2020

COMPENDIUM OF ENERGY ECONOMIC RESEARCH

15 DECEMBER 2020 | ENERGY RESEARCH SYMPOSIUM

IEPRe Institute of Energy Policy and Research
Universiti Tenaga Nasional The Energy University
TENAGA NASIONAL Better. Brighter.
Suruhanjaya Tenaga Energy Commission

The Compendium of Energy Economic Research 2020 is to provide information about the research of the six projects funded under the Chair of Energy Economics program. The compendium briefly describes the key findings, policy implications and recommendations for each undertaken project in the year 2020 i.e., cogeneration analysis, optimized tariff setting, comparative analysis for gas market liberalization, energy efficiency requirement, energy sustainability index, and the circular economy. A contact person is given for each of the research listed so that interested readers can obtain more information. The purpose of publishing this document is to compile all the information for easy reference for internal use only. It is not for public consumption.

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Energy Symposium Chair of Energy Economics No 2/2020

15 December 2020 (Tuesday)
Program Agenda

Objective:

The Energy Symposium 2020 is the second symposium organized by the Institute of Energy Policy and Research (IEPRe) in collaboration with Suruhanjaya Tenaga (ST). The symposium aims to provide a platform for IEPRe Project team to present the findings to ST for projects undertaken in the year 2020 which include cogeneration analysis, optimized tariff setting, comparative analysis for gas market liberalization, energy efficiency requirement, energy sustainability index, and the circular economy. The symposium hopes to foster discussion amongst the researchers, enable knowledge sharing between researchers and stakeholders, as well as providing inputs and constructive comments from stakeholders to assist the respective research teams in preparing the final project report by 31st March 2021.

Time	Agenda
2.00 pm	Registration
2.10 pm	Welcoming Remarks by YBrs. En. Abdul Razib Bin Dawood Chief Executive Officer, Suruhanjaya Tenaga
2.20 pm	Introduction of The Symposium by YBrs. Dr. Siti Indati Mustapa Director of IEPRe, UNITEN
PRESENTATION SESSION	
2.30 pm	Development of Energy Sustainability Index for Malaysia *By Dr. Nora Yusma Yusoff*
2.40 pm	*Q & A session and commentary by Chair of Energy Economics, Prof Dr. Ken Koyama/Project Champion, Tuan Hj Ir Abdul Rahim Ibrahim*
2.50 pm	Optimized Tariff Setting Framework for Prosumers *By Dr. Noriza Saad*
3.00 pm	*Q & A session and commentary by Chair of Energy Economics, Prof Dr. Ken Koyama/Project Champion, Pn Marlinda Mohd Rosli.*
3.10 pm	A Techno-economic Study on the High-Efficiency Cogeneration in Malaysia By Dr. Hasmaizan Hassan
3.20 pm	*Q & A session and commentary by Chair of Energy Economics, Prof Dr. Ken Koyama/Project Champion, En Zulkiflee Umar.*
3.30 pm	A Comparative Analysis for Gas Market Liberalization Across Countries Based on Long-Term and Short Term Contract Initiation By Dr. Muhammad Khairul Islam
3.40 pm	*Q & A session and commentary by Chair of Energy Economics, Prof Dr. Ken Koyama/Project Champion, En Rumaizi A. Halim*
3.50 pm	Study on Circular Economy of Urban Wastewater Treatment *By Dr. Siti Indati Mustapa*
4.00 pm	*Q & A session and commentary by Chair of Energy Economics, Prof Dr. Ken Koyama/Project Champion, En Hilmi Ramli*
4.10 pm	Continuous Improvement To MEPS Requirements In The Malaysian Electrical Appliance Market: Its Impact On Energy Efficiency *By Dr. Amar Hisham Jaafar*
4.20 pm	*Q & A session and commentary by Chair of Energy Economics, Prof Dr. Ken Koyama/Project Champion, Puan Hafiza Yob*
END OF PRESENTATION SESSION	
4.30 pm	Closing Speech by YBrs. Tn Hj Abd Rahim Ibrahim, Chief Operational Officer (COO), Suruhanjaya Tenaga
4.45 pm	End of Symposium

Researchers of IEPRe and Title of Research

1.	Dr. Noriza Saad	Development of Energy Sustainability Index (ESI) for Malaysia
2.	Dr. Nora Yusma Yusoff	A Techno-economic Study on the High-Efficiency Cogeneration in Malaysia.
3.	Dr. Hasmaizan Hassan	A Techno-economic Study on the High-Efficiency Cogeneration in Malaysia
4.	Dr. Muhummad Khairul Islam	A Comparative Analysis for Gas Market Liberalization Across Countries Based on Long-Term and Short-Term Contract Initiation
5.	Dr. Siti Indati Mustapa	Study on Circular Economy of Urban Wastewater Treatment
6.	Dr. Amar Hisham Jaafar	Continuous Improvement to MEPS Requirements in The Malaysian Electrical Appliance Market: Its Impact on Energy Efficiency

Project 1:

Development of Energy Sustainability Index for Malaysia

Project Leader: Dr. Nora Yusma Mohd Yusof

Project Members:

Dr. Hasmaizan binti Hassan

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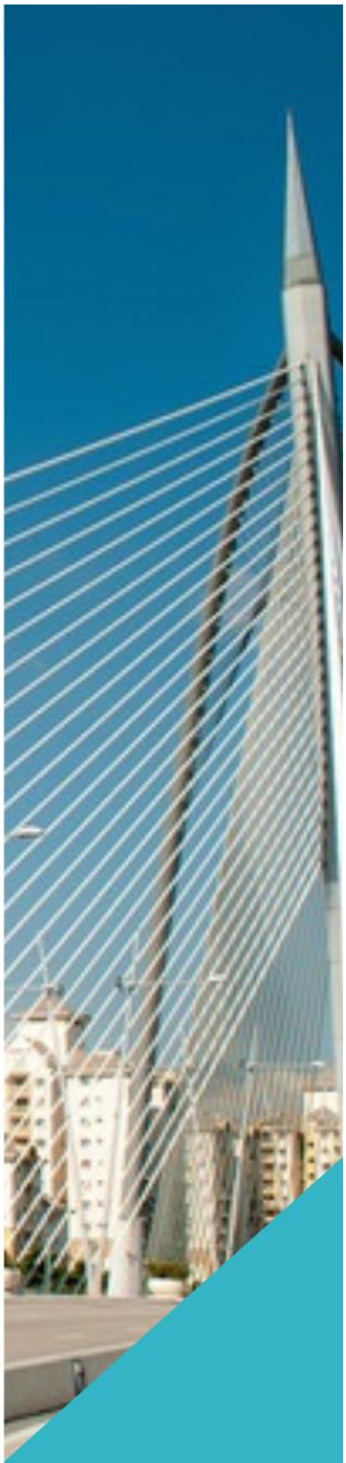


Institute of Energy Policy and Research

POLICYBRIEF

Development of Energy Sustainability Index for Malaysia

EXECUTIVE SUMMARY

The concept of sustainable energy has emerged and become global policy interest due to the recent economic and environmental policy, which concerns more on global warming, climate change and sustainable development. Sustainability can be defined as the ability to meet demand of energy service needs in reliable circumstances through great period of time (The Cambridge-MIT Institute, 2006). Sustainable energy security must not only take into account the security of energy supply and affordability of energy demand, but it must also emphasis on the harmonized and balanced between energy resources, socio-economy and environmental sustainability. This means that current and future energy needs have a high probability of being met, irrespective of economic or political instability. Also, ssecuring energy is vital for our economy and society to function, and policy decisions are often made on the basis of 'improving energy security'.

Thus, this research is set out to develop the energy sustainability index with risk and security drawing on discussions with energy key experts in Malaysia and Japan energy institutional sectors. The focus was on the five dimensions of energy sustainability which are availability, accessibility, affordability, acceptability, and develop-ability. Based on the linkages and overlaps between energy supply demand dimensions and the dimensions of environmental sustainability and sustainable development, a framework for evaluating and measuring the relative attributes of different approaches to energy sector development is develop. An Energy Symposium is conducted with ST energy experts in the Malaysia and Japan, to get the feedback on the research findings

KEY FINDINGS

AVAILIBILITY INDEX

- *The findings show that Malaysia has experiencing decreasing trend in availability performance index, especially between 2010-2015 due to the decreasing trend in both Reserve Production Ratio (RPR) and energy self-sufficiency ratio. The RPR averagely decreased by 0.02% per year while the value of Energy Self-Sufficient Index is below than 1 or 100% indicating that Malaysia would no longer have the status of net energy exporter.*

#ACCESIBILITY

- *The volatility of accessibility performance is due to the exposure Malaysia to world oil market and oil import dependency. Reduce the oil dependency through fuel diversification policy can reduce the energy security risk and volatility effects. Thus, it is truly important for Malaysia to diversify its import source countries as well increase the energy source diversification.*

#ACCEPTABILITY INDEX

- *The findings show there were positive effects of Malaysia's Five Fuel Diversification Policy (2001), Renewable Energy Policy (2009) SREP Program and the New Energy Policy (2012) on both RE utilization in power sector and efficiency use of energy.*

DEVELOP-ABILITY INDEX

- *The impressive progressive growth in the develop-ability index by 14% per annum were mainly contributed by the decreasing trend in CO2 emission per unit primary energy consumption and per unit electricity generation.*

ENERGY SUSTAINABILITY INDEX (ESI)

- *As, overall, Malaysia- ESI shows a stable and positive growth throughout (2005-2018) year, which would reflect the effectiveness of the New Energy Policy (2012, SREP Program and RE Policy (2009), especially on the RE utilization in power sector, reduction of CO2 emission from power generation, increasing trend in diversification of energy and improvement of efficiency use of energy.*

OVERVIEW

In the late 2000s, the concept of sustainable energy security (ESI) emerged and became a global policy interest due to the recent economic and environmental policy, which emphasized on global warming, climate change, and sustainable development. Sustainability can be defined as the ability to meet the demand for energy service needs in reliable circumstances through a great period (The Cambridge-MIT Institute, 2006). Since then, the energy security concept experienced evolution, whereby its scope and definition have varied over time (Ang et al., 2013).

Moreover, energy security has become an important aspect of sustainable development in modern society. On the other hand, ESI is defined as 'provisioning of uninterrupted energy services in an affordable, equitable, efficient, and environmentally benign manner' (Narula et al., 2015). The sustainable security of energy has become an end goal of every country's energy policy. By considering the differences in energy systems between different countries and regions, scholars have assessed energy security at different levels and from different perspectives (Fang et al., 2018). Nevertheless, ESI must not only consider the security of energy supply-demand in the long-term and short-term, but also emphasize the balance between energy, economy, social, and environmental aspects.

Indeed, sustainable of energy security is strongly related to other policy issues that concern energy system (such as affordable energy, climate change, and environmental policy). This implies that it is imperative to examine the energy security consequences of different development pathways (Kruyt et al., 2009). Although the term 'energy security' is widely used, the interest in investigating the methodology for evaluating energy security performance together with sustainability is low. Besides including harmonization and sustainability of energy, economic, social, and environmental development, the high efficiency and diversity, and degree of vulnerability of the energy system due to political instability and international risk exposures should also be incorporated.

Undoubtedly, secure and sustainable energy provision plays a fundamental role in the economy and in people's everyday lives. In many countries such as Malaysia it is seen as imperative that energy provision is affordable and meets demand levels at any given moment. Energy shortages or severe spikes in consumer fuel price are politically very damaging. Stability concerns in some key fuel export regions have increased recently, as well as the investment requirements to replace ageing generation and network infrastructure. At the same time, energy systems are under increasing pressure to reduce carbon emissions to mitigate dangerous climate change. Sustainable of energy security has become a key factor in responding to these pressures and has been the justification of much energy policy in recent years.

RESULT

Table 1 illustrates the five dimensions' index weight scores for energy security level between 2005 and 2016 for Malaysia. Measurement of ESI performance index was based on three levels (safe, warning, and danger). According to the ESI evaluation based on Table 1, the weight of develop-ability (A5) and energy acceptability(A13) were relatively large, i.e. 0.2486 and 0.2467, respectively. The highest weight in develop-ability index reflected the sustainable development capacity of the energy system in low carbon, clean, and optimized mode, which plays a significant role in Malaysia's ESI.

Table 1: Weight and Ideal Solutions

Weight and Ideal Solutions for ESI Using Entrophy Techniques and Min-Max Method

Indicator	Weight, Wj	Positive Ideal Solution, A^+	Negative Ideal Solution, A^-
A1	0.0389	0.0299	0.0006
A2	0.2257	0.1638	0.0140
A3	0.2401	0.1564	0.0049
A4	0.2467	0.1161	0.0467
A5	0.2486	0.2106	0.0189

The achievement of the develop-ability index (A5) will be a good sign for Malaysia towards its sustainable development plan. On the other hand, acceptability (A4) the average growth rate of acceptability index by 9% per annum indicates that there are positive effects of Malaysia 's Five Fuel Diversification Policy (2001) and the New Energy Policy (2012) on RE utilization in power sector and efficiency use of energy. The growth in share of RE in power generation which has increased progressively by 8% per annum and decreasing in energy intensity could also due to the continued of Energy Policy under the Ninth Malaysian Plan (2006-2010) which were emphasized on providing a more conducive environment to support RE projects and the introducing of the National Green Technology Policy (2009) which aimed to be key driver in accelerating the national economy and sustainable development.

Additionally, among the weights of the develop-ability index (A5), energy diversification index (A53) had the highest weight value, which was 0.4148. The high weight value of diversification reflects the importance of diversifying energy resources in Malaysia. Specifically, the Five-fuel Diversification Policy, and Renewable Energy Policy were introduced in 2001 and 2009, respectively. This result is supported by the empirical findings of Sovacool et al. (2013). The study found that Malaysia has achieved some favorable impacts because of its diversification and almost universal energy access due to a large number of fuel subsidies. Since the diversification of energy resources can reduce the vulnerability and insecurity of excessive dependence on an energy source, the diversification index has positive impacts on ESI.

Moreover, Malaysia's power sector is diverse with a balanced energy supply consisting of different energy types. The electrification programme and the Small Renewable Energy Power (SREP) Programme were introduced to expand access to energy services and further diversify the energy mix (Sovacool et al., 2013), besides increasing the diversity of energy production technology. The results also established that the index revealed trade-offs within different dimensions of energy security index, which could explain why many countries continue to struggle in their attempt to improve any holistic sense of energy security (Sovacool et al., 2013).

Based on Mac Queen (1967) (Figure 2), the k-means clustering analysis method was used to classify the ESI performance index into three levels: 1) danger zone level (<0.4276); 2) warning zone level (0.4276 to 0.5668); and 3) safety zone level (>0.5668). The k-means clustering results for Malaysia are reported in Table 2 and the ESI performance is illustrated in Figure 3 for the 2005–2018 period.

Figure 2: MC QUEEN K-CLUSTERING METHOD

MC QUEEN K-CLUSTERING VALUE

0.4276	<	High Risk (Insecure)
0.4276-0.5668	<>	Medium Risk
0.5668	>	Low Risk (Secure)

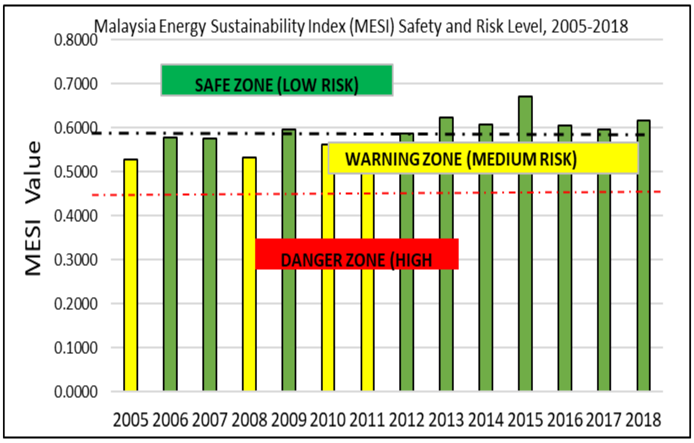
The overall trend of ESI performance index for Malaysia between 2005 and 2018 is shown in Figure 3 and the Table 3, respectively. The results indicated that Malaysia's ESI performance was quite stable throughout 2005–2018, whereby the ESI index was above 0.4276, and the highest ESI level was achieved in 2015. This would imply that energy and environmental policies and regulations were effective and significant in sustaining the energy security and improve the environmental protection level.

Table 2: ESI RISK AND SAFTEY LEVEL, 2005-2018

Year	MSES	RISK LEVEL	ESI SECURITY LEVEL
2005	0.5281	Medium Risk	MODERATELY SECURE
2006	0.5783	Low Risk	SECURE
2007	0.5750	Low Risk	SECURE
2008	0.5326	Medium Risk	MODERATELY SECURE
2009	0.5945	Low Risk	SECURE
2010	0.5622	Medium Risk	MODERATELY SECURE
2011	0.5514	Medium Risk	MODERATELY SECURE
2012	0.5868	Low Risk	SECURE
2013	0.6223	Low Risk	SECURE
2014	0.6068	Low Risk	SECURE
2015	0.6709	Low Risk	SECURE
2016	0.6051	Low Risk	SECURE
2017	0.5944	Low Risk	SECURE
2018	0.6170	Low Risk	SECURE

Furthermore, this also proveed that Malaysia's Five-fuel Diversification Policy (2001), Renewable Energy Policy (2009), SREP and the New Energy Policy (2011–2015) have emphasized on diversification of energy resources to renewable energy, energy security, and economic efficiency and that environmental and social considerations have brought significant favorable impacts to the nation. Malaysia's higher level of energy security, as revealed in this study, is supported by the findings of Sovacool et al. (2013), which investigated 18 countries' energy security. The study discovered that among South East Asian countries, Malaysia had achieved the highest in terms of energy security improvements, i.e. an improvement of 31% between 1990 and 2010, followed by Brunei (28%). Furthermore, the improvement level of energy security index for Malaysia was higher than the achievement of developed countries like Australia, USA, Japan, and New Zealand (Sovacool et al., 2013).

Figure 3: Malaysia ESI, 2005-2018



Among the factors that contributed to the stable positive growth in ESI are: 1) the increasing growth in share of RE in power generation and decreasing of the GhG emissions from power generations (both in Develop-ability dimension); 2) Decreasing in energy intensity (Acceptability dimension) and; 3) increasing trend in energy diversification index (Availability dimension). The increasing of these factors could also due to the continued of Energy Policy under the Ninth Malaysian Plan (2006-2010) which were emphasized on providing a more conducive environment to support RE projects and the introducing of the National Green Technology Policy (2009) which aimed to be key driver in accelerating the national economy and sustainable development.

