

Economic and environmental analysis of energy resource supply

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論 文 内 容 の 要 旨

Japan needs to address domestic and international issues with regard to energy supply. The distribution of natural resources for electric power generation has changed because of the unplanned outage of nuclear power stations after the Fukushima disaster. The change led to the increase in the dependence ratio of natural resources for power generation on the Middle East. The sea lane from the Middle East to Japan for energy resource imports has two choke points and the South China Sea where some countries claim their sovereignty. Climate change has become a global issue. This research deals with these energy security and environmental issues.

This thesis is structured as follows. Chapter 1 describes the background of this research such as the share of on-site power in power supply for some manufacturing industries, CO₂ emissions reduction targets of some countries, the overseas dependency ratios of energy resources in Japan.

Chapter 2 focuses on on-site power for manufacturing firms. The on-site power generation has attracted a public attention due to the electricity rate increase after the Fukushima disaster, the planned blackout and the peak demand reduction in 2011 according to the *Electricity Business Act*. While firms or researchers may use fixed prices of fuels and fixed purchased electricity rate at the stage of evaluation for an on-site power generator introduction, the changes in these prices affect operation of on-site power generators. In addition, national environmental policies can affect the operation. In this study, the comparison between on-site power and purchased power from the economic and environmental aspects are conducted. The expenditure elasticities and price elasticities of purchased electricity and fuels for on-site power generation are estimated. The temporal changes in advantage of on-site power generation and distribution of natural resources for on-site power generation are also evaluated in various industries. One of the implications from this study is that electricity-rate increase does not always result in a substitution between purchased power and on-site power, while firms may expect the mitigation of electricity-rate increase effect by using on-site power generation. In addition, the evaluation result shows that the changes in fuel mix and impact on emission reductions vary depending on an industry.

Chapter 3 discusses the performance of the voluntary approach by industry for reduction in CO₂ emissions and the effect of the carbon tax exemption for the special use of fuels in the iron and steel industry. Japan introduced the carbon tax in 2012. Japan's manufacturing industry has expressed concerns with the carbon tax's negative impact on its competitiveness and overall economic growth. Policy makers and researchers may want to facilitate to introduce carbon pricing such as carbon tax and emissions trading. However, the industry succeeded in reducing CO₂ emissions to the target level set at the third

Conference of the Parties to the United Nations Framework Convention on Climate Change (COP3) for the first commitment period without the carbon pricing. This study reveals that the energy-intensive industries achieved a significant share of CO₂ emissions reduction through voluntary reduction measures with negative abatement costs prior to the introduction of the carbon tax. It also evaluates the effect of removing carbon tax exemption for the special use of fuel used in the iron and steel industry and finds that removing the tax exemption can lead to a disproportional decrease in energy consumption and a negative impact on the industry. The recommendations for a future revision of the current carbon tax institution is provided based on the evaluation results.

Chapter 4 presents the simulation results based on some scenarios of energy resource supply disruption in foreign countries for Japan. Energy security is a concern for Japan because of its low self-sufficiency ratio in energy supply. Energy supply in Japan heavily depends on the Middle East countries with a high degree of political instability. The sea lane from the Middle East to Japan for energy resource imports has two choke points. In addition, the countries surrounding the South China Sea on the sea lane claim sovereignty over the area. The energy resource supply disruption from the Middle East is one of the worst scenarios for Japan. This research presents the simulation based on a few scenarios of energy resource supply disruption. The simulation shows that town gas supply interruption due to a liquefied natural gas supply disruption is a weak point in Japan. A few mitigation plans are suggested against the consequences.

Chapter 5 provides an overall feature of international oil trade. The decision making about oil procurement based on the whole picture of international oil trade is of importance. In this study, complex network analysis reveals the possible fierce competitive relationships between Japan and other countries in oil trade. Furthermore, econometric analysis shows the driving forces and resistances in bilateral oil trade. The last chapter presents the conclusions.