気候変動を考慮した日本の水力発電ポテンシャル評価

Assessment of hydropower potential in Japan with consideration of climate change

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In the big trend of shifting energy sources from nuclear power and thermal generation to renewable energy, hydropower has been paid attention in Japan. In this study, targeting existing 93 multipurpose dams belong to MLIT and JWA, it is shown how much potential it generates in Japan only by changing the maximum water use and how it changes by the effect of the climate change.

1. Introduction

Hydropower generation is pure domestic energy and operated at more than 500 existing dams in Japan. Making use of them in better way[1], more electricity can be obtained, and it is defined as "potential" in this study.

2. Methodology

Draw a flow duration curve for each dam by using past 10 years outflow data[2] (Q) and calculate electricity generation by using the equation $P=9.8QH\eta$ [3],[4]. Assume the outflow more than the maximum usage water (Q_{max}) is equal to the Q_{max}, and ignore outflow less than 20% of Q_{max}. The hydropower production "P" become the largest one at a certain Q_{opt} value. The difference between P_{opt} and current P is the current potential of the hydropower at the dam. Future and current flow data for 25 years is calculated by substituting climate data which is given by MRI-AGCM 3.2S into Hydro-Beam. In this study, the worst scenario RCP8.5 is applied to check the change clearly.

[1] By changing maximum discharge.
[2] It can be less than 10 years.
[3] H:=effective head difference×2/3
[4] η: coefficient of efficiency =0.82

After making average flow duration curve both for current/future climates, climate factors can be obtained by dividing 365 elements of future duration curve by current ones. Calculate P' for the future duration curve, which is obtained by multiplying the climate factor to the actual current flow duration curve, with the same Q_{max} setting and get P'_{opt} at certain Q'_{opt} value.

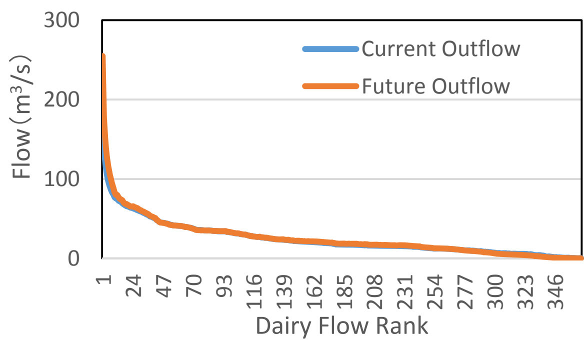


Fig.1 Comparison of current/future flow duration curves at the Tamagawa dam

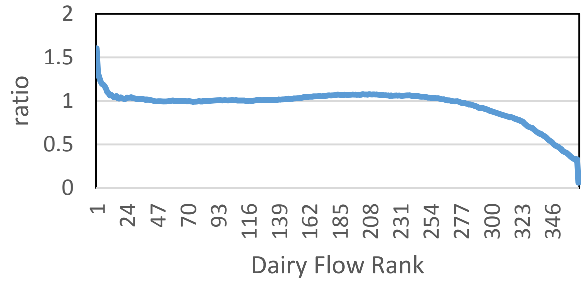


Fig. 2 Current/future flow ratio at the Tamagawa dam

3. Results

Fig.1 shows comparison of current/future flow duration curves at the Tamagawa dam. Fig. 1 can be converted to current/future flow ratio as shown in Fig.2. In this case, higher flow rate larger than 10 will increase but lower than 280 will decrease drastically. Fig.3 shows difference of annual hydropower production by changing Q_{max}. Since current value is 40 m^3/s, around 2,000MWh can be increased from Q_{max} = 40 to 55-60 m^3/s.

