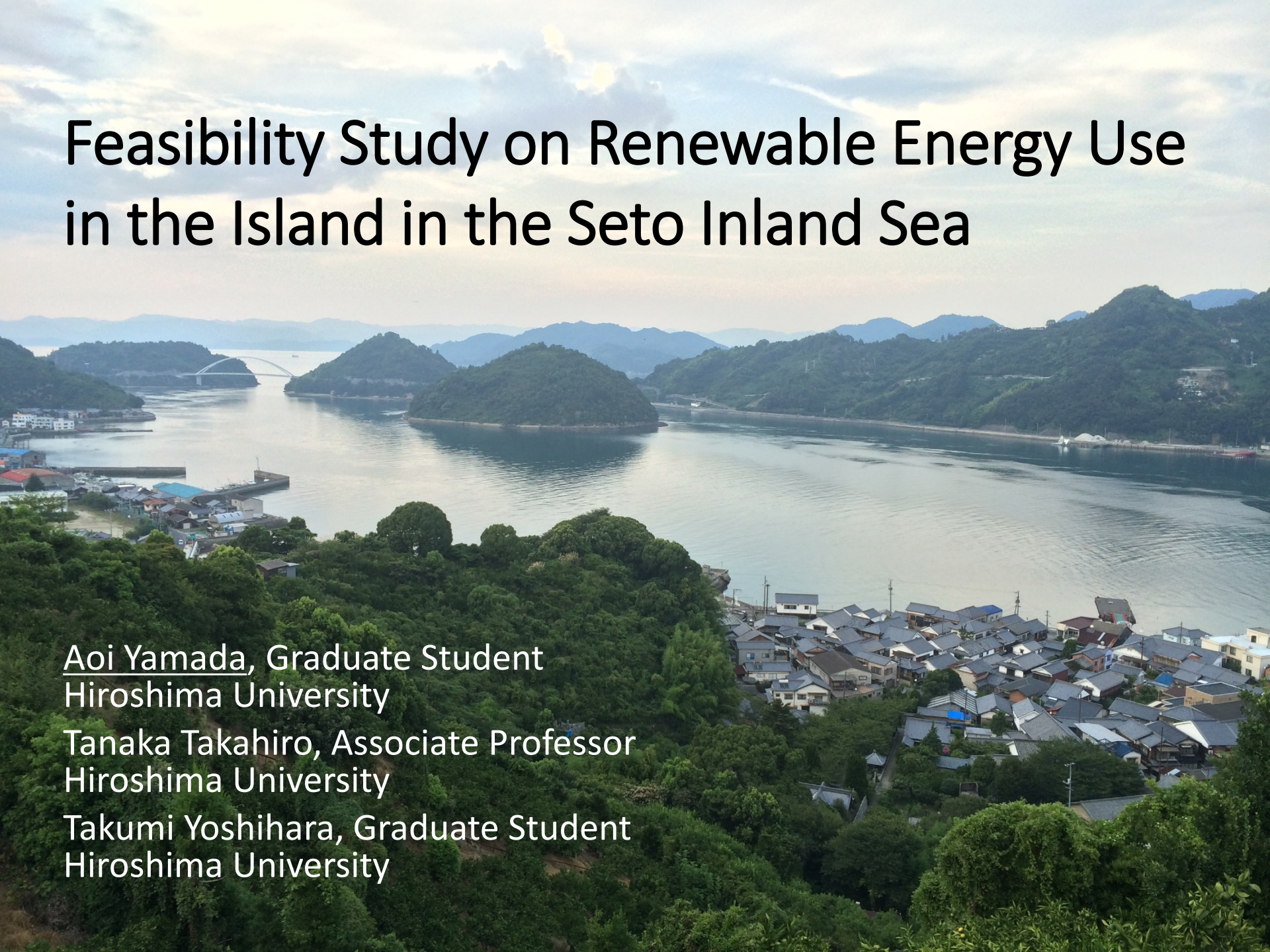
Feasibility Study on Renewable Energy Use in the Island in the Seto Inland Sea



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Overview

Islands in the Seto Inland Sea

- Rich natural resources : forests, mild climate, vast farmland
- Beautiful landscape
- Local culture and custom

Local decline

The population decreasing and the aging

vicious circle

- Decline of community
- Inconvenience of daily life
- Increasing of low-used land
- Decline in agriculture



Effective use of local characteristics

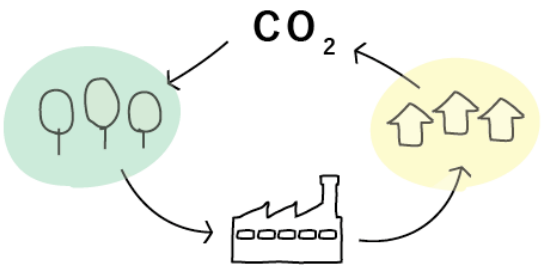
+

Measure against local problems

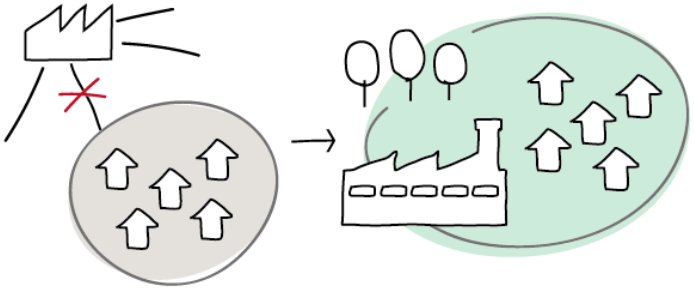
Renewable energy use

Effect of renewable energy use

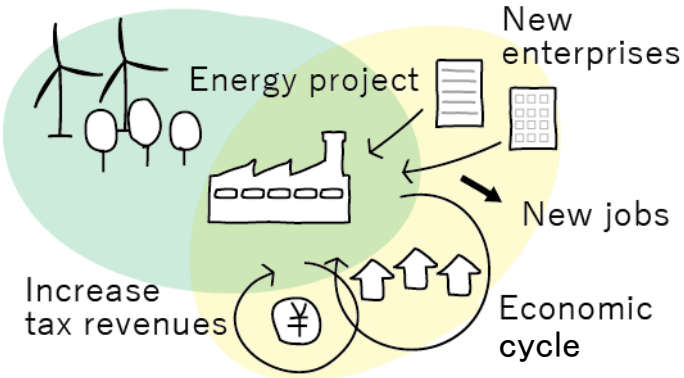
Saving fossil fuel and reduce carbon dioxide



