear power plant in Malaysia, the benefits of building nuclear power plant must be justified. Therefore, it is the aim of this research to study the impact of

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nuclear power plant on Malaysia's power system in term of the cost, reliability and CO_2 emission. Analysis is performed by comparing two scenarios of power system in 2030; 1) existing generation mix and 2) generation mix with nuclear as targeted by KETTHA.

This paper is organized as follows; in section II we first describe the Malaysia's Nuclear Program. In section III we describe the model description. In section IV we present the test data and section V provides the results and discussion. Finally in section VI we draw some relevant conclusions.

II. MALAYSIA'S NUCLEAR PROGRAM

In May 2010 a Nuclear Power Development Steering Committee was set up which consist of three bodies; 1) nuclear power program working group under the Malaysian Nuclear Energy (MNA), 2) the nuclear power project working group under the utility Tenaga Nasional Berhad (TNB) and 3) a legal and regulatory coordination working committee involving the Atomic Energy Licensing Board (AELB) [6]. End of 2013 was a target date for the steering committees of Nuclear Power Infrastructure Development Plan (NPIDP) and government to decide whether to proceed with the nuclear plant or not. In order to complete the Nuclear Power Program (NPP) in Malaysia, the NPIDP will assess the STATE-of-READINESS, as per IAEA 19 key infrastructure issues during Phase 1 to Phase 3 of Nuclear Power Development [6].

Milestone 1 describes the readiness of the country to make a knowledgeable commitment to a nuclear power program. In June 2009, the Malaysian Government decided for nuclear energy to be considered as one of the fuel options for electricity supply post-2020, especially for the Peninsular Malaysia. Milestone 2, is the readiness to invite bids for the first NPP which was targeted in 2013, based on the Malaysia Entry Point Project (EPP) timeline. However the invitation may be deferred to early 2014, taking into consideration the delay on preparing the activities and the concern in Fukushima incident. Milestone 3, is the readiness to commission and operate the first NPP which was targeted in 2021 based on the EPP timeline but may be postponed as well. According to the IAEA milestones approach, Malaysia is still at the Milestone 1 [4,9].

III. MODEL DESCRIPTION

A. *Operation and Investment Cost*

In assessing the economics of nuclear power, decommissioning and waste disposal costs are fully taken into account. The total cost of generating electricity is equal to the sum of production cost, investment cost, fixed and variable operating cost, and the cost of disposing waste for nuclear power plant. These costs can be mathematically expressed as follows:

$$TC_t = PCall_t + A_{\ investment\ ,t} + FOMall_t + VOMall + NWCt \quad (1)$$

TC is the total cost of generation in year *t*, PC_{all} is the total production cost of all the generating units in the system at year *t*, $A_{investment,t}$ is the annualized investment cost of the new investments at year *t*. Multiplying the marginal cost by the energy produced gives the production cost of each unit. The energy produced each year is computed by performing economic dispatch for each segment of the load duration curve (LDC). FOM_{all} is the total fixed O&M cost of all the generating units at year *t*, $VOM_{all,t}$ is the total variable O&M cost of all the generating units at year *t*, NWC_t is the total nuclear waste cost of nuclear technologies at year *t*.

The mathematical description of *FOM*, *VOM* and *NWC* of the individual generating units in the system are shown below:

$$PC = \sum_{s=1}^{S} MCb_s p_s d_s \quad (2)$$

$$FOM = F_{O\&M} P^{max} \quad (3)$$

$$VOM = \sum_{s=1}^{S} V_{O\&M} p_s d_s \quad (4)$$

$$NWF = \sum_{s=1}^{S} WF p_s d_s \quad (5)$$

where *S* is the number of segments in the LDC, MCb_i is the marginal cost of the generating unit, $p_{j,s}$ is the power produced by the generating unit at segment s (obtain from economic dispatch) and d_s is the duration in hours of segment *s*. $F_{O\&M,}$ is the annual fixed O&M cost per MW capacity of the generating unit, $V_{O\&M,}$ is the variable O&M cost per MWh of energy produced by the generating unit at segment *s* of the LDC, *WF* is the nuclear waste fee per MWh of energy produced using nuclear technology at segment *s* of the LDC

The economic dispatch is modeled as an optimization problem in which the total yearly operating cost is minimized:

$$\min\left\{\sum_{s=1}^{S}\sum_{i=1}^{I}\left(MCb_i\ p_{i,s}\ d_s\right)\right\} \quad (6)$$

The objective function is subject to several constraints:

$$\sum_{i=1}^{I} p_{i,s} = pd_s \quad (7)$$

$$p_i^{min} \leq p_{i,s} \leq p_i^{max} \quad (8)$$

where pd_s is the system demand at segment *s*, P_i^{min} and P_i^{max} is minimum and maximum output power of the generating unit.