Therefore, reliable energy supplies are vital to allowing a countries industry and economy to function, whilst human survival and well-being require clean and reliable food and water supplies. When food water and energy are abundant relative to the number of people living in a place, their quality-of-life increases. Sustainable in energy is truly important because when energy is in short supply, it costs more to buy. This makes manufacturing more expensive. Countries that experience energy insecurity usually have a lower industrial output. Conflict - energy insecurity can cause conflict when countries compete to obtain energy supplies.

POLICY IMPLICATIONS

- Reliable energy supplies are vital to allowing a countries industry and economy to function, whilst human survival and well-being require clean and reliable food and water supplies. When food water and energy are abundant relative to the number of people living in a place, their quality of life increases.

- Sustainable in energy is truly important because when energy is in short supply, it costs more to buy. This makes manufacturing more expensive. Countries that experience energy insecurity usually have a lower industrial output. Conflict - energy insecurity can cause conflict when countries compete to obtain energy supplies.

- Energy security policy should allow for measures of flexibility and resilience of the energy system. Examples; flexible supply and demand, electricity storage and interconnection.

- There should be increased focus on measures that bring about co-benefits in multiple areas, such as reducing overall energy demand.

- Adequate infrastructure investment is critical and requires policy stability and long-term planning. Energy security assessments tend to exclude these aspects because they are difficult to measure.

- The particular perspective being applied in making an sustainable energy security assessment should be clearly stated since there a wide variety can be taken. In addition, consideration of any impact that opposing perspectives could have on the results or conclusions should be undertaken.

FURTHER INFORMATION

This research was sponsored by Chair Energy Economics (CEE) of ST-UNITEN. The study was conducted in 2020.

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Project 2:

Optimized Tariff Setting Framework for Prosumers

Project Leader: Assoc. Prof. Dr. Noriza Binti Saad

Project Members:

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Project Champion: Mrs. Marlinda Binti Mohd Rosli

Institute of Energy Policy and Research

POLICYBRIEF

Solar PV Prosumer Tariff in Malaysia

EXECUTIVE SUMMARY

The Malaysian electricity market is highly regulated. Electricity tariffs for different consumer groups are distributed by the Tenaga Nasional Berhad (TNB) based on a base tariff rate as stipulated by the regulatory agency, the Malaysian Energy Commission (EC). Thus, tariff design is the key mechanism used to allocate electricity generation and distribution costs to customers. The designing process can be very complex not only due to the regulatory policies surrounding it but also due to the need of satisfying various parties such as the electricity distributor and the different types of electricity customers.

Additionally, prosumer tariff design is the key mechanism used to allocate electricity generation and distribution costs to producer or customers which is currently through Net Energy Metering (NEM) in Peninsular of Malaysia. The designing process can be very complex not only due to the regulatory policies surrounding it but also due to the need of satisfying various parties such as the electricity distributor and the different types of prosumers such as domestic or residential, commercial, industrial and agriculture at difference level of megawatt (MW) quota allocated. This paper discusses an overview of the solar PV prosumer in Peninsular of Malaysia with respect to the Net Energy Metering (NEM) used in which the tariff is disbursed to the different types of prosumer categories. Technically, the cost disbursement requires a more accurate and justifiable mechanism that lead to the need to reform the tariff design technique since solar PV technologies have reached socket parity in Malaysia. This can be done through a Tariff Optimization Modelling which advocates a robust optimization technique.

OBJECTIVE

- To revising current tariff NEM based on 1 to 1.
- To discuss a possible design options for future electricity tariff model for solar PV prosumer by considering the policy and scenario impacts include economic wide effects with optimized valuation.
- To provide recommendations to EC on potential actions based on other countries that already have prosumer market.

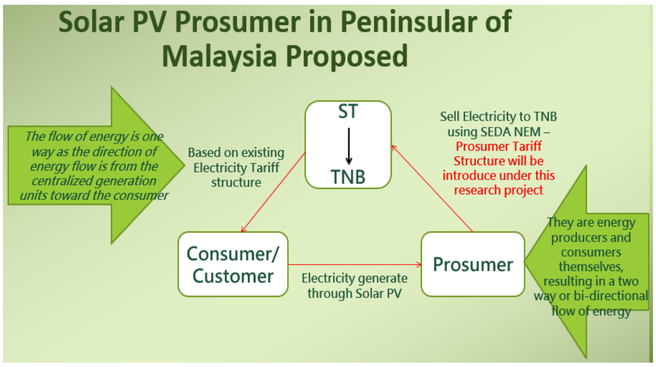
OVERVIEW

In Malaysia, the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) has introduced few solar PV initiatives to encourage Malaysia's Renewable Energy (RE), one of the significant initiatives is by introducing the NEM system in November 2016. On 12th July 2018, PV industry highlighted the issue on the essential to alteration the concept of NEM from the existing net billing to true net energy metering (TNEM) for promised the return of investment of solar PV. Starting from 1st January 2019, the NEM was enhanced by espousing the TNEM concept and this will allow excess solar PV generated energy to be exported back to the grid on a "one-on-one" offset basis. This means that every 1kWh exported to the grid will be offset against 1kWh consumed from the grid, instead of at the Displaced Cost previously. The quota allocation for NEM is 500 MW up to year 2020. This quota provided for both categories, domestic/residential and non-domestic. In details, these categories are Residential, Commercial, Industrial and Agriculture whereby the new NEM scheme is only applicable to Peninsular Malaysia and applicants must be a registered TNB customers. NEM is executed by the MESTECC and regulated by the Energy Commission (EC) with Sustainable Energy Development Authority (SEDA) Malaysia as the implementing agency [4].

Since the revised NEM (NEM 2.0) is up to year 2020, there are any considerations to review the system as well as to revised the solar PV prosumer tariff structure by analyzing the segregation of the KWh/ KWp tariff is either optimize or under/over optimize, fairness to both parties involved and cost reflective to the utility provider. In addition to that, the issue on lacking in policy areas especially on energy prosumer tariff structure analysis motivate this study to be conducted.

With respect to the definition of NEM, main electricity utility provider in Peninsular of Malaysia, that is TNB was defined the NEM as a mechanism for customer to use own solar energy produced for self-consumption. Then, if any excess energy generated will be exported to TNB grid and will be turned to credit that may be used to offset part of the electricity bill [7]. Similar to the SEDA and Pekat, they derived the concept of NEM as the energy generated from the installed solar PV system for self-consume, and if any excess energy will be exported to the TNB grid on a "one-on-one" offset basis. This scheme is applicable to all TNB customers include domestic, commercial, industrial and agricultural sectors. The PV systems can be installed at available rooftops or car porch within their own premises. In further perspectives of Pekat, NEM is government-promoted initiatives to encourage prosumer to generate clean energy that benefit to reduce electrical energy consumption, low electricity costs, alleviate carbon footprint, and promote corporate social responsibility (CSR) program

FIGURE 1



With respect to the definition of NEM, main electricity utility provider in Peninsular of Malaysia, that is TNB was defined the NEM as a mechanism for customer to use own solar
As much as 500MWac capacity that will end at the end 2020 has been allocated for domestic consumers, commercial and industrial. The concept of NEM is energy produced from an installed solar PV system will be used first and any excess will exported and sold to Distribution License Holders which is Tenaga Nasional Berhad (TNB). NEM is less well received since the program started. Each 1kWh exported to the grid will be off-set 1kWh used from the grid, rather than at such supply costs NEM before. Therefore, the NEM guidelines have been amended based on new mechanism such as billing method, NEM contract and others. NEM can used for TNB customers and that category are as follows:

i. Domestic
ii. Commercial
iii. Industry
iv. Agriculture

Additionally, the rise of the energy prosumers in ASEAN has shown a significant increase with total additional capacity of 28 GW in last 8 years. According to the 4th ASEAN Energy Outlook (AEO4), RE will have an estimated average growth of 5.6% between year 2013 to 2035 in the power sector. As reported in the Business as Usual (BAU) scenario, the value of 152 GW total installed power capacity will then generating around 392 TWh of electricity in year 2035. In the perspectives of Solar PV, the total installed capacity is predicted to reach around 10 GW in 2035 from the current capacity of almost 2 GW. Thus, the ASEAN region seen an outstanding growth in solar PV deployment with 62% of the compound annual growth rate.

In ASEAN, some Member States like Malaysia, Indonesia, Philippines and Singapore have applied the net-metering, where prosumers could export and sell their excess power to the grid. For instance, in Malaysian energy market, the excess energy will receive credit in Ringgit Malaysia to be used in offsetting part of the electricity bill (refer Table I) provided by utility companies.

Table I: Tariff Group Under NEM Calculator in Malaysia

Type of Customers	Tariff Category	Voltage
Domestic/ Residential	A	Domestic
Commercial	B	Low Voltage
	C1	Medium Voltage General
	C2	Medium Voltage Peak
Industrial	D	Low Voltage (LV)
Type of Customers	**Tariff Category**	**Lifeline Band**
Industrial	Ds	Special LV
	E1	Medium Voltage General
	E2	Medium Voltage Peak
	E2s	Special HV
	E3	High Voltage
	E3s	Special HV

From the Figure 2 below, we can see that a new paradigm for utilities by rise of the solar energy capacity in Malaysia from 2009 to 2019 (in megawatts) among solar PV prosumer. A significant increasing in trend happened in year 2012 from only 1MW in 3 years before respectively increase to 25MW. This solar energy capacity increasing year by year with the amount of 882MW in 2019. The quota allocation and allocated in Peninsular of Malaysia also shown in increasing in value as shown in Table II.

Table II: The Quota Allocation and Allocated for The Solar PV Customers in Peninsular of Malaysia

Quota Allocation		
Region (Year)	*Peninsular Malaysia (2019-2020)*	
Category of consumers	*Quota*	*Quota Balance*
Domestic, MWac	50	
Commercial, MWac	450	231.6153
Industrial, Mwac		
Agriculture, MWac		
Total	500	269.9091

Table III: NEM in Other Countries

Country/ State	Allowable Technology	Allowable Customer	Allowable Capacity	Net Excess Generation (NEG) Rate Price
Australia/ Queensland [3]	Solar	Households, Small businesses Consume less than 100 MWh a year	10kW	AUD$0.44/kWh for excess electricity exported to the grid
Australia/ South Australia [3]	Solar	Households, Small businesses, Community buildings, Churches Consume less than 160 MWh a year	5kW	AUD$0.44/kWh for excess electricity exported to the grid
Australia/ Victoria [3]	Solar	Households, Small businesses, Community groups	5kW	AUD$0.60/kWh for excess electricity exported to the grid
Canada/ Nova Scotia	Wind, solar, hydro and biomass	Home, business	100kW	CAD$0.126/kWh for excess electricity exported to the grid [9]
Canada/ Quebec	Wind, solar, hydropower, geothermal, bioenergy	Residential, farmers, small-business	50kW	Any remaining credits will be set to zero. No payment to the customer for energy excess [9].
Cyprus	Solar	Residential [12]	5.2kWp [13]	Any remaining credits will be set to zero. No payment to the customer for energy excess [12]

Summary

- Energy regulators and policymakers presently are tapping an exertion to enhance its system and policies of the solar PV prosumer tariff so that optimize all parties involved. It should be cost reflectively and justifiable to particularly four types of consumer group, i.e; domestic/residential, commercial, industrial and agriculture.
- Difficulties of such disbursement have becoming more challenging when several cost of installation, payback period, displaced cost and many more have to be incorporated in the final set tariffs.
- It is best that an optimize, fairness and justifiable method of Constrained Optimization by taking into account the marginal costs of distribution to the different consumer groups is developed in improving the NEM calculator system.
- Therefore, it is the aim of this project to design an optimal prosumer tariff-setting framework for solar PV that might probably use by electricity distribution companies, prosumers, peer-to-peer users and other significant parties involved.
- This framework translated into a simulation model to enable quick computation of tariff given changes in business parameters. While the model is still need to be tested, the model can be used by Malaysian EC, TNB, SEDA and possibly other country' electricity distribution companies for future tariff negotiations, bearing in mind the needs of the nation and the company.

FURTHER INFORMATION

This research report reports the findings of the paper referenced below and please refer to that paper for further background information and references. This study also is an overview part of the research project granted by Chair in Energy Economics (GCEE) 2020, Universiti Tenaga Nasional-Suruhanjaya Tenaga, 2020002KETST.

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Project 3:

A Techno-economic Study on the High-Efficiency Cogeneration in Malaysia

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Project Members:

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POLICYBRIEF

A Techno-Economic Study on the High-efficiency Cogeneration in Malaysia

EXECUTIVE SUMMARY

Many countries all over the world have been implementing cogeneration widely since cogeneration provides a wide range of technologies for application in various domains of economic activities with efficiency of energy use can be more than 70 per cent. In addition, since cogeneration installations are located close to consumers, electrical grid losses can be reduced when cogeneration is applied. Because of its high efficiency (>70%) thus effectively it reduces the cost of energy.

In spite of all that promisingly positive benefits, its development in Malaysia is relatively slow. There are big questions here that need some answers. Therefore, this research is set out to explore, to study, to understand and to identify issues that hinders cogeneration development and find possible solutions that could help to drive the development of cogeneration in Malaysia.

Three natural gas based private cogeneration operators cum energy users in Peninsular Malaysia have been selected as case studies. This study examine their barriers and challenges in operating the cogeneration and evaluate its economic performance. Several workshops and focus groups discussion also have been conducted to gather data and information. The economic data thus been analyzed by employing cost benefit analysis. Four key findings of this study are highlighted in this policy brief hence provides some recommendation and policy implications for promotion of enhance used of cogeneration in Malaysia.

KEY FINDINGS

#1-Cogeneration Current State

- The pace of cogeneration in Malaysia remained sluggish and lags far off expectation.

#2-Critical Issues on Cogeneration

- Lack of knowledge on detailed cogeneration technical and financial analysis for cogeneration system planning and design.
- Risks of cogeneration failure was wholly borne by cogeneration operator
- Low confident level on cogeneration energy security and reliability.

#3-Feasibility of Cogeneration is proven.

- Positive energy saving and net present value for all three case studies.
- Investment return rate are significantly different for all three case studies.
- Payback period as early as 3 years.

#4-Call for national planning and coordination of cogeneration.

Overview

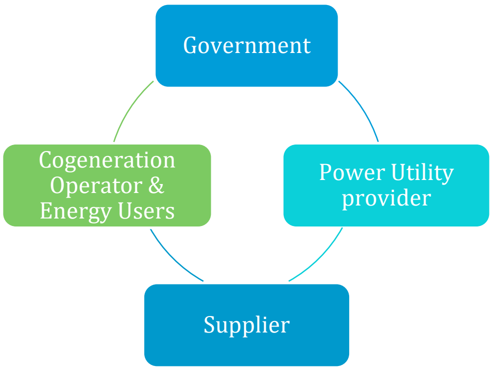
In Malaysia, The National Energy Efficiency Action Plan, 2015 under Key initiative 4: Promotion of Co-generations Generating emphasis electricity and thermal energy using cogeneration. This action plan is to promote cogeneration in industries and buildings by reducing barriers, including standby and top up charges, gas tariff pricing (TPA), possible lack of incentives, technical hurdles such as lack of capability to locally manufacture some energy supply equipment which leads to higher investments, connection to the grid which implication on the reserve margin for the utilities and lack of awareness on benefits of cogeneration.

In spite of proven successful of cogeneration systems, its development is relatively slow in Malaysia.
The question is why this happened?

At current, Malaysian government offers a raft of incentives for investors in cogeneration plants. These incentives are available for companies entering into performance contracting schemes, Energy Service Companies (ESCOs) or investors in cogeneration plants serving their own energy needs. The Energy Commission evaluates applications for import duty and sales tax exemptions for cogeneration equipment while MIDA processes Investment Tax Allowance and Pioneer Status applications for energy efficient investment.

All in all, the industry has in place an attractive set of incentives offered by the Government, a clearly published definition of cogeneration's top-up and standby rates as well as qualified turnkey contractors and engineering consultants. However, with all incentives offered for cogeneration plants, the speed of cogeneration in Malaysia remained delays far off expectation.

Key Stakeholders in Malaysian Cogeneration Ecosystem



Generally, the government, the cogeneration operators cum energy users, cogeneration system and fuel suppliers and power utility are the four major stakeholders in the cogeneration development. Each has its own goals and perspectives on cogeneration system. The government for example, intent to improve energy efficiency and reduce emissions. For cogeneration owners', their objectives are to reduce their facility, operational costs, improve the reliability and continuity of supply. The power utility, on the other hand, would like the cogeneration system to reduce network losses, improve reliability and continuity of supply and improve network performance.

The cogeneration development will have an impact to all these stakeholders.

In this development, there is a possibility of a positive impact to one party, which may result in a negative impact to another.

For example, reduced fuel price brings positive impacts to the cogeneration owners while resulting in a negative impact to fuel suppliers. Similarly, reduction of customers' operational cost may cause an increase in the power utility operational cost due to the special operation and maintenance needs and requirements.

In a way, these conflicts would create barrier to the cogeneration development.

Key Findings1: Cogeneration Current State

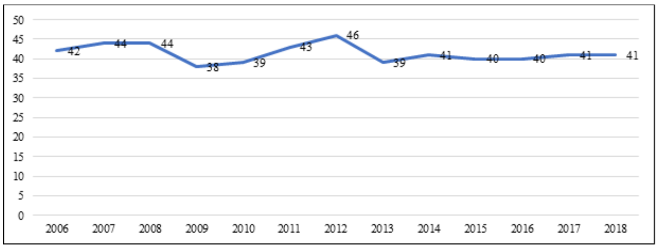
The pace of cogeneration in Malaysia remained sluggish and lags far off expectation

Cogeneration technology has been used in Malaysia by several industries since 2000. There are two types of licenses issued by the Energy Commission of Malaysia to cogeneration operator, namely private and public. Private licenses are for license holders who generate electricity for their own use. While a public license is where the cogeneration operator generates electricity and is channeled or sold to other consumers.

There were 25 private licenses and 27 public licenses were issued in 2006 and as of March 2020, a total of 34 private licenses and 20 public licenses have been issued by the Energy Commission of Malaysia.

