Analysis of CO_2 emission reduction scenario in the municipal scale focusing on biomass energy: A case of Maniwa, Okayama, Japan

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Introduction

- After the Paris Agreement, the number of municipalities declaring net-zero emissions has been increasing.
- Municipality-level emission reduction scenarios favor the use of local energy resources, such as biomass.
- It is desirable to implement scenario analysis to present a future energy system that achieves net-zero emissions while taking into account the constraints of the energy resource potentials of the municipality.

Methods

Target Region

Name: Maniwa Okayama, Japan
Population: 44,529 **Area:** 828km^2
Features: SDGs Future City (2018~),
Biomass Industrial Community (2013~)
Biomass Power Plant (10MW, 2015~)

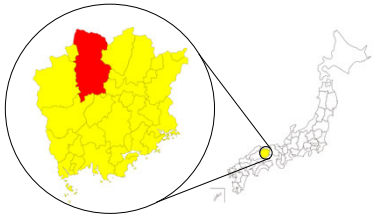

Figure 1. Location of Maniwa, Okayama, Japan

Data collection

# of Household: National Institute of Population and Social Security Research
Final Energy Consumption: Agency for Natural Resources and Energy
The municipal values were derived by scaling the prefectural values based on the relevant indexes.
Renewable Energy Potential: Renewable Energy Potential System (Solar, small Hydro)
Own estimation by local government (Biomass)
Renewable Energy Stock: Agency for Natural Resources and Energy

AIM / Enduse [Local] [1)]

Spatial resolution: 1 region (Maniwa city), **Time resolution:** 1 (Yearly)
Optimization: dynamic recursive optimization,
Sector: manufacturing, construction, transport, residential, commercial, agriculture, power (local)
Objective function: minimizing total system cost (TC)

$$TC = \sum_{m} \left(TINV_{m,t} + TVOM_{m,t} + TVAR_{m,t} \right) \quad (1)$$

where,
m: index for technology, t: index for analytical year (2015, 2020, ..., 2050)
TINV: annual investment cost, TVOM: annual operation & maintenance cost,
TVAR: annual fuel cost

Scenario

CO_2 targets: no policy, x% reduction compared to 2015 level (x = 70, 75, …, 100)
Biomass energy use in industrial sector: status quo, expansion, maximize
expansion case: fuels for boiler, CHP, and diesel-powered generation can be replaced by biomass
maximize case: expansion + direct combustion including material use can be replaced by biomass
Fuel price: IEEJ (current price for non-household sector),
EnviroLife Research Institute (current price for household sector),
IEA (future energy price), own estimation by local government (biomass energy price)

Results and Discussion

Energy balances in Maniwa in 2015

- Manufacturing sector accounts 54% of final energy consumption

Reference scenario

- Even without emission target, CO_2 emission were decreased by 58% from 2015 levels due to population decrease.

Policy scenario

- By expanding the biomass use in the industrial sector, an 85% reduction of CO_2 emissions were available in Maniwa in 2050.
- Emission reduction measures include installing biomass power plants and residential solar PVs, increasing biomass and LP gas use in the industrial sector, and promoting the use of EVs in the transport sector.

Net-zero scenario

- Net zero can be achieved by maximizing biomass use in hard-to-abate sectors, but the feasibility is questionable.

Table 1. Energy balances in Maniwa in 2015 [unit: TJ]

	Oil	Coal	City gas	LP gas	Biomass	Electricity	Heat	Total
Agriculture	298	0	0	0	0	17	0	316
Construction	57	0	1	0	0	12	0	70
Manufacturing	569	525	97	31	63	390	16	1,691
Household	85	0	0	137	11	343	0	577
Commercial	99	10	0	24	10	306	1	449
Transport	1,312	0	0	0	0	0	0	1,312
Total	2,421	535	98	192	84	1,068	17	4,415

Table 2. Results of each scenario run

CO_2 targets	Biomass energy use in industrial sector: status quo	expansion	maximization
no policy	✓ **Reference scenario**		
70%	✓	✓	✓
75%	✓	✓	✓
80%	✓	✓	✓
85%	*infeasible*	✓ **Policy scenario**	✓
90%	*infeasible*	*infeasible*	✓
95%	*infeasible*	*infeasible*	✓
100%	*infeasible*	*infeasible*	✓ **Net-zero scenario**

Among the scenarios that is feasible (✓), three scenarios were selected and analyzed in detail as representative scenarios (Figure 2).

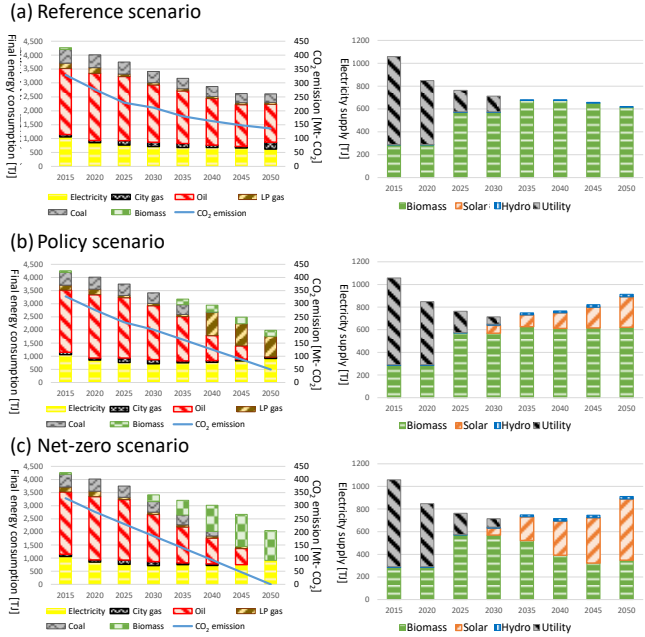

Figure 2. Energy composition in Maniwa

Asia-Pacific Integrated Model
http://www-iam.nies.go.jp/aim

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1) Shiraki, H. and Asina, S.: Scenario analysis of Low-carbon-society in municipal scale and its regional comparison, The 31th Proceedings of the Conference on Energy, Economy, and Environment, 24-2 , 2015.