The first constraint is enforced so that the selected generation meets the load demand of segment *s,* as in equation (7). Each of generating unit is also constrained by its minimum stable generation and the maximum capacity that can be supplied as in equation (8).

The annualized investment cost is calculated as follows:

$$A_{investment,m} = I_{PWV}\left(\sum_{n=1}^{lt}\frac{1}{(1+MARR)^n}\right)^{-1} \quad (9)$$

where $A_{investment}$ is the annualized investment cost of the new generation, *MARR* is the minimum acceptable rate of return, I_{PWV} is the present worth value of the investment, *n* is the number of years and *lt* is the lifetime of the new power plant.

B. *Carbon dioxide (CO_2) Gaseous Emission*

The CO_2 emission in the system is calculated as follows:

$$Total\ CO_2 = \sum_{s=1}^{S}\sum_{i=1}^{I} pdis \times dur \times slope \times co2int \quad (10)$$

where *slope* is stand for the heat rate of the generating unit in

MBtu/MWh and *co2int* is the carbon intensity for coal and gas generating unit.

C. System Reliability

In this paper, power system reliability is calculated using Loss of Load Probability (LOLP). Capacity outage indicates a loss of generation which may or may not result in a loss of load. This condition depends upon the generating capacity reserve margin and the system load level. A loss of load will occur only when the capability of the generating capacity remaining in service is exceeded by the system load level [10]. The LOLP in each segment of the LDC is computed as follows:

$$LOLP_s = \sum_{z=1}^{Z} P_z((AC_s - CA_z) < pd_s) \quad (11)$$

where AC_s is the actual committed capacity at segment *s* of the load duration curve, CA_z is the capacity on outage for element *z* in the cumulative outage probability table (COPT), pd_s is the system demand at segment *s*, $P_z((AC_s - CA_z) < pd_s)$ is the probability of loss of load for element *z* when the system demand exceeds the capacity in service, which can be directly obtained from the COPT.

IV. TEST DATA

In this paper, the total generation cost, the CO_2 emission and the system reliability are calculated for one year i.e. year 2030. In such case, the generation supply in 2030 was forecasted assuming two scenarios; 1) Existing generation mix as in 2013, 2) Generation mix as targeted by KETTHA in 2030 with nuclear generation. The LDC in 2030 is modelled using the LDC in 2013, considering the increase in load by 3% each year.

The technical and cost parameters for nuclear, coal and gas power plant used in the analysis are shown in Table I.

TABLE I. TECHNICAL AND COST PARAMETERS FOR NUCLEAR, COAL AND GAS POWER PLANT.

Parameters	**Unit**	**Nuclear**	**Coal**	**Gas**
Technical parameters				
Investment Cost	$/kW	1810	1175	452
Carbon intensity	tC/MBTU	0	0.0258	0.0145
Cost parameters				
Fixed O&M	$/kW/yr	57.14	20.63	14.29
Variable O&M	$/MWh	0.365	3.063	0.476
fuel cost	$/MBTU	0.75	2.70	6.13
Fuel escalation rate	%	0.5	0.5	1.5
Nuclear waste fee	$/MWh	0.91	0	0

A. Load Duration Curve for 2030

The load in each segment of the LDC in 2013 is shown in the third column of Table 2. The LDC in 2030 is modelled considering that the load in each of the segment of the LDC increases 3% each year. The forth column of Table II shows the load in each segment of the LDC in 2030. Figure 1 shows the forecasted LDC in 2030.