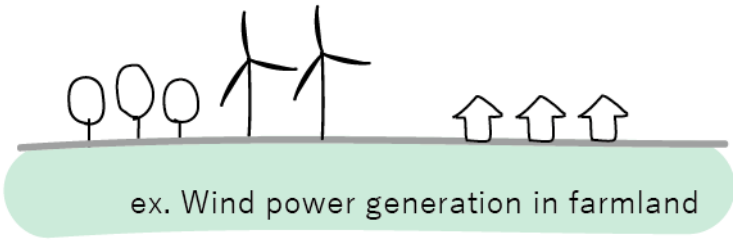
Stable energy supply



Local economical effects



Synergistic effect of regional industries



Estimates the energy demands and the energy supply potentials targeting an island in the Seto Inland Sea

demand

The heat and electric demands of the houses in the island

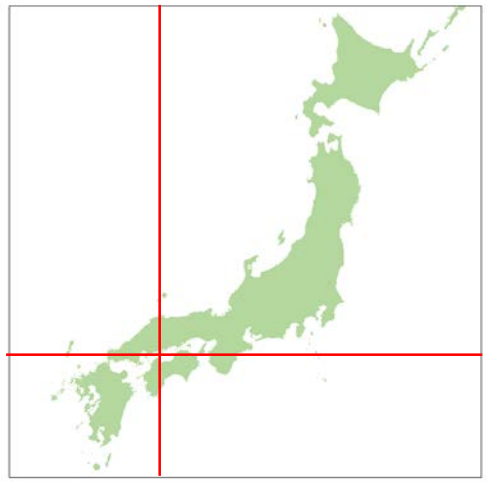
compare

supply

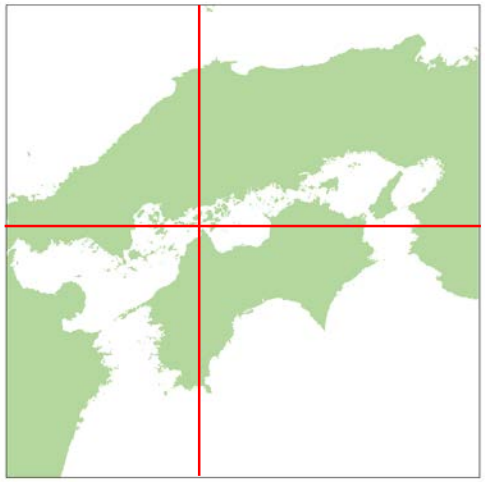
The supply potential of renewable energy considering local characteristics

Evaluates the feasibility of energy independence in the island

2.1 Target island



Japan



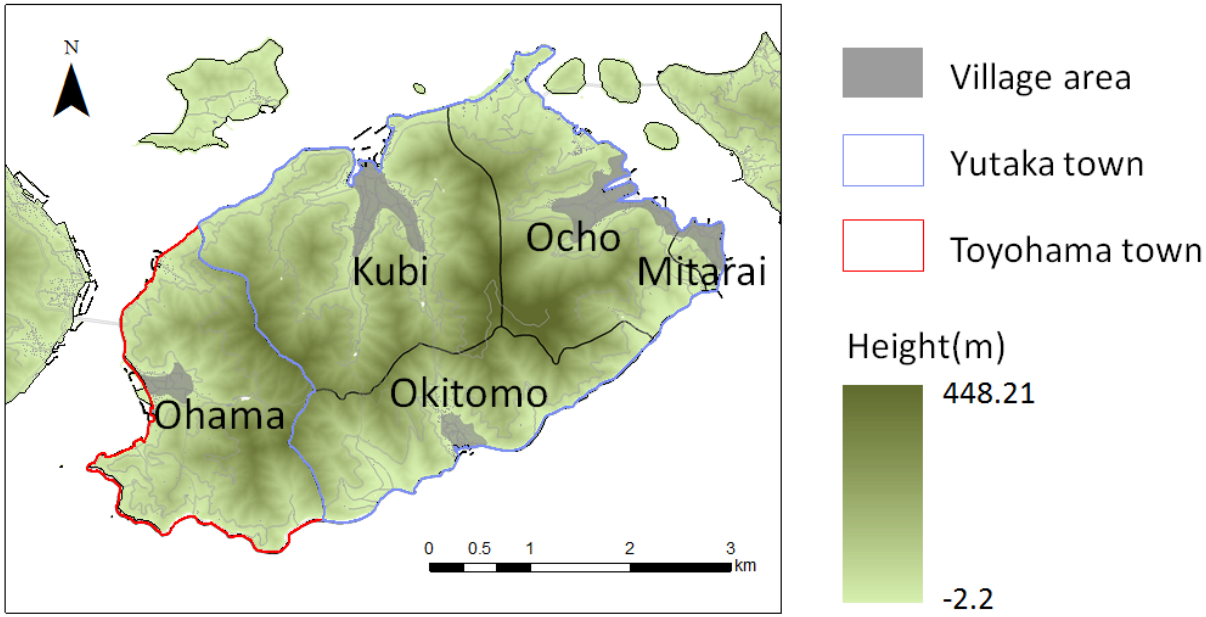
Seto Inland Sea

Osakishomojima

Osakishomojima

2235 person
17.82 km^2

Having 5 districts facing the sea



Seto Inland Sea Type Climate
– mild climate, low rainfall, high radiation

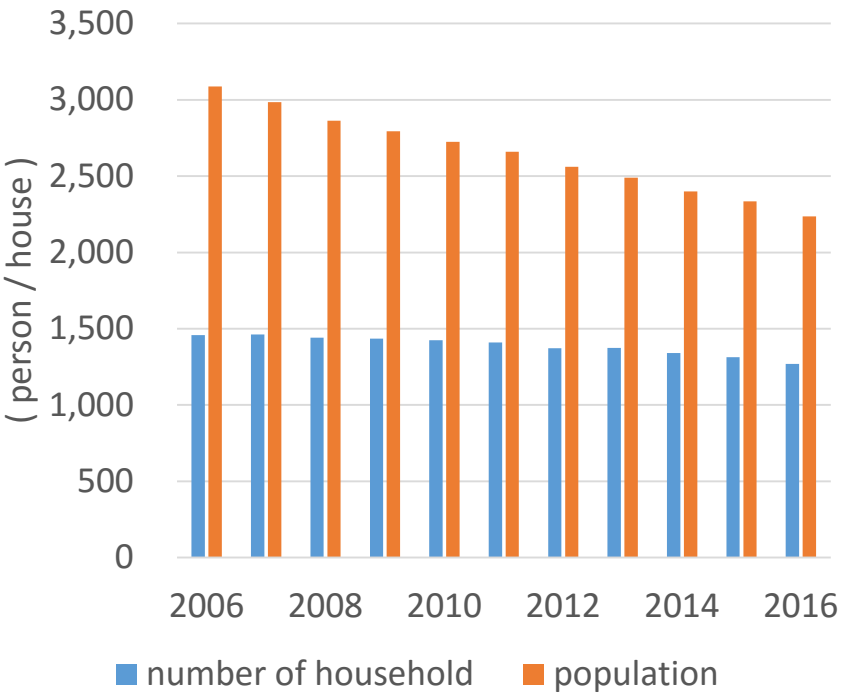
Having steep terrain

Cultivation of mandarin orange is active

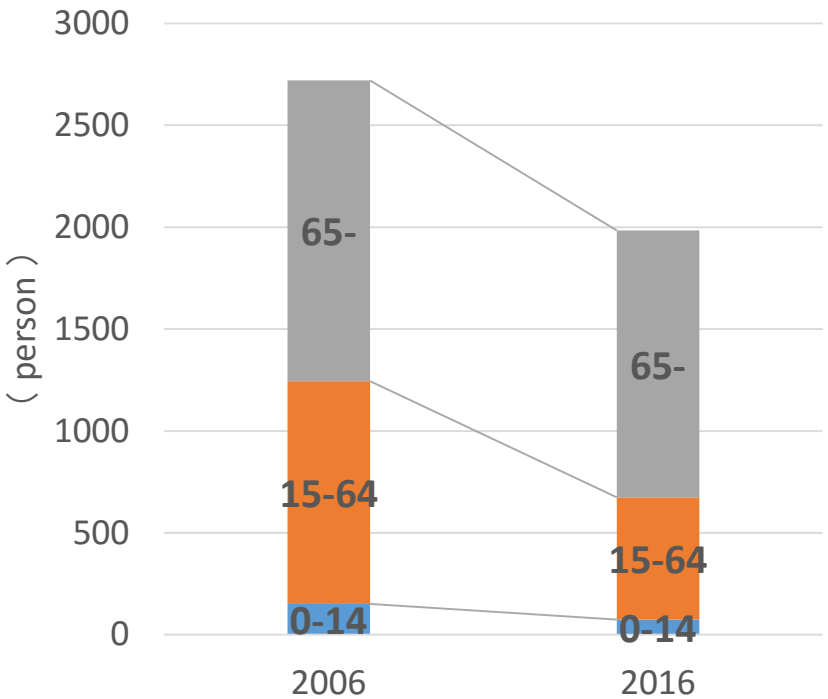
Vast orchard (Terraced field)

