

A Study on Integrated System Model for  
Energy Security Evaluation of East Asian Countries

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## **Abstract**

Energy security is an issue of great importance in many regions around the World because energy underpins economic development. The importance of the issue is much more profound in the East Asia region due to the staggering increase of energy consumption as the consequence of the regions' rapid economic growth. Therefore, improving energy security is an important policy agenda for East Asia countries. This study aims to provide policy recommendation to East Asia countries in improving their energy security.

This thesis can be divided into three main parts. The first part comprises chapters 2 and 3. These chapters address the background and motivation that underpin the integrated system model approach proposed in this thesis. Chapter 2 explains the importance of energy security for East Asia region. The rapid economic growth consequently brings rapid increase of energy consumption. However, East Asia's energy resources are limited and also subject to depletion. In the wake of this, East Asia countries acknowledged that energy security is a fundamental factor for the region's economic growth. In chapter 3, the variations of energy security definition and conventional approaches to energy security evaluation are reviewed. Two shortcomings of conventional approaches are identified; the lack of consideration on interactions among the factors of energy security and the lack of consideration on the context of evaluation. The study tackled the shortcomings by proposing integrated system model approach and considers the definition of energy security from the context of the countries being evaluated. This approach towards energy security evaluation is the originality of the study.

The second part of the thesis consists of chapter 4. In this chapter, the process developing integrated model for energy security evaluation is presented. The model development starts from defining energy security based on the countries situation. Based on the energy security definition, an evaluation framework is developed by determining the dimensions of energy security and the indicators to measure them. The indicators are then decomposed into its components by identifying their factors. At the same time, interrelationships among these

factors were also identified. As a result, the initial structure of the system model is developed. Based on this structure, a model is constructed using a system modeling tool, namely system dynamics. Afterwards, structural and behavioral verification tests are performed for the model. The structural test is done by checking statistically the relationships between the factors. The Behavior test is performed by comparing the simulation result with historical data. The process of model construction and verification is iterative. Finally, validation of the model is performed to check whether the model is in concord with the evaluation framework. This is done simply by a checklist of dimensions and indicators that can be measured by the final model.

The third part of thesis demonstrates the application and usefulness of the proposed approach. Three case studies are presented in chapters 5, 6 and 7. In chapter 5, a case study that takes into account multiple dimensions and indicators of energy security is presented. This case study shows the usefulness of the approach for the broad energy security evaluation. Indonesia is selected for this case study. Indonesia is facing multiple issues of energy security; dwindling oil production, utilization of the abundant coal and gas is obstructed by market situation, the country population is still largely dependent on energy subsidy and its CO<sub>2</sub> emission from energy use is worsening. In this case, four energy security dimensions of availability, affordability, efficiency and acceptability are considered. Two central policies are identified and simulated; increasing energy production and subsidy reduction.

Chapters 6 and 7 present two energy security evaluations. These cases show the usefulness of the proposed approach to narrow energy security evaluation. The case study in chapter 6 is focused on oil sector. Malaysia is expected to transform from oil exporter country to oil importer country. Recently, this issue has drawn many high profile debates in Malaysia politics. The results of six policy scenarios simulations show the expected dynamics of Malaysia's dependence on oil import and when it will likely to become a net oil importer country. In Chapter 7, evaluation of environmental aspect of energy security of China, Japan and Indonesia is presented. The selected countries represent three distinct country characteristics in East Asia region. In the East Asia context, China's economy is the largest, where as Japan is the most advanced country. China is the highest CO<sub>2</sub> emitter from the developing economies of the region, whereas Japan is the highest emitter from the advanced economies of the region. On the other hand, Indonesia is experiencing dynamic socioeconomic development which may direct its energy requirement to expose higher CO<sub>2</sub>

emission. Under the Cebu declaration on East Asia Energy Security, the three countries are expected to contribute to CO<sub>2</sub> emission mitigation through their policy and measures. However, the case study shows that the different circumstances of the selected countries lead to different policy preference and eventually resulted in different speed and magnitude of the dynamics of energy security level.

Chapter 8 presents the conclusion from this study. In relation to energy security of East Asia countries, it can be suggested to Indonesia that in order to improve its overall energy security, policy to reduce energy subsidy is more effective than policy to increase production of energy. For Malaysia, it can be suggested that the most effective strategy to delay the transformation to a net oil importer country is by reducing oil consumption through eliminating oil subsidy. Considering the performance of China, Japan and Indonesia, this study suggests East Asia countries to advance the Cebu declaration towards a more obligatory pledge with clear CO<sub>2</sub> emission reduction targets. In relation to the approach to energy security evaluation, the study shows that the integrated system model able to shows the various impact of one policy implementation to multiple dimensions of energy security. In addition, the model allows ex-ante energy security evaluation to be performed more accurately due to consideration of various factors influencing energy security level.