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Local Energy Planning and Evaluation Using Actual Power Supply Data from a Local Power Producer and Supplier: A Case Study of Nose and Toyono Towns#

Yujiro Hirano[1*], Tsuyoshi Yoshioka[2], Takahiro Yoshida[3], Yoshiki Yamagata[4], Kyoichiro Isozaki[5], Kenichi Adachi[5], Tomoki Ehara[6], Yukiko Yoshida[7]

1 National Institute for Environmental Studies, 16-2, Onogawa, Tsukuba City, Ibaraki 305-8506, Japan

2 The University of Tokyo, 7-3-1, Hongo, Bunkyo-ku, Tokyo 113-8656, Japan

3 The University of Tokyo, 5-1-5, Kashiwanoha, Kashiwa City, Chiba, 277-8568, Japan

4 Keio University, Kyousei-kan, 4-1-1, Hiyoshi, Kohoku-ku, Yokohama, 223-8526, Japan

5 Japan Environment Systems Co., Ltd., 5-5-5, Koishikawa, Bunkyo-ku, Tokyo 112-0002, Japan

6 E-konzal Co., Ltd., SYNTH, 1F Breeze Tower, 2-4-9 Umeda, Kita-ku, Osaka City, Osaka Prefecture, 530-0001, Japan

7 CTI Engineering Co., Ltd., 3-3-2 Nihonbashihamacho, Chuo-ku, Tokyo 103-0007, Japan

(*Corresponding Author: yhirano@nies.go.jp)

ABSTRACT

To realize a decarbonized community, it is increasingly important for local governments and various other regional entities to introduce and expand local production of local consumption-type energy systems. We conducted a case study on the regional energy supply using a local energy planning and evaluation system we are developing to promote such localized consumption of energy. Specifically, using actual supply data from local power companies in Nose Town and Toyono Town, reductions in primary energy consumption were calculated by assuming scenarios in which renewable energy and energy management technologies were introduced. The evaluated scenarios included the use of conventional equipment, distributed regional energy supply, the adoption of renewable energy and local power producers and suppliers (PPS), the use of mobility devices such as EVs for energy storage, and optimal control of storage batteries. The results indicate that the introduction of renewable energy can significantly reduce the electricity supplied from grid power outside the area. However, since the actual reduction effects naturally depend on the assumed scale of implementation, evaluation cases based on various scenarios should be accumulated and knowledge should be standardized in the future.

Keywords: Renewable Energy, Local Energy Supply, Decarbonized Town Development

1. INTRODUCTION

The introduction and deployment of distributed energy systems by local governments and other local entities are becoming important issues in decarbonized town development [1-4]. “Local production of energy for local consumption” using local renewable energy resources is especially important because it contributes to significant reductions in CO_2 emissions and local economic development. In addition, given the increase in natural disasters, local renewable energy sources can strengthen energy supply resilience during disasters.

The potential for renewable energy power generation depends on local conditions, including climate and land use. In addition, the output of major renewable energy sources such as solar power and wind generation is unstable and varies over time depending on meteorological and other conditions. Because energy demand also changes over time owing to consumer lifestyle patterns, balancing supply and demand is a significant consideration when designing local energy systems. To this end, we are developing a “Local Energy Planning and Evaluation System” based on detailed energy management simulations that consider local conditions to support the planning and evaluation of local energy systems. To develop this evaluation system,

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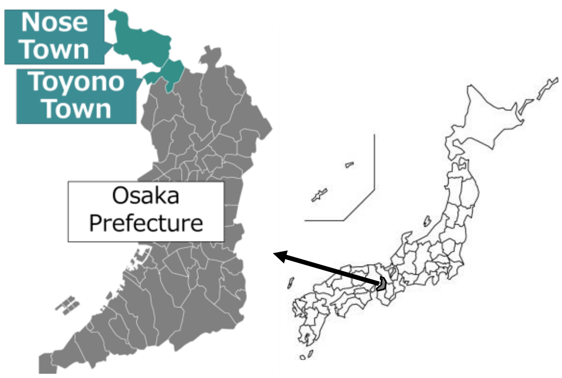

Fig.1. Location of the Study Area.

we conducted energy management simulations [5] and constructed a prototype system with a user interface [6].

However, regional energy management in Shinchi town, which has been used as a model for development thus far, is a microgrid using private lines [5,6] and has not yet been applied to a local power producer and supplier (PPS) that uses grid power.