2.1 Target island

Changing of population and household



Changing of the age structure



Population decreasing and the aging is advancing rapidly

Local decline

Decline of community

Increasing of low-used land

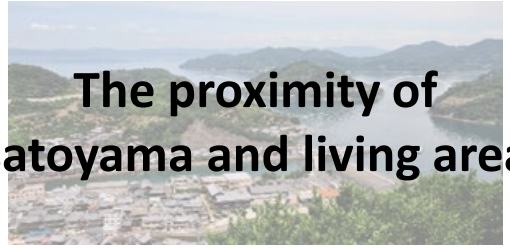
Inconvenience of daily life

Decline in agriculture

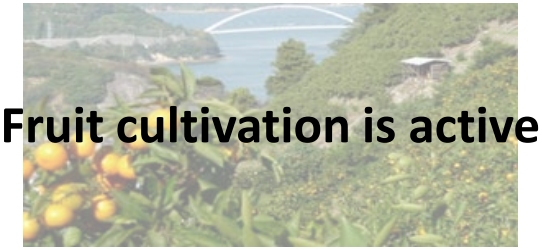
Measures against local decline are required

2.2 Local characteristics and prospected renewable energy

Considering local characteristics of the target area, 4 types of renewable energies are selected as effective sources.



Woody biomass energy by forest utilization



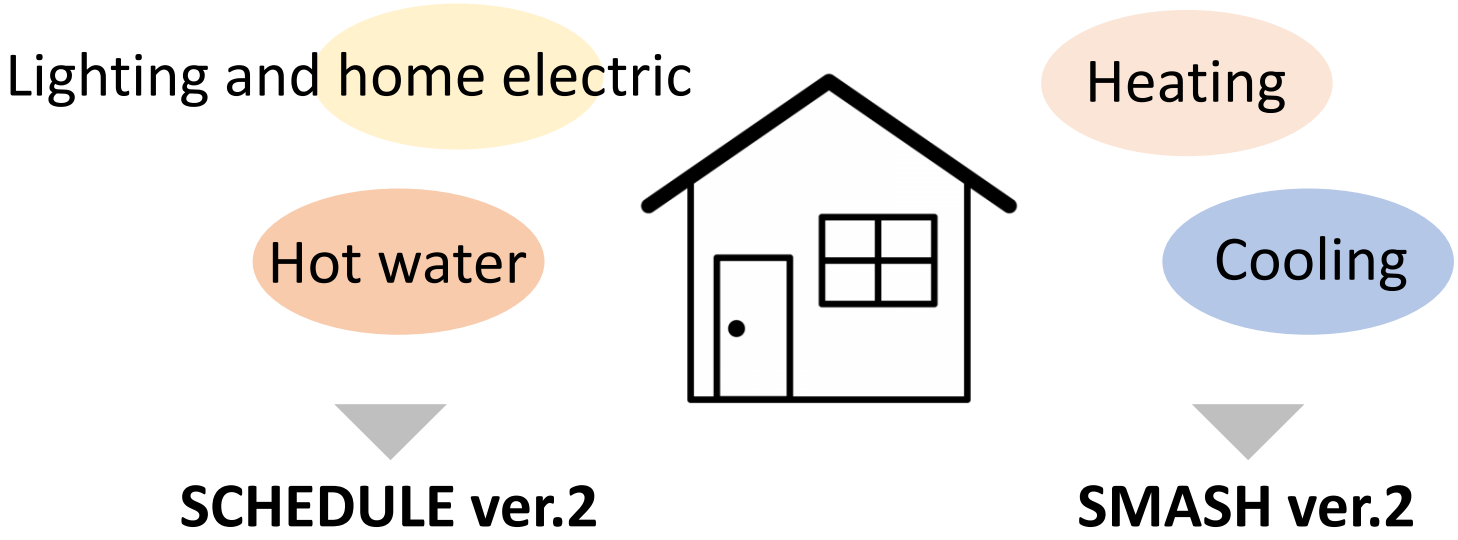
Woody biomass energy by pruning branches

Solar energy

Small hydropower generation

Overview

Estimates the unit value of energy consumption per house



Simulation tool	SCHEDULE ver.2	SMASH ver.2
Estimated load	**Lighting and home electric**	**Heating**
	Hot water	**Cooling**
Input condition	• Number of persons in a household • Population composition by age and gender • Weather data • House model	• Number of persons in a household • Weather data • House model • Thermal insulation levels of houses

* Setting conditions

Standard House Model by Architectural Institute of Japan

Extended AMeDAS weather data

Simulation tool	SCHEDULE ver.2	SMASH ver.2
Estimated load	Lighting and home electric	Heating
	Hot water	Cooling
Input condition	• Number of persons in a household • Population composition by age and gender • Weather data • House model	• Number of persons in a household • Weather data • House model • Thermal insulation levels of houses

Weighted mean in consideration of the ratio of household types

Simulation tool	SCHEDULE ver.2	SMASH ver.2
Estimated load	**Lighting and home electric**	**Heating**
	Hot water	**Cooling**
Input condition	• Number of persons in a household • Population composition by age and gender • Weather data • House model	• Number of persons in a household • Weather data • House model • Thermal insulation levels of houses

▸ Lighting and home appliance electricity load (GJ/house/year)

attribute	0-69 years old		70- years old		Weighted mean
	female	male	female	Male	
Household by 1 person	17.46		16.60		17.01
Household by 2 person	14.95	11.37	14.98	11.69	13.40
Load (GJ/house/year)					**16.14**

▸ Hot water supply heat load (GJ/house/year)

attribute	male	female	Weighted mean
Household by 1 person	11.57		11.57
Household by 2 person	10.24	9.6	9.95
Load (GJ/house/year)			**11.18**

▸ Heating heat load (GJ/house/year)

attribute	No insulation	old	new	next	Weighted mean
Household by 1 person	11.23	5.99	4.19	2.77	8.64
Household by 2 person	10.91	5.68	3.9	2.52	8.33
Load (GJ/house/year)					**8.41**

