Economic Evaluation of Space Solar Power Systems Using an Energy System Model

Ryo Eto*, Yu Nagatomi*, Yuhji Matsuo**, Yuka Saito***, Atsushi Uchida****, Hiroyuki Nagayama*****

This study evaluates the potential contribution of Space Solar Power Systems (SSPS) to achieving carbon neutrality in Japan by 2050. Using the high-resolution linear programming energy system model "IEEJ-NE Japan," the analysis assesses the economic feasibility and deployment potential of SSPS under multiple cases. The model represents Japan's energy system across five regions and simulates supply–demand balances on an hourly basis, considering renewable variability, energy storage, and sectoral flexibility. Two SSPS configurations were analyzed: systems with batteries (SSPS-B) and without batteries (SSPS-N). Results indicate that, under the assumed cost conditions, SSPS would be introduced in all cases except the non-battery type in Hokkaido. Without investment constraints, the installed capacity in Tokyo could exceed 60 GW by 2050. The introduction of SSPS reduces average electricity costs and substitutes for ammonia, and variable renewables. The SSPS-B exhibits superior economic performance, with feasible deployment achieved at investment costs below JPY1,380 billion per GW, compared with JPY850 billion per GW for SSPS-N. The findings suggest that continued technological progress and coordinated efforts between the space and energy sectors will be essential for realizing the commercial deployment of SSPS by 2050.

Keywords: Carbon neutrality, Space Solar Power System, Linear programming energy system model, Economic feasibility

1. Introduction

In Japan, in February 2025, the Cabinet approved the Seventh Strategic Energy Plan[1], which set a target of reducing greenhouse gas emissions by 73% from FY2013 levels by 2040 and presented a pathway toward achieving carbon neutrality (CN) by 2050. Scenario analyses conducted by various expert institutions, published at the "66th Strategic Policy Committee,"[2] have explored multiple scenarios with varying assumptions regarding technological progress uncertainties in renewable energy, carbon capture and storage (CCS), hydrogen, and ammonia, under the assumptions of meeting the 2040 target and achieving CN by 2050. In addition, the Organization for Cross-regional Coordination of Transmission Operators (OCCTO), through its "Study Group on Future Electricity Supply and Demand Scenarios"[3], has presented several nationwide scenarios of power supply–demand balances (kW and kWh) for 2040 and 2050 to facilitate smooth implementation of long-term decarbonized power-source auctions and promote planned power-source development. Both sets of scenario analyses project that total electricity generation in 2050 will increase relative to 2023.

Space Solar Power Systems (SSPS), while a renewable energy source, are identified in the Seventh Strategic Energy Plan as a field in which research, development, and demonstration should be steadily advanced because they can supply stable electricity independent of weather conditions. However, SSPS is regarded as a technology expected to be introduced after 2050. Meanwhile, in Europe, the European Space Agency (ESA) is promoting Solaris, an initiative aimed at achieving CN by 2050, with the goal of constructing a commercial-scale plant by 2040 through clarifying technological challenges and advancing development. The latest academic study[4] has assessed the potential impact of incorporating SSPS into Europe's overall power mix using PyPSA-Eur, a cost-minimizing model. Under assumptions based on the National Aeronautics and Space Administration (NASA) SPS-ALPHA concept—featuring an innovative heliostat swarm—system costs fall by 7–15% in 2050, SSPS could displace up to 80% of wind and ground-mounted solar photovoltaics (PV) power generation capacity, and cut battery needs by more than 70%.

In this paper, we evaluate the potential of SSPS in Japan by using an energy system model under the assumptions of SSPS costs and its power-output variability to achieve CN by 2050. The SSPS architecture is based on the USEF2006 model, and its

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technical specifications and cost assumptions are based on a report by the Mitsubishi Research Institute (MRI) and the Japan Space Forum (JSF) in this paper[5].

2. Methodology

2.1 Overview of model workflow

In this study, we evaluate the economic feasibility of SSPS using the "IEEJ-NE_Japan" model[6][7][8]. The IEEJ-NE_Japan model is an energy system model based on linear programming with high temporal resolution. It derives an efficient energy supply–demand structure by minimizing cumulative costs over the analysis period under various constraints, including energy supply–demand balance and energy-related carbon dioxide (CO_2) emission constraints. Accordingly, among greenhouse gases, it evaluates only energy-related CO_2 emissions. Japan is divided into five regions (Hokkaido, Tohoku, Tokyo, Western Japan, and Kyushu/Okinawa), taking into account the regional unevenness of variable renewable energy (VRE) resources and interregional transmission line capacity constraints. The analysis period spans 2022–2050, and energy supply–demand balances are calculated for the representative years 2022, 2030, 2035, 2040, and 2050.

