

Design and Planning of a Nuclear Power Plant in Malaysia: A Feasibility Report

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Abstract – Malaysia is currently planning on building its first nuclear power plant to add on more variety of national energy mix. This paper is on the study on the feasibility of the plan. We will show the current and forecast energy demand that make the nuclear power plant as the major solution to cover the deficit. Malaysia current strategy and action on building the plant will be presented in this paper. The challenge on delivering this project of energy mix is also a major aspect that will be discussed. The international and national policy regarding of nuclear power and its waste has provide a rough guidelines to execute this planning. While existing literature points to a correlation between nuclear power, strong state involvement, centralized energy planning and the rhetoric linking energy to national prestige and security, we show that these factors are not sufficient for a successful nuclear program. Another motivation on pursuing nuclear power is to reduce the carbon emission to the environment. By the end of this paper, we include the nuclear conventions that Malaysia involve and future prospect for nuclear power plant development. **Copyright © 2016 Penerbit Akademia Baru - All rights reserved.**

Keywords: Nuclear Power Plant, Malaysia, Feasibility, Design and Planning

1.0 INTRODUCTION

Malaysia have a lot of source of energy that use as a fuel in power plant to supply electricity such as oil, coal, natural gas and renewable energy. Currently, power generation in Peninsular Malaysia relies heavily on natural gas and coal. The natural gas will be the dominant source that important for more two decades and will continue to be an essential component for years to come. Moving forward, Malaysia need to explore alternative sources as well as capitalizing on well-developed fossil fuel infrastructure. According to Sustainable Energy Development Authority Malaysia, SEDA the development of renewable energy project will contribute to overall fuel mix that expected to increase.

Malaysia has been exploring the option of deploying nuclear energy to meet future demand and diversifying the energy mix for Peninsular Malaysia. Since 2009, a Nuclear Power Development Steering Committee, driven by Ministry of Energy, Green Technology and Water (KeTTHA), has been conducting various studies towards preparing a Nuclear Power Infrastructure Development Plan (NPIDP). The committee also worked on nuclear pre-feasibility and initial site selection studies.

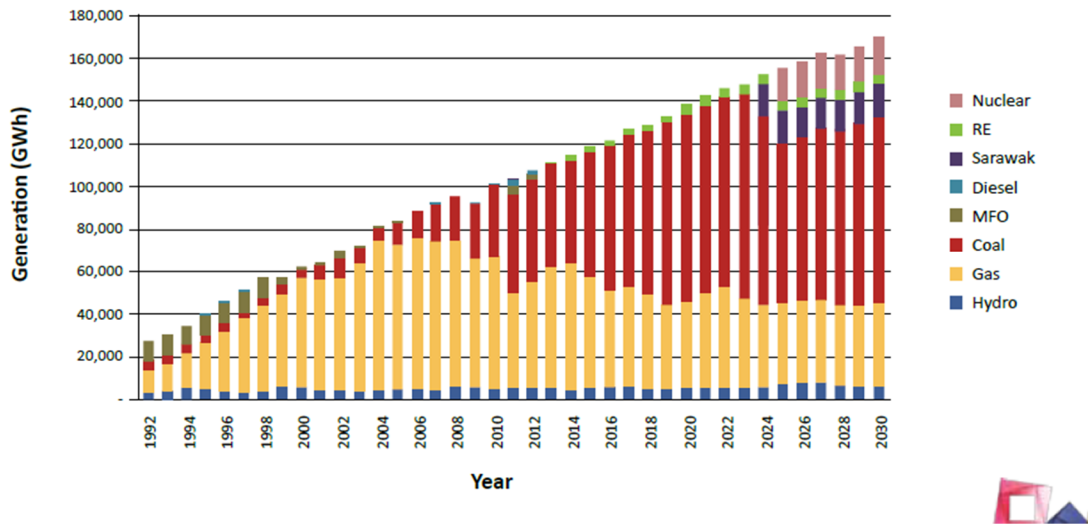


Figure 1: Generation Mix

*source from Malaysia Energy Commission

In 2011, the Government formed the Malaysia Nuclear Power Corporation (MNPC) to lead the feasibility study of this project taking into consideration safety and environment impacts [1]. Reliable and adequate electricity supply is an important catalyst for the economic development in the country. Industrial and commercial sectors are the two largest electricity users in Peninsular Malaysia that take consideration for electrical demand growth that heavily influenced by prevailing economic condition.