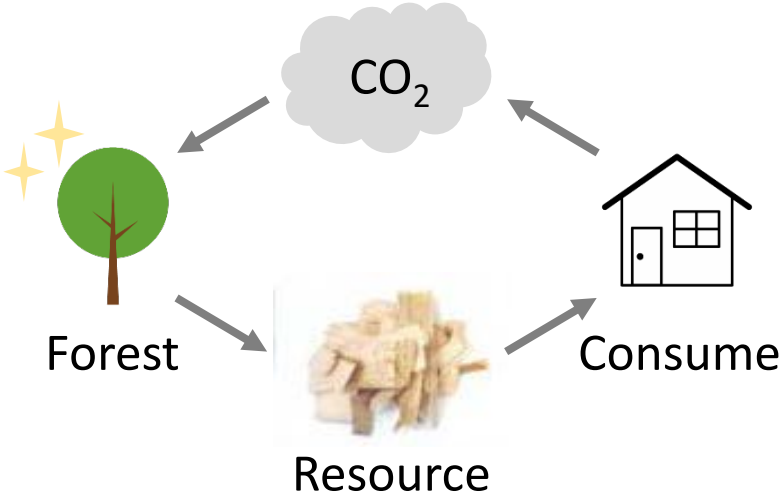
▸ Cooling electric load (GJ/house/year)

attribute	No insulation	old	new	next	Weighted mean
Household by 1 person	2.10	2.11	2.18	2.30	2.13
Household by 2 person	2.21	2.24	2.33	2.45	2.26
Load (GJ/house/year)					**2.23**

Overview

Effect

Carbon neutral
Conservation of Satoyama

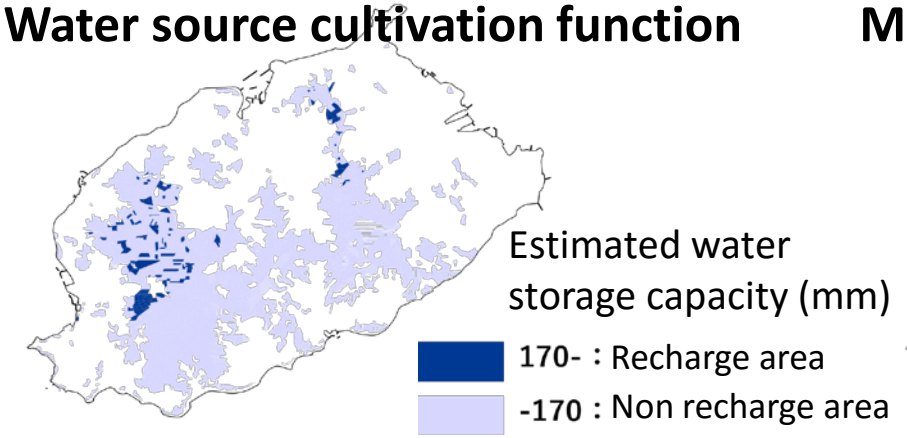


Vegetation distribution in Osakishimojima

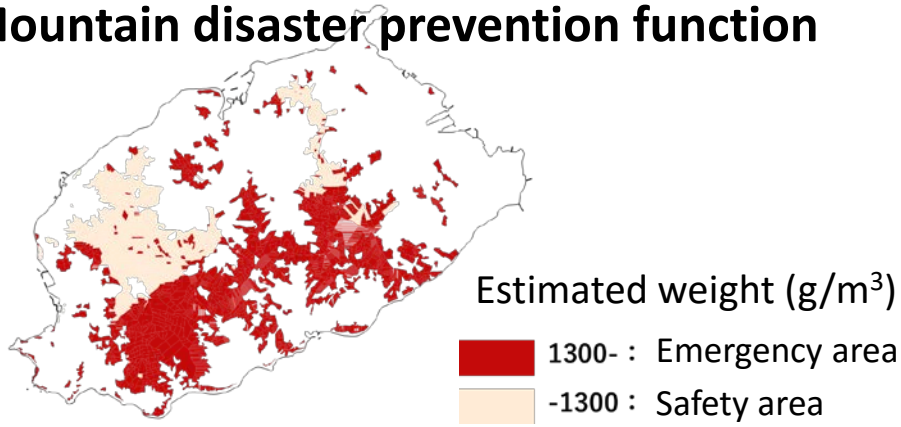
Estimates the supply potential of the broadleaf tree

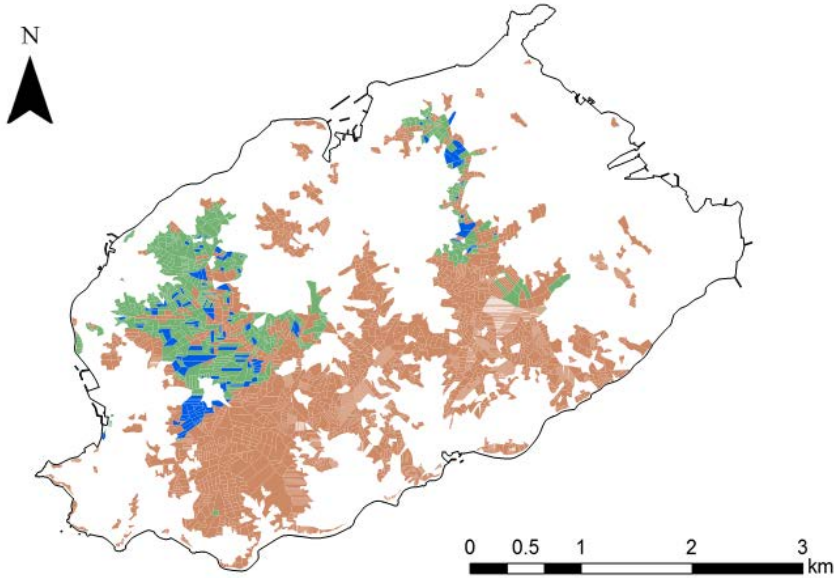
Creating of cutting strategy in consideration of multi function of forest

Water source cultivation function



Mountain disaster prevention function





Forest zoning	Cutting rate
Biomass production zone	100%
Soil conservation zone Water source cultivation zone	70%

Calculations

$$G_t = A/BC/DEF$$
$$= 579 \text{ (t/year)}$$

G_t	Annual available woody biomass quantity by forest utilization (t/year)
A	Total forest area of the zone to be logged (ha)
B	The age of the forest to be cleared (years)
C	Forest volume of logging forest (m^3)
D	Forest area of logging forests (ha)
E	Cut clearance rate (%)
F	Dry specific gravity of wood (0.6 t/m^3)

Pellet stoves

$$W_{tp} = G_t H_t I$$
$$= 6883 \text{ (GJ/year)}$$

W_{tp}	Available heat supply amount by using pellet stove (GJ/year)
H_t	Calorific value of hardwoods (18.017GJ/t)
I	Thermal efficiency of pellet stove (66%)

