論 文 の 内 容 の 要 旨

論文題目　Evaluation of Sewage Heat Utilization Potential Based on Urban Sewage State Prediction Model
（都市下水状態予測モデルに基づく下水熱利用可能性の評価に関する研究）

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This thesis proposed an estimation methodology to evaluate the sewage heat utilization potential and suggested the optimal strategies for utilizing sewage heat in urban area by the urban sewage state prediction model. The utilization of sewage heat is a novel issue within the field of the development of renewable energy in the world. However, the features and the utilization potential of sewage heat have not been completely explored so far; therefore, there is still the possibility to draw up the sewage heat utilization plan and strategies in detail to efficiently take advantage of the sewage heat which abundantly exists in urban areas, and eventually reduce the environmental load. Consequently, this thesis proposed an evaluation methodology to estimate the regional sewage heat utilization potential; furthermore, the optimal strategies for utilizing the sewage heat are proposed as well.

Chapter 1 elaborated on the research background, literature review, research objective, the originality of this research, and the overall structure of this thesis. From the perspective of reducing the environmental load and energy saving in the urban area, an estimation methodology for evaluating the sewage heat utilization potential based on the urban sewage state prediction model is proposed in this thesis in order to suggest the optimal plan for utilizing sewage heat. In addition, the evaluation methodology can be applied to urban planning when drawing up the regional energy utilization plan for not only the existed areas but new areas that are still under development.

Chapter 2 built up a theoretical sewage physical model which is close to the realistic situation of sewage pipeline for clarifying the sewage physical state in pipelines at the step before utilizing the sewage heat

utilization system. Specifically specking, the timely variation of sewage physical state including flow rate, temperature, and flow velocity can be simulated through the partially full pipe model which is based on the thermal equilibrium, Manning-Strickler formula, and finite difference method. Moreover, the factors that make the influence on retained heat amount in pipelines are all taken into consideration such as heat loss in the pipeline, the volumetric specific heat of raw wastewater.

Chapter 3 verified the sewage physical model by the measurement data in an actual area in Osaka city to confirm the adequacy of the model; besides, the synopsis of verification area and the provided measurement data have been overviewed to make an overall understanding for readers to comprehend the data which was utilized in the study. Consequently, the sewage physical conditions are simulated through the sewage physical model proposed in chapter 2 which provides the databases of sewage flow rate and sewage temperature before conducting the simulation of sewage heat utilization potential.

Chapter 4 built up a sewage heat utilization system model. From the aspect of building heat demand which is the energy demand side to the sewage water of the energy supply side, the connection between energy demand and supply side are all taken into consideration in the sewage heat utilization system model. According to the sewage heat utilization system model, the pivotal factors of evaluating the regional sewage heat utilization potential can be simulated. For instance, the outlet temperature which makes an influence on the sewage water temperature after utilizing the sewage heat, the sewage heat amount that can be recovered from sewage, and the required heat amount of building side. Moreover, the building energy consumption is calculated at the final step.

Chapter 5 applied the urban sewage state prediction model to an actual urban area to discuss the variation of sewage temperature and the regional sewage heat utilization potential. The setting condition of the cases discussed in this chapter are set from a general perspective of approximately comprehend the sewage heat utilization potential in the whole area, and simply discuss the objective result of different setting conditions without considering the optimal strategies.
According to the simulation results, it is known that there is a great potential of sewage heat utilization in the urban area. However, it is notable that there is still a limitation of maximum utilization rate for achieving greater sewage heat utilization potential, excessively recover the sewage heat may lead to the worse effect and lead to the increase of energy consumption.

Chapter 6 proposed the strategies for the optimal utilization of sewage heat in urban areas through several case studies and eventually proves by an optimal case. Based on the approximately comprehending of sewage heat utilization potential and the factors that may make influences on utilizing sewage heat proposed in chapter 5, the optimal strategies of utilizing sewage heat are discussed from the perspective

of a practical view in chapter 6. Specifically speaking, the sewage heat utilization strategies summarized by the former sections are set as the conditions of an optimal case to propose and clarify the district sewage heat utilization potential of the study area. Besides, another case that the setting conditions are contrary to the optimal case is also proposed to compare the sewage heat utilization potential with the optimal case.

Chapter 7 summarized the conclusions and achievement of this thesis. In addition, the recommendations for future works and the issues related to the regional sewage heat utilization are elaborated in this chapter. For instance, the comprehensive evaluation method which including social impacts for the development of sewage heat utilization and regional energy planning, the integrated evaluation method which including multiple types of renewable energy is expected to be developed. According to these recommended future works suggested in this chapter, the overall regional energy plans and the efficient utilization strategies of renewable energy are expected to be upgraded.