TABLE II. LOAD DURATION CURVE 2013

Segment	Durations (hours)	Load (MW) 2013	Load (MW) 2030
1	345	17,407	28,772
2	1720	15,974	26,403
3	2064	14,904	24,635
4	2064	13,835	22,867
5	1720	12,902	21,325
6	847	11,628	19,219

The forecasted peak load in 2030 is 28,772MW. To consider 20% reserve margin as targeted by KETHHA, a 34,526MW of installed capacity is required in the system in 2030. The total installed capacity in 2013 is 21,978MW, therefore 12,548MW of new installed capacity is required to meet the demand and expected system reserve margin in 2030.

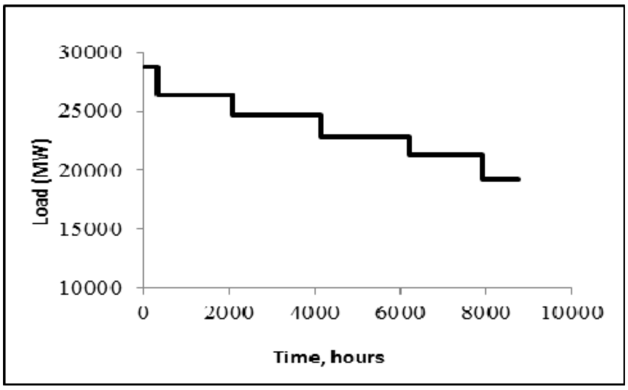

Fig. 1. Six-Segment of discretized LDC in 2030

B. Generation Supply Scenario in 2030

1) Scenario 1: As Existing Generation Mix in 2013

In Scenario 1, the generation mix in 2030 is assumed similar to the existing generation mix as in 2013 i.e. 57.64% of generation is from gas, 32.62% from coal, 8.69 from hydro and 1.04% RE (with no nuclear in the system). A total of 12,548MW of new capacity have been added in the system to meet the forecasted demand in 2030 and to meet the 20% reserve margin. The capacity and the type of the new additional plants are selected to meet the generation mix as in 2013. In this case, there are 16 new power plants have been added in the system to achieve the 34,526MW total installed capacity in 2030. The existing power plants and the additional plants (as highlighted in yellow) in 2030 for Scenario 1 are shown in Table III below.

Scenario 2: Generation Mix with Nuclear

In Scenario 2, the generation mix in 2030 is assumed similar to the generation mix as targeted by KETTHA [3] with 41.3% generation is from gas, 28.9% from coal, 7.4% from RE, 17.8% from nuclear and 4.6% from hydro. Similar to scenario 1, the capacity and type of the additional 12,548MW new plants are selected to meet the targeted new generation mix with nuclear plant.

The existing power plants and the additional plants (as highlighted in yellow) in 2030 for scenario 2 are shown in Table IV below.

TABLE III. EXISTING AND ADDITIONAL POWER GENERATION IN 2030 WITH A SIMILAR GENERATION MIX AS IN 2013 (SCENARIO 1)

