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Comparison of the Amount of Resources and Expansion Support Policy of Photovoltaic Power Generation: A Case on Hokkaido and Aichi Prefecture, Japan

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***Abstract*—**Now, the use of renewable energy power generation has been advanced. In this paper, we compared the usable amount of resource for photovoltaic power generation which was estimated using the NEDO formula and the expansion support policy of photovoltaic power generation which was researched using Internet in the municipality level in Hokkaido and Aichi Prefecture, Japan. This paper will contribute to grasp the current situation especially about the policy. As a result, there were municipalities which seemed to be no consideration of fitting the amount of resources. We think it would need to consider the suitability between the resources and policies.

***Keywords*—**Photovoltaic power generation, expansion support policy, amount of resources, Japan.

I. Introduction

RENEWABLE energy generation has been used in Japan now. Especially it has been carried out to install photovoltaic power generation facilities to house. For the installation, there are expansion support policies such as subsidies by prefectures and municipalities. However, it is questionable whether there is good fit between the amount of resource and the policy. In this paper, therefore, we test the comparison of them in the Hokkaido and Aichi Prefecture in Japan as an example.

II. Methods

A. Amount of Resource

As amount of resource, we estimated the usable amount of photovoltaic power generation (*S*) by municipality unit, and compared that with the electric power consumption (*D*). From this result, we calculated the *S*/*D* rate, and classified it to four groups by cluster analysis [1] (Figs. 1 (a) and 2 (a)). The formulas, variables, and groups are shown in Tables I- III.

Firstly, we describe the variables for the usable amount of photovoltaic power generation estimation formula (Table I). *SR* is the amount of solar radiation for optimal inclination angle. This numerical value was obtained from NEDO homepage: the amount of solar radiation database viewing system MONSOLA-11 [2]. *A* is possible installation area. In this paper, this numerical value was calculated using the basic unit by the number of houses and the number of establishments. The number of houses and establishments were taken from Japan Statistics Bureau dates [3]-[5]. *E1* is conversion efficiency (16%). *E2* is design factor (70%). Both rates are set based on the values reported in previous researches [1], [6], [7]. *d* is the number of operating days (365 days). Then, we describe the variables of electric power usage estimation formula (Table II). Here, *n* is the number of households in each municipality. *TD* is prefectural electric power consumption. *N* is the number of prefectural households. *Ce* is Basic unit of prefectural electric power usage. This is obtained by dividing the *TD* by *N*.

TABLE I
Available Amount of Photovoltaic Power Generation Estimation Formula
$P = (SR \times A \times E1 \times E2 \times d) / 10^6$

Symbol	Unit	Content	Data
P	GWh	photovoltaic power generation usable amount	NEDO formula
SR	kWh/m^2	amount of solar radiation for optimal inclination angle	NEDO [2]
A	m^2	possible installation area (the number of houses and the number of establishments)	Japan Statistics Bureau [3]-[5]
E1	%	conversion efficiency (16%)	Sumi et al. [1] Yamanashi Pref. [6] Tottori City [7]
E2	%	design factor (70%)	(Same as the above)
d	day	number of operating days (365 day)	-
10^6	-	unit conversion (kWh to GWh)	-

TABLE II
Electric Power Usage Estimation Formula
$EP = (Ce \times n) / 10^6$

Symbol	Unit	Content	Data
EP	GWh	electric power usage	Sumi et al. [1]
n	number	the number of households in each municipality	Japan Statistics Bureau [7]
Ce	kWh/year	basic unit of prefectural electric power usage	Sumi et al. [1]
TD	kWh/year	prefectural electric power consumption	Japan Statistics Bureau [8] Japan Agency for Natural Resources and Energy [9]-[11] FEPC [12]
N	number	number of prefectural households	Japan Statistics Bureau [7]
10^6	-	unit conversion (kWh to GWh)	-

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B. Policy

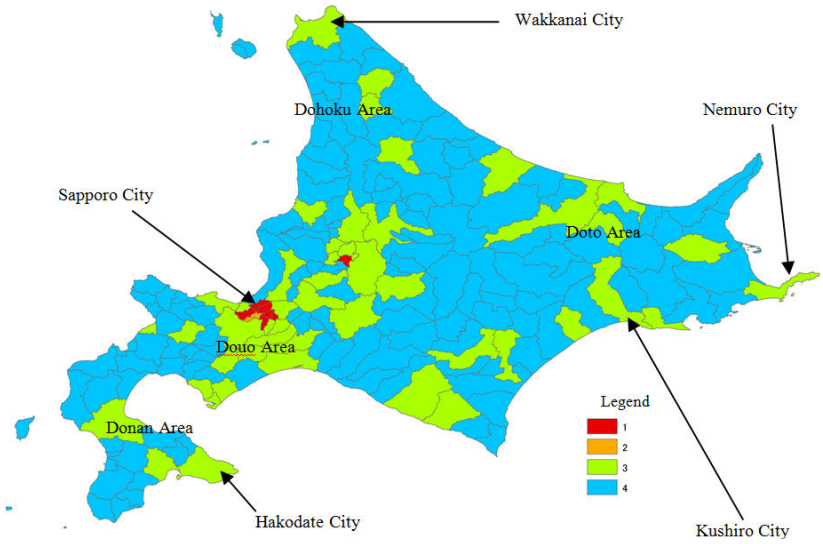
We collected the dates of expansion support policies by municipality for photovoltaic power generation by using Internet. Then, we explored municipality homepages about photovoltaic power generation policy.