Gasification cogeneration

$$W_{th} = G_t H_t J$$
$$= 4172 \text{ (GJ/year)}$$

$$W_{te} = G_t H_t JK*0.8$$
$$= 667 \text{ (GJ/year)}$$

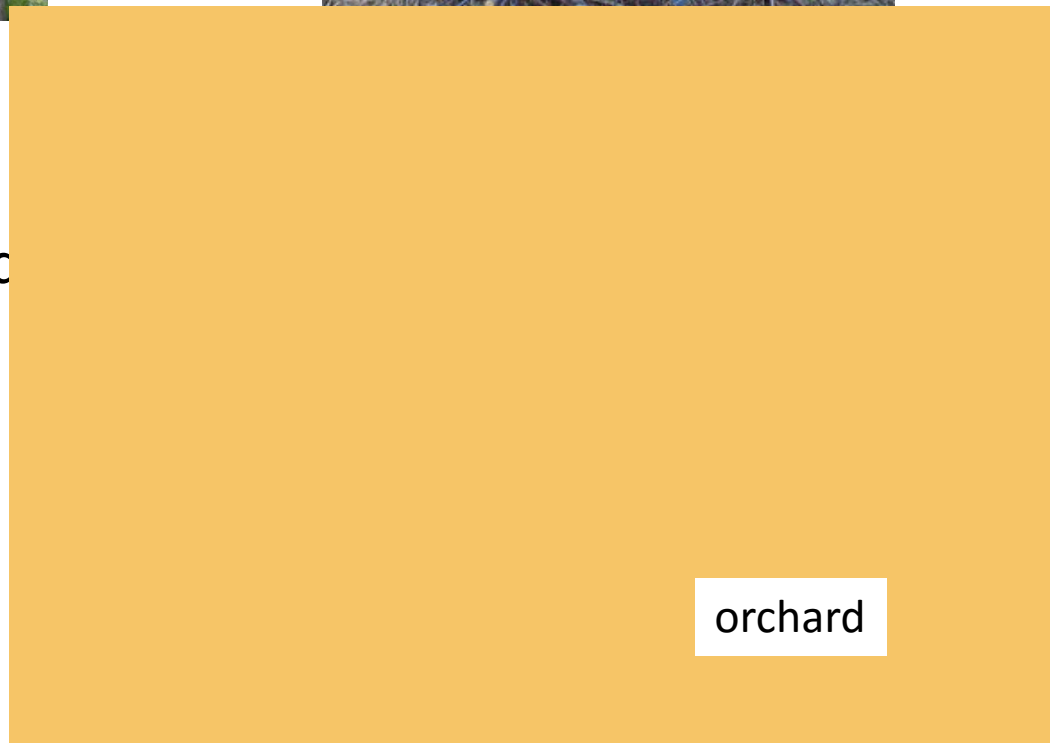
W_{th}	Available heat supply amount by cogeneration (GJ/year)
J	Thermal efficiency by gasification (40%)

W_{te}	Available electric power supply amount by cogeneration (GJ/year)
K	Power generation efficiency (20%)

4.2 Woody biomass energy by pruning branches

“Pruning branches” are branches discarded from the tree of the orchard

The location of orchard
in Osakishimojima



Calculations

$$G_p = LM$$
$$= 4055 \text{ (t/year)}$$

G_p	Annual available woody biomass quantity (t/year)
L	Orchard area (ha)
M	Pruned branch of oranges per unit of discharge (t/ha/year)

M=4.1 (Sano et al., 2003)

Pellet stoves

$$W_{pp} = G_p H_p IN$$
$$= 16255 \text{ (GJ/year)}$$

W_{pp}	Available heat supply amount by pellet stove (GJ / year)
H_p	Calorific value of pruned branch (7.95 GJ/t)
N	Availability rate of pruned branch (76.4%)

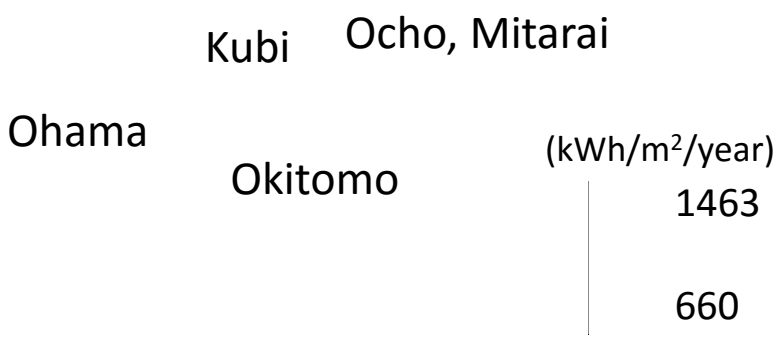
Gasification cogeneration

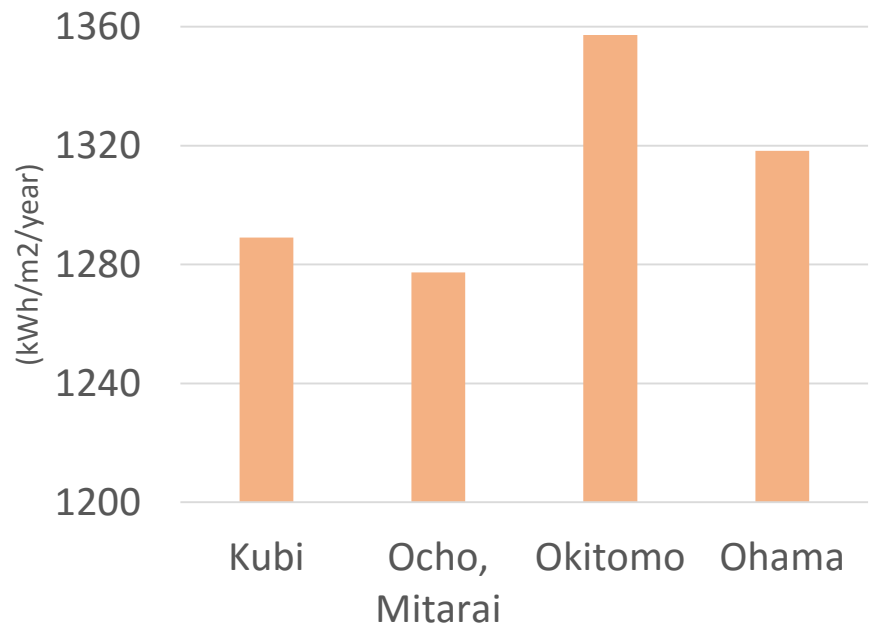
$$W_{ph} = G_p H_p JN$$
$$= 9851 \text{ (GJ/year)}$$

$$W_{pe} = G_p H_p JKN*0.8$$
$$= 1576 \text{ (GJ/year)}$$

W_{ph}	Available heat supply amount by cogeneration (GJ / year)
W_{pe}	Available electric power supply amount by cogeneration (GJ/year)

Amount of solar radiation each area



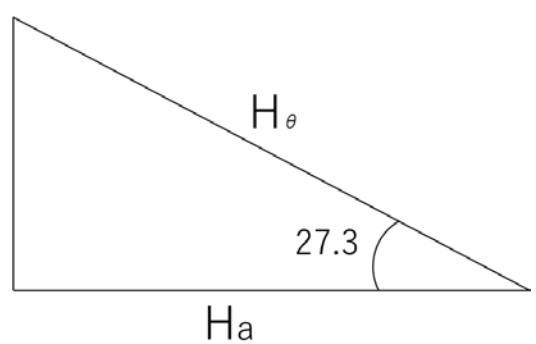


Average solar radiation of optimum inclination angle

$$H_\theta = H_a / \cos\theta$$

θ : Optimum inclination angle

H_a : Average solar radiation (kWh/m²/year)