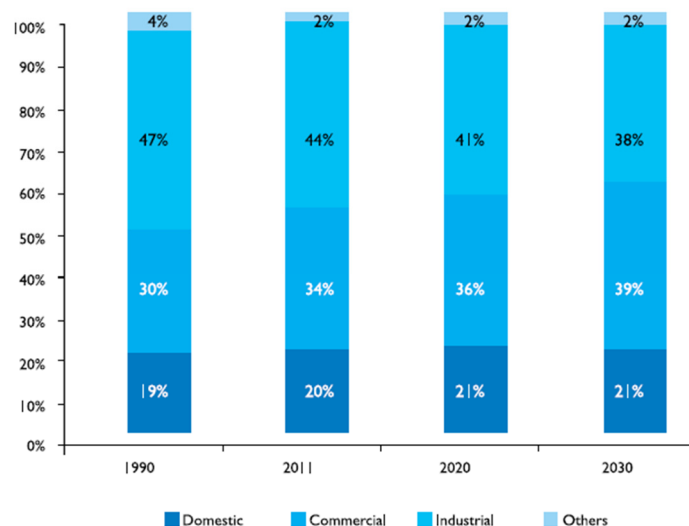


Figure 2: Latest sectoral forecast for Peninsular

*source by Malaysia Energy Commission

Electricity sales are expected to reach 104,840GWh in 2015, which is a 2.4% growth from that in the previous year. Sales are estimated to rise to 3.4% in 2016 and 3.8% the following year. Electricity generation is forecasted to reach 116,813GWh in FY2015 and peak demand is estimated to reach 17,461MW in the same year. This is a 560MW increase or 3.3% growth from that in the previous year[2]. Malaysia's Electricity demand will rise when become a developed nation 2020 and beyond. New Power Capacity must be planned and installed.

Table 1: Average period growth rates, % pa:

Average period growth rates, % pa:			
Years	Sales Forecast	Generation Forecast	Peak Demand Forecast
2015 - 2020	3.4%	3.2%	3.1%
2015 - 2025	3.0%	2.8%	2.6%
2025 - 2035	1.7%	1.5%	1.4%

*source by Malaysia Energy Commission

2.0 HISTORY

According to Economic Transformation Programme (ETP) that have been introduce by prime minister of Malaysia, in 2009 a Nuclear Power Development Steering Committee, headed by the Ministry of Energy, Green Technology and Water was being set up. The committee had been tasked to plan and conducted various studies toward preparing a Nuclear Power Infrastructure Development Plan (NPIDP), which targeted to be ready in 2013.

The nuclear power plant is targeted to be a twin-unit power plant with total capacity of 2 gigawatts with the first unit in operation by 2021. The cost of twin-unit power plant is expected RM21.3 billion. Before the project be launched, there are four path that are require to be fulfil[3]

Four path the are required: -

1. There must be public acceptance of the project
2. Malaysia must ratify the relevant international treaty
3. The government must ensure that the correct regulatory framework is put in place
4. Approval for plan sites including from local populace must be obtain

These four high priorities items must be completed during the pre-project phase. In 2010 government are agree to establish a Nuclear Energy Programme Implementing Organization (NEPIO) as recommended by International Atomic Energy Agency (IAEA). By 7th January 2011 Malaysia Nuclear Power Corporation (MNPC) was established as NEPIO. MNPC will lead the nuclear power planning based on IAEA requirements and ETP nuclear timeline.

Original Milestones for Nuclear Power Development in Malaysia

1) Milestone 1 : June 2009

- Ready to make a knowledgeable commitment for a nuclear power programme
- Cabinet decision for nuclear energy to be a fuel option post-2020

2) Milestone 2 : 2013

- Ready to invite bids for the first nuclear power plant
- Ready to commission and operate the first nuclear power plant

The gap between milestone 2 and 3 are 8-9 years.

Post Fukushima

The situation today are more challenging compared in 2010 when the nuclear timeline was proposed in ETP 2010 report. This is because the cost-competitiveness of nuclear electricity is now less promising with higher nuclear capital cost to incorporate extra safety designs and lower fossil fuel prices today. Public are hardly to be tolerate because they have witness news of explosion in Fukushima Dai-ichi in 2011. After the incidence there are no nuclear-related decision that have been made by the government of Malaysia[4].