Fig.1 shows the overview of the model workflow. Given assumptions regarding the performance, efficiency, and costs of the assumed energy technologies (on both the demand and supply sides), the model determines the optimal (cost-minimizing) technology mix that satisfies energy demand across 37 subsectors in the industrial, residential/commercial, and transport sectors. For the power generation sector, the model represents one full year with hourly resolution to simulate output variability of VRE. To address variability, it considers thermal power output adjustment, VRE curtailment, energy storage (pumped hydro storage, sodium–sulfur batteries, lithium-ion batteries, redox flow batteries, water electrolysis, and compressed hydrogen storage), and demand response measures (charging/discharging of electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs), as well as operation control of residential heat pump water heaters).

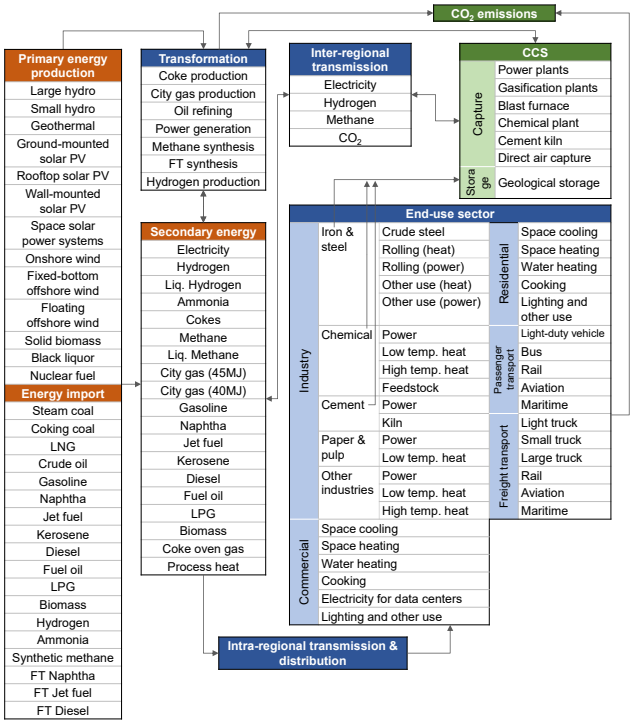


Fig.1 Overview of model workflow

2.2 Objective function and constraints

The model minimizes the discounted cumulative energy system cost for all of Japan. This cost includes capital and operation & maintenance (O&M) costs for both demand-side and supply-side facilities, as well as energy procurement costs (imports or domestic production of primary energy and imports of secondary energy). Capital costs are annualized over the service lifetime of each facility. The subjective discount rate for investment is based on the model of the Research Institute of Innovative Technology for the Earth (RITE)[9], and a real social discount rate of 5% is applied.

As constraints, the model imposes balance equations ensuring that supply meets demand for each item (energy source) represented in the model. For example, for gasoline, the supply, such as production at refineries, must equal the consumption in vehicles and other uses. In the case of electricity, the model represents both the supply–demand balance before regional transmission and distribution, and the balance on the final demand side after transmission and distribution. As mentioned above, electricity supply and demand are modeled on an hourly basis throughout the year (8,760 time steps). In this study, the optimization model uses hourly VRE capacity factor based on historical weather data; therefore, effects such as forecast errors are neglected. VRE output is assumed to be freely curtailable, and surplus electricity can be absorbed through charging storage systems or through demand-side flexibility (e.g., EVs and

residential heat pump water heaters). However, in this model, the following "single-day constraints" are imposed regarding demand-side flexibility. For EVs, the state of charge of on-board batteries at the time of 0:00 must be the same for every day. For residential heat pump water heaters, flexibility is allowed only within a single day.

3. Main assumptions and cases

3.1 Energy-related CO_2 emissions

In this study, we assume that energy-related CO_2 emissions decrease from 964 $MtCO_2$ in FY2022 to net zero in FY2050 (**Fig.2**), and we evaluate the economic feasibility of SSPS under this condition. The purchase of CO_2 emissions credits from overseas is not explicitly considered. However, if the Direct Air Capture of CO_2 (DAC) were estimated to be implemented abroad, it could be treated as a credit depending on the institutional framework.