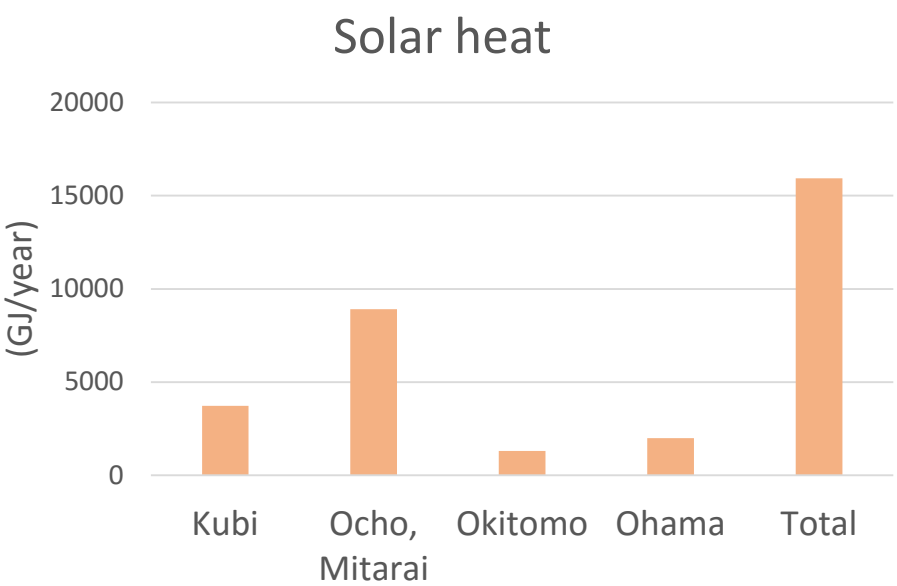
Calculations

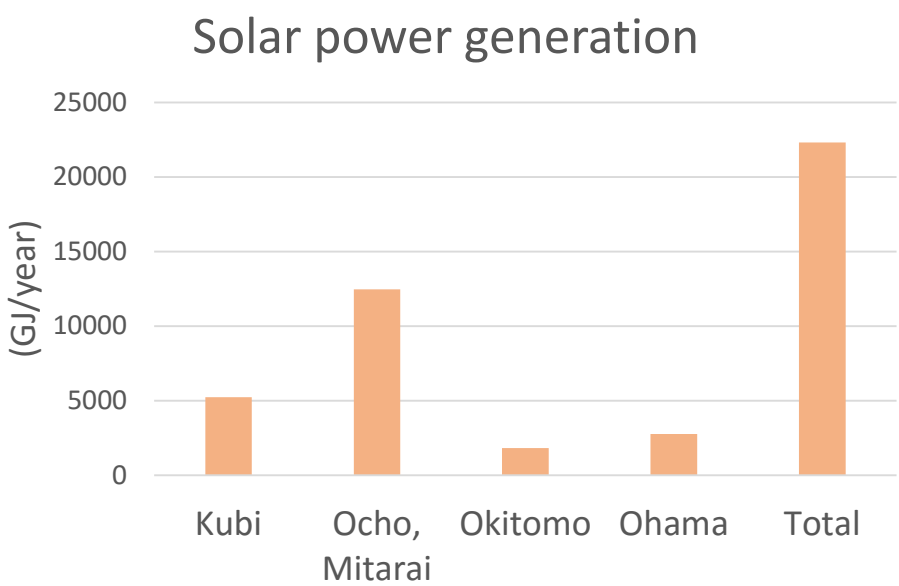
$$E_H = A_S H_\theta a * 3.6/1000$$

E_H	Available heat supply by using solar heat (GJ/year/house)
A_h	Solar collector area (40m^2)
a	Heat collecting efficiency of solar heat (0.4)

$$E_S = A_S H_\theta b * 3.6/1000$$

E_S	Electricity supply potential by solar power generation (GJ/year/house)
A_S	Solar panel area (6m^2)
b	Overall efficiency by solar power generation (0.084)





A river is extracted

using the hydrological analysis tool of GIS

Flow rate (m^3/s)

Head difference (m)

0

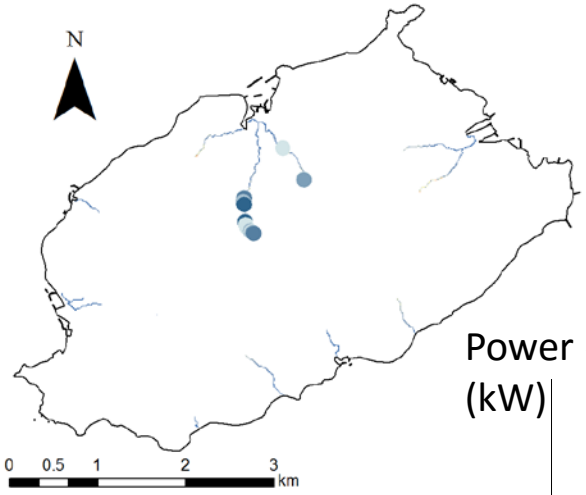
27

0

The power generation potentials

$$P = 9.8*QHc/1000$$

P	Power generation by small hydropower (kW)
Q	Flow rate (m^3/s)
H	Heading difference (m)
c	Overall efficiency of small hydropower generation (0.72)



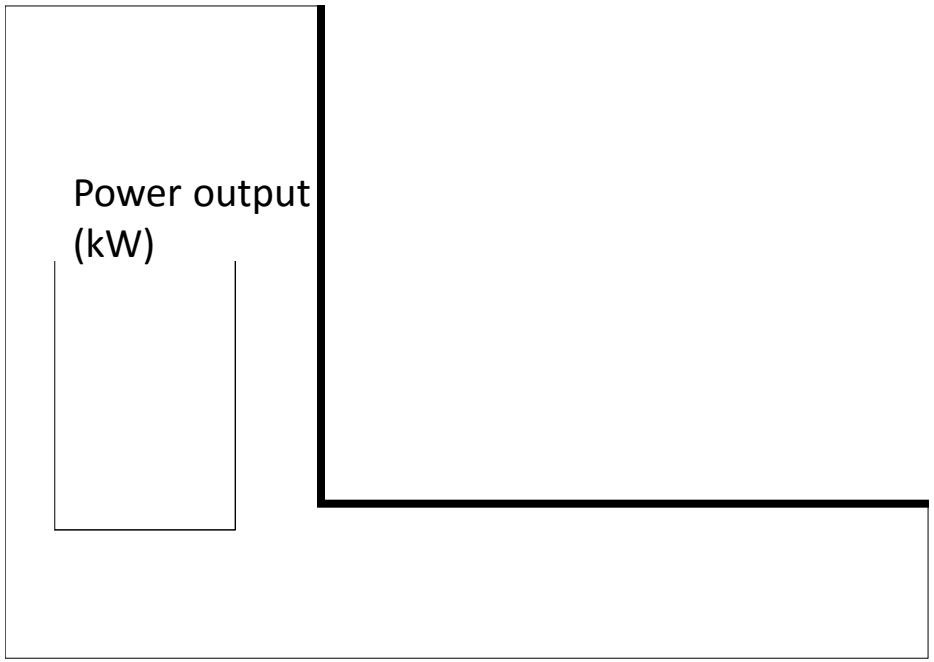
Power output (kW)