In the result, we selected number '0.5' if the municipality has the policy, and selected the number '0' otherwise. In this paper, if the municipality has implemented a policy for photovoltaic power generation even a little, we consider that the municipality is regarded to have policy.

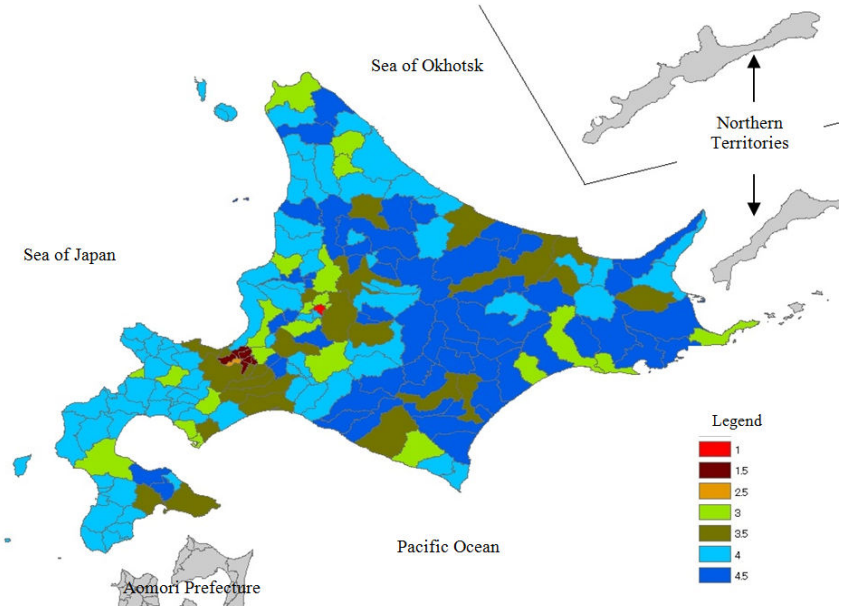
C. Comparison

In order to compare the amount of resource with the policy, we added the group number of section A (cluster analysis) (Table III and Figs. 1 (a) and 2 (a)) and the number of section B (policy research (0 or 0.5)) for each municipality.

The analysis result is Table IV. '1' and '2' represent that the amount resource is enough but the policy isn't implemented. '1.5' and '2.5' represent that the amount resource is enough and the policy is implemented. '3' does that the amount of resource is insufficient in winter and the policy isn't implemented. '3.5' does that the amount of resource is insufficient in winter but the policy is implemented. '4' does that the amount of resource is insufficient and the policy isn't implemented. '4.5' does that the amount resource is insufficient but the policy is implemented.

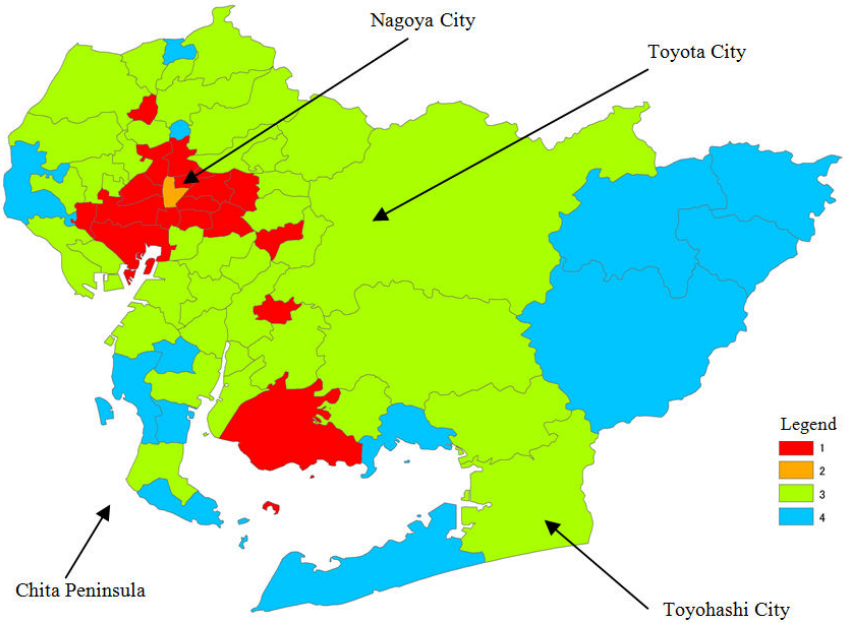


(a)