Revised Target Milestones for Nuclear Power Development in Malaysia

1) Milestone 1 : June 2009

- Ready to make a knowledgeable commitment for a nuclear power programme
- Cabinet decision for nuclear energy to be a fuel option post-2020

2) Milestone 2 : 2019/2020 (reschedule from 2013)

- Ready to invite bids for the first nuclear power plant

3) Milestone 3 : 2030

Ready to commission and operate the first nuclear power plant.

3.0 CURRENT SITUATION AND PLANS

3.1 Global and Asian context on nuclear power

The world's energy consumption is expected to rise between 2012 and 2035 by 41% and it is surely gives us challenge to ensure long-term, sustainable access to secure, cost-effective and lower carbon power. This phenomena leading to developing nuclear power. Nuclear power generation is perfect match to meet this need as it is seen by many as the only readily available large-scale alternative to fossil fuels for production of continuous, reliable supplies of electricity. Moreover, nuclear market is well established and accepted as a core element of the global energy mix, making up 4.5 percent of total energy consumption. Furthermore, the increasing attention on reducing carbon emissions has driven steady growth in investments in renewable power sources globally [5].

In the context of Asia, the existing 119 nuclear power reactors in Asia have a combined capacity of 85 Gigawatt (GW) in 2012. A total of 331 terawatt hours (TWh) of electricity is generated by these facilities, down from 460 TWh in 2011. This is due to a near 100 percent

decrease of power generation in Japan's nuclear power plants which have been taken offline since the Fukushima accident in 2011. Despite Fukushima, the regional nuclear development trend seems less pronounced. Nuclear power is growing in traditional markets of China and India, and emerging in Southeast Asia, most notably in Vietnam, and also in Indonesia. There are a total of 55 research reactors in 14 countries in Asia including eight countries (six are in Southeast Asia) that do not currently operate nuclear power on a commercial scale [5].

In Malaysia, nuclear energy is a suitable option and there is an emerging interest for the option. The status of nuclear energy in Malaysia is influenced by the 1979 National Energy Policy and National Energy Security & Fuel Diversification Policies. Here is some of the major energy policies in Malaysia: [6, 7] supply and social, economic efficiency, and environmental objectives. There are five pillars regarding this policy which are energy pricing, energy supply, energy efficiency, governance, and change management.

Here is the timeline for the recent policy directions towards nuclear power development [8].

29 th August 2008	: 2009 budget in Parliament to explore nuclear energy and formulate new National Energy Policy
10 th September 2008	: Decision to draft National Nuclear Policy
26 th June 2009	: Nuclear energy is adopted as one of fuel options for electricity supply post- 2020, especially for Peninsular Malaysia
10 th June 2010	: New National Energy Policy incorporated in Tenth Malaysia Plan with nuclear energy as longer term option for Peninsular Malaysia
16 th July 2010	: Adoption of National Nuclear Policy
25 October 2010	: Economic Transformation Programme (ETP) launched with nuclear power deployment included
10 th December 2010	: Decision to establish Nuclear Energy Programme Implementing Organisation (NEPIO)
7 th January 2011	: Incorporation of MNPC as NEPIO

Together with the Malaysia plan for nuclear reactor deployment, there will always be some challenges to fulfil it. The most difficult challenge would be public acceptance of nuclear energy. The Malaysian government has been receiving criticisms from the public ever since the suggestion of implementing nuclear power plant in our country. Nuclear energy is a rather new and fresh idea nowadays as compared to the fossil fuels, coals, natural gas and hydropower. The public in general does not possess deep understanding and comprehensive knowledge on the characteristics of nuclear energy. Thus, they are normally fear of the negative impacts and influences brought by the nuclear energy and do not accept or take in these risks into their lives.

In order to ensure the smooth implementation of nuclear energy in the country, the activists or government agencies involved must first ensure public confidence and acceptance regarding the issue. There are various perspectives that we need to look into and take consideration before making final decision as this involves the safety and interest of a nation and public.