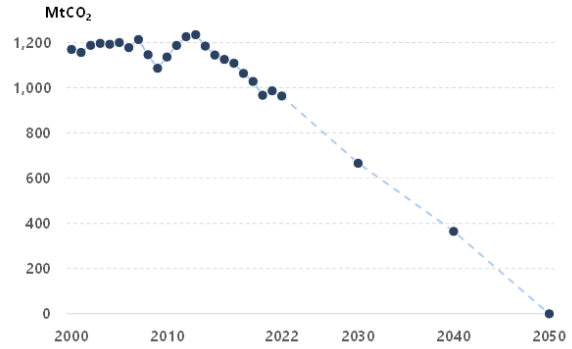


Fig.2 Assumptions for energy-related CO_2 emissions

3.2 Macroeconomic Framework

The real gross domestic product (GDP) growth rate used to estimate energy demand is based on the IEEJ Outlook 2026[10] published by the Institute of Energy Economics, Japan (IEEJ), which projects an average annual growth rate of 0.7% for 2022–2050. Indicators of economic activity were estimated accordingly. Fossil fuel import prices were estimated using FY2023 actual values (Cost, Insurance and Freight (CIF) prices from the Trade Statistics of Japan) and the rate of change in prices under the "Net Zero Emissions by 2050" scenario of World Energy Outlook 2024[11] published by the International Energy Agency (IEA).

3.3 Nuclear Power Generation

For nuclear power generation, it is assumed that the three reactors currently under construction will begin operation in the future, while several existing reactors will be decommissioned. Conversely, reactors that are not decommissioned are assumed to restart by around FY2030 and extend their operational lifetimes to 60 years. Based on the GX Decarbonized Power Source Act enacted in 2023, the operational period is extended to account for the time reactors were offline for regulatory compliance reviews. Consequently, the operating capacity is projected to reach 32 GW in FY2050 (**Fig.3**).

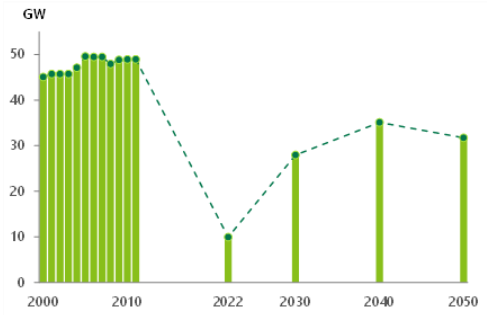


Fig.3 Assumed total installed capacity of operating nuclear power plants

3.4 Hydrogen and CCS

For hydrogen energy carriers, liquefied hydrogen, methylcyclohexane (MCH), ammonia, e-methane, and e-fuel are considered. Their prices [1] are estimated by aggregating international supply chain costs based on specifications and methodologies from the IEA[12] and Otsuki and Shibata[13] (**Fig.4**). No upper limits are imposed on the import volumes of any hydrogen energy carrier.

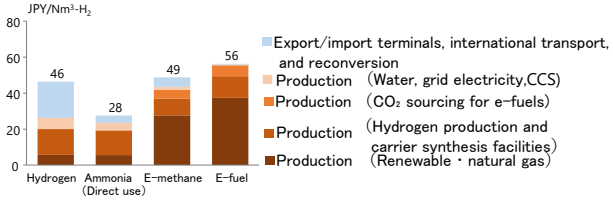


Fig.4 Assumptions for hydrogen price in 2050

For CCS, following the Final Report of "the CCS Long-term Roadmap Review Committee"[14], we assume an upper limit of 240 $MtCO_2$ per year (total for domestic and overseas storage).

3.5 Potential of VRE installation

The upper limits for rooftop solar PV, ground mounted solar PV, and onshore wind power deployment are set based on Obane et al.[15], for agrivoltaics (solar sharing) based on Asano et al.[16], and for offshore wind based on Obane et al.[17] and Obane et al.[18] (**Table 1**).

[1] All Japanese yen in this paper are in 2022 prices.

Table 1 The concept of the upper limits for terrestrial solar PV and wind power deployment

	Upper limits
Rooftop solar PV (detached houses)	Installed on south- and east/west-facing roofs.
Rooftop solar PV (non-public and public buildings)	Installed on 7.9%–38.8% of total roof area depending on building type (based on historical installation data).
Ground-mounted solar PV, Onshore wind	All zones restricted by local ordinances are excluded.
Agrivoltaics (solar sharing)	All 840,000 farming entities in 2023 install 50 kW systems, which is within the range exempt from requiring a chief electrical engineer.
Offshore wind	Installed in areas 10–100 km offshore, considering landscape impact and grid-connection constraints.

3.6 Generation costs of VRE

Generation costs for each power source are set in accordance with the publicly available materials of the Working Group on Verification of Generation Costs[19]. **Fig.5** shows the levelized cost of electricity (LCOE) for terrestrial solar PV and wind power, calculated with a 3% discount rate.