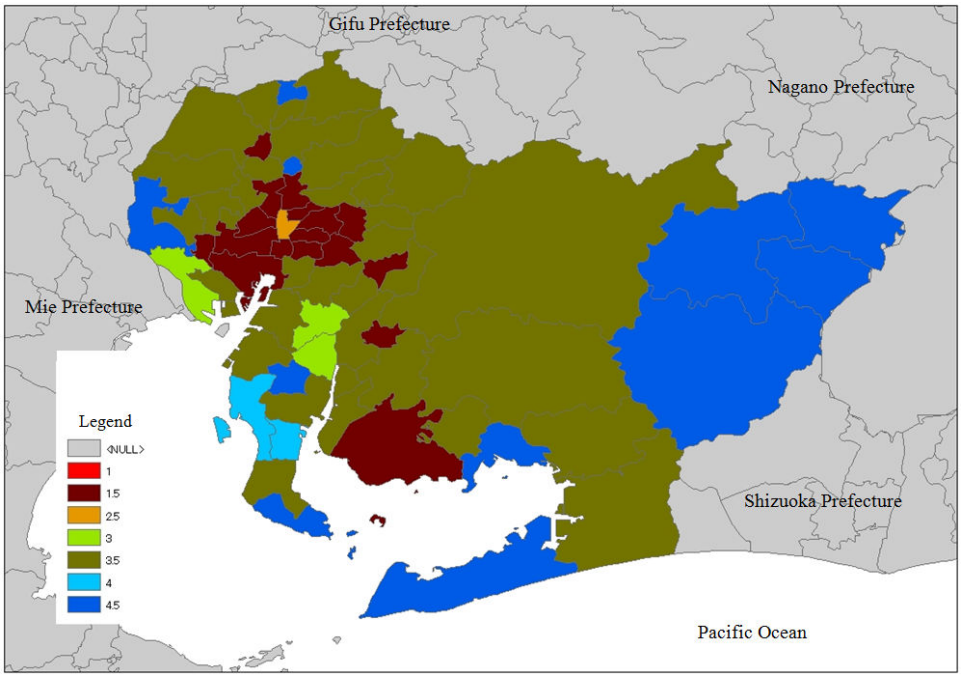


(b)

Fig. 1 Result of Hokkaido Prefecture (a) Policy, (b) Comparison



(a)



(b)

Fig. 2 Result of Aichi Prefecture

III. Result and Discussion

The comparison results are shown in Figs. 1 (b) (Hokkaido Pref.) and 2 (b) (Aichi Pref.).

Major cities called *Seirei-shitei-toshi* in Japanese (in this paper, Nagoya and Sapporo city) and the municipalities adjacent to them (cluster 1 and 2) have policies for photovoltaic power generation and have enough amount of resources for electric power consumption.

With regard to other municipalities (cluster 3 and 4), in Aichi prefecture, most of the municipalities have policy. However, the municipalities around Chita Peninsula have no policy. About the resources, the municipalities in cluster 3 and 4 have insufficient resources (Tables III, IV).

TABLE III
4 GROUPS BY CLUSTER ANALYSIS

Group (Cluster)	Amount of Resource	Municipalities (Principal Example)
1	enough for *EP*	major cities called *Seirei-shitei-toshi* in Japanese and its around
2	enough for *EP*	central major cities called *Seirei-shitei-toshi* in Japanese
3	insufficient for *EP* in winter	other cities
4	insufficient for *EP*	towns and villages

TABLE IV
COMPARISON WITH AMOUNT OF RESOURCE AND THE POLICY

Number of Calculation Result	Amount of Resource	Policy
1 and 2	enough	unimplemented
1.5 and 2.5	enough	implemented
3	insufficient in winter	unimplemented
3.5	insufficient in winter	implemented
4	insufficient	unimplemented
4.5	insufficient	implemented

In Hokkaido prefecture, the municipalities in its eastern and northern areas, which are called Doto and Dohoku areas in Japanese, have policy. On the other hand, the municipalities in its central and southern areas, which are called Douo and Donan, have no policy. But in view of resource, almost all the municipalities in Hokkaido Prefecture belong cluster 3 or 4.

As the result shows, there is mismatch between the amount of resource and policy. Therefore, we need to consider the way of matching the amount of resources with the policies in the municipality level.

IV. CONCLUSION

In this paper, we compared the expansion support policy of photovoltaic power generation and amount of resource of photovoltaic power generation in the municipality unit in Hokkaido and Aichi Prefecture, Japan. As a result, there were cases which were no consideration of fitting the amount of resource and the policy.

In the future, we are going to need to research whether the pre-investigation and consideration are carried out in the planning stages of the policy.

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