

COMPARATIVE STUDY OF ELECTRICITY SUSTAINABILITY ISSUES IN ASEAN-5 USING THE ELECTRICITY SECTOR SUSTAINABILITY INDICATORS

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Overview

The region of the Association of Southeast Asian Nations (ASEAN) is one of the fastest developing regions in the world. With the substantial increase in electricity demand over the past decades, driven by social and economic development, these regions have been identified as playing an increasingly important role in world energy demand in the coming decades. In addition to rapid increase in electricity demand, the context of the electricity sector in the Southeast Asian region can be characterised by unparalleled rural and urban electrification as well as domestic and international pressure to reform the sector to cope with climate change challenges. The electricity sector is the major source of growth in greenhouse emissions in this region therefore there are concerns over global climate risk caused by electricity sector development. These factors add to the challenges of delivering additional electricity-based energy services to keep up with the societal and economic progresses. Therefore it is important that the development in the electricity sector in these countries progresses in a sustainable manner, which is to ensure reliable and affordable access to electricity in an economic viable, environmentally acceptable manner.

This paper aims to provide an initial framework for assessing key policy challenges for electricity industries and the effectiveness of key energy and climate policies in five largest energy consuming countries in ASEAN: Indonesia, Malaysia, the Philippines, Thailand and Vietnam (ASEAN-5). These countries have a combined population of around 0.5 billion and their electricity demand accounts for more than 10 percent of the world's electricity demand. The paper proposes a quantitative framework for assessing sustainability of electricity sector development by using a set of quantitative indicators which focuses specifically on the electricity sector. These indicators are selected and adapted to suit the context of the electricity sector in the ASEAN-5 in order to assess the current state of achieving sustainability and/or monitor the progress towards energy sustainability objectives. This framework can provide a better understanding and relationship between energy, environment and economic nexus, which facilitates policy making towards improved sustainability in the electricity sectors of the ASEAN-5.

Methods

This study draws together a set of chosen quantitative indicators, with a focus on the electricity industry in the context of the ASEAN-5, encompassing four dimensions: *social*, *economic*, *environment* and *electricity supply security*. Key quantitative indicators were adapted from the Indicators for Sustainable Energy Development (ISED) framework which aims to provide a deeper understanding for relationships between energy, environment and economic nexus as well as tracking the progress towards sustainability [1]. A multi-criteria analysis is proposed as an evaluation tool which then revealed interesting results on sector structuring, reform policy, investment potentials as well as short-coming in neighbouring countries. It may be well a useful tool for governments to understand regional, national and sectoral socio-environmental, economic and financial aspects to facilitate policy decision-making. Furthermore they can be applied to assess policy effectiveness. These indicators are shown in Table 1.

Table 1. Summary of selected indicators

Social dimension	Economic dimension	Environmental dimension
Electrification rate (%)	Household electricity affordability (%)	Share of renewables in electricity generation (%)
Electricity intensity (kWh/GDP)	Total investment in electricity sector (2010\$)	CO ₂ emission per capita (tCO ₂)
Electricity consumption per capita (kWh)	Investment structure (%), Sectoral growth (%)	CO ₂ intensity (CO ₂ /kWh)
	Electricity Import (2010\$)	

Electricity Supply Security dimension
Reserve margin (%)
Cross-border supply and interconnections
Fuel mix in electricity generation (%)
Reliance on imported fuels for electricity generation (%)

The social dimension reflects the accessibility to electricity services while the economic dimension reflects the affordability of the electricity as well as the level of investment in the electricity infrastructure to meet the demand growth. The environment dimension is related to greenhouse emissions from the electricity sector.

The electricity supply security dimension is to reflect reliability and continuity of electricity supply. These indicators include the system reserve margin, the shares of fuel mix in electricity generation and the reliance on imported fuel for electricity generation. Over-dependence on particular types of fuels can have serious potentially consequences for long-term continuity of supply. As such, fuel mix is a useful indicator for measuring diversity and possible long-term security of electricity supply [2]. The Herfindahl-Hirschman Index (HHI) is used as a quantifiable indicator to

measure concentration or diversity of fuel used for electricity generation, and can be expressed as follows:

$$H = -\sum_{i=1}^N p_i \ln p_i \quad \text{where } p_i \text{ is the share of electricity generation from fuel source } i$$

