Potential Capacity and Cost of Pumped-Storage Power in Japan (Vol. 3)

Summary

The 2019 paper puts forward *new pumped storage power* as a system for storing power from renewables, a major source of electricity in a zero-carbon society[1]. This new system calls for utilizing an existing multipurpose dam for a lower reservoir and constructing plural smaller upper reservoirs and power plants. The 2020 paper estimates the total potential storage capacity under this system in Japan at 750-2,200 GWh/cycle/day without considering individual topographic conditions[2]. In this paper we consider more realistic conditions, including local topography and land use regulations, in reassessing the potential capacity and power generation cost of a feasible new pumped storage power plant. We conclude new pumped storage power offering a viable power storage solution for the future.

Proposals for Policy Development

- Potential storage capacity that can be developed is expected to be 585-1,392 GWh/cycle/day, well above 510 GWh/cycle/day[3], a level that needs to be secured by 2050. The power generation cost is estimated at 18.5-20.5 JPY/kWh.
- Potential sites are widely distributed across the country. It is necessary to investigate site suitability of pumped storage power plants in each region and an optimal renewable energy combination with the plants. Development plan should be proceeded according to the investigation.
- A smaller dam means easier with which to pinpoint the sites for upper reservoirs, as well as easier and less costly construction. As a development procedure, it is preferable to begin with smaller dams.
- Water stored in a multipurpose dam is used for various purposes. It is thus important to ensure that water use for pumped storage power does not undermine the functions of water utilization and flood control of the dam.

1. Distribution of New Pumped Storage Power Plants

A new pumped storage power plant involves plural upper reservoirs and power plants of the same specifications (Figure 1). The power storage capacity of such a plant depends on the scale of the multipurpose dam (lower reservoir). A total of 931 multipurpose dams in Japan that can serve as lower reservoirs are classified into five categories according to their scale (water storage capacity) to assess the distribution of potential sites. The findings are shown in Figure 2.