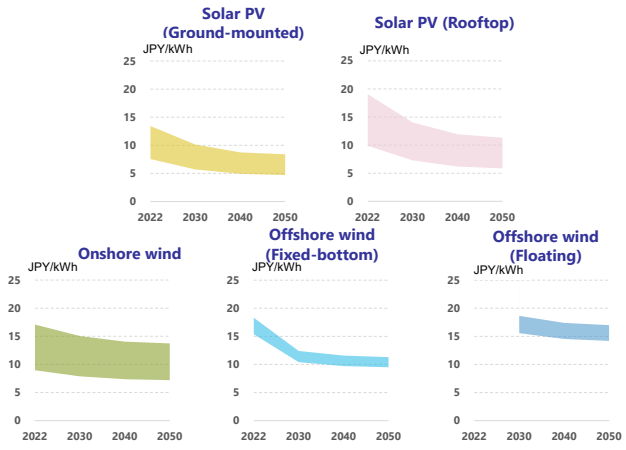


Fig.5 LCOE for terrestrial solar PV and wind power

The cost ranges reflect differences in site conditions and capacity factors. As cumulative installed capacity increases, LCOE declines due to learning effects, but faces upward pressure as installations move to more challenging sites. Furthermore, as the VRE share increases, system integration costs—including the costs of securing balancing capacity—also increase. Consequently, the VRE generation cost (LCOE*), which accounts for a part of these integration costs, rises as well.

3.7 SSPS

The SSPS evaluated in this study is the USEF2006 model, established in 2006 by the Institute for Unmanned Space Experiment Free Flyer (USEF), the predecessor of the Japan Space Systems (JSS), as a target conceptual model for developing a roadmap for SSPS research and development (**Fig.6**)[20]. A single unit consists of a panel assembly deployed over a 100 m × 100 m area and connected to the satellite bus by a tether-like structure. Multiple units are arranged to form a satellite system with a solar array approximately 2.5 km × 2.5 km in area, which is placed in geostationary orbit to generate power.

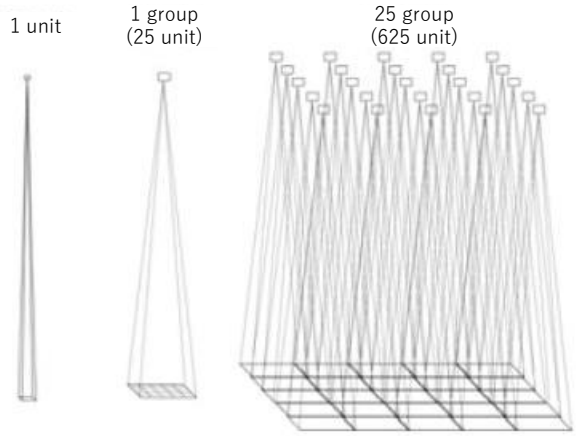


Fig.6 Space-segment of the USEF2006 model

Cost is the primary challenge for SSPS, and system lightweighting can reduce launch costs. In particular, batteries account for a large share of mass in the space segment. In this study, we consider two types of SSPS: an SSPS equipped with onboard storage batteries (SSPS-B) and one without batteries (SSPS-N).

Most SSPS designs proposed worldwide assume constant power output around the clock, whereas the power generation of the USEF2006 model varies with the angle of incidence of sunlight. During the “eclipse season” around the spring and autumn equinoxes, satellite eclipses occur—when the satellite enters the Earth’s shadow and cannot receive sunlight—resulting in the suspension of power generation for several tens of minutes

to a maximum of about 70 minutes per day. Because SSPS-N does not equip batteries, the incident angle of sunlight is set to 0° (06:00) to 180° (18:00), and the corresponding hourly generation profile is defined (**Fig.7**). Since eclipses occur around midnight, output during the time drops to zero. Note that because the model calculations use one-hour averages, the power generation rate does not fall to zero at 6:00, 18:00, or 0:00, when the satellite is in eclipse. Consequently, the annual power-generation time of SSPS-N is 62.5% (i.e., 1/1.6) of that of SSPS-B.

However, these output variations can be anticipated based on orbital conditions and the position of the Sun, and do not involve the weather-related uncertainty associated with terrestrial solar PV and wind power. Consequently, SSPS has smaller output forecast errors than VRE, giving it an advantage in grid operation. In addition, because SSPS can provide a stable output on a daily basis regardless of weather, it can reduce the amount of balancing resources, such as batteries, needed to mitigate variability and may therefore help lower integration costs.