Name	Name	Type	Pmax MW	MCb \$/MWh	FOR %
Teknologi Tenaga Perlis Consor tium	Unit1	gas	650	81.2225	0.04
Panglima Power	Unit2	gas	720	81.2225	0.04
Prai Power Sdn. Bhd.	Unit3	gas	350	81.2225	0.04
S.J. Tuanku Jaafar, Port Dickson	Unit4	gas	1409	81.2225	0.04
Kapar Ener gy Ventures (gas)	Unit5	gas	820	81.2225	0.04
Kapar Ener gy Ventures(coal)	Unit6	coal	1600	20.709	0.06
TNB Janamanjung	Unit7	coal	2070	20.709	0.06
Tanjung Bin Power	Unit8	coal	2100	20.709	0.06
Jimah Energy Ventures	Unit9	coal	1400	20.709	0.06
S.J. Pergau	Unit10	Hyd	600	5.49	0.05
NewPlant1	Unit11	coal	1010	20.709	0.06
NewPlant2	Unit12	coal	1000	20.709	0.06
NewPlant3	Unit13	gas	343	81.2225	0.04
NewPlant4	Unit14	gas	1071	81.2225	0.04
NewPlant5	Unit15	gas	1129	81.2225	0.04
NewPlant6	Unit16	hyd	250	5.49	0.05
Hulu Terengganu , Tembat	Unit17	hyd	15	5.49	0.05
Ulu Jelai	Unit18	hyd	372	5.49	0.05
Additional Chenderoh	Unit19	hyd	12	5.49	0.05
Tekai	Unit20	hyd	156	5.49	0.05
Telom	Unit21	hyd	132	5.49	0.05
Nenggiri	Unit22	hyd	165	5.49	0.05
YTL Power generation	Unit23	gas	1938	81.2225	0.04
Segari Energy Ventures Sdn.Bhd.	Unit24	gas	742	81.2225	0.04
powertek sdn.bhd	Unit25	gas	1790	81.2225	0.04
Pengerang Co-Gener ation	Unit26	gas	1790	81.2225	0.04
Port Dickson Sdn.Bhd	Unit27	gas	1390	81.2225	0.04
NewPlant7	Unit28	gas	1600	81.2225	0.04
NewPlant8	Unit29	gas	1500	81.2225	0.04
NewPlant9	Unit30	gas	1589	81.2225	0.04
S.J. Sultan Iskandar, Pasir Gudang (PGPS)	Unit31	gas	1070	81.2225	0.04
NewPlant10	Unit32	hyd	225	5.49	0.05
NewPlant11	Unit33	hyd	36	5.49	0.05
NewPlant12	Unit34	hyd	286	5.49	0.05
mini hydro	Unit35	hyd	458	5.49	0.05
NewPlant13	Unit36	coal	1101	20.709	0.06
NewPlant14	Unit37	coal	982	20.709	0.06
NewPlant15	Unit38	hyd	295	5.49	0.05
NewPlant16	Unit39	RE	131	4.31	0.05
Bumibiopower	Unit40	RE	229	4.31	0.05

TABLE IV. EXISTING AND ADDITIONAL POWER GENERATION IN 2030 WITH A GENERATION MIX AS TARGETED BY KETTHA (SCENARIO 2)

Name	Name	Type	Pmax MW	Mcb \$/MWh	FOR %
Segari Energy Ventures Sdn.Bhd.	Unit1	gas	1303	81.2225	0.04
Port Dickson Sdn.Bhd	Unit2	gas	436	81.2225	0.04
Pahlawan Power	Unit3	gas	322	81.2225	0.04
genting sanyen power sdn.bhd	Unit4	gas	762	81.2225	0.04
Teknologi Tenaga Perlis Consor tium	Unit5	gas	650	81.2225	0.04
Panglima Power Sdn.	Unit6	gas	720	81.2225	0.04
GB3 Sdn. Bhd.	Unit7	gas	640	81.2225	0.04
Prai Power Sdn. Bhd.	Unit8	gas	350	81.2225	0.04
S.J. Sultan Ismail	Unit9	gas	1136	81.2225	0.04
S.J. Serdang	Unit10	gas	625	81.2225	0.04
S.J. Gelugor	Unit11	gas	330	81.2225	0.04
S.J. Tuanku Jaafar, Por t Dickson	Unit12	gas	1409	81.2225	0.04
Kapar Ener gy Ventures Sdn. Bhd.(gas)	Unit13	gas	820	81.2225	0.04
Kapar Ener gy Ventures Sdn. Bhd.(coal)	Unit14	coal	1923	20.709	0.06
S.J. Sultan Iskandar, Pasir Gudang (PGPS)	Unit15	Gas	729	81.2225	0.04
TNB Janamanjung Sdn. Bhd.	Unit16	coal	2433	20.709	0.06
NewPlant1	Unit17	coal	1777	20.709	0.06
Jimah Energy Ventures Sdn. Bhd.	Unit18	coal	1763	20.709	0.06
NewPlant2	Unit19	Gas	234	81.8355	0.04
Genting Sanyen Power Sdn. Bhd.	Unit20	gas	675	81.8355	0.04
Segari Energy Ventures Sdn. Bhd.	Unit21	gas	1303	81.8355	0.04
Manjung IV	Unit22	coal	1374	20.709	0.06
NewPlant3	Unit23	coal	708	20.709	0.06
CBPS Repowering	Unit24	gas	458	81.2225	0.04
NewPlant4	Unit25	gas	957	81.2225	0.04
NewPlant5	Unit26	gas	400	81.2225	0.04
Hulu Terengganu	Unit27	hyd	250	5.49	0.05
Hulu Terengganu ,tembat	Unit28	hyd	15	5.49	0.05
Ulu Jelai	Unit29	hyd	372	5.49	0.05
Additional Chenderoh	Unit30	hyd	12	5.49	0.05
Tekai	Unit31	hyd	156	5.49	0.05
Telom	Unit32	hyd	132	5.49	0.05
Nenggiri	Unit33	hyd	416	5.49	0.05
NewPlant6	Unit34	LWR	1537	14.835	0.04
NewPlant7	Unit35	LWR	1537	14.835	0.04
NewPlant8	Unit36	LWR	1537	14.835	0.04
NewPlant9	Unit37	LWR	1537	14.835	0.04
NewPlant10	Unit38	RE	1215	4.31	0.05
Biogas	Unit39	RE	229	4.31	0.05
NewPlant11	Unit40	RE	1111	4.31	0.05
S.J. Pergau	Unit41	hyd	235	5.49	0.05