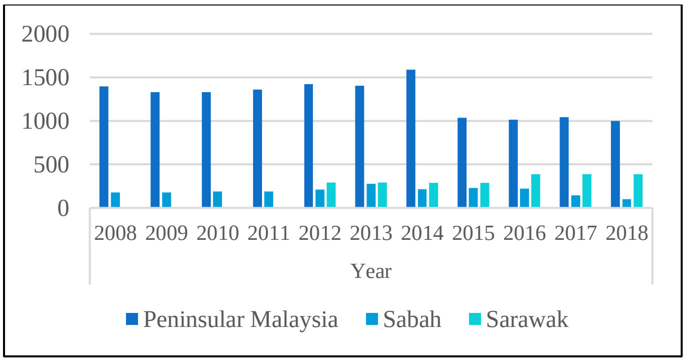
Figure 1 provide the number of cogeneration operators from 2006 until 2018. The graph indicates the uneven trend where numbers of cogeneration operators are incline in 2006 until 2008, slightly going down in 2009 and slightly drop in 2013 but maintain until 2018.

Figure 1: Trend of co-generator's numbers in Malaysia from 2006 until 2018



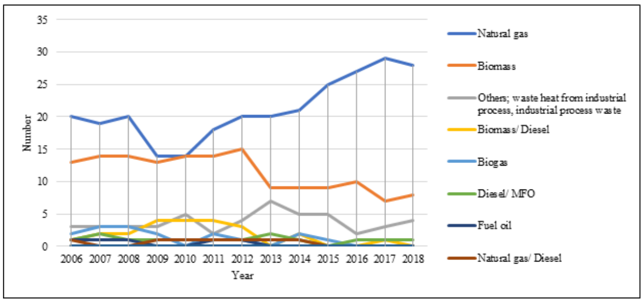
In 2008, there are 1,571.85 installed capacity of cogeneration in peninsular Malaysia and Sabah however, only 1,099.85 installed capacity of cogeneration In Peninsular Malaysia and Sabah are available in 2018, showing a decrease of 30% in 10 years.

Figure 2: Cogeneration operators installed capacity in Malaysia from 2006 until 2018



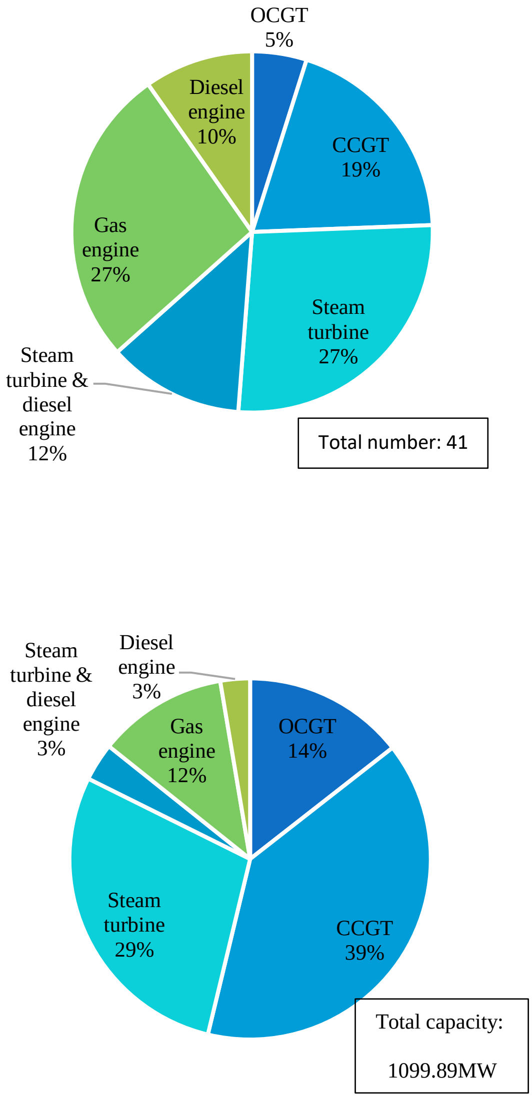
There are several types of fuel for power generations in Malaysia which were coal, natural gas and large hydro. Figure 2 indicates the type of energy sources use for cogeneration in Malaysia from 2006 until 2018. The graph shows number of co-generators by energy sources lead by natural gas, followed by biomass and zero user for natural gas/diesel.

Figure 3: Energy source of cogeneration in Malaysia from 2006 until 2018



One important element in cogeneration systems is the type of prime mover that drives the system. Figure 4 shows the types of cogeneration technologies employed in Malaysia in year 2018. Steam turbine and gas engine are the most used which represent 27% of all installations followed by CCGT with 19%, and diesel engine 10%.

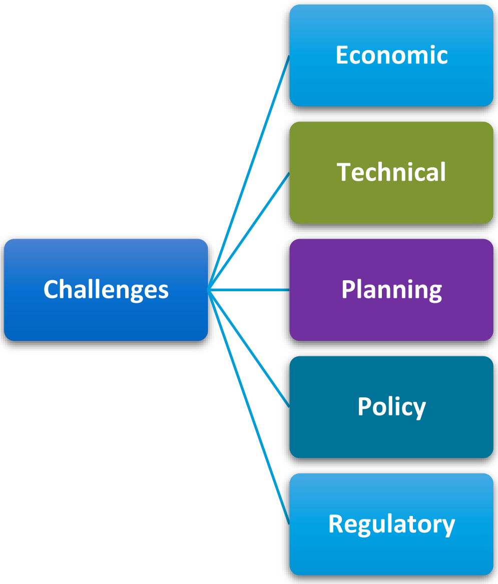
Figure 4: Technology used in 2018



Source: Malaysian Energy Information Hub, 2018

Key Finding 2:
Critical Issues on Cogeneration

- **Lack of knowledge on detailed cogeneration technical and financial analysis for cogeneration system planning and design.**
- **Risks of cogeneration failure was wholly borne by cogeneration operator.**
- **Low confident level on cogeneration energy security and reliability.**



Challenges of cogeneration operators are different depending on the unique characteristics of the plant and company itself. Generally challenges faced by the co-generators are economic, technical, planning, policy and regulatory.

Technical challenges are mostly interconnection issues such as reliability and quality supply, protection, metering and operating protocol for connection and disconnection, islanding and reactive power management. Other than that, the technology performance, coordination with utility, system operation, environmental and safety characteristics and natural gas infrastructure. Some of the challenges including top-up and standby charges, connection/exit fees, planning/siting and/or ownership and metering

The absence of commercial model and risk thus lead to the economic challenges from the investment cost, cost application, cost of installation up to operational cost.

All these challenges occurred due to the lack of knowledge on detailed cogeneration technical and financial analysis for cogeneration system planning and design among cogeneration operators thus lower the confident level on cogeneration energy security and reliability. Furthermore, 100% of the cogeneration system failure is under cogeneration operator which led them not to invest in this system.

Key Findings 3:
Economic Feasibility of Cogeneration system is proven.

- **Positive energy saving for all three case studies**
- **Double-digit investment return rate for all three case studies.**
- **Pay back at most less than 10 years for every case study.**

A techno-economic study was conducted to evaluate the annual cost saving, net present value (NPV), internal rate return (IRR) and payback period for cogeneration installation in Malaysia. Table 1 present the final result of calculation. Result of three case studies shows double digit of rate returns with payback period less than 10 years. Therefore, the result proves the economic feasibility study.

	Company A	Company B	Company C
Year Installation	1999	2006	2018
Capacity Installed	44,000KW	14,400KW	6,500KW
	RM	RM	RM
Capital Cost	203,449,941	47,000,000	50,000,000
Annual Cost Without Cogen	455,103,624	82,573,094	36,435,380
Annual Cost With Cogen	422,932,352	61,826,200	35,440,088
Annual Saving	**32,171,272**	**16,252,404**	**995,291**
NPV (RM)	**428,757,042**	**208,970,465**	**19,243,516**
IRR (%)	**19.7%**	**36.4%**	**7.8%**
Payback Period (year)	**6.324**	**2.892**	**11.525**

Key Findings 4:
Call for national planning and coordination of cogeneration

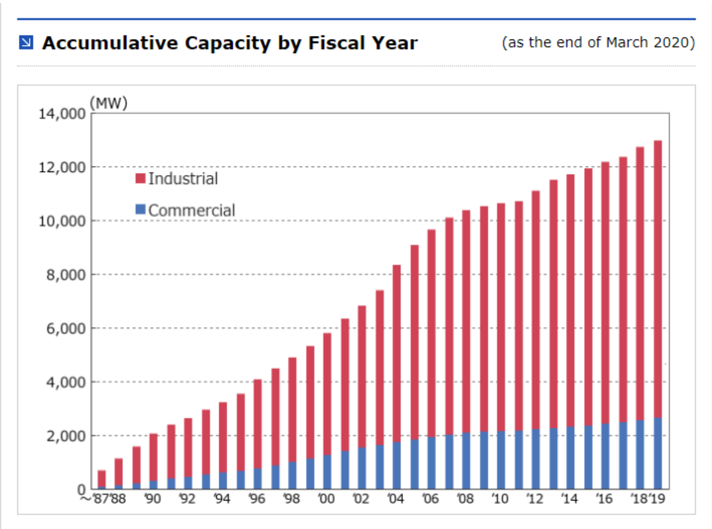
- **Non-availability of current potential cogeneration in Malaysia to gauge the total impact of cogeneration system to the national energy consumption and pollution reduction as well as system network for national planning and coordination as other countries**

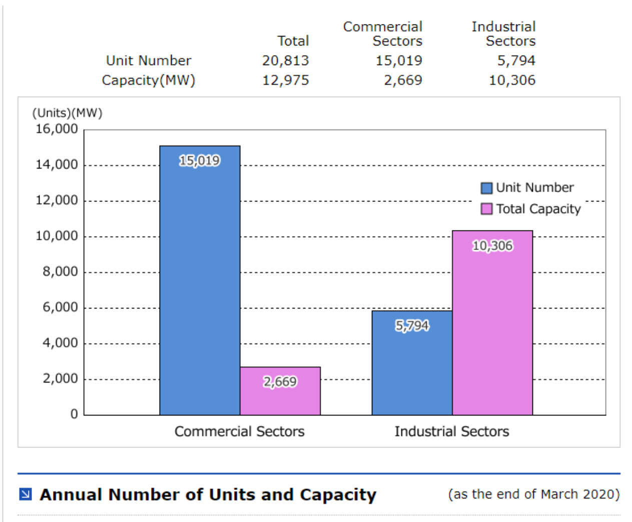
Cogeneration in Japan

The earthquake and tsunami that hit Japan left in its wake a revived debate over the country's long-term energy mix, along with enduring power shortages in the hardest hit Tohoku region and neighbouring Kanto, which includes Tokyo.

In the wake of the 2011 Tohoku earthquake and tsunami, cogeneration systems are attracting growing interest not only as means of saving energy and reducing carbon dioxide emissions, but also as distributed energy resources that can help prevent and mitigate disasters. Reflecting these rising expectations, in 2015 the Japanese government announced a target of raising cogeneration capacity to 119 billion kilowatt-hours.

The Ministry of Economy Trade and Industry (METI) forecasts that promoting CHP could deliver almost 7 GW of new capacity, including fuel cell applications, by 2030.





Japan's largest industrial use of CHP is in chemical and petrochemical manufacturing. In mid-2010 the chemicals and petrochemicals sector had installed CHP units at 386 sites, totalling 2050 MW and providing 27% of Japan's installed industrial CHP capacity. The chemicals and petrochemicals industry accounted for 18% of Japan's industrial CHP sites.

Japan is the world-wide leading country in developing and deploying cogeneration. The lesson from this success journey;

- ✓ The establishment of the Advanced Cogeneration and Energy Utilization Center JAPAN (ACEJ) to promote the wider use of cogeneration and other advanced energy technologies.
- ✓ The Japanese government funded initiative to develop and install Fuel Cell micro-Cogeneration:
  - ➢ Japan has installed around 270,000 active units as of 2018. Over 235,000 of these active unites have been installed under the ENE-FARM programme.
  - ➢ A demonstration project which took place between 2005 and 2008, had installed 3,000 Fuel Cell micro-Cogeneration units in Japan.
  - ➢ There was extensive cooperation between the Japanese government and the Fuel Cell micro-Cogeneration industry. The project has had 9 years of steady financial support by the government and technological development of high-quality units.
  - ➢ Annual sales volumes amount currently to 40,000 units. As the technology has reached maturity, government subsidies under the ENE-FARM project stopped by the end of March 2019.

Cogeneration in Other Countries

EUROPE	▪ **Directives 2012/42/EU** ▪ **Guidelines for each country (44 countries)** ▪ **CHP Site Assessment tools** ▪ **Consultancy Group** ▪ **Council: COGEN Europe and etc.**
United States	▪ Energy Policy Act 2005 ▪ CHP Screening Tools ▪ Consultancy Group ▪ Council: US Combined Heat and Power Partnership
Brazil	❖ The Brazilian Government has the power to intervene through the direct actions of its regulatory agency ANEEL, in terms of the first four points, introducing financing mechanisms for cogeneration projects through tax incentives or subsidies on equipment purchases. ❖ The regulatory agency has no power to work on this barrier and is limited to merely minimizing its impact for the private investor by lowering the other barriers, particularly those linked to financing. In fact, introducing incentive mechanisms for cogeneration equipment purchases, the agency can reduce the risk perceived by the private investor, faced with foreign exchange rate oscillations. ❖ Available incentive: Exemption of import tariff for PIS and CONFIS. This reduces the tariff to 14%. Also, 50% reduction in the cost usage for transmission and distribution systems for cogeneration surplus sales up to 30 MW.

Barriers of Cogeneration in Other Countries

Cogeneration Observatory and Dissemination Europe (CODE) 2015	U.S Department Energy 2015	American Council for an Energy Efficiency Economic (ACEE) 2011
1. The energy markets do not consistently reward CHP for its energy efficiency as well as long and medium-term cost savings. **- This is partly due to a lack of awareness of the opportunities of CHP solutions.** **2. Barriers for distributed generators in accessing and operating on the electricity network remain.** **3. Regulatory and legislative uncertainties add very significant risk and cost to projects.** **4. The lack of an appropriate focus on primary energy savings and heat in the European Energy Efficiency policy**	1. Economic and Financial Barriers i. Internal competition for capital ii. Natural gas outlook iii. Accounting practices iv. Financial risk v. Access to favorable tax structures vi. Sales of excess power 2. Informational barriers - Awareness of available incentives 3. Technical knowledge and resource availability	1. Economics - Market for excess power - Spark spread - Payback, risk and Recession 2. Financing 3. Regional and sectoral differences 4. Incentives - Tax credits and feed-in-tariffs - Loans and loan guarantees - Net metering - Grants - Portfolio standard 5. Other barriers - Carbon regulation unknowns - Regulatory bodies - Interconnection - Uncooperative utilities company - Permitting - Standby rates

Recommendations

- Establishment of Cogeneration Advisory Technical Expert Panel
- Development of Cogeneration Business Model
- Publication of Detailed Cogeneration Guidelines
- Setting specific national target of Cogeneration installed capacity.

FURTHER INFORMATION

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POLICY IMPLICATIONS

- Government should encourage the development of special training to build capacity expert in cogeneration.
- There should be increased focus on the reviewing of existing rules, regulation and related administrative requirements for cogeneration implementation in Malaysia.

What can be done?

- Get utility provider involve in the business model as strategic partner for large scale cogeneration as mini utility.
- Suruhanjaya Tenaga to champion the cogeneration initiative towards localized energy and energy efficiency improvement.

Project 4:

A Comparative Analysis for Gas Market Liberalization Across Countries Based on Long-Term and Short-Term Contract Initiation

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Institute of Energy Policy and Research

POLICY BRIEF

A comparative analysis for gas market liberalization across countries based on long-term and short-term contract initiation

EXECUTIVE SUMMARY

Gas liberalization has an important impact to the Malaysian economy by decreasing the government burden through subsidy elimination and increasing international and local market participation. Although, the government have initiated the third-party access (TPA) system, but there is lack of study to have this system more attractive to the potential market players as this is an infancy stage. Therefore, this research focused on comparing other country's gas price mechanism that how and what basis they have make them successful and liberalized their gas market and to see which is best suits for Malaysia. More specifically, what should be the guideline for attractive and competitive price mechanism to encourage more players in the liberalized Malaysian gas market.

A comparative analysis conducted regarding the development of gas pricing mechanism among gas market liberalization on UK, Netherland, Eastern Australia and Japan, and the effect of long term and short-term contract on gas pricing mechanism among those countries.

Malaysia is currently aiming to create a competitive gas market through restructuring, privatization and creating a platform for the entry of new market players. The establishment of the independent regulatory institution and amendment of the gas legislations are some of the initiatives taken to facilitate the gas market reform. The gas supply industry plays a vital role in the Malaysian energy sector and in line with the Economic Transformation Plan (ETP), the local gas market is opening up to a competitive market. The rising demand especially in Peninsular Malaysia and regulating prices for natural gas saw PETRONAS selling natural gas at a relatively low price that affects the Governments revenue collection negatively.

Therefore, the government wants to ensure sufficient supply of natural gas in Peninsular Malaysia and Sabah by encouraging petroleum companies to start supplying LNG into Malaysian market and getting the necessary framework for third party access (TPA) to pave way for the liberalization of the gas market in Malaysia.

KEY FINDINGS

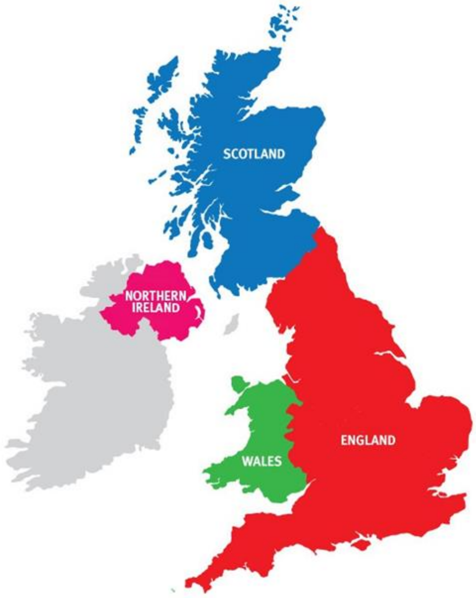
1. ***Price mechanism and Gas Trading Hub***
In Europe, Britain's National Balancing Point (NBP) and Dutch Title Transfer Facility (TTF) hub emerged as the main natural gas hub. The hub is a central pricing point for the network's natural gas. It allows participants to sell and purchase gas volumes. The gas trading hub also had boosted the market demand and gained importance.