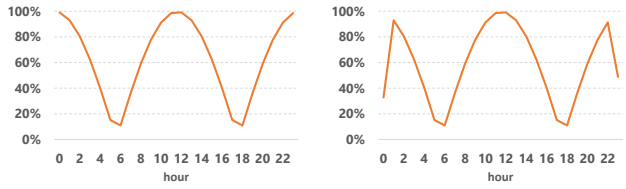


Fig.7 Hourly power generation ratio relative to the maximum output of SSPS-N (Left: normal operation; Right: during satellite eclipse around the equinoxes)

For SSPS-B, 1.6 GW of space solar panels are installed for a microwave transmission capacity of 1 GW, and by using battery storage in combination, it is assumed that a constant 1 GW of power is transmitted at all times. In contrast, SSPS-N installs 1 GW of space solar panels and transmits microwave power following the generation curve shown in **Fig.7**. Therefore, even with the same transmission capacity, the annual transmitted energy of SSPS-N corresponds to 1/1.6 of SSPS-B.

The masses of SSPS-B and SSPS-N, as well as the costs estimated from those masses, are based on MRI and JSF[5]. **Table 2** shows the assumption of costs of the first SSPS and **Fig.8** shows the assumed costs of each SSPS.

Table 2 Assumption of costs of the first SSPS (JPY billion)

	SSPS-B	SSPS-N
Total space segment cost	837	560
Total terrestrial segment cost	153	153
Total transport cost	285	110
Total cost	1,275	823

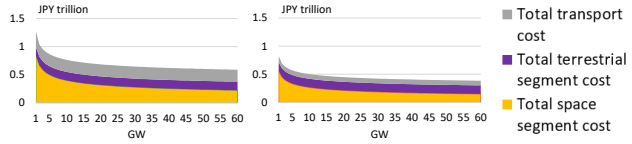


Fig.8 Assumptions of total cost of SSPS-B, SSPS-N in 2050 (Left: SSPS-B, right: SSPS-N)

According to MRI and JSF[5], these values were re-evaluated based on the cost model developed by the JSS[20], using assumptions and calculation conditions comparable to those used in cost studies conducted by ESA[21) 22) 23)], for the battery onboard SSPS-B, a specific mass of 0.667 g/Wh and a cost of 13 JPY/Wh are assumed. SSPS is assumed to become commercially viable in FY2040, with power generation beginning in FY2041, one year after launch. Because SSPS units are assumed to be manufactured under an unmanned mass-production system, the manufacturing cost differs between the first and the tenth unit. Therefore, for the construction costs of SSPS-B and SSPS-N, an 80% learning curve was applied to represent cost reduction.

While the total mass of SSPS-B is 15,771 t, SSPS-N is 6,066 t because it does not have battery storage. As a result, the space-segment and transportation costs of SSPS-N are significantly lower. The maintenance rates were set at 3% for the space segment and 1% for the terrestrial segment, and the decommissioning cost ratios were set at 0% for the space segment and 5% for the terrestrial segment. The grid connection efficiency to the commercial power network was assumed to be 95%, and the lifetime was set at 30 years (one year for construction and 29 years for operation).

The LCOE calculated from the hourly capacity factor in **Fig.7** and the costs in **Fig.8** is shown in **Fig.9**. Regardless of the installed power generation capacity, SSPS-B is less expensive than SSPS-N. The primary reason, as described earlier, is that, because the capacity factor of equipment such as the microwave power transmission system on SSPS-N is only 1/1.6 that of SSPS-B, SSPS-B generates 1.6 times more electricity than SSPS-N for

the same installed capacity.

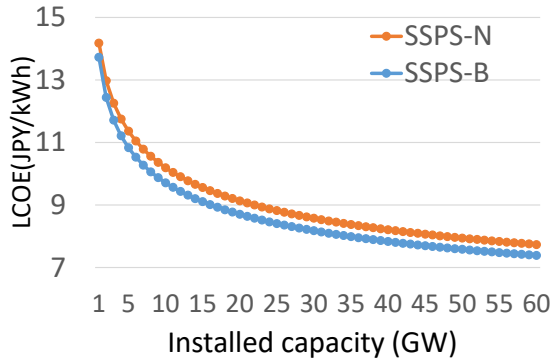


Fig.9 Power generation cost (LCOE) of each SSPS

3.8 Case definitions

Since SSPS transmits the electricity generated in space to the ground in the form of microwaves, rectennas—devices that convert microwaves into direct current electricity—must be installed on the ground. For a 1 GW-class SSPS, an area of approximately 3 to 10 km^2 is required for rectennas. However, because the rectenna area and installation site account for only a small proportion of the total cost, their impact on cost is omitted from consideration. In this case study, the introduction of SSPS is assumed within the Hokkaido Electric Power Company service area, where securing land is relatively easy. Additionally, because significant benefits are expected in regions with large electricity demand, a case in which SSPS is introduced in the Tokyo Electric Power Company service area is also evaluated.

Five analysis cases were defined (**Table 3**). First, "Without SSPS" case was established as a baseline. Next, for both SSPS-B and SSPS-N, two types of deployment cases were set: one in which the construction pace is limited to one unit (1 GW) per year, reflecting investment and construction constraints, and the other one in which no construction pace constraint is applied, allowing cumulative deployment up to 60 GW by FY2050.