V. RESULTS AND DISCUSSION

The impact of two different generation mixes as in Scenario1 (no nuclear) and Scenario 2 (with nuclear) are evaluated in term of total generation cost, CO_2 emission and power system reliability.

A. Total Generation Cost

1) Scenario 1

Figure 2 shows the total power produced in 2030 by each of the technologies in each segment of the LDC for scenario 1. It is seen that coal produced power most of the time, and the production of gas increases from the base segment to peak segment as the load increases. The total operation cost in 2030 for Scenario 1 is \$9,272,200,000 and total annualized investment cost for the new power plants is \$1,691,400,000. Total generation cost for Scenario 1 is \$10,963,600,000.

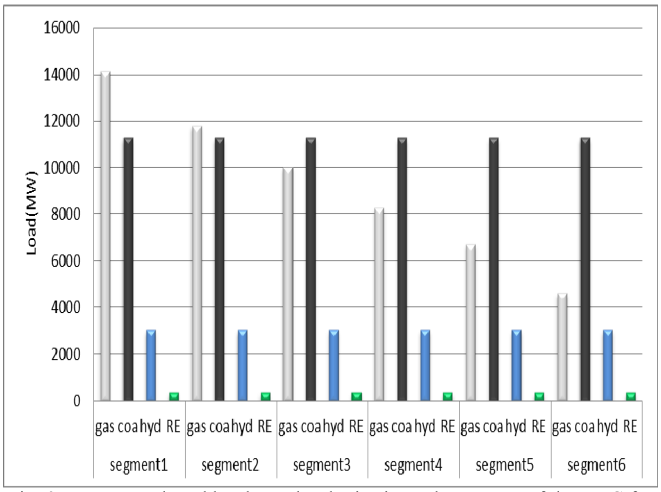

Fig. 2. Power produced by the technologies in each segment of the LDC for scenario 1

2) Scenario 2

Figure 3 shows the total power produced in 2030 by each of the technologies in each segment of the LDC for Scenario 2. Different to Scenario 1, nuclear power plant acts as the primary base unit to serve the load followed by the coal then gas units. The introduction of nuclear power plant in the system reduces the production from coal especially in segment 6 (the lowest base segment) and significantly reduces the output from gas. The production of coal and gas increases from the base segment to the peak segment as the load increases. In Scenario 2, the output of RE is seen higher than Scenario 1 as more RE is installed in the system.

The total operation cost in 2030 for Scenario 2 is \$6,139,200,000 which is lower than Scenario 1. This is due to the marginal cost of nuclear plant is cheaper than the marginal cost of coal and gas power plant. On the other hand, the total annualized investment cost for the new power plants in Scenario 2 is \$2,411,900,000 which is higher than Scenario 1. This is because the investment cost of nuclear power plant is higher compare to the investment cost of coal and gas power plant. However, the total generation cost for Scenario 2, with nuclear plant is found cheaper i.e. \$8,551,100,000 than having a generation mix without nuclear as in Scenario 1. These are shown in Figure 4.