2. ***Short-term contract and Long-term contract***
Contract length tended to decrease after liberalization for both United Kingdom (UK) and Netherland countries. Short-term contract leads to the increasing in liquidity, delivered an effectual TPA, and created the requirements for unbundling supply. For Japan, most contract period are also getting shorten. However, Eastern Australia and prefers long-term contract due to most LNG trades occur through long-term bilateral contracts.

3. ***Natural Resources***
One of the Eastern Australia liberalization factors is because of its richness of natural resources with 14 main gas basins that owns over 23,000km of gas pipelines. This pipeline has put Queensland at the forefront of their gas industry. UK natural gas produces in the Southern North Sea in the Morecambe Bay in the form of methane and transported via well-established pipeline infrastructure inland. A giant natural gas field located near Slochteren in Groningen, Netherland.

4. ***LNG oil-indexed gas price***
The Australian LNG exports is reliant on the purchasing of an Asian LNG importer that connected to the oil prices. The export of LNG has connected domestic gas prices with global market prices. LNG in East Asia countries are mostly connected to Japan Crude Cocktail (JCC) pricing index of oil imports. By providing similar pricing mechanism, gas could stay competitive with oil.

UNITED KINGDOM (UK)



GAS PRICE MECHANISM PRACTICE

Oil-indexation was previously the leading gas price mechanism and started to lost importance due to the major changes with oil and gas substitutes in many processes over the years. In development of independent natural gas market, gas-on-gas competition along gas trading hubs happened to be the dominant price mechanism. The United Kingdom (UK) also was the first country to develop National Balancing Point (NBP) a gas trading hub model in 1990s.

EVOLUTION AND FORMATION OF GAS PRICING OF LONG-TERM AND SHORT-TERM CONTRACT

During 1986 before market liberalization, long term purchase contract and the usage of storage facility undertake an established balancing with a contract period of 8 to 10 years. Long term contract contained price formula as the gas upstream was highly variable. In 1990s, United Kingdom (UK) has started to liberalize in stages while the contract of gas market undergoes from only long-term field expenditure to shorter term supply and contract. However, producers seek to secure gas volumes through long term contract due to the declining in domestic gas production.

When gas market has fully liberalized in 1999, contract length tended to decrease. Thus, long-term contract brings a decreasing capital intensity and unit cost for newly built facilities. New contract market tends to be in a shorter period and leads to the increasing in liquidity. In 2003, trading grew rapidly, and traded volumes being locked into long term contract with only minor volumes of gas and the rest are being supplied through short term.

CHALLENGES FACED BY UNITED KINGDOM (UK) TO LIBERALIZE THEIR GAS MARKET

Security prices rise to high levels and show high volatility when under a breakdown in quantity supply. Hence, market volatility resulted in investment shortfall. In addition, regulated price is more stable as compared to market price. Hence, consumer may be reluctant to accept the price volatility in gas market. This proves as one of the biggest challenges faced by United Kingdom (UK) gas market.

Nevertheless, the United Kingdom (UK) create demands at the National Balancing Point (NBP) which cannot be met quickly because of the infrastructural constraint. In 2006, infrastructural issues related to the gas storage where consumers were to supply and demand imbalances addressed by landfall swings and extent storage. Furthermore, problems occur in supply of security which were previously absent in the years prior to non-existent of gas-on-gas supply competition.

KEY SUCCESS FACTORS OF THEIR COUNTRIES FOR THEIR LIBERALIZED GAS MARKET

A few factors that were identified are the increasing demand for natural gas that leads to lower cost of gas price. These improves industrial competitiveness which is crucial for companies competing in the global market and liberalizing the entire gas market down to the residential level. UK price of gas had exploited from the spot price growth as an indicator of the value of the product in the British market. The gas market is now fully competitive by encouraging the end-consumer of a levelling playing field and regulation of the transmission facilities.

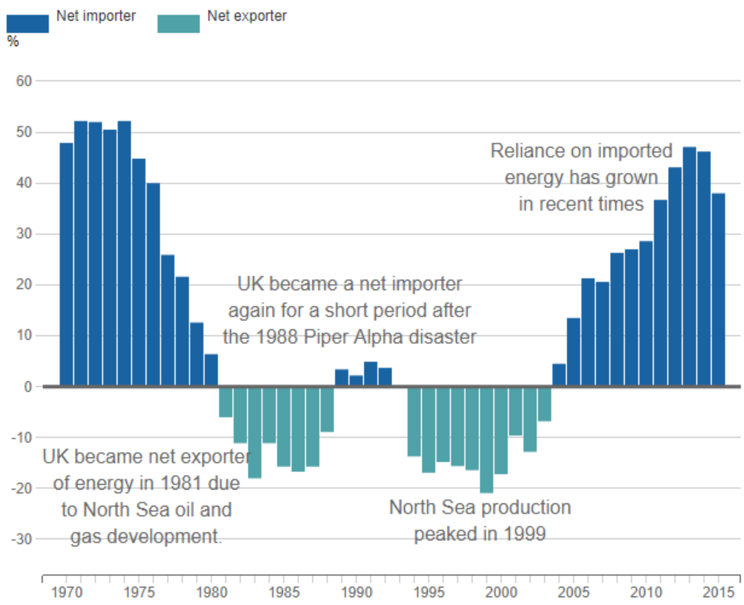
Gas prices in the UK had emerged because the oil-indexed had become re-established due to the interconnector of UK and Continental European markets. From oil-indexed the gas market had switch to gas-on-gas competition and hub pricing. Furthermore, UK became more dependent from major exporter to major importer in response to price spikes, outages and market demand which to deliver competition and lower the price of gas to the consumer on liberalization.

GAS MARKET CHANGING PROCESS FROM MAJOR EXPORTER TO MAJOR IMPORTER

Since the rising in North Sea production, the UK has limited its net imports of imported gas since the mid-1980s. For almost a decade, the United Kingdom (UK) became a natural gas net exporter before becoming a net importer of natural gas beginning in 2004 as demand increased and gas production in the North Sea declined. UK has matured towards a gas importing in order to bring competition and lower the gas price to the consumer.

Since 1998, the UK had a transitioned from being a net exporter to a net importer as a confirms that all European Union countries imported more energy than exported in 2014. Demand and production have indeed been declining led by the diminished of industrial consumption. Imports of natural gas reached a peak in 2010 along with the net pipeline imports from Netherlands, Norway and Belgium have

FIGURE 1



Most of the gas import comes through pipelines that compensated during 2015 for 61% from Norway and 7% from Netherlands respectively. However, due to a threefold rise in LNG imports there is a decreased by 0.9% of import levels in 2019. This was the outcome of excess supply diversification from other countries and a decline in prices triggered by global oversupply.

NETHERLAND

GAS PRICE MECHANISM PRACTICE

Gas network has existed before the discovery of the Groningen field located near Slochteren highly known as the largest gas field in Netherland and largely produce natural gas. Trading of gas under bilateral agreements and through the Title Transfer Facility (TTF) hub also gained rapid importance in the gas market. The TTF hub allows participants to sell and purchase gas volumes injected into the transmission system of the Netherlands.

The Netherland gas priced is related to other energy source and gas production began after oil, coal and electricity markets established. Energy products can be substituted to each other and when the price of the energy product changes, formula linked gas prices would also be changed.

EVOLUTION AND FORMATION OF GAS PRICING ON LONG-TERM AND SHORT-TERM CONTRACT

The evolution of the Groningen field was form on the long-term minimum pay export contract. Long-term contract needed as a proposition of energy governance in diverse market in order to allure the maximum possible rent for gas field before declining. Energy governance has started to encounter a turning point including the structure of long-term contract with pre-agreed price between both parties, oil-indexed price and netback pricing. The long-term context has changed due to the increasing pressure to reassess the main long-term natural gas contract and pricing mechanism. This had driven by the regulatory and market-based factor and results in rapid dwindle in demand and enough supply of LNG.

Furthermore, the new management regulations are also targeted at shorter capacity contracting which has changed the legal framework under the operation of long-term gas contract. These changes attempted to liberalize their gas market and generate a competitive domestic market. The intended result of this changes delivered an effectual TPA, move towards reservation of short-term capacity and created the requirements for unbundling supply.

CHALLENGES FACED BY NETHERLAND TO LIBERALIZE THEIR GAS MARKET

SEISMIC ACTIVITY

One of the largest issues in Netherland is due to the seismic activity, an earth tremor happened since 1990s and became more frequent when in 2008 gas output increased at the Groningen field. The bigger impact of the seismic activity happened in August 2012 where Huizinge quake take place that caused by the extraction of gas. For that reason, a sharp decline in production occurred. Moreover, citizens prompted the government to take action and restrain production from the field to help minimize seismicity. Government cannot operate in isolation because they need support from the citizens, cooperation with companies the import transport, distribute and market the gas.

RESPONSIBILITES FOR CERTAIN WORK ON EACH ROLE

The responsibilities are uncertain between suppliers, transport company and end consumers. These problems are in relation to the continuity of supply, the assurance of adequate gas, and the intention to construct a pipeline because of the potential future benefit and the back-up gas contract. Gas players also had difference considerations whereas the lack of knowledge and unequal power of the stakeholders. These considerations slow down the transition from oil and coal towards a gas-based economy. For instance, end consumers worried about the future of gas prices and investor also build a transport pipeline that can only last for a couple of years.

DIFFERENCE OF ELECTRICITY AND GAS REGULATORY

Last but not least, there were a difference fundamental where the electricity market is based on regulated TPA and gas market is based in negotiated TPA. The discrepancies make the experience of liberalization more problematic, led to a lack of information system of imperative.

KEY SUCCESS FACTORS OF THEIR COUNTRIES FOR THEIR LIBERALIZED GAS MARKET

The Dutch energy market liberalization process began in 1998 and concluded in 2004 by introducing the energy market to small business as well as households. The European Union membership is one of the circumstances on the liberalization of Dutch energy market. A range of legal rules, procedures and regulations have been created to ensure fair opportunity for all parties, establish market integrity, ensure continuity of supply and protect the consumer.

In the current market circumstances, the grid operators bring forth the technological security, register the exchange of energy across their grid and are generate billing services for suppliers and transport system operators. The legal framework for the liberalization of energy market determined by the Electricity Law from 1998 and the Gas Law from 2000. Hence, this legal framework creates equal changes for all market players. The government also had an important role of creating the market conditions needed for open energy market. The government are stabilizing the investment climate, provide transparent market and stabilizing the political situations. The liberalization in Netherland resulted in more suppliers and lower energy prices.

THE ROLE AND EVOLVEMENT OF SHELL IN NETHERLAND GAS MARKET

Royal Dutch Shell operated as dual-listed company defined as an Anglo-Dutch multinational oil and gas company. The company was established correspondingly to the disclosure that Shell had been overstating its oil reserves. Shell had invested more than $200 million in its headquarters located in the Hague, Netherlands.

The Netherland has encouraged the activities of Shell New Energies and will continue to be cantered in the Netherlands since it is known to be the competent leader country in energy transition. The New Energies hub is expecting to grow in providing jobs. Nevertheless, Shell Technology Centre Amsterdam (STCA) has an R&D hub to operate as the innovation global center for Shell. The STCA also produced a world leading consumer goods including lubricants attain from natural gas.

EUROPEAN UNION SUCCESFUL REASON FOR THEM TO HARMONIZE THE ARRANGEMENT AMONG 55 COUNTRIES

As a community of 27 nations, the European Union works together to ensure that there are peace and people have decent lives. The European Union also valued the languages and cultures of each country and also used Euro currency to do business together. In order for a country to become parts of the EU, all European Union laws and principles must be agreed upon by that country. Human rights, independence, democracy and equality are the ideals of the European Union.

The fundamental value is indicated in the Treaty of Lisbon (Lissabonin sopimuksessa) in 2009. The Treaty of Lison established citizens right, political, economic and social rights. New countries joining EU must comply with the rights and obligations laid down in the rules of European Convention on Human Rights and the Charter of Fundamental Rights of the European Union. Any discrimination based on gender, skin color or race is prohibited by this law. Hence to enforce the law, law enforcement must be properly trained and equipped.

EASTERN AUSTRALIA

GAS PRICE MECHANISM PRACTICE

Australian east-cost gas market has been under the development of coal seam gas (CSG) and a Liquefied Natural Gas (LNG) export in Queensland. The export of LNG has “connected” to domestic gas prices with global market prices for LNG. The Australian LNG exports of contemporary pricing under long term contract is reliant on the purchasing of an Asian LNG importer that connected to the oil prices. Australia’s LNG export prices are tied to oil prices, if a fluctuation appear in global oil prices it would have a significant effect on the gas trading.

Hence, international LNG pricing cannot be directly compared to the cost domestic production on the Australian east-cost. These are due to the LNG price does not include the expenses of other main supply chain components. If these costs are considered theoretically, an LNG exporter would be oblivious to an international buyer or a domestic client.

EVOLUTION AND FORMATION OF GAS PRICING ON LONG-TERM AND SHORT-TERM CONTRACT

Eastern Australia has been liberalized their gas market in 1997. Throughout the time, the restructuring of the gas sector started later than the electricity market and its attributes have lowered barriers to the construction of regional pipelines and closed gaps in the national gas grid.

During 1999, gas market has been industrialized in Eastern Australia together with the declared wholesale gas market (DWGM) hub in Victoria. Moreover, a virtual hub that comprises a chain of pipelines and encompasses the Victoria Declared Transmission System (DTS). Hence, Victoria DWGM hub caused a huge proportion of gas that have remained sealed in long-term contract. Besides, the Queensland gas sector has undergone rapid growth over the past decade.

The first gas supply hub was initiated in May 2014 that provide market players through an electronic platform to transfer physical gas products that are standardized and short-term. However, Australia prefers long-term gas contract rather than hub trading due to most trades occur through long-term bilateral contracts with the terms and rates were store confidential. Gas trading around 80% has eventuated outside of the trading market and during 2016 in the configuration of gas supply agreements

CHALLENGES FACED BY EASTERN AUSTRALIA TO LIBERALIZE THEIR GAS MARKET

LACK OF SUSTAINABLE BENCHMARK RATES AND LIMITED TRADING VOLUMES

One of the problems faced is that the DWGM and short-term trading market (STTM) hub do not serve a long-term contract. The mandatory use of the DWGM caused a major proportion of gas to auction at a zero price ($0 / GJ) to ensure the supply of gas. There is also a small number of large producers for the bulk of gas production when a successful gas hub requires a large number of buyers and sellers willing to trade.

LOWER OIL PRICES

In different circumstances, a downturn in LNG investment and a growth in LNG production and exports are expected to influence Australian economic growth and national profit in a variety of ways. Whereas, the trade conditions are enhanced by lower oil prices which are compensated to be offset to some extent by lower LNG prices.

UNCONVENTIONAL SOURCES

On the contrary, there are 3 types of gas which require more extraction methods considered as unconventional such as coal seam gas (CSG), shale gas and tight gas. There is a concern over the technology used to extract gas from unconventional sources has prompted governments in Australia to hold independent inquiries. The risks can be managed through a monitoring program and a high-quality engineering. In addition, as a result of the advancement of new exploration technologies, gas reserves have increased significantly due to a seismic change in the global gas sector.

KEY SUCCESS FACTORS EASTERN AUSTRALIA FOR THEIR LIBERALIZED GAS MARKET

During 1980s, Australian begun to explore for Coal Seam Gas (CSG) that tend to become the dominant source of gas in Queensland. The other main successful factors are the construction of Roma Brisbane pipeline (RBP), Queensland gas pipeline (QGP) and South West Queensland pipeline (SWQP) that put Queensland at the forefront of the gas industry. Australia is rich on natural resources where they have 14 main gas basins located throughout the country that owns over 23,000km of gas pipelines. Australia natural gas extracted from a conventional gas deposits and unconventional gas deposits. In any case, both terms utilize to describe the reservoir structure and the gas produce is still the same product. During mid-1990s, the development of Australia's unconventional gas resources reached commercial levels with the commencement of coal seam gas production.

Australia is equipped with massive natural gas resources and has been exporting liquefied natural gas (LNG) since 1989. Australia also has become the world's 2nd largest LNG exporter in 2016. There is a total of 7 operating LNG facilities in Australia bust most importantly 3 LNG facilities in Queensland. On top of that, most major energy companies such as Shell, Exxon-mobil, Woodside, BHP, Petronas, Tokyo Gas, Chevron, Korean Gas (Kogas) have invested over $200billion in Australia's LNG infrastructure.

GAS PRICE MECHANISM PRACTICE

Natural gas prices are indexed to crude oil prices contract where most natural gas is imported as LNG. LNG in most East Asia countries connected to Japan Crude Cocktail (JCC) oil import prices. JCC was formulated to create an average pricing index of customs-cleared crude oil imports. Most LNG exports to East Asia are still oil-indexed compared to European prices which the country have linked both oil prices and hub prices. However, most East Asian nations continue to use the JCC price LNG which is a cheaper alternative.

The government of Japan, China and Singapore are exploring the possibility of an establishing an LNG market hub. It is expected to be the LNG spot cargo trading as the center for the regional gas future market. This is because intra-regional pipeline connection is largely non-existent in East Asia. By developing LNG trading hubs, the liquid transaction is conducted to fully reflects market condition in pricing and contribute to enhance market functions.

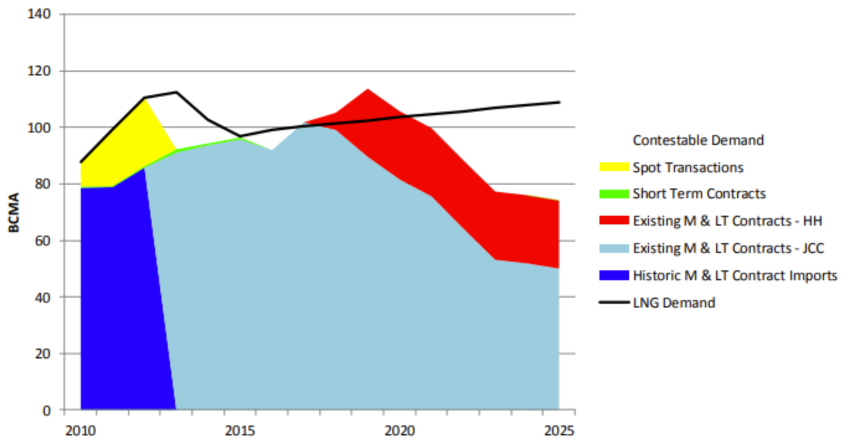
Unfortunately, these countries have so far not been successful in establishing market-based gas pricing benchmark for the global LNG market. To create a functional hubs and transition to hub-indexation, these governments need to liberalize both gas and electricity market and transit from oil-indexation to hub-indexation.