Table 2: Major Energy Policies in Malaysia

POLICY NAME	OBJECTIVES
National Petroleum Policy 1975	To regulate downstream oil & gas industry via the Petroleum Regulations 1974
National Energy Policy	To ensure adequacy, security, and cost-effectiveness of energy supply To promote efficient utilization of energy & discourage wasteful and non-productive patterns of energy consumption To minimize negative environmental impacts in the energy supply chain
National Depletion Policy 1980	To prolong lifespan of Malaysia's oil reserves for future security & stability of oil supply
Four-Fuel Diversification Strategy 1981	To pursue balanced utilization of oil, gas, hydro and coal To reduce over-dependence on single fuel source To focus on four main source of fuel such as oil, hydropower, natural gas and coal
Five-Fuel Diversification Strategy 2001	Renewable Energy included as the fifth fuel in energy supply mix To expand source of fuel to comprise oil, hydropower, gas, coal, and renewable energy
National Renewable Energy Policy & Action 2009	To increase renewable energy contribution in the national power generation mix To facilitate the growth of the renewable energy industry To ensure the reasonable renewable energy generation costs To conserve the environment for future generations To enhance awareness on the role and importance of renewable energy
New Energy Policy 2010	To encapsulate all efforts to ensure economic efficiency, security of supply and meet social as well as environmental objectives

All parties from various backgrounds should be involved in the decision-making and development of nuclear energy and given a chance to raise their doubts. Government should also provide a right path for the public to raise their concerns and opinions. Also, there is a necessity to open up any regulatory finding and judgment for the public to justify and scrutinize. This would in turn ensure the justice and equality of rights or interest among all parties. Lastly, public should be presented the advantages of nuclear energy compared to other alternatives. Some campaigns or seminars should be organised for all ages from children, students, and adults. [9]

3.2 Nuclear science and technology education and training

Almost all public universities and some private universities offered science, technology and engineering programs. In Malaysia, Universiti Kebangsaan Malaysia (UKM) offers nuclear science undergraduate program since 1978 while Universiti Teknologi Malaysia (UTM) offers medical physics undergraduate program. Moreover, Universiti Sains Malaysia (USM) and Universiti Malaya (UM) provide postgraduate programs in medical physics. Other universities in Malaysia also offer nuclear science & technology as subject in Engineering, Science & Technology and also medical courses.

UTM started to offer Bachelor of Nuclear Engineering program in 2012 and the first intake of about 32 students. Universiti Tenaga Nasional (UNITEN) also offering nuclear engineering

elective courses to all engineering student in 2009 and plan to offer Nuclear Engineering minor in 2014. Meanwhile, Universiti Islam Antarabangsa Malaysia (UIAM) also planned to offer Bachelor of Nuclear Engineering followed by Universiti Tun Hussein Onn which planned to offer Master of Nuclear Engineering in collaboration with Malaysian Nuclear Agency as sister campus. MNA collaborates with all universities in Nuclear Engineering Education. In 2012, Ministry of Higher Education commissioned a study on the Roadmap of Nuclear Engineering Education in Malaysia. [10]

3.3 Nuclear conventions that Malaysia is a party or signatory to

Table 3 shows some conventions that Malaysia takes place in nuclear sector

Table 3: The Nuclear Treaty, Convention, or Agreement involving Malaysia [6]

No	Treaty, Convention, or Agreement	Status of Malaysia
1	1956 Statue of the International Atomic Energy Agency (IAEA)	Acceded to on 15 January 1969
2	1968 Treaty on the Non-proliferation of Nuclear Weapon (NPT)	Signed on 1 July 1969 and ratified on 3 May 1970
3	1972 Agreement between the Malaysia Government and the IAEA for the application of safeguards in connection with the NPT (Comprehensive Safeguards Agreement)	Concluded and entered into force on 29 February 1972
4	1997 Additional Protocol to the IAEA Comprehensive Safeguards Agreement	Signed on 22 November 2005, but yet to be ratified
5	1980 Agreement between the IAEA and the governments of Malaysia and the United States of America concerning the transfer of a research reactor and enriched uranium (IAEA Project and Supply Agreement)	Concluded and entered into force on 20 September 1980
6	1959 Agreement on privileges and immunities of IAEA	Not a party to
7	1986 IAEA Convention on Early Notification of A Nuclear Accident	Acceded to on 1 September 1987 and entered into force on 2 October 1987
8	1986 IAEA Convention on Assistance in the Case of Nuclear Accident or Radiological Emergency	Acceded to on 1 September 1987 and entered into force on 2 October 1987
9	1979 Convention on the Physical Protection of Nuclear Material (CPPNM)	Cabinet approval to accede to made on 27 October 2003, but legal process to criminalize related offences still on-going
10	2005 protocol to amend the convention on Physical Protection of Nuclear Material	Yet to accede to, but related offences will be criminalized together with those for 1979 CPPNM
11	1994 Convention on Nuclear Safety	Yet to accede to, but need to accede, especially with nuclear power
12	1963 Vienna convention on Civil Liability for Nuclear Damage	Not a party to
13	1997 protocol to amend the Vienna Convention on Civil Liability for nuclear Damage	Yet to accede to, but may need to accede or adopt provisions in national legislation, especially with nuclear power
14	1997 Convention on Supplementary Compensation for Nuclear Damage	Yet to accede to, but may need to accede or adopt provisions in national legislation, especially with nuclear power