In this study, the towns of Toyono and Nose in Osaka Prefecture (Fig. 1), which are already being supplied with power by a local PPS company [7], were selected as case study areas for the evaluation system. We conducted an evaluation based on scenarios assuming the introduction of renewable energy and energy management technologies, and using actual power supply performance data.

2. Local Energy Planning and Evaluation System

Based on various local conditions, the Local Energy Planning and Evaluation System assesses how a given energy demand can be satisfied using local energy supplies, including renewable energy and cogeneration. The software also calculates the effects of optimizing local energy management, including customer-side demand response, EV battery charge/discharge, and control of battery energy storage systems (BESS). The system outputs enable optimized deployment of the local energy supply and an understanding of the environmental and economic benefits for the targeted area.

The calculation flow of the evaluation system is illustrated in Fig. 2. First, the parameters for the target area, including the floor area by use and deployment of various technologies, were set. For each case, the effects of the local energy system and the renewable energy to be deployed were calculated for the assumed energy demand. Furthermore, a menu of power-control methods was considered, including the use of EV batteries, charge/discharge of BESSs, and power interchange within the region, to calculate the effect of deploying an optimal energy system for a given locality.

3. Case Studies for the Nose-Toyono Area

Power supply data provided by "Nose-Toyono Machizukuri," a local PPS company serving the towns of Nose and Toyono [7], was used to evaluate scenarios assuming the deployment of various technologies by the local energy company using the Local Energy Planning and Evaluation System. The facilities evaluated using the simulation tool were 11 public facilities in Nose and Toyono, including local government offices, primary and middle schools, and community centers (total floor area of 51,848 m2). Electric power demand by time of day for each month is shown in Fig. 3.

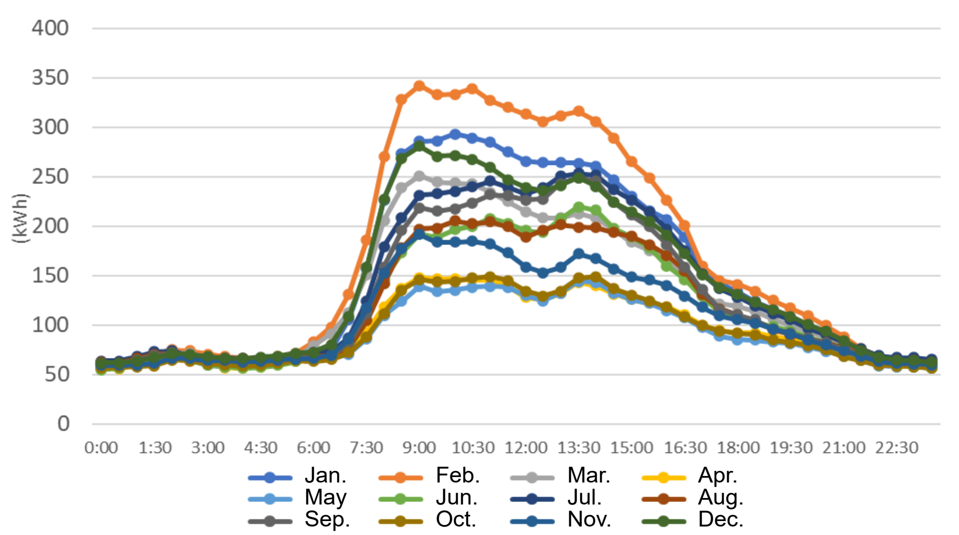

Fig.3. Hourly by Month Electric Power Supply Performance Data (Total of Target Facilities).