EVOLUTION AND FORMATION OF GAS PRICING OF LONG-TERM AND SHORT-TERM

Japan also has taken several steps to liberalize their gas market. Firstly, during 1995 the Gas Utilities Industry Law (GUIL) was amended to allow industrial customers with contracted amounts of more than 2 million cubic meters per year to directly negotiate price with suppliers. Retail liberalization began first by a large-scale of consumers. Then, the Gas Utilities Industry Law (GUIL) was further enhanced in 1999. By reducing the annual contract volume to 1 million cubic meters each year and above, the deregulation for large volume supply was prolonged.

Finally, in April 2017, the law was further improved and customers are entitled to choose their utility companies with contracted amounts of 0.1 million cubic meters per year. The sector was eventually liberalized in April 2017 and is intended to minimize costs by introduced competition and also to enhance consumer convenience.

FIGURE 2



LNG spot has increased by supplementing long-term contracts during the Fukushima accident in 2011. Since 2012, Japan were more rely on spot cargoes prior to the restart of nuclear generating plant. A significant resumption of nuclear generation also would see Japan well covered by existing long term JCC priced contracts to 2018. Ever since the Fukushima disaster, many buyers looked for solutions which would allow for flexibility in the LNG market. However, most contract period currently in Japan is getting shorten. Japan is now more dominant and major getting more popular into medium-term and short-term contract

CHALLENGES FACED BY JAPAN TO LIBERALIZE THEIR GAS MARKET

OIL-INDEXED PRICE HIGHER THAN US NATURAL GAS

Japan have led to a rigid, inflexible market due to the reason of Asian LNG prices been indexed to crude oil which plunged on rapid supply expansion. The Global Financial Crisis during 2007 until 2008 also has impact on the JCC price from $100.98 USD/bbl in 2008 declining to $61.29 USD/bbl in 2009. As JCC is based off oil prices has been a rise in objection to its use. Europe and North America has shifted from JCC to gas-based indexed.

GEOGRAPHICAL MOUNTAINOUS TERRAIN

Japan has limited domestic natural gas. The transportation cost and distribution cost are high due to the complicated transportation methods, the high cost of pipeline construction, high price for the land and less consumption per family.

KEY SUCCESS FACTORS JAPAN FOR THEIR LIBERALIZED GAS MARKET

Japan's rapid industrialization made them one of the largest energy consumers. Japan began importing LNG from Alaska since 1969 due to its limited natural gas resources. Japan also has 32 operating LNG import terminals with a total of 8.7 Tcf/y gas capacity located in the centers of Tokyo, Nagoya and Osaka. As of October 1998, there are 238 gas companies and four city gas companies namely Tokyo Gas, Osaka Gas, Toho Gas and Saibu Gas dominate with 75% market shares. For substantially all of its natural gas production, Japan depends more on LNG imports.

The nuclear plants were progressively shut down during 2011 until 2012 caused by the Fukushima Daiichi Nuclear Disaster. As the consequences, demand for LNG imports grew dramatically when the loss of these nuclear energy sources placed massive pressure on the Japanese economy. During this earthquake between 2011 and 2012, Japan substituting the loss of its nuclear capacity with natural gas and other energy source.

Japan is seen as a candidate for the Asian LNG trading hub. Japan's advantage is its physical demand platform as the world's largest LNG importer and in having numerous LNG terminals. Nevertheless, Japan has also promoted electricity and gas system reform becoming a top runner in liberalization or deregulation in Asia. However, a long period of time is required for highly liquid transactions to be realized even after full-fledged liberalization. However, Japan does not have as ready an ecosystem of players in commodity trading and would need to attract market players into the country and augment capabilities with investment in training and development.

POLICY RECOMMENDATIONS

1. *Revising the terms of long-term production contract in order to release a portion of existing production. This can boost the competition in the gas market.*

2. *In the state of declining in natural gas production, if a portion of existing production is to be released and if the gas security supply is to be ensured, the extension of the TPA system is imperative incorporating the processing plants. New entrants also need to have access to gas processing.*

3. *Liberalize the gas market in Peninsular Malaysia and bring in new entrants to supply gas, released by Petronas or import domestic purchase.*

4. *Replacing the regulated gas price with a market-based price system where the supply-demand conditions and international LNG price benchmark will be reflected. It will help balancing the price and a level playing field would be ensured for the market participants.*

5. *The government needs to stabilizing the investment climate, provide transparent market and stabilizing the political situations to create a market conditions for open energy market.*

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Project 5:

Study on Circular Economy of Urban Wastewater Treatment

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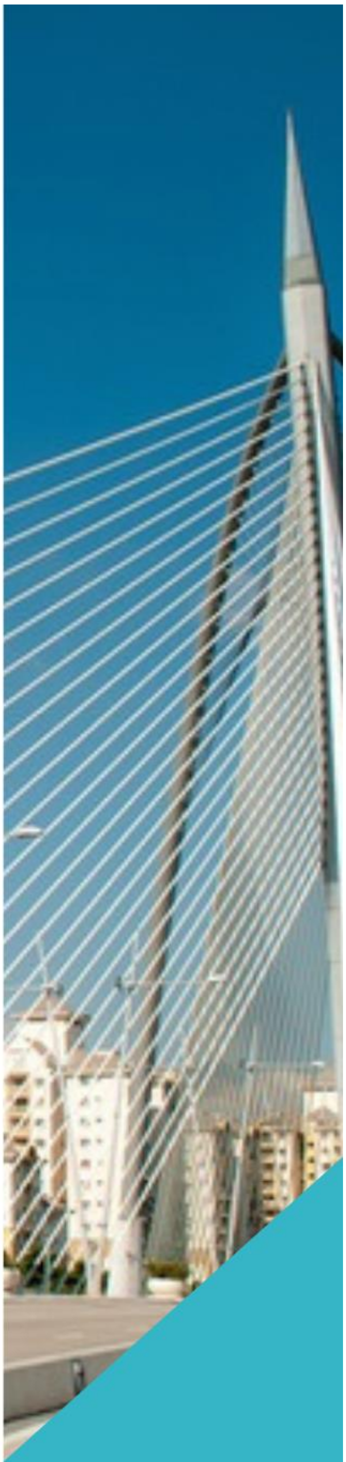


Institute of Energy Policy and Research

POLICYBRIEF

Circular Economy Pathways for Sludge Waste Management: Life Cycle Cost Perspective

EXECUTIVE SUMMARY

Sustainable energy development had been signified as the pathways for the global energy transition that drive important changes in how energy is being generated, transmitted, and consumed. The concept of Circular Economy (CE) in waste management has been proposed to address sustainability issues by minimizing the resource inputs and emission generation, reuse the waste and refuse from the conventional production process for added-value benefit.

The management of sludge waste is one of the most critical environmental issues in Malaysia. The rapid increase of sludge production due to sewerage extension and new installation of wastewater treatment facilities has led to the increasing of sludge waste in Malaysia. Landfilling has been a simple route for sludge disposal, especially when recycling is not of primary importance, being possibly limited only to biogas recovery. Thus, it is necessary to focus on the concept of recovering energy from sludge waste for a low-carbon energy system. Based on a circular economy concept, this research set out to explore the economic potential of treating domestic sludge waste for energy production by adopting life cycle cost analysis. The purpose is to provide insights into the potential consequences or benefits related to economic and environmental associated with sludge waste treatment which covers the following:

- What options of energy recovery from sewage sludge waste for power generation?
- Which of these scenarios are feasible for sewage sludge management?
- What is the management strategies of sludge management towards circular economy pathways?

The analysis revealed that recovering energy from sludge can be a convenient solution, but cost becomes an important driving factor of this solution due to its huge investment requirement. However, the study establishes that direct benefits through recovered resources from sludge waste could make it economically attractive to adopt circular economy pathways in sludge waste management. In this case, the future development of sludge management for energy recovery will be strongly influenced by the government directive on sewage sludge. This research suggests that intervention is needed to focus on changing production patterns and improving resource management towards environmental sustainability. A proactive approach and leadership from the internal (i.e., industries, treatment facilities, utilities, environmental awareness, etc) and external (i.e., government, academia, and societies) sector are essential towards successful intervention in this sector.

KEY FINDINGS

- There are potential for energy recovery in a large scale sewerage plant for power generation that maximizes the usage of sludge to achieve almost zero waste production.

- The treatment of sludge produces about 70% of biogas which can be utilized for generating energy rather than being disposed of and the energy produced can be used to offset the energy usage generated by fossil fuel or be sold to help increase self-sufficiency.

- The expected energy production of treating sewage sludge to biogas using anaerobic digestion and improve processes of sludge waste to create a solid fuel to displace coal for utilities are economically viable in a short term due to additional revenue generated from electricity and fuel sold. However, when the total capital investment and operation cost are included, the IRR becomes negative for the biogas and biofuel scenarios within the long-term operational life of the plant.

- Sufficient infrastructure investment is crucial for energy recovery initiatives. The current low sewerage tariff is unable to support the high operation and maintenance costs for full-cost recovery to reflect actual operational expenses.

- Consumers have an important responsibility to change mindset to support energy cost recovery and safer environment. The recent government decision to introduce joint billing for water supply and sewerage services is commendable to support the sustainability of plant operation.

- The Quintuple Helix (QH) engagement of industrial symbiosis and public-private partnerships would improve the direction on reuse and recycling for the efficiency of resource utilization and solves environmental issues among industries.

OVERVIEW

Rapid development as well as an increase in population in Malaysia, has led to the increasing of sewage sludge. The population has reached 30 million and Malaysia has been expected to generate approximately 3 million m^3 of sewage sludge annually and is projected to rise 7 million m^3 of sewage sludge a year by 2020. Malaysia is estimated to reach 10 million m^3 per year which require a proper treatment of large sewage sludge production.

The sewerage treatment technology in Malaysia has advanced from basic treatment method to deployment of a modern anaerobic digester plant due to industrialization and demand for a cleaner and safer environment. The National Water Services Commission (SPAN) was set-up to regulate the water supply services and sewerage services industry through fair, effective, and transparent implementation of Water Services Industry Act 2006 (Act 655) towards a sustainable, reliable and affordable water services for all. The Environmental Quality Regulation (Sewage and Industrial Effluents) 2010 under the Department of Environment is designed to address waste-related such as sludge to fulfil biological stability and possible pollution for landfilling.

Currently, some modern plants have been upgraded whereby the sludge waste is treated to produce methane or biogas which is a valuable energy source for electricity generation. It has been reported that 120,000 tonnes of sludge are produced by Indah Water Consortium (IWK) treatment plants nationwide annually. However, the sewage sludge is commonly being disposed of either at the landfill and trenching sites or being burned in incinerators. This is not good for the environment as it may still contain contaminants which remain as ash and contributing to crucial concern among the service providers and consumers.

The depletion of fossil fuels and environmental issues have led to a comprehensive research and development programs to investigate technology which improves energy yield from sewage sludge, which the industry has in abundance.

In this research, the economic potential of treating sewage sludge to biogas using anaerobic digestion for energy production and improve processes of sludge waste to create a solid fuel to displace coal for utilities are explored. Figure 1 presents the business as usual processes of sludge treatment for two sewerage treatment plant (STP) in Peninsular Malaysia. Firstly, a common mechanized STP A with 360,000 population equivalent (PE) and their business as usual daily operation is without anaerobic digestion process and the sludge waste is dumped into the landfill. Secondly, a modern mechanized STP B with 360,000 PE daily operation which installed with anaerobic digester for biogas production and the remaining sludge waste is dumped into the landfill. The anaerobic digestion process is added to reduce the mass sludge for disposal and producing rich biogas (methane) for energy recovery.

In this case, the economic feasibility of energy recovery and by-product transformation to biofuel from the sludge of the STPs was analysed. As depicted in Figure 2, both STPs were modelled into two energy recovery scenarios as per Scenario 1 and Scenario 2, respectively. The life cycle cost analysis (Eq. 1 & Eq. 2) has been applied to explore the economic potential of treating domestic sludge waste for energy production. Appropriate variables including the capital cost, operation and maintenance cost, electricity cost, and revenue as well as benefits were collected and generalised from the wastewater treatment plants and data from literature were utilised when required.

FIGURE 1

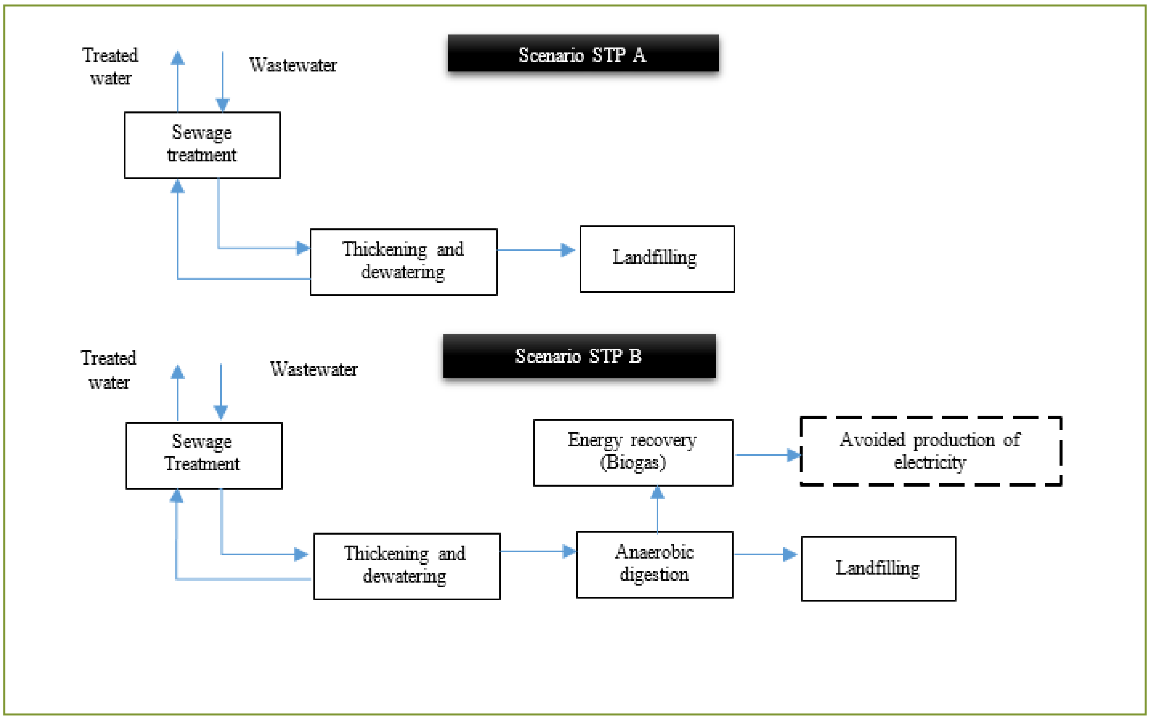


FIGURE 2

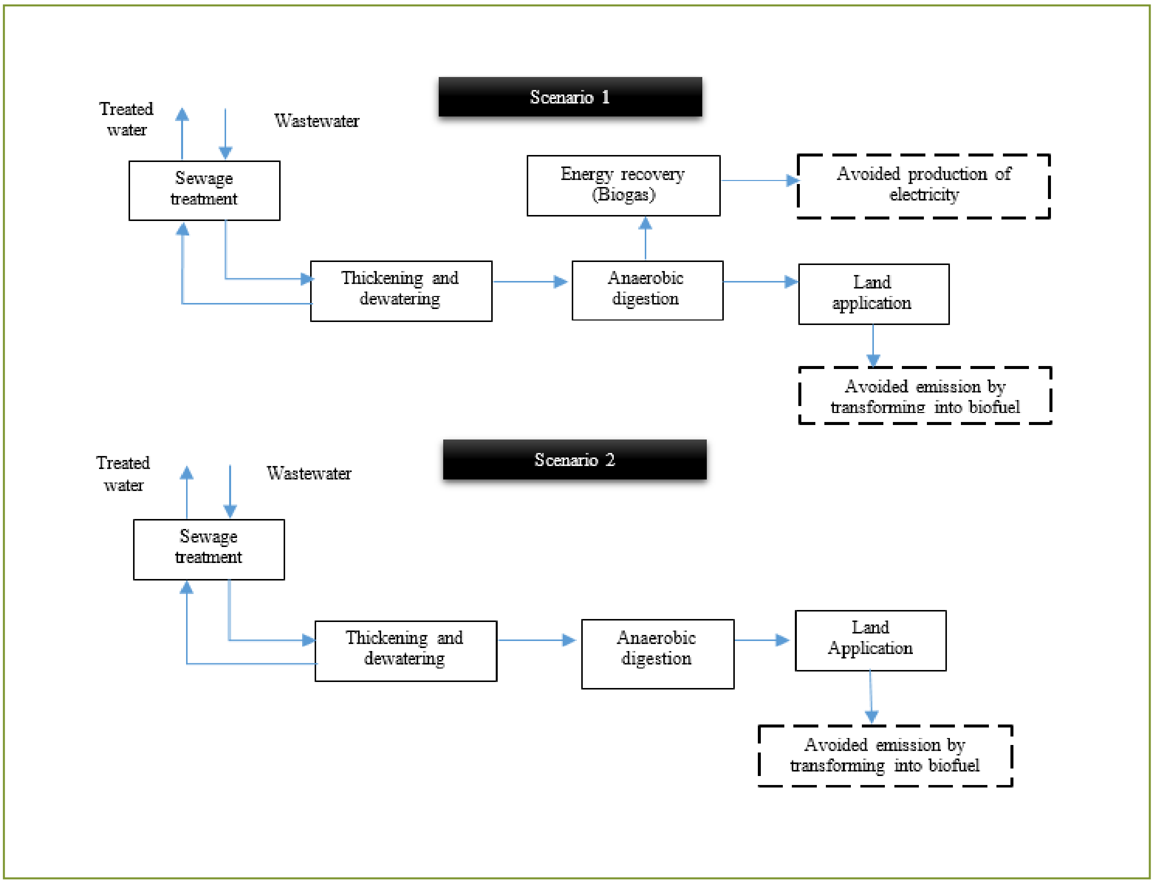


TABLE 1

STP A refers to a large scale centralised sewerage treatment plant of 360,000 population equivalent (PE) with the daily operation is without anaerobic digestion process and the sludge waste is dumped into the landfill. Similarly, STP B with 377,000 PE plant with the daily operation is with anaerobic digestion process and electricity recovery from biogas production and the remaining sludge waste is dumped into the landfill. The anaerobic digestion process is added to reduce the mass sludge for disposal and producing rich biogas (methane) for energy recovery. Detail information on STP A and STP B on the generalised parameters used to calculate the LCC is provided in Table 1.