Table 3 Case definition

Without SSPS	SSPS is not deployed by FY2050
With an annual cap: SSPS-B	SSPS-B launches start as early as FY2040 (operation begins the following year). Afterward, annual deployment is limited to a maximum of one unit (1 GW) per year due to investment and other constraints.
With an annual cap: SSPS-N	SSPS-N launches start as early as FY2040 (operation begins the following year). Afterward, annual deployment is limited to a maximum of one unit (1 GW) per year due to investment and other constraints.
Without an annual cap: SSPS-B	SSPS-B launches start as early as FY2040. With no constraints on the annual deployment pace, up to a cumulative total of 60 units (60 GW) can be deployed by FY2050.
Without an annual cap: SSPS-N	SSPS-N launches start as early as FY2040. With no constraints on the annual deployment pace, up to a cumulative total of 60 units (60 GW) can be deployed by FY2050.

4. Results

4.1 Without SSPS case

The primary energy supply and the power generation mix from FY2022 to FY2050 in the Without SSPS case are shown in **Fig. 10** and **Fig.11**. Although the use of fossil fuels (coal, oil, and natural gas) declines rapidly going forward, their share in primary energy supply remains at 35% in FY2050. This is because they continue to be used in the power sector for thermal power generation with CCS, and in the final consumption sectors, some fossil fuel consumption, such as city gas, persists where complete electrification is difficult, in addition to oil and natural gas used as petrochemical feedstocks. The associated CO_2 emissions are offset by negative-emission technologies. The share of renewable energy reaches 28% in FY2050, and imports of ammonia increase rapidly after FY2040, accounting for 13% of total primary energy supply in FY2050.

Although the LCOE of VRE is assumed to be lower than that of thermal power generation in FY2050, additional integration costs arise under conditions where VRE penetration is extremely high. As a result, in the cost-optimal solution, not only renewable energy and nuclear power but also thermal power generation continues to be utilized to some extent in FY2050. Specifically, gas-fired power generation with CCS is deployed within the CCS

upper-limit constraint, and beyond this limit, ammonia-fired power generation is introduced. The latter expands rapidly as the energy system reaches the final stage of decarbonization between FY2040 and FY2050, ultimately accounting for 13% of total electricity generation in FY2050. Therefore, SSPS competes with ammonia-fired power generation in regions where deployment would exceed the CCS upper-limit constraint.

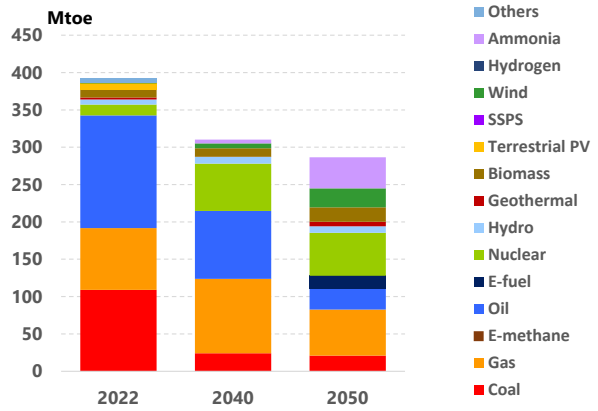


Fig. 10 The primary energy supply FY2022 to FY2050 (Without SSPS case)

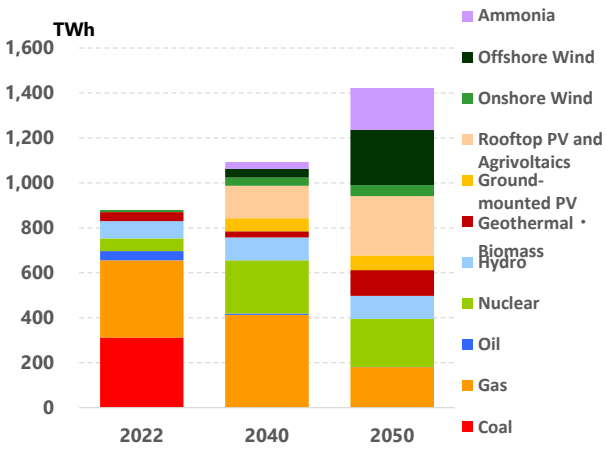


Fig.11 The power generation mix from FY2022 to FY2050 (Without SSPS case)

4.2 Results of SSPS deployment

Fig.12 shows the installed power generation capacity in FY2050 calculated under the assumption of SSPS deployment.