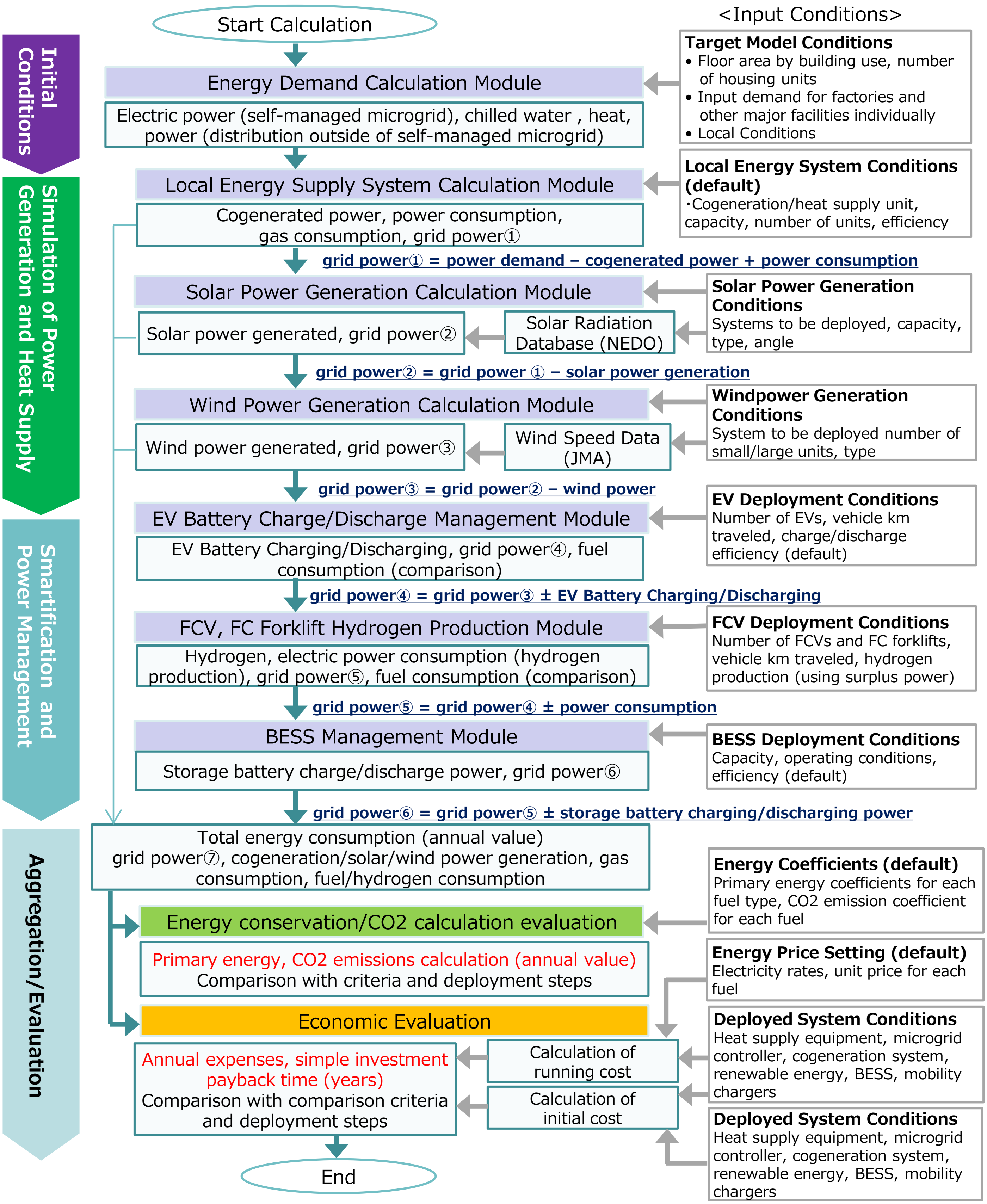

Fig.2. Calculation flow of the Local Energy Planning and Evaluation System.

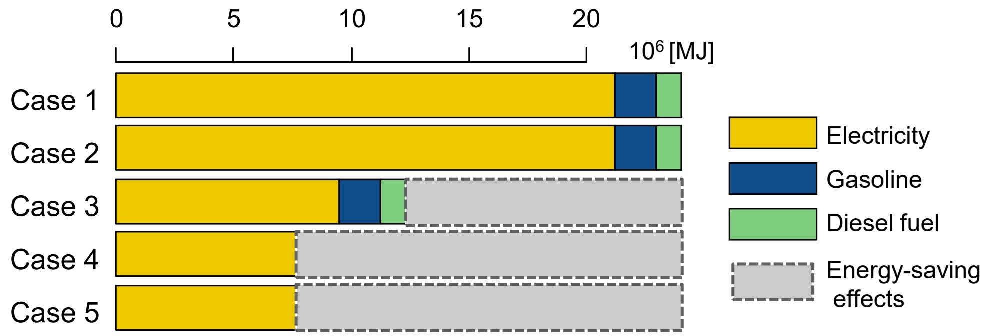

Fig.4. Primary energy consumption calculated for each case.

although it is possible to calculate energy demand based on the building floor area for a given use and standard energy demand values for that use, as the buildings analyzed in our study were public facilities, the values obtained using standard energy demand values were high compared to the actual demand. Thus, in our study, the demand was calculated using the power supply data provided by Nose-Toyono Machizukuri.

The evaluated cases assumed the deployment of conventional facilities, distributed local energy supply, renewable energy deployment, local PPS, deployment of EVs and other e-mobilities, and optimal control using BESSs. The outline of each case is as follows.