The net present value would be calculated by the following formula (1) and (2). The base year for the analysis was in 2018 and all the value was converted to a base year. To calculate the discount rate, interest rate and inflation rate was considered for a 25-year concession.

Table 1: Summary of Parameter Inventory Data

LCCA COMPONENT	INPUT VARIABLE	SOURCE
INITIAL COSTS, OPERATIONAL AND FUTURE COSTS	Investment Cost, C_c	Estimate
	Maintenance, C_m	Estimate
	Decommissions, C_d	Estimate
	Energy, C_{o1}	Estimate
	Polymer, C_{o2}	Estimate
	Administration, C_{o3}	Estimate
	Labour, C_{o4}	Estimate
	Security, C_{o5}	Estimate
	Waste Disposal, C_{o6}	Estimate
	Sludge Disposal, C_{o7}	Estimate
	Water Consumption, C_{o8}	Estimate
	Plant lifetime	Assumption
LIFE CYCLE (LC) REVENUE	Bio-fuel Cost (R_f)	Assumption, RM324/tonne
	Electricity Cost (R_e)	Assumption, RM0.37/kWh
	Disposal cost (R_d)	Assumption, RM175/m3
NET PRESENT VALUE	Discount Rate (r)	Assumption, 10%

Note: All costs are assumed for model calculation. Future costs such as decommission/salvage value are estimated whenever this info is applicable in literature.

EQUATION (1) & (2)

$$C_t = C_c + C_o + C_m + C_d - R_f - R_e - R_d - R_s \qquad (1)$$

$$LCC = \sum_{t=0}^{LC} \frac{C_t}{(1+r)^t} \qquad (2)$$

LCC	- Current Value of Total Life Cycle Cost
C_c	- Capital Cost
C_o	- Operational Cost (i.e., C_{o1}.... C_{o8})
C_m	- Maintenance Cost
C_d	- Decommissioning Cost
R_f	- Revenue from biofuel
R_e	- Revenue from electricity avoidance
R_d	- Revenue from less disposal cost
R_s	- Revenue from decommissioning
r	- Growth rate, 11% (include discount rate)
LC	- Life Cycle, 25 years
C_t	- Sum of relevant LC of the project after deducting the positive cash flow

RESULTS

In Table 2, the energy recovery of biogas and biofuel offers notable benefits in term of energy potential whereby the excess of energy can be used to reduce the energy cost of the treatment plant. Currently, about 2,900 kWh/day electricity can be generated which able to replace 7% of the electricity consumption during the treatment of wastewater itself. With the assumption of full utilisation of sludge waste for energy recovery, STP A would be able to produce 45,960 kWh/day and 54,197 kWh/day in Scenario A and Scenario B, respectively. While STP B would be able to produce 83,893 kWh/day in Scenario A and 54,191 kWh/day in Scenario B.

These findings show that the energy recovery from wastewater process residuals may significantly contribute to achieving cost saving and improving the energy balance of the wastewater treatment plant. It is estimated that if the engine conversion efficiency is running with 70% efficiency rate, the net emission could be only 172.5 kg CO_2 eq. for STP A and 181.3 kg CO_2 eq. for STP B. It is a significant amount of emission reduction rather than if the plant operates without biogas facility whereby it could contribute to 576.9 kg CO_2 eq. emitted.

TABLE 2

Table 2: Potential of Energy production and emission reduction

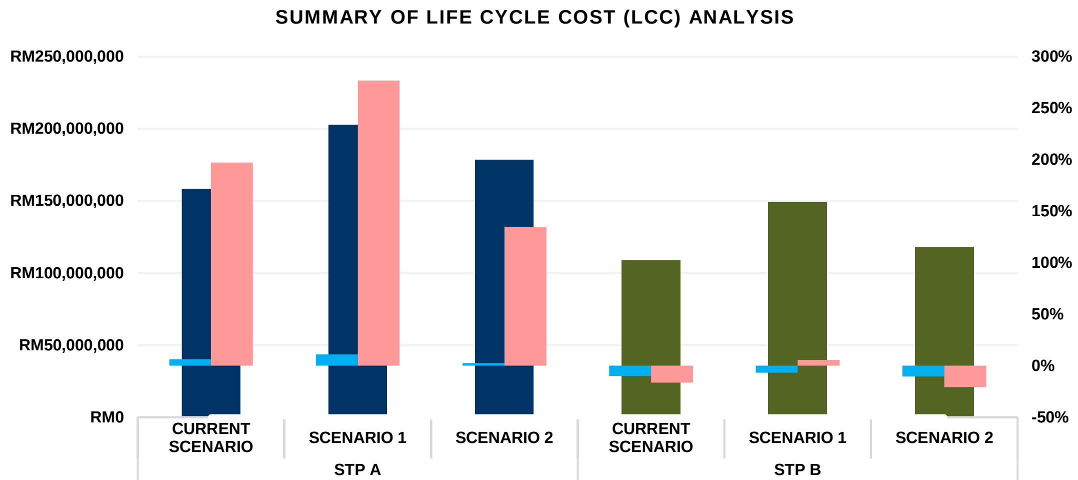
	Biogas Production (m3/day)	Energy Potential (kWh/day)	Net Emission Potential (kg CO eq.)
STP A			
Business As Usual	nil	nil	576.9
Scenario A	5,000	45,960.0	172.5**
Scenario B	nil	54,197	-
STP B			
Business As Usual	1,150	2,900	228.0*
Scenario A	5,000	83,893	181.3**
Scenario B	nil	54,191	-

*Note: * Assumed 38% efficiency rate. ** Assumed 70% efficiency rate.*

It is assumed that one ton of biofuel can produce 2,500 kWh of electricity. The CH4 GWP is 25 x CO (IPCC 2006).

It is assumed that one ton of biofuel can produce 2,500 kWh of electricity. The CH_4 GWP is 25 x CO2 (IPCC 2006).

FIGURE 3



	STP A CURRENT SCENARIO	STP A SCENARIO 1	STP A SCENARIO 2	STP B CURRENT SCENARIO	STP B SCENARIO 1	STP B SCENARIO 2
LCC	RM158,300,629	RM202,884,649	RM178,524,165	RM108,696,474	RM149,206,172	RM118,045,332
IRR	6%	11%	2%	-10%	-7%	-11%
ROI	197%	277%	135%	-17%	6%	-21%
Paybank	11	8	16	0	0	0

Note: IRR-Internal Rate of Return, ROI-Return on Investment and (0) payback means that the period is not available to be calculated and define as more that 25-years.

Figure 3 shows the economic cost of the scenarios in STP A and STP B which analyze the costs of investment over the service life of the treatment plant. Which all the scenario cases could generate net revenue when the sludge treated by anaerobic digester technology.

The analysis showed the net present value is higher for Scenario 1 in both STP A and STP B. The reasons of this might due to the higher capital investment for installing a modern and efficient technology for the biogas facility which requires large assets and capital intensive as well as huge operation and maintenance cost (Rebitanim, Wan Ab Karim Ghani, Rebitanim, & Amran Mohd Salleh, 2013). **In the case of STP A,** the application of anaerobic digester (S1) has significantly positive present value of RM202,884,649 million, indicating of beneficial investment for the treatment facility with 11% IRR and a payback period of 8 years as compared to the investment required to dry the sludge waste into biofuel (S2) for utility usage. The potential benefit of S1 is attributed to displacing the burden associated with grid electricity consumption and disposal cost avoidance.

While in STP B, it is estimated that within 25 years, the NPV of S1 and S2 are RM149,206,172 million and RM118,3045,332 million, respectively. The biofuel alternative has a higher initial cost as compared to the biogas facility, but its costs over the asset's life cycle seem to be lower than other alternatives. From the estimation, it offers the value of investing through selling all the sludge production as biofuel relatively better than the two-fold alternative which is to improve the efficiency rate of the biogas engine and anaerobic digester to produce more biogas for generating electricity. This result is consistent with the case of the UK (Mills et al., 2014) which found the option to create biofuel was the most economical and sustainable solution. The investment of Scenario 1 and 2 in STP B seems not worthwhile in the 25-year concession. However, with the improvement of the digester operation and selling all the sludge remaining, the revenue generation of S1 over S2 is relatively worthwhile to the operation with a 6 per cent return on investment (ROI).

From the LCCA estimation, even though the findings of the STP B scenarios seems not economically feasible for commercial implementation, the results show that the move from conventional technology to reap all the sludge waste has advantages due to promising source of energy production and the net environmental impact which support the future direction of wastewater treatment in Malaysia in reducing the greenhouse gas emission (see Figure 4 & Figure 5).

In the industrial ecosystem, the creation and dissemination of sustainable energy technology have been based on the initiative of firms but limited by governmental regulation. In this case, wastewater operators have the responsibility of providing public services to the local communities. However, maintaining and sustaining the sector with the ageing, malfunction, and failing infrastructure and inefficient technology becomes an enormous challenge (Carayannis, Barth and Campbell, 2012). The engagement with Quintuple Helix (QH) such as the technology availability in the industry, awareness of the society, and feasibility of other stakeholders and authority body must be addressed deeply to well understand the impact of the energy recovery initiative. As a country that is blessed with abundant natural resources supported by several compromised sector in producing the raw material for power generation, Malaysia strived to promote renewable energy. The proposed framework as shown in Figure 6 and Table 3 below summarised the inter-relationship between each of the five QH element (i.e., government, industry, academia, society, and environment) which is important to align with the circular economy concept

FIGURE 4 & 5

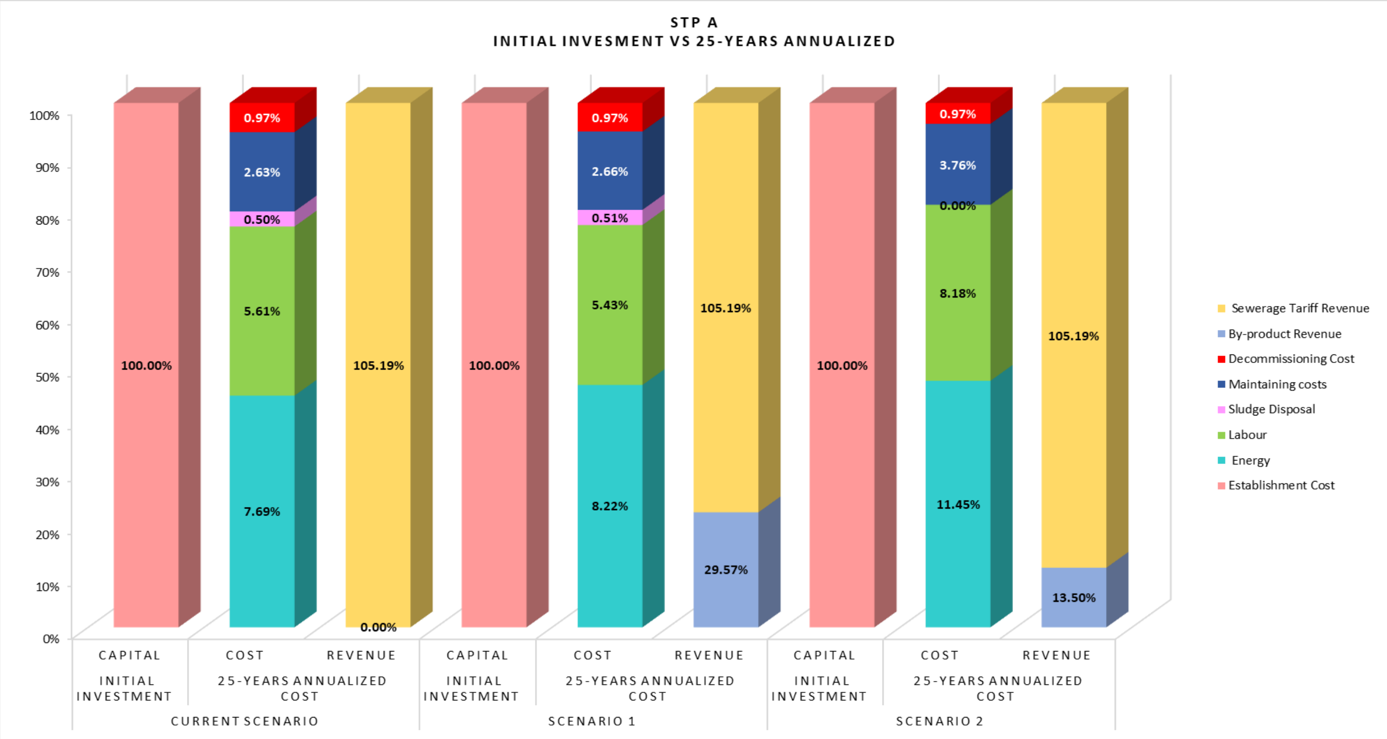


Figure 4: Summary initial investment and 25-years annualized for STP A

Figure 5: Summary initial investment and 25-years annualized for STP B

FIGURE 6

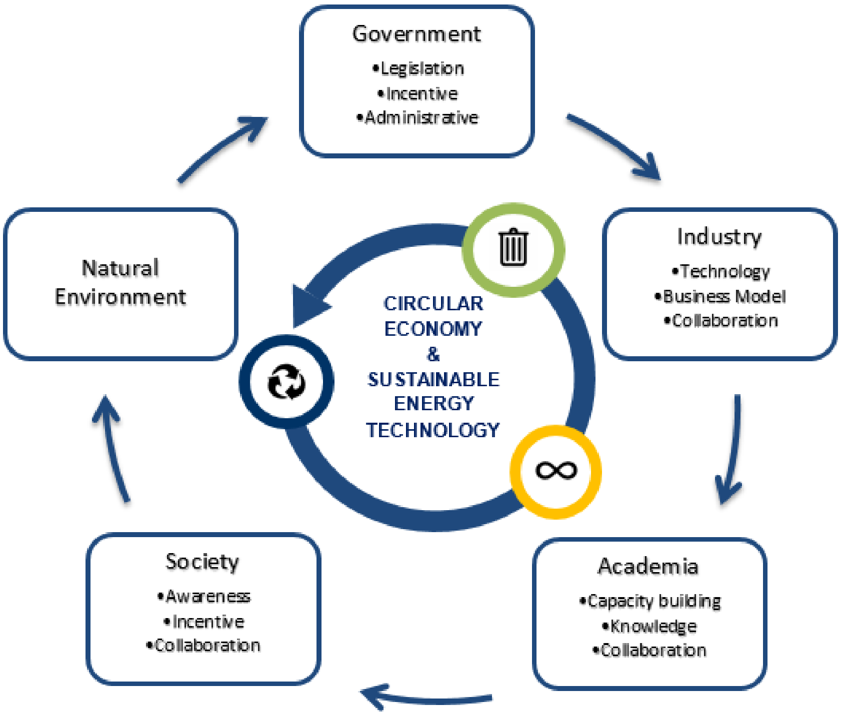


Figure 6: Framework of the CE system through Quintuple Helix.
Source: Adapted from (Carayannis, Barth and Campbell, 2012; Durán-Romero *et al.*, 2020)

TABLE 3

Table 3: QH Element Related to the Circular Economy System

MAIN DRIVERS	APPROACHES
INDUSTRY	Advance technology, product development, and environmental concern are the major driving factor triggering the industry. Monitoring and study a new method in the technological aspect could lead to improvement measures and increase the reliability of the system. Additionally, the long-term strategy also would be based on the project cost. The adoption of new energy recovery technology suitable for the industry and sufficiently verified by the regulator to secure a good circular economy system.
GOVERNMENT	Laws, standards, guidelines, and regulations are prepared by the Government. Regulations and standards for energy recovery technology need to be established. The local authority, private partnership, and the public must collaborate in improving the policy and strategy. The private partnership support for a more attractive investment opportunity under the Build, Own, Operate, and Transfer (BOOT) mechanism. A blended finance model of sharing equal risks under BOOT mode could boost public-private partnerships which reduce the Government burden for the adoption of advanced wastewater treatment technologies.
ACADEMIA	In the context of technological intervention, the changing role of academia from merely research universities to a more entrepreneurial stance is also important in translating knowledge produced within the university into economic and social efficacy. The collaboration with academia can increase confrontation with industry and society to address the sustainability issues and work towards viable technological solutions.
SOCIETY	Improving awareness is important for selecting the location of facilities and to cope with the technology used and its impact on society. This requires strong participation from various stakeholders including non-governmental organizations (NGOs), industries, and financial institutions. The NGOs could influence the society at large through awareness program on the sludge-related impact on health and the benefits of considering the circular economy.
ENVIRONMENT	The direct effect of the technology and system is to improve the environment which is periodically analyzed by national and public research institutes, government agencies, and industrial technology expert.

POLICY IMPLICATIONS

- Recovering energy from sludge waste can be a convenient solution for a large scale sewerage treatment plant, but cost becomes an important driving factor.
- Setting the governmental target such as to achieve 20% RE including biogas in the energy mix by 2025 and 100% sludge to be recycled by 2030 which collaborate for the production of renewable energy in the country, will lead to economic gains that enable the country for a well-defined directive towards energy sustainability.
- The existing subsidy of sewerage cost could be relocated to recover operational expenses in exploiting circular economy initiatives. However, sewerage tariff upward revisions could be politically sensitive for the Government despite it being sensible for the wastewater sector to be self-sustained as it could increase the burdens of the lower-income households.
- Realistic regulatory policies on sludge management play an important role in determining the sustainability of wastewater treatment. However, establishing regulation and standards for energy recovery for sludge management would be a long-term process, given the fragmented wastewater asset ownerships across the states that are still present, coupled with the budget limitation from the Government.
- A practical regulatory framework for enforcement should be formulated to support development on anaerobic digester deployment in waste treatment facilities to minimize the amount of sludge and reap recoverable energy.
- The achievement of sustainable energy technology in the sector could be facilitated by quintuple helix framework which drives the participation of multiple stakeholders underpinning by actions from government, industry, academia, society, and environment.
- Public participation should be encouraged to help to create awareness of co-benefits of sludge waste and appreciation of the right value of energy and environment.