Preliminary Results

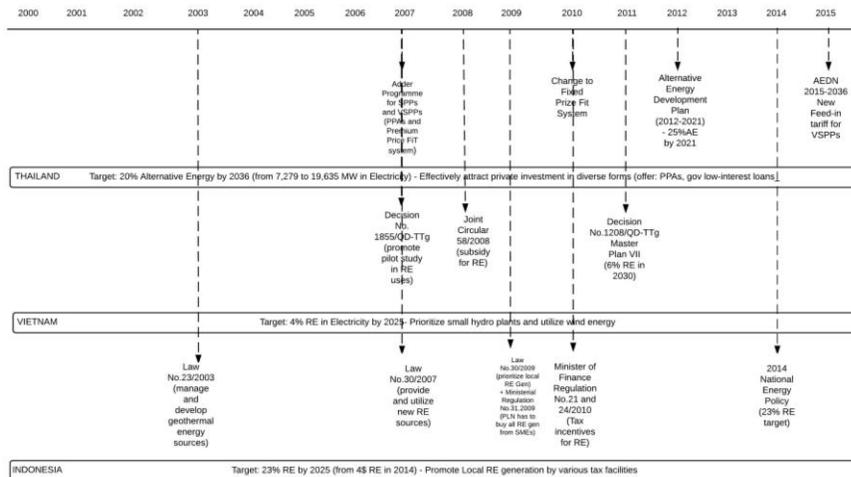


Figure 1. Renewable policies of countries in ASEAN-5

An example of the analysis of renewable policy effectiveness using some of the indicators is illustrated in Figure 1. For example, Thailand's Adder Program was very effective in attracting private investment in diverse forms of renewable energy, and in its early framework for streamlined interconnection arrangements and standardized documents including power purchase agreements. As a result, it has been able to induce impressive amount of investment in renewables.

Figure 2 shows the HHI for fuel diversity. It has been suggested that a HHI value above 0.25 indicates that the system is highly concentrated and could threaten security of electricity supply while a value between 0.15 and 0.25 indicates moderate concentration. All of the countries except the Philippines have HHI above 0.25, suggesting that the electricity generation is highly dependent on a particular fuel. The Philippines has a well-diversified fuel mix with even proportion of coal, gas, hydro and geothermal. Thailand has the highest HHI due to its heavy dependence on gas for electricity generation respectively, accounting for more than 70%. Vietnam relies heavily on hydro and gas while both Indonesia and Malaysia are highly dependent on coal and gas. This could have significant electricity supply security implications in the long run due to the exposure to risk from fuel availability and price fluctuation.

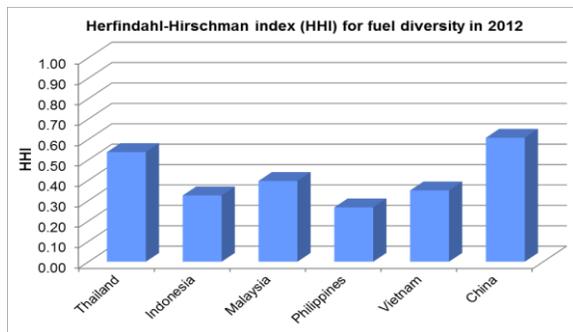


Figure 2. Herfindahl index for fuel diversity in 2012

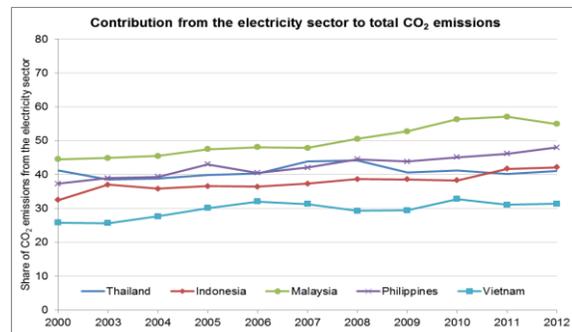


Figure 3. Share of CO₂ emissions from the electricity sector

Figure 3 shows the share of CO₂ emissions from the electricity sector during 2000-2012. The electricity sector in the ASEAN-5 contributes between 30% and 50% of total national greenhouse emissions in 2012. The share of CO₂ emissions from the electricity in Malaysia is significant due to the heavy reliance of coal in electricity generation. The share of emissions from the electricity sector in this region has continued to increase over the last ten years.

Conclusions

- The paper has presented a practical framework for the development of sustainable electricity indicators to assess proactive/reactive power sector policy impacts on social, financial, environmental and supply security factors. The framework provides a foundation for future expansion to other countries.
- The cross-country comparison is intended to support benchmarking of the performance, policy effectiveness and emerging issues within the electricity sector of each country. It helps policy makers to identify opportunities for greater collaboration in addressing their sustainability challenges.
- The paper offers a framework for comparison of sustainability issues tailored to electricity sector and longitudinal policy evaluation to explain key policy practices in the countries.

References

- [1] IAEA, "Energy Indicators for sustainable development: guidelines and methodologies," International Atomic Energy Agency, Vienna, 2005.
- [2] WEC, "Deciding the Future: Energy Policy Scenarios to 2050," World Energy Council, London, 2007.