Case 1. Conventional facilities (base case for comparison): Conventional system composition and energy use.

Case 2. Distributed local energy supply: In contrast to Case 1, a microgrid controller was deployed to serve as a local energy supply hub in the service area. The energy system uses a cogeneration system, a network of heat supply conduits, and dedicated lines in the supply area to supply hot and cold water for heating, cooling, hot water supply, and electric power.

Case 3. Case 2 + renewable energy deployment + local PPS: In addition to the portfolio assumed in Case 2, renewable energy including solar and wind power generation was deployed. Additionally, a local PPS was established to supply electric power procured from the wholesale power market and renewable energy generated in the local area and procured from outside the area served by the microgrid.

Case 4. Case 3 + Deployment of EVs and other e-mobilities: In addition to the portfolio assumed in Case 3, EVs were introduced to the local government, EVs for ride sharing, and electric buses were deployed.

Case 5. Case 4 + Optimal control using BESSs: In addition to the portfolio assumed in Case 4, surplus electricity from renewable energy sources, including solar power and wind power, is stored in the BESSs, and the system is controlled to supply power to the local system when local power generation is insufficient.

Fig. 4 shows the primary energy consumption calculated for each case. Electric power purchased from the grid is converted into primary energy. As shown in Fig. 4, deploying renewable energy significantly reduces purchased grid power. Fig. 5 shows examples of the electricity supply and demand on typical days when solar power generation was introduced in the case considered in this study. However, because the magnitude of the reduction depends on the amount of renewable energy assumed to be deployed, the results represent one of many possible outcomes. In the future, it will be necessary to increase the number and types of scenarios evaluated to generalize the findings.

4. Conclusions

This study used the Local Energy Planning and Evaluation System that we are developing to evaluate case studies for the introduction of various technologies using power supply data provided by a local PPS company serving the towns of Nose and Toyono. However, further studies are required to confirm these findings. Furthermore, as the evaluation results depend on the amount of renewable energy assumed to be deployed, as well as other factors, it will be necessary to evaluate more examples to increase the generalizability of the findings.

Programs sponsored by the Ministry of Environment, including the Decarbonization Leading Areas Initiative, highlight the importance of planning local government-led decarbonization. The Local Energy Planning and Evaluation System is a highly flexible tool that allows for

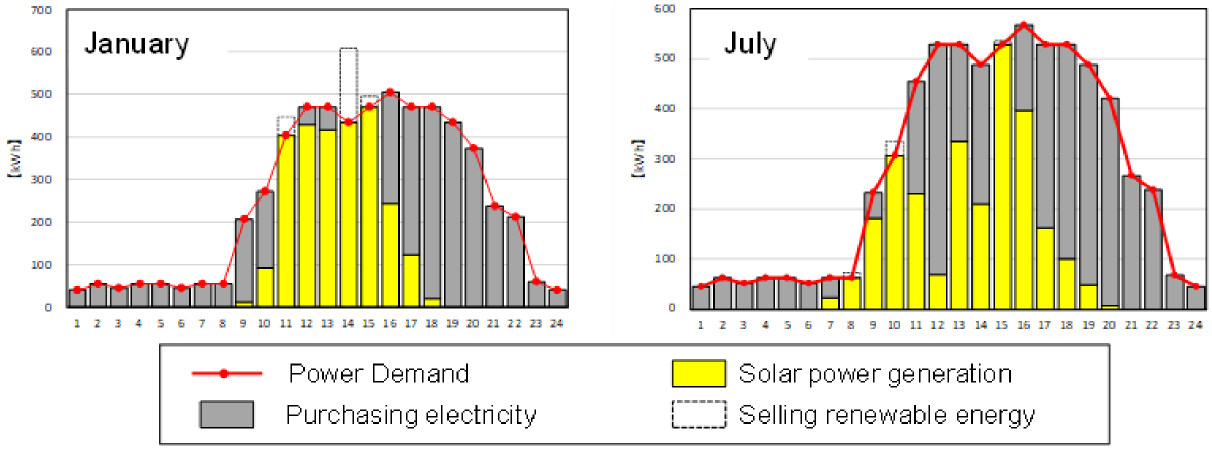

Fig.5. Examples of Typical Daily Electricity Supply and Demand Conditions in Winter and Summer

the easy setting of assumed conditions and a broad range of target facilities and renewable energy deployments. Given these circumstances, we believe that this evaluation system will be useful for local government officials and others to easily assess the scale and cost of energy systems. We plan to expand the use of the evaluation system to a greater range of target area conditions, evaluation stages, and levels.

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