FURTHER INFORMATION

This research report reports the findings of the paper referenced below; please refer to that paper for further background information and references. This research was funded by Chair in Energy Economics of Energy Commission at Universiti Tenaga Nasional.

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Mustapa S.I, Mohamad Ishak, W. W., Hayder G., Mohammmad Jais, A. (2021). Circular Economy: Life Cycle Cost Analysis of Management Alternatives for Sewage Sludge in Malaysia. *Global Business and Management Research: An International Journal, 13*(1); International. Symposium of Business and Accounting (ISEBA), 2020.

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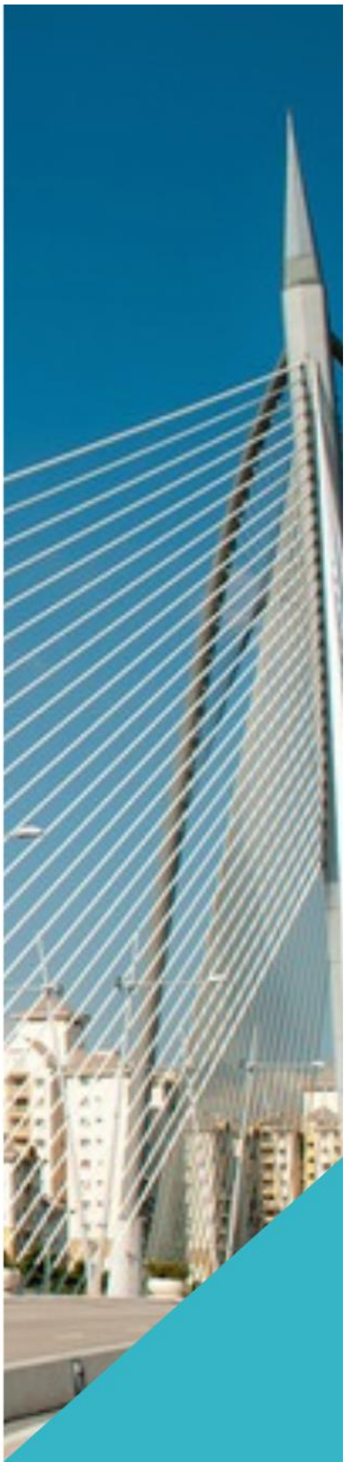
Jalan IKRAM-UNITEN

APPENDIX

<table>
<tr><th>STEPS</th><th colspan="3">EXAMPLES AND DETAILED ACTIVITIES</th></tr>
<tr><td>1. PROBLEM STATEMENT</td><td colspan="3">What options of energy recovery from sewage sludge waste for power generation?
Which of these scenarios are feasible for sewage sludge management?
What is the management strategies of sludge management towards circular economy pathways?</td></tr>
<tr><td>2. SELECTED ANALYSIS PERIOD</td><td colspan="3">25 years</td></tr>
<tr><td rowspan="3">3. PROPOSED ALTERNATIVES</td><td></td><td>STP A</td><td>STP B</td></tr>
<tr><td>Scenario 1 (S1)</td><td>Installed anaerobic digester for biogas production for energy recovery. It assumed the electricity produced credits the system by displacing grid-produced electricity.</td><td>Improve the efficiency rate of the biogas engine and anaerobic digester to produce more biogas for generating electricity and selling the remaining sludge production. It assumed the electricity produced credits the system by displacing grid-produced electricity.</td></tr>
<tr><td>Scenario 2 (S2)</td><td>The remaining sludge waste dried to produce biofuel and sell to utilities.</td><td>The remaining sludge waste dried to produce biofuel and sell to utilities.</td></tr>
<tr><td>4. ECONOMIC COST MODEL</td><td colspan="3">Cost Benefit Analysis or Rate of Return method (discount rate = 10%).</td></tr>
<tr><td rowspan="7">5. PREPARE COST BREAKDOWN</td><td>Plant</td><td>STP A (S1-25 Years)</td><td>STP B (S2-25 Years)</td></tr>
<tr><td>Design (PE)</td><td>360,000</td><td>377,000</td></tr>
<tr><td>Establishment Cost (RM)</td><td>202,000,000</td><td>610,450,000</td></tr>
<tr><td>Operating Cost (RM)</td><td>3,442,784</td><td>20,837,903</td></tr>
<tr><td>Maintenance Cost (RM)</td><td>569,785</td><td>3,969,204</td></tr>
<tr><td>Decommissioning Cost (RM)</td><td>207,652</td><td>217,457</td></tr>
<tr><td>Life Cycle Cost (RM)</td><td>202,884,649</td><td>118,045,332</td></tr>
<tr><td>NOTE</td><td colspan="3">All Costs are assumed for model calculation only based on Ringgit Malaysia (RM).</td></tr>
</table>

Project 6:

Continuous Improvement To MEPS Requirements In The Malaysian Electrical Appliance Market: Its Impact On Energy Efficiency



Project Leader: Dr. Amar Hisham Bin Jaafar

Project Members:

Assoc. Prof. Dr. R. Jegatheesan A/L V. Rajadurai

Ms. Neezlin Aznam

Project Champion: Mrs. Hafiza Yob

Institute of Energy Policy and Research

POLICYBRIEF

CONTINUOUS IMPROVEMENT TO MEPS REQUIREMENTS IN THE MALAYSIAN ELECTRICAL APPLIANCE MARKET: ITS IMPACT ON ENERGY EFFICIENCY

EXECUTIVE SUMMARY

Minimum Energy Performance Standards (MEPS) are very important standards that can drive the promotion of high efficiency electrical appliances (i.e. 5-Star Rated Appliance) as well as being an effective mechanism for the advancement of energy efficient electrical products produced by industry players. Since MEPS were imposed in 2013, the number of electrical appliances that have met the MEPS requirements and gained energy efficiency labels has steadily increased. As there is a serious need for the mandatory review of MEPS ratings, ST reviewed some requirements in 2018, particularly those relating to the standards used to measure energy consumption and savings and the introduction of new appliances including washing machines. Therefore, there is a need to study and assess the impact of continuous improvements to MEPS requirements that include: 1) sales volume, 2) market share, 3) total annual electricity consumption and saving, 4) GHG Emission Reduction, and 5) Consumer purchasing behavior relating to MEPS-compliant appliances in the Malaysian market. The research findings provide insights into how to gauge the overall impact of MEPS performance in Malaysia as well determining areas for improvement in MEPS implementation in Malaysia; a move which will prevent Malaysia becoming a dumping ground for inefficient appliances.

A quantitative survey was conducted on electrical appliances manufacturers, retailers, importers and consumers from each part of the country to determine the impact of continuous improvements to MEPS requirement since 2018. The data used in this study is from 2018 to 2020.

Continuous improvement to MEPS requirements is needed as it has been recommended that MEPS standards need to be revised every 3-5 years to match the MEPS standards of neighbouring countries that have reviewed their ratings. Moreover, previous studies have revealed that higher performance range cannot exceed the timeframe of 2-3 years and the existing MEPS appliance cannot exceed 25 percent of their market share. The availability of new testing standards and the introduction of new technology also make revision is very important. The details of the improvement to MEPS requirements made by ST are as follows:

Air Conditioner: 1st March 2018

Refrigerator: 1st March 2018

Washing Machine: 24th July 2018

Television: 1st May 2019

STUDY OBJECTIVES

- To determine whether continuous improvement to MEPS requirements has a positive effect on the sales volume of the MEPS-compliant appliances.
- To determine whether continuous improvement to MEPS requirements has a positive effect on the market share of the new MEPS-compliant appliances.
- To determine whether the continuous improvement to MEPS requirements has a positive effect on the total annual electricity consumption and savings of the new MEPS-compliant appliances.
- To determine whether the continuous improvement to MEPS requirements has a positive effect on the GHG Emission Reduction.
- To determine whether the continuous improvement to MEPS requirement has a positive effect on consumer purchase behavior of energy efficient appliances.

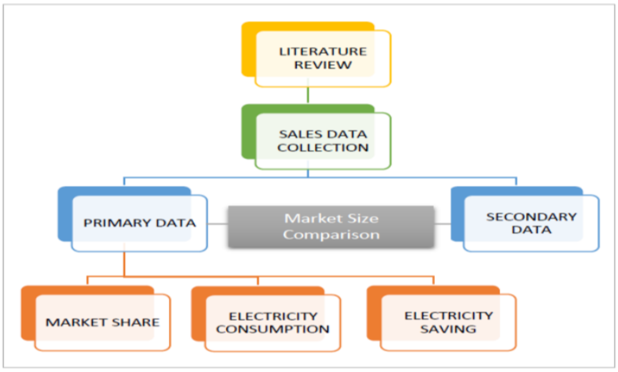


Figure 1: Flow chart of study's methodology

In order to analyze the impact of the revised MEPS requirements for electrical appliances (e.g. Air-Conditioner, Refrigerator, Fan, TV, Lamp and Washing Machine) on energy efficiency, sales data of MEPS electrical appliances covering the years 2018-2020 will be gathered from local manufacturers, importers, distributors and retailers, as well as consumers. The data will be cross-matched to the MEPS registration database (COA as issued by the Energy Commission of Malaysia). The sales data includes sales per model and the average price paid per model in each year. The registration database included all technical details such as the tested energy and energy consumption for each model. Cross-matched model data will be then aggregated into product categories and star ratings. The data will be used to evaluate the impact of the improved MEPS requirements. The step-by-step approach to evaluate the impact of the improved MEPS requirements, in terms of energy efficiency and savings, starting from 2018, is as follows:

1) Obtain the sales data from MEPS-registered brand companies.
2) Determine the market share percentage of MEPS appliance in each year with each energy efficiency label.
3) Calculate the annual electricity consumption and savings for the original market share based on the continuous improvement to MEPS requirements.
4) Evaluate the effect of energy efficiency improvements on GHG emission reduction based on the continuous improvement to MEPS requirements.
5) Conduct a survey of consumers to measure the impact of the improvements to MEPS requirements on their Energy Efficiency consumption value and buying behavior.

KEY FINDINGS OF THE STUDY

Impact of Continuous Improvement to MEPS Requirements on the Sales Volumes

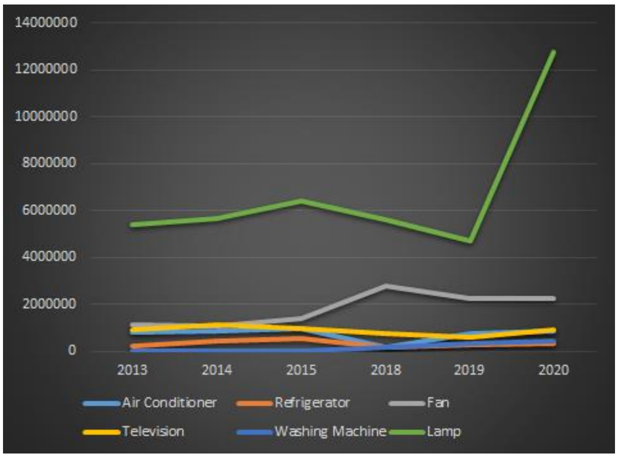


Figure 2: Sales volume of MEPS appliances (2013-2015 vs 2018-2020)

Figure 2 shows the comparison between sales volumes of MEPS appliances in the early phase of MEPS enforcement (2013-2015) and after the improvement has been made in 2018. It can be concluded that the sales volume of MEPS appliances is relatively stable except for lamp. This is because the coverage of the recent study is wider than the previous study.

Impact of Continuous Improvement to MEPS Requirement on the Market Share

MEPS APPLIANCES	Market Share of 2-STAR (%)			Market Share of 5-STAR (%)		
	2013	2014	2015	2013	2014	2015
Air Conditioner	41.69	34.95	33.18	19.71	18.38	21.63
Refrigerator	29.36	19.84	8.80	22.54	39.76	57.30
Fan	0.90	1.28	1.22	93.79	96.90	92.67
Television	0.00133	0.00459	0.00011	99.67595	98.28299	98.63353
MEPS APPLIANCES	Market Share of 2-STAR (%)			Market Share of 5-STAR (%)		
	2018	2019	2020	2018	2019	2020
Air Conditioner	21.73	43.88	33.20	2.34	6.63	5.99
Refrigerator	18.55	24.26	18.34	20.71	17.30	25.38
Fan	0.40	0.16	0.40	91.67	92.18	92.21
Television	0.06	1.35	18.67	99.25	62.18	32.96
Washing Machine	0.00	0.00	1.54	0.00	0.14	7.07
MEPS APPLIANCES	Market Share 50 lm/W			Market Share 85 lm/W		
	2013	2014	2015	2013	2014	2015
Lamp	0.097	0.816	1.029	45.560	32.665	28.527
MEPS APPLIANCES	Market Share 50 lm/W			Market Share 85 lm/W		
	2018	2019	2020	2018	2019	2020
Lamp	83.030	78.971	96.365	20.209	21.029	3.635

Table 1: Market share of MEPS appliances (2013-2015 vs 2018-2020)

Table 1 shows the comparison between market shares of MEPS appliances in the early phase of MEPS enforcement (2013-2015) and after the improvements were made in 2018. It can be seen that for air-conditioning and television appliances, the market share of 5-Star appliances decreased significantly from 2018. This decrease was due to results of the improvements to the testing standards to determine 5 Star rating appliances.

For refrigerators and fans, the market share for 2-Star and 5-Star appliances was relatively stable although there were changing on the calculation on energy efficiency factor. For the lamp appliances, there were significant changes in the market share of lamp fittings, less than 50 lm/W and more than 85 lm/W in 2018 when compared to 2013. These results may be due to changing demands in the market. For washing machines, since MEPS became mandatory in 2018, it can be seen that the market share of 5-Star appliances has increased positively from 2018 to 2020.

Impact of Continuous Improvement to MEPS Requirements on the Annual Electricity Consumption and Saving

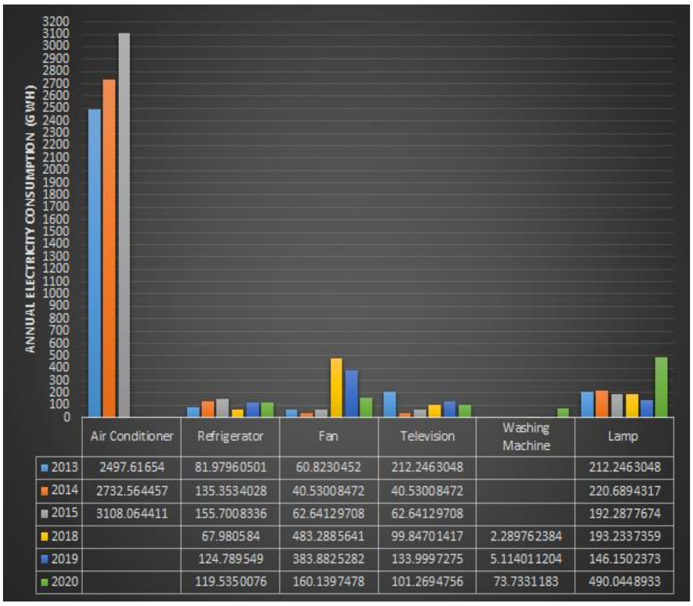


Figure 3: Annual electricity consumption of MEPS appliances (2013-2015 vs 2018-2020)

	Air Conditioner	Refrigerator	Fan	Television	Washing Machine	Lamp
2013	403.9446495	36.821614	55.38535285	138.6773118		0.03229313
2014	598.4675386	82.174846	55.62108166	189.5814073		0.046801998
2015	762.0894341	124.900785	72.14842612	164.8826911		0.057881554
2018		7.922650816	533.7549815	114.1378174	2287.596937	0.052959985
2019		20.63684397	437.0393287	57.65778703	3.44122	0.049930549
2020		37.48270888	247.0704248	164.3109219	362.2234225	0.115119385

Figure 4: Annual electricity saving of MEPS appliances (2013-2015 vs 2018-2020)

Figure 3 and Figure 4 shows the comparison between annual electricity and consumption of MEPS appliances in the early phase of MEPS enforcement (2013-2015) and after the improvements had been made in 2018. The calculation of electricity consumption and saving of air-condition were excluded as this study need further data from the manufacturers, distributors, and retailers regarding the Tested CSPF and Tested CSEC. Based on Figure 3, the electricity consumption of fans has shown an increasing pattern. For refrigerators, televisions, and lamp fittings, annual electricity consumption has shown a stable pattern. For washing machines, the electrical consumption associated with MEPS appliances has shown an increasing trend since its enforcement in 2018.

Regarding the electricity savings, as shown in Figure 4, it can be noticed that fan appliances have shown a sizeable improvement compared to the savings during the early phase of MEPS enforcement, 2013-2015. Refrigerators, televisions and lamp fittings have shown a constant energy pattern since the early phase of MEPS enforcement in 2013 and since the revision of MEPS requirements in 2018. For washing machine appliances, since MEPS enforcement in 2018, the potential for energy savings for these appliances is promising. It should be noted that washing machines are one of the appliances that have high potential in energy saving. With the inclusion of the air-conditioning further, it would be expected that washing-machine will be contributed to second highest saving behind air-conditioner appliances.

Impact of Continuous Improvement to MEPS Requirements on the Cumulative Electrical Saving, Cost Saving, and GHG Reduction

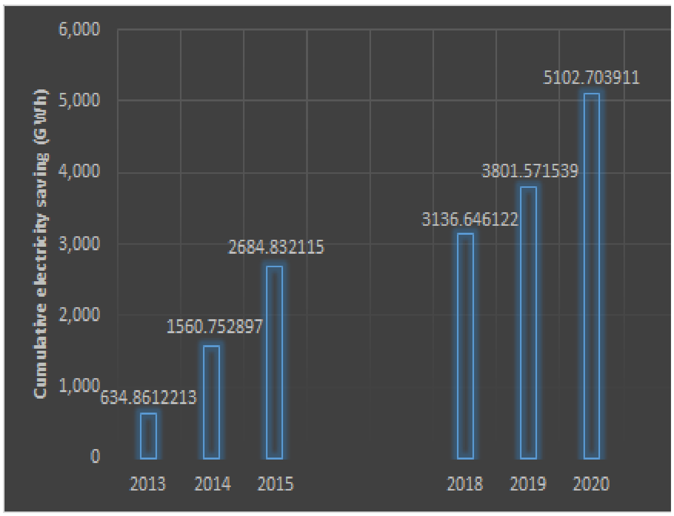


Figure 5: Cumulative electricity saving of MEPS appliances (2013-2015 vs 2018-2020) (Without Air-Conditioner)

Figure 5 shows the comparison between cumulative electricity savings of MEPS appliances in the early phase of MEPS enforcement (2013-2015) and after the improvements had been made in 2018. It can be concluded that the improvement in MEPS requirements have provided a positive result in the cumulative energy savings of MEPS appliances although without the inclusion of electricity saving from air-conditioner appliances.