Sites where the output is 20 kW or more are selected

Calculations

$$E_{pm} = Pd*8640*3.6/1000$$

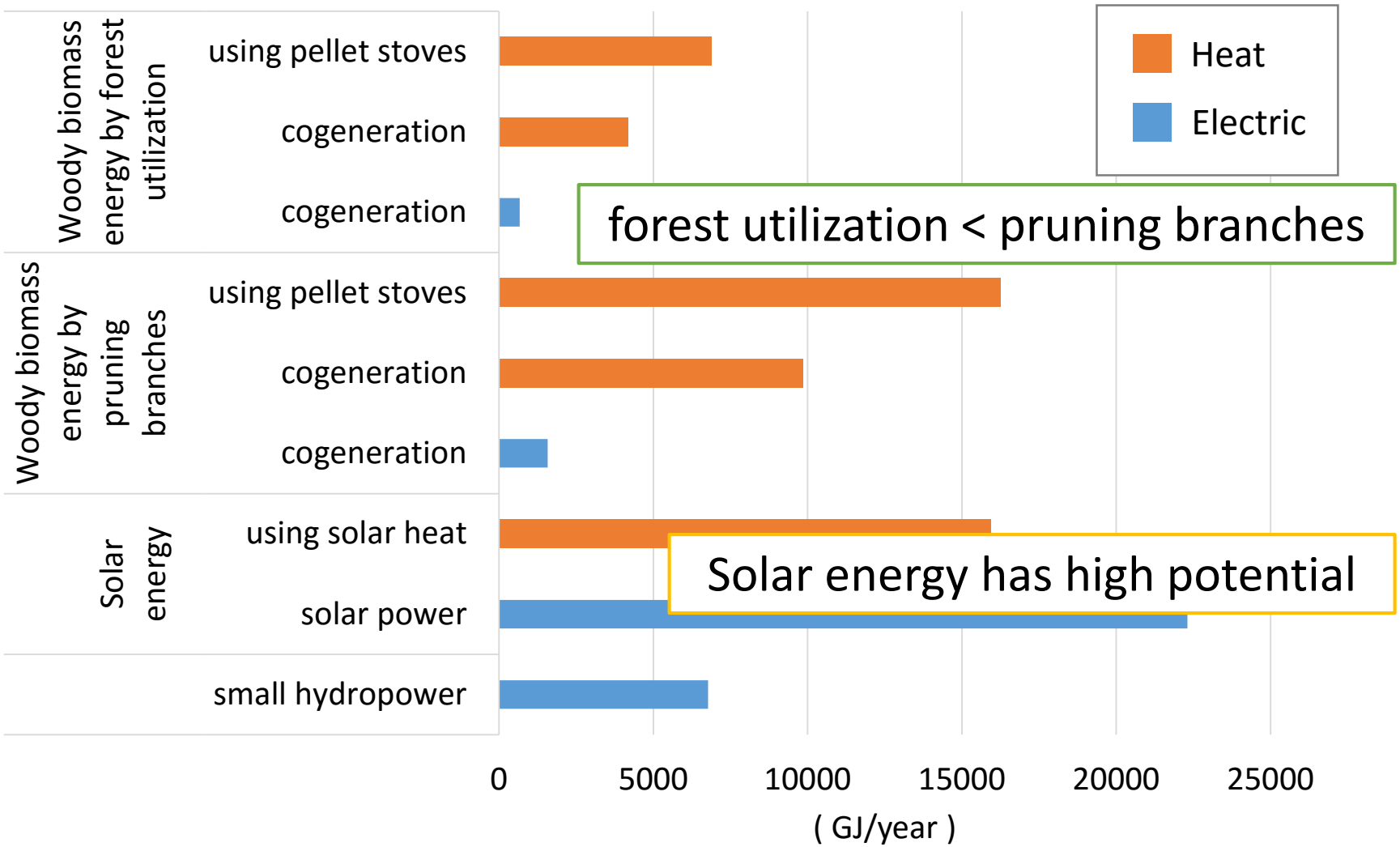
E_{pm}	Annual power generation capacity (GJ / year)
d	Facility utilization of small hydropower generation (55%)



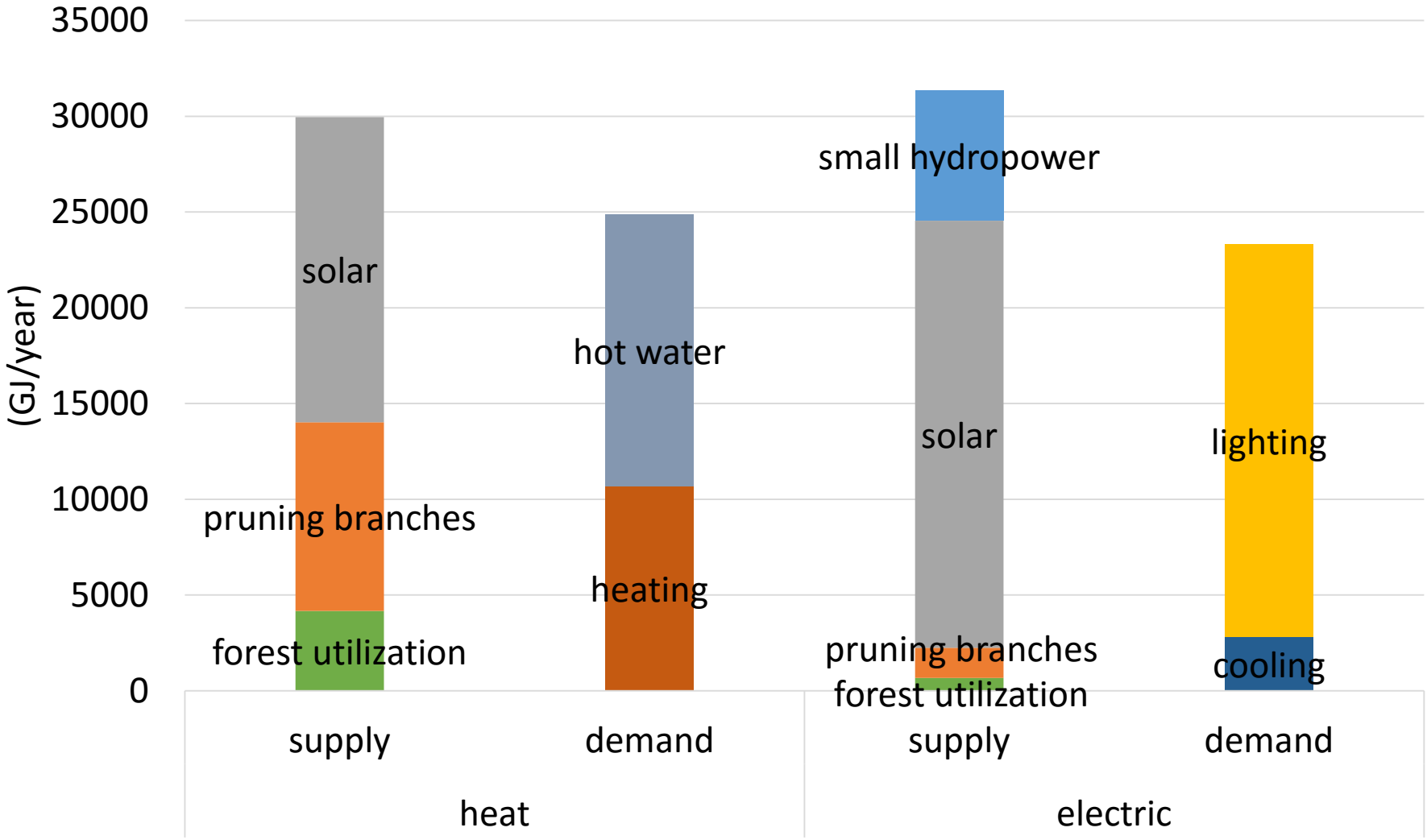
Sites where a power generation can provaide 20kW or more