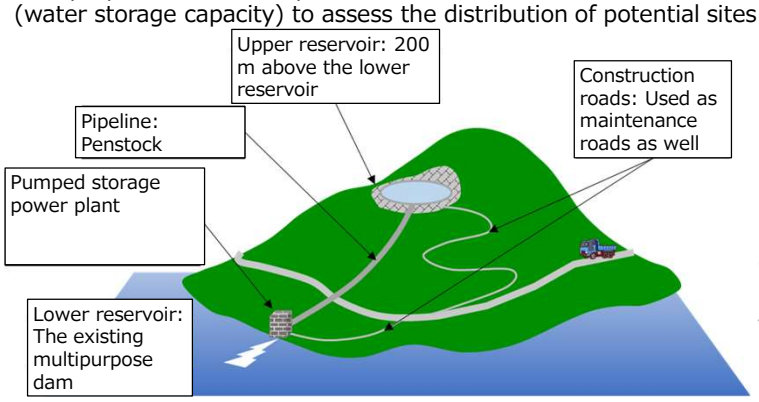

Figure 1 Schematic Diagram of a New Pumped Storage Power

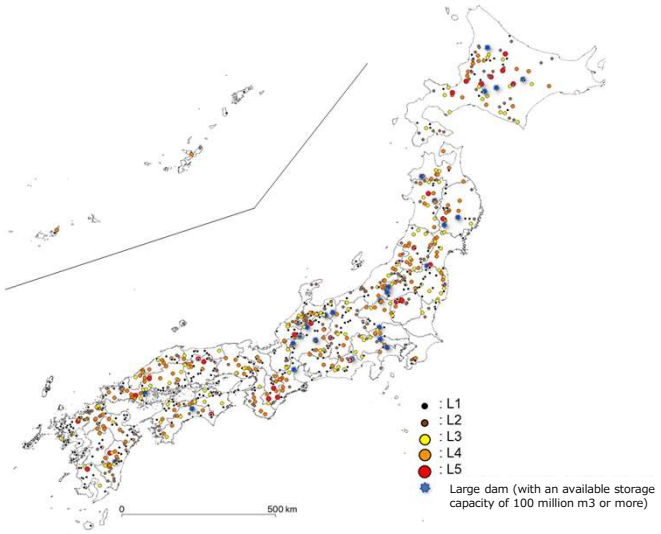

Figure 2 Locations of New Pumped Storage Power Plants in Japan

2. The Construction Cost of a New Pumped Storage Power Plant

Detailed estimation that factored in topography and other conditions has found that the total construction cost of a new pumped storage power plant will be 2.73 billion JPY. For 80% of such stations, the cost will range from 2.5 to 3 billion JPY. The steeper the upper reservoir site and the longer the pipeline, the higher the construction cost.

The cost of leveling land and constructing upper reservoirs accounts for more than 50% of the total construction cost (Figure 3).

3. Estimates under Different Conditions

Table 1 shows the estimates of power generation cost and potential storage capacity under different conditions in comparison with those used in the 2020 paper[2] (Plan 0). Plan 1 considers more accurate topographic conditions. Plans 2-5 also reflect two other factors: the ratio of water usage to the available water storage capacity of the dam and whether or not a large dam is involved.

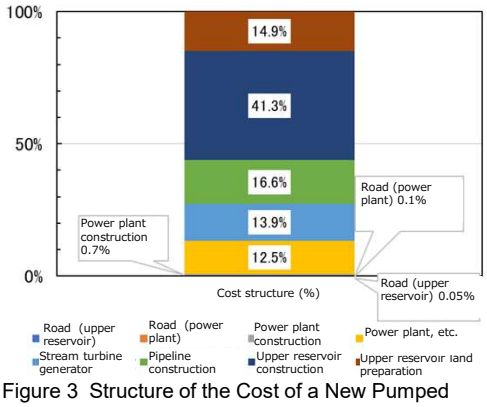

Figure 3 Structure of the Cost of a New Pumped Storage Power Plant

Table 1 Potential Storage Capacity and Cost of a New Pumped Storage Power Plant

Plan	Topographic conditions considered or not	A. Ratio of water usage to effective storage capacity (%)	B. Large dam (with an available water storage capacity of 100 million m3 or more) involved?	C. Facility cost (JPY/Wh)	D. Power generation cost (JPY/KWh)	E. Installed storage capacity (MWh/power-house/cycle/day)	F. Total no. of dams	G. Total no. of upper reservoirs that can be constructed	H. National total of installed storage capacity (GWh/cycle/day)	I. Average installed storage capacity (GWh/dam/cycle/day)	J. National total of annual installed storage capacity (TWh/year)
0	No(*)	20	No	44.5	20.4	61	1000	14900	907	0.91	272
1	Yes	20	No	44.9	20.5	61	931	9640	585	0.63	176
2	Yes	30	No	34.9	18.5	91	931	9640	878	0.94	263
3	Yes	20	Yes	44.9	20.5	61	959	15280	928	0.97	278
4	Yes	30	Yes	34.9	18.5	91	959	15280	1392	1.45	417
5	Yes	20(**)	No	40.9	19.7	70	931	9640	655	0.7	196

(*)No (Assumptions: 20% of stored water can all be used for pumped storage power and all pumped storage power plants share the same specifications, i.e., Plan A in the 2019 proposal paper[2])
(**) 20 (or 30 for Hokkaido and Tohoku)

[1] LCS, "Potential Capacity and Cost of Pumped-Storage Power in Japan," Proposal Paper for Policy Making and Governmental Action toward Low Carbon Societies, January, 2019.
[2] LCS, "Potential Capacity and Cost of Pumped-Storage Power in Japan (Vol. 2)," Proposal Paper for Policy Making and Governmental Action toward Low Carbon Societies, February, 2020.
[3] LCS, "Economic Evaluation for Low Carbon Electric Power System Considering System Stability (Vol. 2)," Proposal Paper for Policy Making and Governmental Action toward Low Carbon Societies, March 2018.

https://www.jst.go.jp/lcs/pdf/fy2020-pp-01.pdf