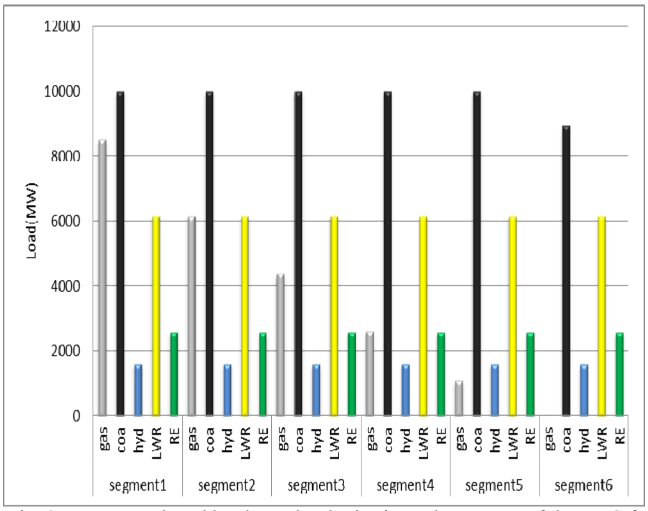

Fig. 3. Power produced by the technologies in each segment of the LDC for Scenario 2

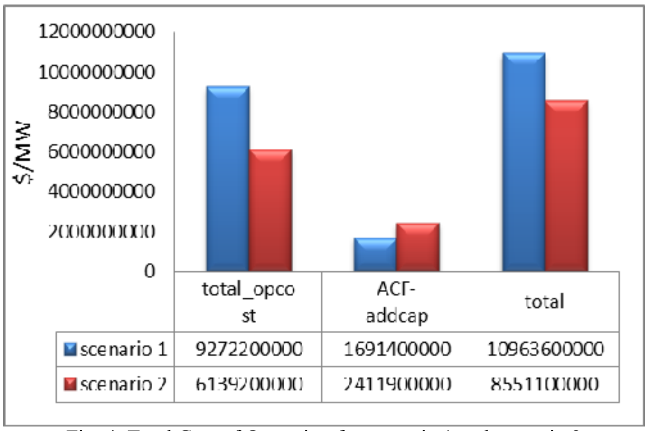

Fig. 4. Total Cost of Operation for scenario 1 and scenario 2

B. CO_2 Emission

1) Scenario 1

Figure 5 shows the total CO_2 emission by each technology in Scenario 1. Coal power plant contributes the highest amount of CO_2 emission compare to other technologies as it has the highest carbon intensity. This is followed by gas power plants.

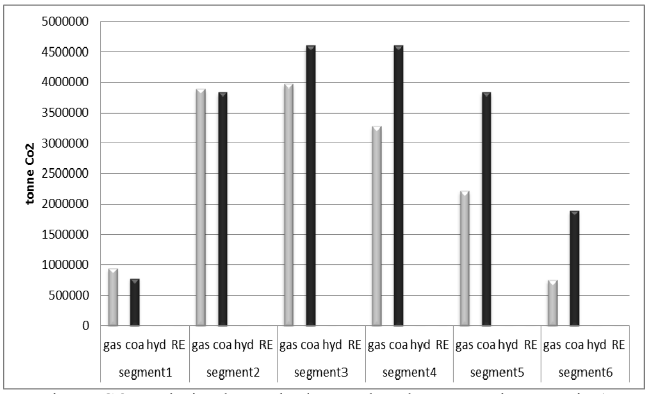

Fig. 5. CO_2 emission by each plant and each segment in scenario 1

2) Scenario 2

Figure 6 shows the total CO_2 emission by each technology type for Scenario 2. It is seen that similar to Scenario 1, coal contributes to the highest CO_2 emission, as it has higher carbon intensity than other fuels. This is followed by gas power plant which acts as medium and peak unit in the system and produces less energy compare to coal. Moreover, gas has lower carbon intensity than coal.

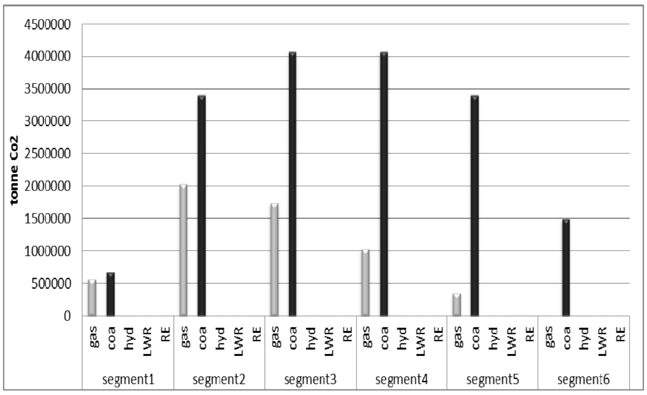

Fig. 6. CO_2 emission by each plant and each segment in scenario 2

Comparing the two scenarios as in Figure 7, Scenario 1 produces 34,553,341tonne of CO_2 in year 2030 which is much higher than Scenario 2 which produces 22,825,154 tonne CO_2 per year. This shows that a more balance generation mix with nuclear and RE plants could reduce the CO_2 emission.