When an annual upper limit on deployment due to investment constraints is imposed, all cases—except SSPS-N in Hokkaido—reach the maximum deployment level of 9 GW under the cost assumptions used in this analysis. As a result, ammonia-fired power generation is substituted.

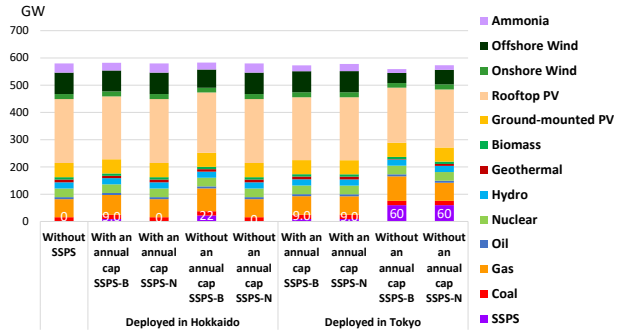


Fig.12 The installed power generation capacity in FY2050

In contrast, when no annual deployment constraint is applied and up to 60 GW can be installed cumulatively by FY2050, both SSPS-N and SSPS-B reach 60 GW in Tokyo. In Hokkaido, however, SSPS-B reaches only 22 GW. Deployment does not reach 60 GW because, at 22 GW, SSPS contributes to a stable electricity supply in Hokkaido, eliminating the need for the 1 GW expansion of the Hokkaido–Honshu interconnection assumed in the Without SSPS case. In other words, expanding deployment beyond 22 GW, up to 60 GW, would require a substantial increase in investment in the interconnection, raising costs and thereby limiting further deployment. In this case, ammonia-fired, rooftop solar PV, and offshore wind are substituted.

Fig.13 presents the resulting power generation mix in FY2050. Because the power generation mix affects electricity prices—and consequently electricity demand—the amount of electricity generated varies across the cases. Under annual deployment constraints, SSPS-B generates 75 TWh in both Hokkaido and Tokyo, and SSPS-N generates 47 TWh in Tokyo, substituting ammonia-fired power. Without annual deployment constraints, SSPS-B generates 183 TWh in Hokkaido and 499 TWh in Tokyo, while SSPS-N generates 311 TWh in Tokyo. In these cases, in addition to ammonia-fired, rooftop solar PV, offshore wind, and gas-fired power generation are also substituted.

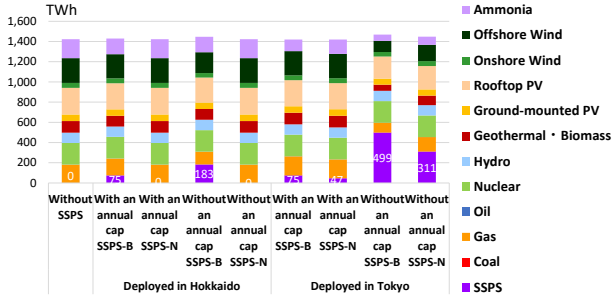


Fig.13 The power generation mix in FY2050

Fig.14 and **Fig.15** show the average electricity price and the

marginal abatement cost of CO_2 in FY2050. The average electricity price decreases when SSPS is deployed, as SSPS is less expensive than ammonia-fired power generation. Furthermore, when no annual deployment limit is imposed, rooftop solar PV and offshore wind are also displaced, resulting in a further cost reduction that includes savings from lower costs of securing balancing capacity. Meanwhile, the marginal abatement cost of CO_2 decreases slightly when no annual deployment limit is applied, but increases slightly in Tokyo when the limit is imposed. This is because the marginal abatement cost is determined by factors other than SSPS (e.g., DAC).

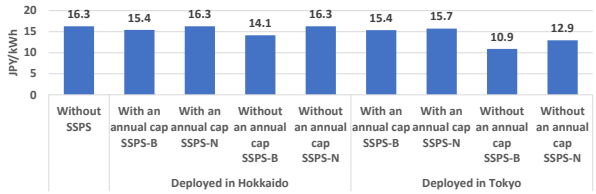


Fig.14 The average electricity price in FY2050

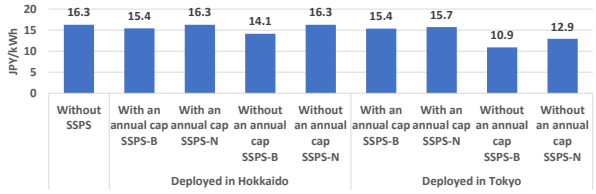


Fig.15 The marginal abatement cost of CO_2 in FY2050

4.3 Sensitivity analysis of total investment cost

SSPS deployment is highly sensitive to total investment cost. **Fig.16** and **Fig.17** show a sensitivity analysis performed by varying total investment cost without applying learning effects.