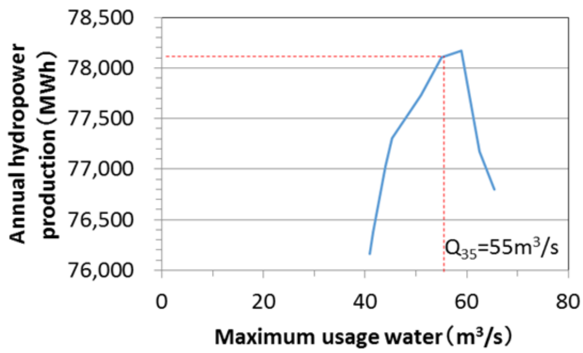


Fig. 3 Difference of annual hydropower production based on the maximum usage water

Based on changing Q_{max}, total calculated hydropower potential of 92 dams can be calculated as follows:

① Current: P=4,104,010MWh

② Current optimized: P_{opt}=4,415,461MWh

③ Future: P'=3,633,497MWh

④ Future optimized: P'_{opt}=3,865,488MWh

⑤ P_{opt}-P (MWh): Current potential by changing the maximum discharge (Q_{max})

⑥ P'-P (MWh): Current/Future change without optimization

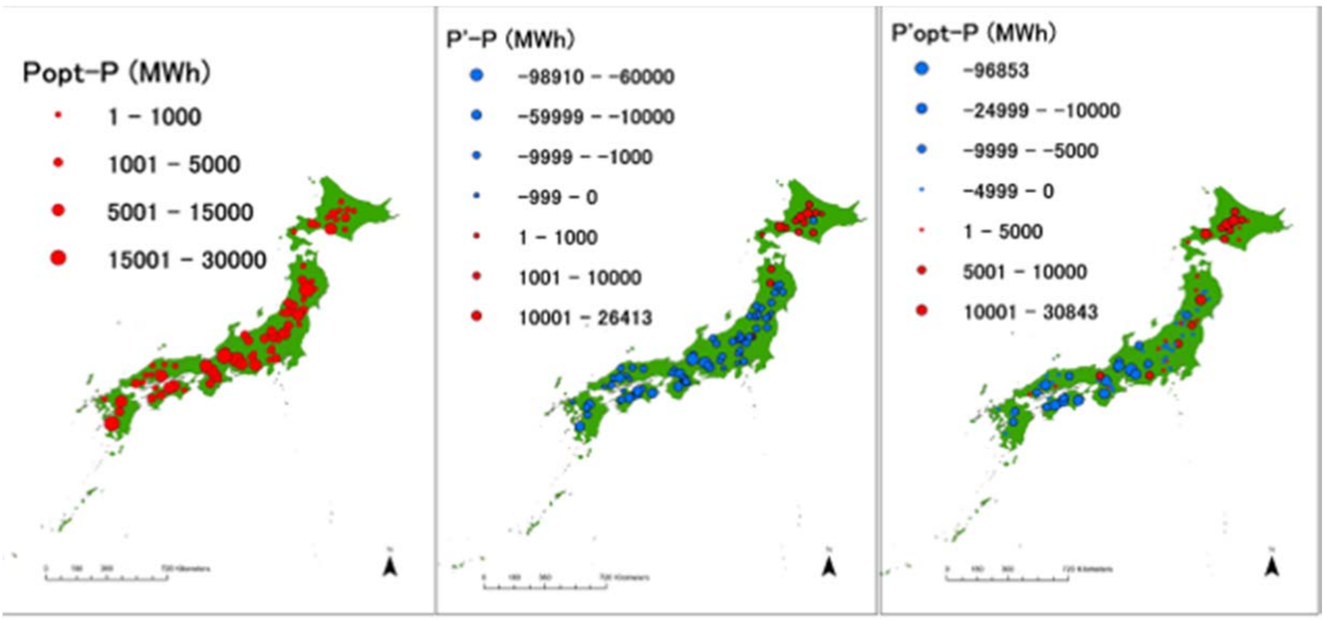
⑦ P'_{opt}-P (MWh): Current/Future change with optimization

4. Conclusion

1) Hydropower generation at existing dams still have huge potential to develop in Japan.

2) Proper Q_{max} can maximize the potential.

3) Regional trend of the effect of climate change should be taken into consideration for future scheme of hydropower generation.



[5]Fig. 4 Total calculated hydropower potential of 93 dams based on P_{opt}-P (left), P'-P (middle) and P'_{opt}-P (right)

[5] GIS base map source: http://www.fas.harvard.edu/~chgis/japan/datasets.html