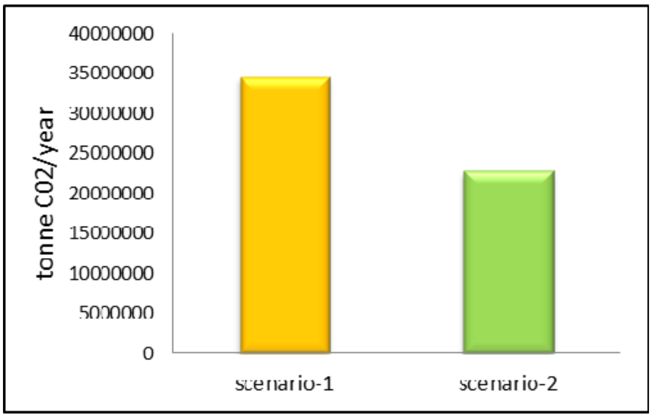

Fig. 7. Total CO_2 emission for scenario 1 and scenario 2

C. System Reliability

The power system reliability of the two scenarios is evaluated using LOLP index. Table 5 shows the LOLP index in each segment of the LDC for Scenario 1 and Scenario 2. It is seen that the loss of load could exist in segment 1 i.e. the peak load. The LOLP in segment 2 to segment 6 are zero as no loss of load could probably be obtained after considering the capacity outage. Comparing the LOLP for both scenarios, LOLP for Scenario 1 (without the nuclear plant) is higher than LOLP in Scenario 2 (with nuclear plant) as seen in Figure 9. This indicates that the power system reliability is higher in generation mix with nuclear compare to scenario without nuclear power plant.

TABLE V. LOLP IN EACH SEGMENT OF THE LDC FOR SCENARIO 1 AND SCENARIO2

Segments	Duration	Load	LOLP-Scenario 1	LOLP-Scenario 2
Segment 1	345	28772.07	0.0064	0.0038
Segment 2	1720	26402.61	0	0
Segment 3	2064	24634.91	0	0
Segment 4	2064	22867.21	0	0
Segment 5	1720	21325.18	0	0
Segment 6	847	19218.99	0	0

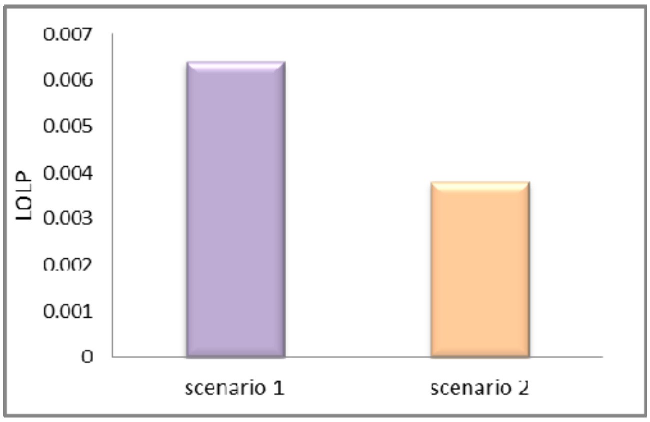

Fig. 8. LOLP for scenario 1 and scenario 2

VI. CONCLUSIONS

This paper studies the impact of nuclear power plant in Malaysia's power system. Two power generation scenarios for 2030 have been modelled; 1) generation mix as in 2013, 2) generation mixes with 17.8% nuclear plant as targeted by KETTHA. The comparison is based on the total cost of electricity generation, amount of CO_2 emission and system reliability measured in LOLP. Results shows that the generation mix with nuclear power plants has lower operation and investment cost, lower CO_2 emission and higher system reliability.

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