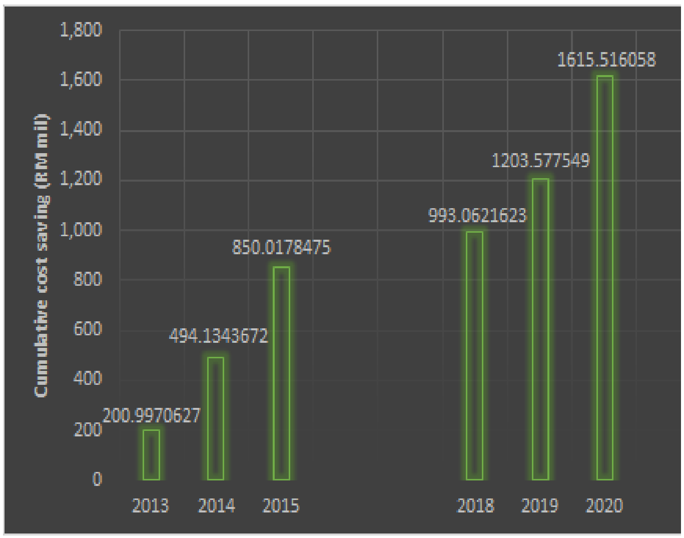


Figure 6: Cumulative cost electricity saving of MEPS appliances (2013-2015 vs 2018-2020) (Without Air-Conditioner)

Figure 6 shows the comparison between the cumulative cost of electricity savings of MEPS appliances in the early phase of MEPS enforcement (2013-2015) and after the improvements had been made in 2018. It would be expected with the inclusion of energy savings from air-conditioner appliances later, the amount of cost of electricity saving of MEPS appliance will become higher due to increase in the test standard.

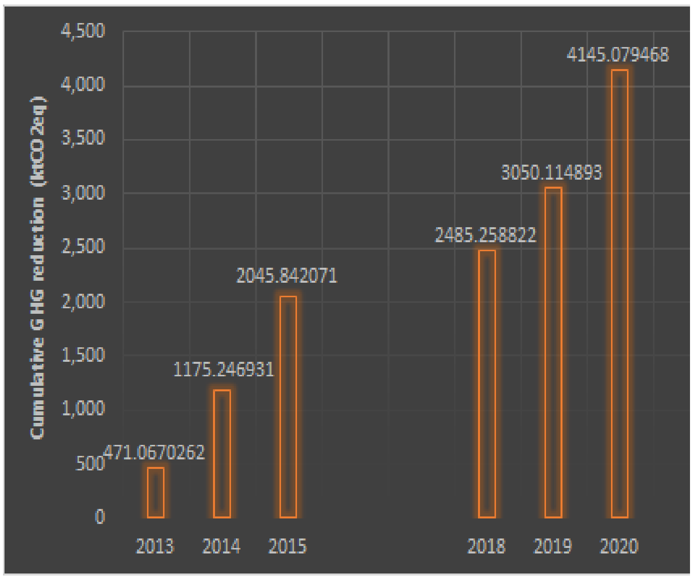


Figure 7: Cumulative GHG reduction of MEPS appliances (2013-2015 vs 2018-2020) (Without Air-Conditioner)

Figure 7 shows the comparison between the cumulative GHG reduction of MEPS appliances in the early phase of MEPS enforcement (2013-2015) and after the improvements had been made in 2018. It can be noticed that the improvements in MEPS requirements have provided a positive result in cumulative GHG reduction savings from 2045.84 ktCO2eq in 2013-2015 to 4145.07 ktCO2eq in 2018-2020.

Impact of Continuous Improvement to MEPS Requirements on the Consumer purchase behaviour of energy efficient appliances

The number of domestic customers in Peninsular Malaysia and Sabah has increased to more than 8 million in 2019. This number is expected to increase in line with the growth of economy. Therefore, it is important to gauge the effect of MEPS implementation on consumer purchasing behaviour. A large-scale survey has been conducted involving 1482 respondents from all states in Malaysia. This survey has been conducted via online platform.

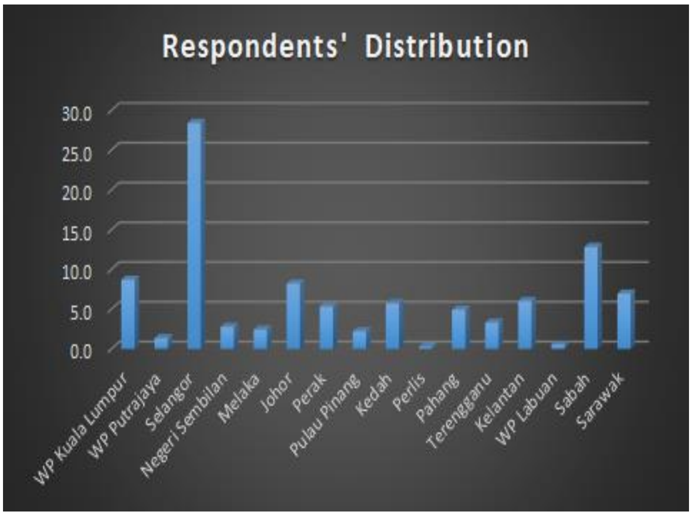
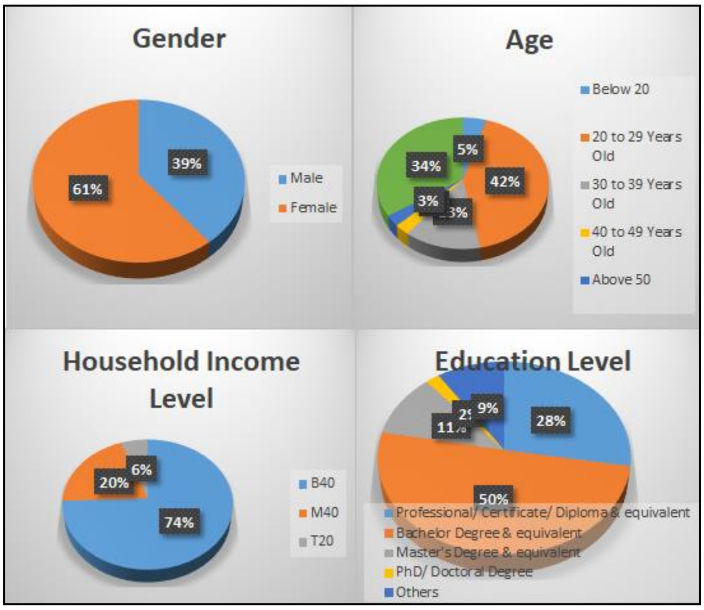


Figure 8: Respondents' Distribution according to State



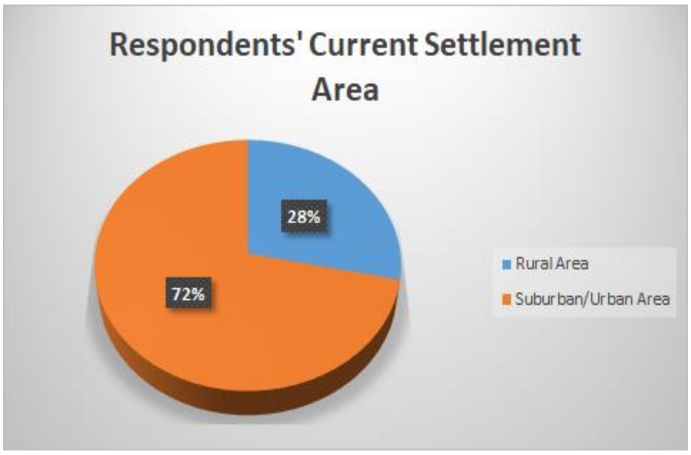


Figure 10: Respondents' Current Settlement Area

Figure 8, Figure 9, and Figure 10 show the respondents' demographic profiles. As seen in Figure 8, the top three highest percentages of respondents were 28.4 percent from Selangor, 12.8 percent from Sabah and 8.7 percent from Kuala Lumpur. The three lowest respondent populations were, at 1.3 percent, Putrajaya, 0.5 percent, Labuan and 0.3 percent, Perlis. As shown in Figure 9, 39 percent of respondents were male and 61 percent were female. Regarding the age groups, 42 percent of the respondents were 20 to 29 years old, 13.5 percent were 30 to 39 years old and 4.7 percent were below 20. Respondents aged more than 40 years represented 5.4 percent of the study. In terms of income groups, 74 percent were under B40 categories, 20 percent from M40 categories and 6 percent from T20 categories. Regarding the education levels, half of the respondents had bachelor degree qualifications while only 9 percent had other or informal education. With reference to Figure 10, 72 percent of the respondents were from Suburban/Urban areas and 28 percent from rural areas.

	Knowledge on MEPS and EE Star Labelling		Consumer Purchase Behaviour on EE Appliances		
	Have Knowledge	No Knowledge	Low	Moderate	High
Gender					
Male	35.80%	3.40%	5.00%	3.0%	31.2%
Female	55.20%	5.50%	5.10%	5.8%	49.9%
Total	91.10%	9.00%	10.10%	8.8%	81.1%
Age					
Below 20	4.3%	0.5%	0.8%	0.2%	3.7%
20 to 29	38.5%	3.8%	4.3%	4.0%	33.9%
30 to 39	12.4%	1.1%	0.9%	0.80%	11.80%
40 to 49	2.4%	0.3%	0.4%	0.10%	2.20%
Above 50	2.5%	0.2%	0.3%	0.20%	2.30%
No Information	31.0%	3.1%	3.4%	3.50%	27.20%
Total	91%	9.00%	10.10%	8.8%	81.1%
Income Group					
B40	67.40%	7%	8.2%	6.6%	59.6%
M40	18.60%	1.40%	1.50%	1.50%	17.10%
T20	5.10%	0.50%	0.40%	0.70%	4.40%
Total	91%	9.00%	10.10%	8.8%	81.1%
Highest Education Level					
Professional/ Certificate/ Diploma & equivalent	25.40%	2.40%	3.70%	2.0%	21.90%
Bachelor Degree & equivalent	46.20%	4.20%	4.30%	4.50%	41.50%
Master's Degree & equivalent	9.60%	1%	0.9%	1.10%	8.70%
PhD/ Doctoral Degree	1.80%	0.10%	0.1%	0.20%	1.70%
Others	8.00%	1.30%	1.10%	1.0%	7.30%
Total	91%	9.00%	10.10%	8.8%	81.1%
Area of Residence					
Rural Area	26%	2.40%	3.0%	2.8%	22.60%
Suburban/Urban Area	65.10%	6.50%	7.10%	6.0%	58.50%
Total	91%	9.00%	10.10%	8.8%	81.10%

Table 2: Percentage of Respondents in Each Demographic Profiles Based on the Knowledge on MEPS and Energy Efficient Star Labelling, and Level of Consumer Purchase Behaviour on Energy Efficient

	Respondent's Purchase Behaviour of Energy Efficient Appliances					
Behaviour	Not at All	Very Unlikely	Unlikely	Undecided	Likely	Very Likely
I am concerned with the efficiency of the electrical appliances I purchase	2.20%	1.70%	5.30%	4.30%	13.40%	14.00%
I look for Energy Efficiency Star Labels every time I purchase electrical appliances	2.50%	2.20%	5.50%	7.10%	12.90%	17.10%
I find ways to replace old electrical appliances with new and energy efficient ones	2.80%	2.50%	6.10%	9.10%	16.40%	16.80%
Even if they cost more than conventional products, I would still purchase energy efficient products.	2.60%	2.80%	5.90%	10.40%	17.70%	20.00%
I think about my electric bills every time I purchase electronics appliances.	3.00%	2.40%	6.70%	7.20%	13.80%	15.90%

Table 3: Percentage of Respondents' Purchase Behaviour of Energy Efficient Appliances

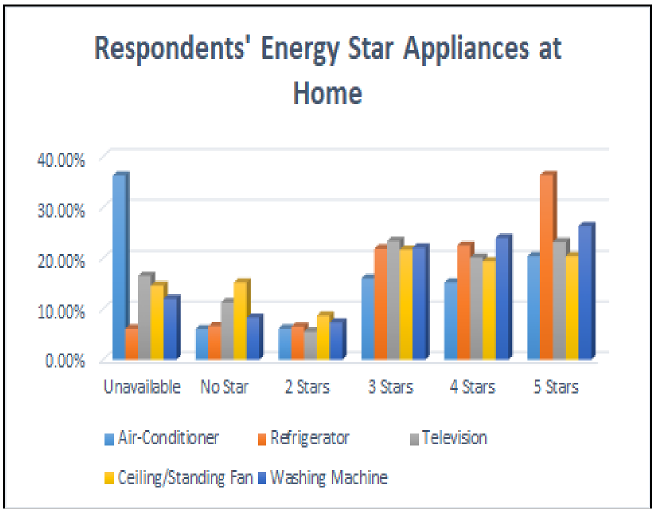


Figure 10: Respondents' Energy Star Appliances at home

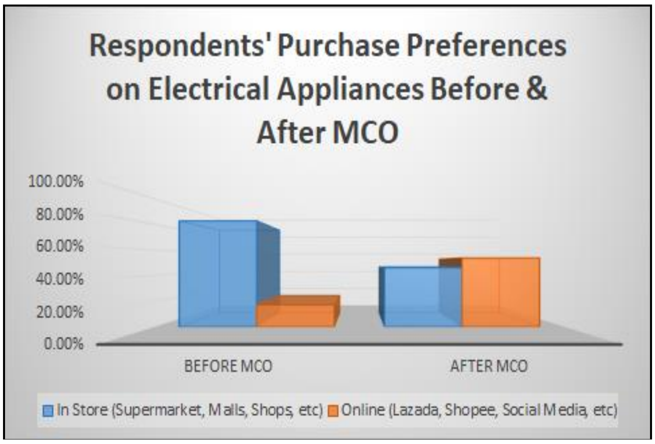


Figure 11: Respondents' Purchase Preferences on Electrical Appliances before & after MCO

Table 2 shows the percentage of respondents in each demographic profile based on their knowledge on MEPS and energy efficient star labelling and the level of consumer purchasing behaviour in relation to energy efficient appliances. Among the demographic elements covered by this analysis were gender, age, income group, highest education level and area of residence. Based on the results on Table 2, the female cohort exhibited the greater knowledge and consumer purchasing behaviour in terms of energy efficient appliances compared to males. The 20-29 age group exhibited the highest level of knowledge and consumer purchasing behaviour when it came to energy efficient appliances. They were followed by the 30 to 39 age group and the below 20 years of age cohort group. The household group with B40 income (monthly income less than RM 4849 per month) category had the highest level of knowledge and consumer purchasing behaviour for energy efficient appliances, followed by M40 group (monthly income between RM 4850 to RM 10959), and T20 group (monthly income more than RM 10960). In terms of the highest educational level, the Bachelor Degree and equivalent group had the highest level of knowledge and consumer purchasing behaviour when it came to energy efficient appliances. This cohort was followed by Professional/ Certificate/ Diploma and equivalent group and Master's Degree and equivalent group. For location of respondents' residence, respondents from suburban/urban areas had the higher level of knowledge and consumer purchasing behaviour compared to respondents from rural area.

Regarding the score of consumer purchasing behaviour in relation to energy efficient appliances, the score generated is based on the respondents' answers in Table 3, A score of more than 5 denotes that the respondents exhibited a high level of consumer purchasing behaviour when it came to energy efficient appliances, score between 4 to 5 indicated moderate behaviour and a score less than 4 indicated a low level of purchasing behaviour. With reference to Figure 10, it can be concluded that more than 73 percent of respondents have electrical appliances with energy star labelling in their homes with the highest number of appliances being refrigerators, followed by washing machines, televisions and fans. Nevertheless, the level of possession of air-conditioners that have passed MEPS requirements still has room for improvement. Only 50 percent of the respondents have air-conditioner appliances with energy star labelling.

However, with regards to respondents' electrical appliance purchasing preferences, Figure 11 reflects the respondents' purchasing preferences before and after the movement control order (MCO) due to pandemic Covid-19. The pandemic has led to changes in consumer purchasing behaviour in the form of a move to online shopping such as Lazada, Shopee and etc. It is therefore very important to ensure that the quality and the reliability of MEPS electrical appliances are protected. Overall, the results of the survey of consumer purchasing behaviour in relation to energy efficient appliances indicate that the level of knowledge and purchasing behaviour are very high, particularly in the younger generation aged from 20 to 39 years. It is very important for the cohort of younger consumers to have a good knowledge and behaviour towards energy efficient appliances since there will become the dominance generation for Malaysian in future.

Impact of the study

This study provides important insight into ST by measuring the overall performance of the MEPS program, determining areas for improvement, and producing outcomes that prevent Malaysia from becoming a dumping ground for inefficient appliances. For the nation, this project provides important knowledge and mechanisms for the journey towards an energy efficient society which subsequently supports the National Energy Efficiency Action Plan (NEEAP).

Limitation of Study and the Action plan to improve it.

This project has several limitations which could affect the findings. Firstly, there is a lack of participants from the manufacturing, retailing, and distributing sectors providing data concerning the number of products sold in the market. Secondly, the data provided by the manufacturers, retailers and distributors is not complete in terms of the number of units sold, the star rating labelling and technical details of the models. Thirdly, there is a possibility that the data provided by the manufactures/distributors was overlapped by the data provided by the retailers.

With regards to the action plan to improve these limitations, the researchers, with the assistance of ST, will re-contact additional manufacturers, retailers and distributors to participate in the survey and provide the missing data needed for this study. To settle the data overlapping issues this study will double-check the list from the ST database.

POLICY RECOMMENDATIONS

1. *Continuous improvements to MEPS requirements will increase the cumulative electricity saving, cost of electricity saving, and reduce GHG emission.*

2. *Continuous improvement to MEPS requirements will stabilize the market share of MEPS appliances by gradually phase out the appliance that have below the par of international standard.*

3. *Continuous improvement to MEPS regulation will create positive synergies to manufacturer of electrical appliance to produce energy efficient appliance in par with the international standard and stabilize the prize of the electrical appliances' price.*

4. *The government need to give full support and incentive to younger generation that majority are in the level of B40 income group in term of subsidies to purchase energy efficient appliances.*

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