Sites	Output(kW)	Annual power generation capacity (GJ/year)
1	20.25	346.46
2	20.71	354.30
3	25.63	438.41
4	22.06	377.34
5	28.43	486.41
6	23.43	400.77
7	23.35	399.39
8	35.16	601.46
9	24.07	411.77
10	32.95	563.64
11	20.84	356.44
12	21.12	361.25
13	23.09	395.01
14	21.39	366.01
15	25.26	432.15
16	28.21	482.63
Amount		**6773.44**

Overview



Renewable energy considered remarkable local characteristic is promising

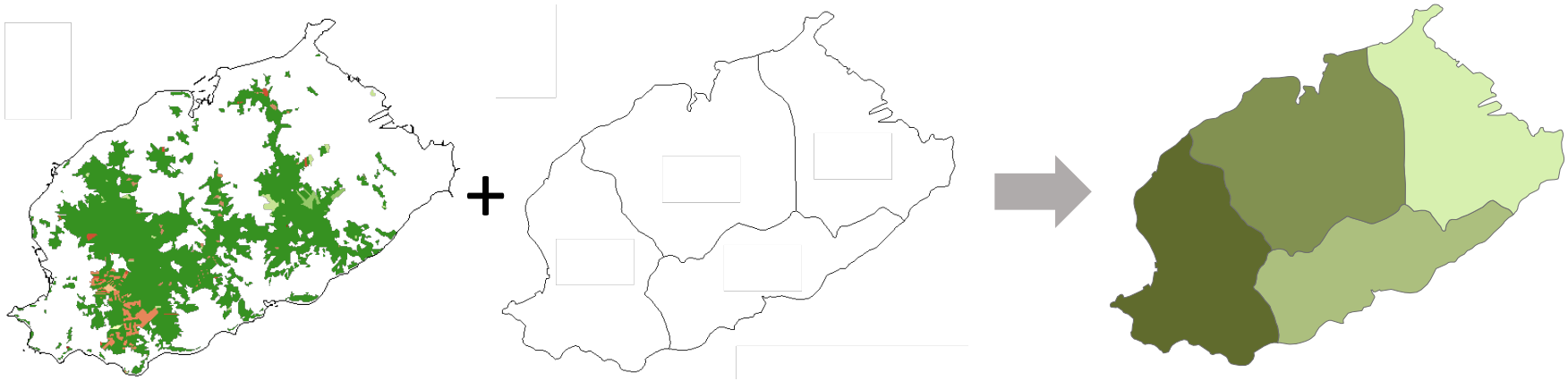


Energy independence in target island is feasible

Overview

6. Renewable energy utilization recommended map

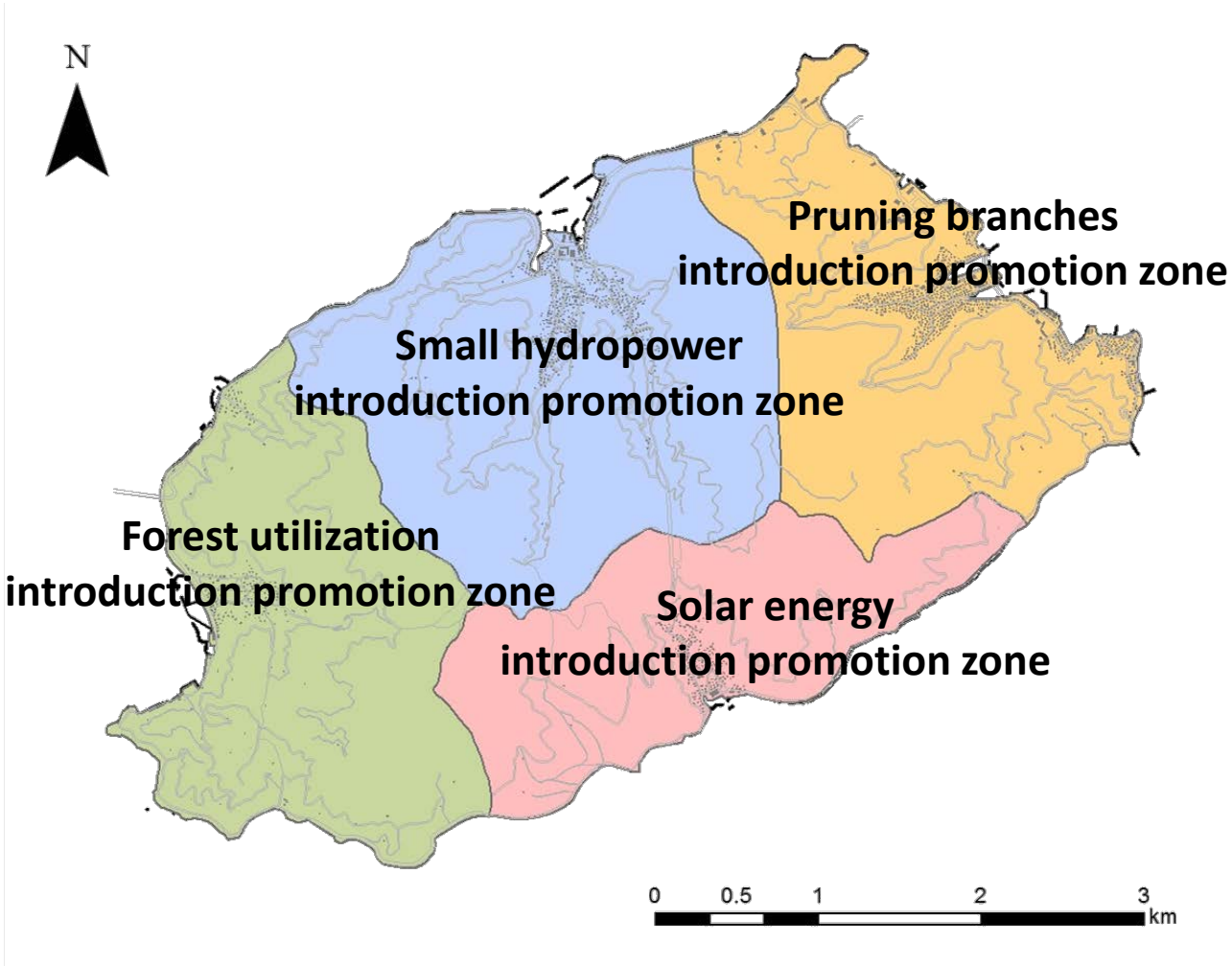
Potential quantity of each energy evaluated in each district, and promising areas is extracted.



Potential quantity　　Each district　　Quantification

Renewable energy	Evaluated potential quantity
Woody biomass energy by forest utilization	· Forest area (ha) · Percentage of biomass production zone in forest zoning (%)
Woody biomass energy by pruning branches	· Percentage of orchard area to district area (%) · Thermal load (GJ / year)
Solar energy	· Average solar radiation in residential area (kWh / ㎡) · Average amount of solar radiation throughout the district (kWh / ㎡)
Small hydropower generation	・Sites where the power output is 20 kW or more (sites)

6. Renewable energy utilization recommended map



This map makes it possible to grasp renewable energy suitable for each district, and it is expected to be a guideline for the introduction of regional renewable energy business.

Overview

Findings

- Target island has high potential of renewable energy considering local characteristics.
- Energy independence is feasible by using renewable energy in the target island.
- Grasping the promising potential by using renewable energy in each district, renewable energy utilization policy map is created.

Future works

- To consider about renewable energy use in islands including the other aspects such as an economic, environment, resident’s intention, and so on.

Thank you for your kind attention