

## 別紙 4

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| 報告番号 | ※ | 第 | 号 |
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## 主 論 文 の 要 旨

論文題目 Spatial Planning and Assessment for District Energy Systems Considering Strategic Urban Renewal

(都市の戦略的更新を考慮した地域エネルギーシステムの空間計画及び評価)

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## 論 文 内 容 の 要 旨

Excessive greenhouse gas emissions from human activities are very likely to be the main cause of global climate change, of which approximately 90% is relating to energy utilization. For realizing a carbon-neutral society, not only substantial energy saving is necessary, but also a dramatic shift of fossil fuel usage toward renewable energy usage is dispensable. District energy system, as an important platform to connect to local renewable energy sources, is expected to be popularized in both dense cities and rural areas. Particularly, production and consumption of renewable energies locally within a city can help in forming an economic circle that keeps a necessary local investment and employment. However, the popularization of district energy systems is facing various barriers including depopulation, low-intensity land use plan, geographic separation between users and district energy sources, as well as other social and financial problems. Previous researches mainly focus on optimization of energy supply system or real-time demand response, that lacks a long-term and cross-sector insight of managing energy demand side through land use measures.

Under this background, this study aims at developing an integrated model framework to simulate the impact from long-term urban renewal on proliferation of district energy system, so as to investigate the most effective way of demand side management for a quicker low-carbon energy transition. Being a summary and reference of the study, this thesis is structured as follows: Chapter 1 and Chapter 2 summarize the research background and related literature review to describe the research problem and needs, as well as the importance and originalities of this study. Chapter 3 describes the analytic framework and model development in this study, including the

methods for estimating the potential of energy demand and supply, with designing district energy systems and evaluating the environmental and socio-economic impacts. On the other hand, urban simulation based on 4-dimension Geographic Information System is conducted with land use and policy scenarios to estimate the future distribution of energy demand. Data sources and main assumptions in this study are also summarized in this chapter.

Based on the model development shown in Chapter 3, two case areas in Japan are selected for case studies, including Soma Region in Fukushima Prefecture and Kitakyushu City in Fukuoka Prefecture. Chapter 4 introduces the case of Soma Region, where the feasibility of introducing district heating system using gas-fired cogeneration around regional stations is discussed. Although results indicate an enhancement on economic feasibility by compact city planning and related policies, the potential of CO<sub>2</sub> emission reductions is limited because of the progressing decarbonization in grid electricity. Therefore, two additional cases are conducted for enhancing the environmental benefit of district heating by utilizing waste heat.

Referring to the case of Soma Region, Chapter 5 provides a more comprehensive case study in Kitakyushu City, where energy saving and demand redistribution during long-term urban renewal is estimated to help distinguish the possible impact of urban renewal on construction material input and energy demand distribution. Results indicate a slight impact from compact land use on total material input and energy consumption under the background of depopulation, but substantial effect on maintaining the energy demand density of compact living areas. This provides an evidence of the positive effect of compact city on the long-term feasibility of district energy systems.

According to the results and discussions in Chapter 4 and Chapter 5, Chapter 6 discusses the knowledge from case studies and policy implications. In addition, the next frontiers of this research for improving the applicability of the models are summarized based on a rethinking on the uncertainties of current models.

This study is especially referable for the local municipalities to plan and assess the comprehensive urban design considering the impacts to local environment and energy systems.