15	1997 Joint Convention on the Safety of Spent Fuel Management and on Safety of Radioactive Waste Management	Yet to accede to, but may need to accede, especially with nuclear power
16	1963 Treaty Banning Nuclear Weapon Tests in the atmosphere on outer space, and under water. (Partial Test ban Treaty, PTBT)	Signed and ratified on 15 July 1964
17	1967 Treaty on Principles Governing the states in the exploration and use of outer space, including the moon and other celestial bodies (Outer Space Treaty)	Signed on 20 February 1967, but yet to ratify
18	1972 Treaty on the prohibition of the emplacement of nuclear weapons and other weapons of mass destruction on the sea bed and the ocean floor and in its sub-soil thereof (sea-bed Treaty)	Signed on 20 May 1971 and ratified on 21 June 1972
19	1995 Treaty on the South-East Asia Nuclear Weapons-Free Zone (SEANWFZ)	Signed on 15 December 1995 and ratified on 11 October 1996
20	1996 Comprehensive Nuclear Test-Ban Treaty (CTBT)	Signed on 23 July 1998 and ratified on 17 January 2008
21	2005 International Convention on Suppression of Acts of Nuclear Terrorism	Signed on 16 December 2005, but yet to ratify

4.0 FUTURE PROSPECTS FOR NUCLEAR POWER IN MALAYSIA

4.1 Motivation for nuclear power development

Table 4: Motivation for nuclear power development in Malaysia [7]

Motivation	Explanation
Long-term energy security	To ensure reliable and secure long term energy supply
Diversification on energy resources	Reduce overdependence on fossil fuel such as natural gas, coal, and oil
Depletion of indigenous energy resources	Declining oil and gas production and proven reserve
Reduce heavy reliance on imports of coal	Coal is fully procured from the international market which are Indonesia, Australia, Russia, and South Africa
Reduce green-house-gas (GHG) emission	To achieve 40% reduction in carbon intensity compared to 2005 level by 2020

4.2 Vision on national prospects for nuclear energy size and growth

Table 5: Vision on National prospects for nuclear energy size and growth [7]

Plan	Explanation
10 th Malaysia Plan (2011-2015)	To explore the usage of nuclear power in order to meet future energy demand and diversify energy mix in Peninsular Malaysia Feasibility studies, human capital development and public awareness campaign will be undertaken
Economic Transfer Programme (ETP) (2010-2020)	Nuclear Power is included as one of Entry Point Projects (EPP) under Oil, Gas and Energy sector Initial target: Twin unit (2GW) nuclear capacity with first unit commissioned in 2021
11 th Malaysia Plan (2016-2020)	To further explore the usage of nuclear power as an alternative energy resource for Peninsular Malaysia To build buy-in for the development of nuclear power plants through effective communication and public awareness programmes and implementation of NPIDP and NPRIDP

5.0 CONCLUSION

This article examines the Malaysia state's motivation, capacity and strategy for implementing nuclear power. Nuclear power has been discussed in Malaysia since 2009 and at first was planned to be finish by 2013. But due to higher nuclear capital cost to incorporate extra safety designs and lower fossil fuel prices and public resistance after they have witness news of explosion in Fukushima Dai-ichi in 2011, the milestone have been reschedule to 2030. From an academic perspective, this paper shows that the nuclear power plant is the major solution for the ever increasing energy demand and will help greatly in reducing the carbon emission. With the increasing awareness of the society and sufficient support from the government, the first nuclear power plant in Malaysia can be made into reality.

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