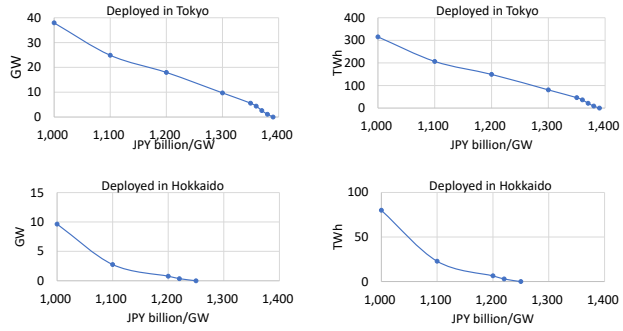


Fig.16 Effects of changing the total investment cost of SSPS-B (Left: installed capacity, right: electricity generated)

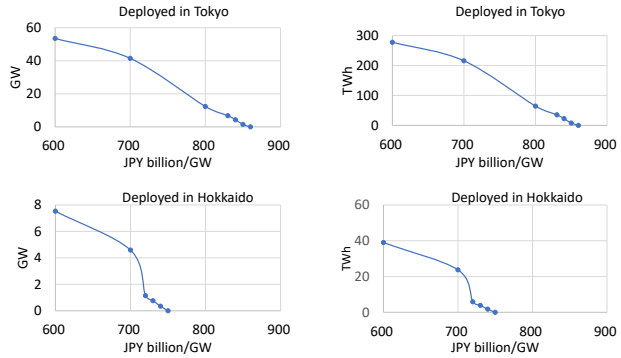


Fig.17 Effects of changing the total investment cost of SSPS-N (Left: installed capacity, right: electricity generated)

The results show that deployment proceeds when the cost for SSPS-B is below JPY1,380 billion/GW (JPY14.9/kWh) in Tokyo and JPY1,220 billion/GW (JPY13.1/kWh) in Hokkaido. For SSPS-N, deployment proceeds below JPY850 billion/GW (JPY14.6/kWh) in Tokyo and JPY740 billion/GW (JPY12.8/kWh) in Hokkaido.

5. Implications from the model analysis

Based on the cost assumptions used here, the analysis shows that when annual deployment constraints exist, SSPS is deployed in all cases except SSPS-N in Hokkaido. When no annual deployment limit is imposed, even greater deployment occurs. In terms of region, Tokyo—with its large electricity demand—shows large deployment, potentially exceeding the assumed upper limit of 60 GW if unconstrained. In Hokkaido, by contrast, deployment does not reach 60 GW, because combined additional investment costs for SSPS and the Hokkaido–Honshu interconnection power line surpass those of competing technologies. Furthermore, despite SSPS-B having higher space-segment and transportation costs, its superior economic performance—due to stable power transmission enabled by onboard storage batteries—leads to greater deployment than SSPS-N. Sensitivity analysis indicates that deployment occurs when the cost falls below JPY1,380 billion/GW for SSPS-B and JPY850 billion/GW for SSPS-N in Tokyo.

6. Conclusion

This study demonstrates that SSPS could potentially contribute to achieving carbon neutrality by 2050. However, several important issues remain for future examination.

First, the assumptions used in this analysis require further refinement. While this study found SSPS-B to be more economically advantageous, it will be necessary to verify whether

this conclusion holds under updated cost models. The relative competitiveness of SSPS-B and SSPS-N depends on the trade-off between increased costs from launching batteries and improved utilization of microwave transmission equipment. Depending on assumption settings, the economic efficiency could reverse. Additionally, although cost reductions based on learning curves were assumed, a more detailed evaluation of learning rates is necessary. This study also assumed that rectenna area and site conditions in Hokkaido and Tokyo have little impact on overall cost, but regional differences in power generation characteristics—such as latitude and temperature—were not considered and should be examined.

Second, non-economic constraints must be incorporated. Although a deployment pace of one unit per year was assumed in this study, assuming more practical deployability will require a detailed assessment of investment feasibility, land availability, and environmental/social constraints.

Third, the analytical framework needs to be broadened and refined. The economics of SSPS depend on many factors beyond SSPS costs themselves, such as other technology costs and fossil fuel prices. It is therefore important to analyze the role of SSPS in the overall energy system while taking into account uncertainties in other elements. Furthermore, although this study analyzed Tokyo and Hokkaido, potential deployment in other regions—such as Kyushu—should also be evaluated.

In summary, many factors remain unaddressed in this analysis, and accurately assessing these issues will be essential in future research. While technological development aimed at cost reduction is progressing in the space sector, a comprehensive evaluation of SSPS within the overall energy system—considering the evolution of other technologies—is needed. Close collaboration between the space sector and the energy-system sector will be crucial for the commercialization and the promotion of SSPS.

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