

Research Activities on Local Decarbonization in Japan: Progress and Way Forward

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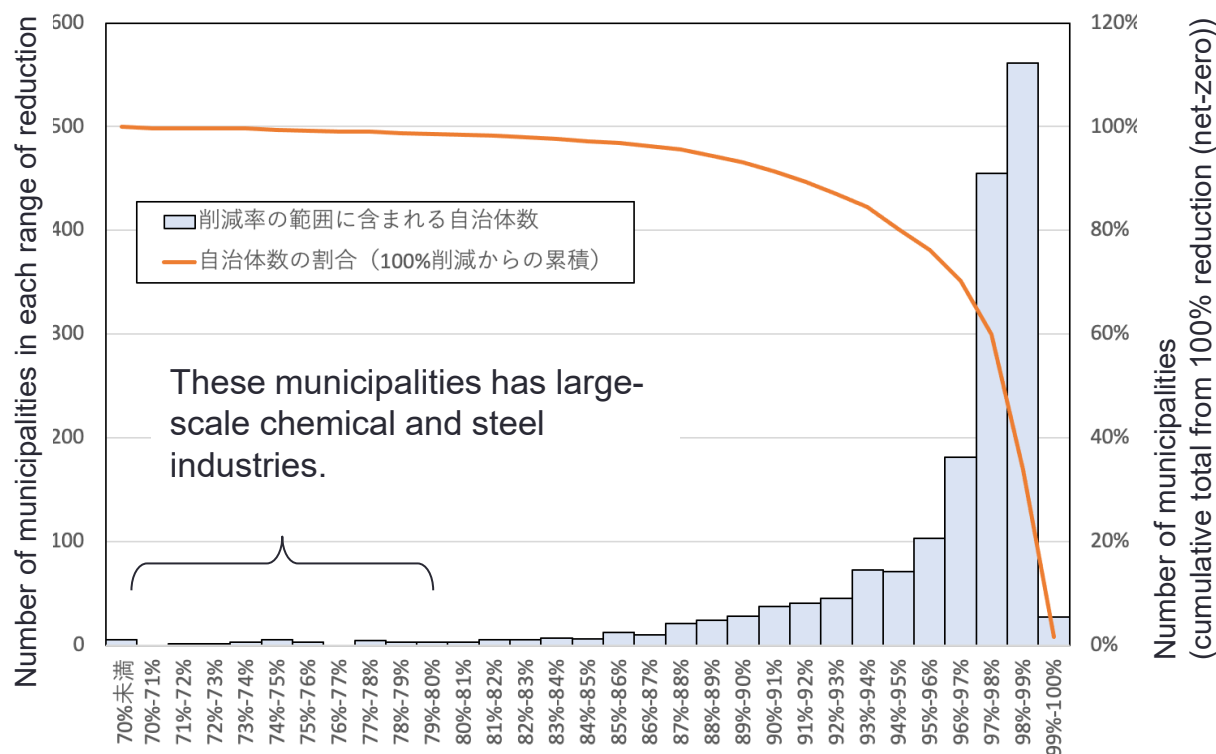
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The presentation includes research outcomes by Environment Research and Technology Development Fund (ERTDF, 1-2003, 1-2305) of Environmental Restoration and Conservation Agency and Ministry of the Environment, Japan, Decarbonized and Sustainable Society Research Program and Co-design Approach for Local Sustainability Research Program (Co-SUS) of NIES, and “Development of Regional Planning System of Green Innovation for a Decarbonized Society and Establishment of Social Implementation Network through Regional Coalition Action” of Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan.

Feasibility Study of a Carbon Neutral Society in 2050

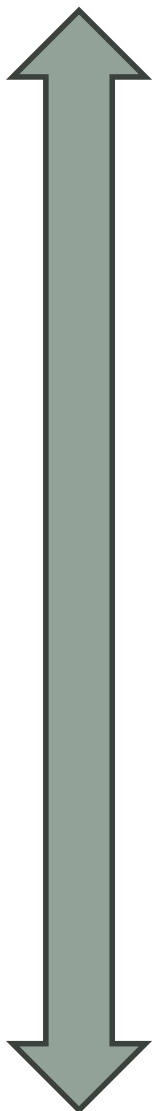
- We have developed **simple but AIM/Enduse-like model**, and applied to feasibility study of net-zero for all municipalities in Japan.
- Taking measures set in AIM's net-zero scenario for Japan, **more than 90% of municipalities will achieve a CO₂ reduction over 90%** from 2013 level.

From presentation in the 28th AIM Int'l WS



Research Progress in the year 2023

Supply



- Estimation of **renewable energy potential in consideration of degradation of biodiversity**

- Design of interregional **transmission network of renewable energies** among country

- **Pathways toward Local Decarbonization** in Japan

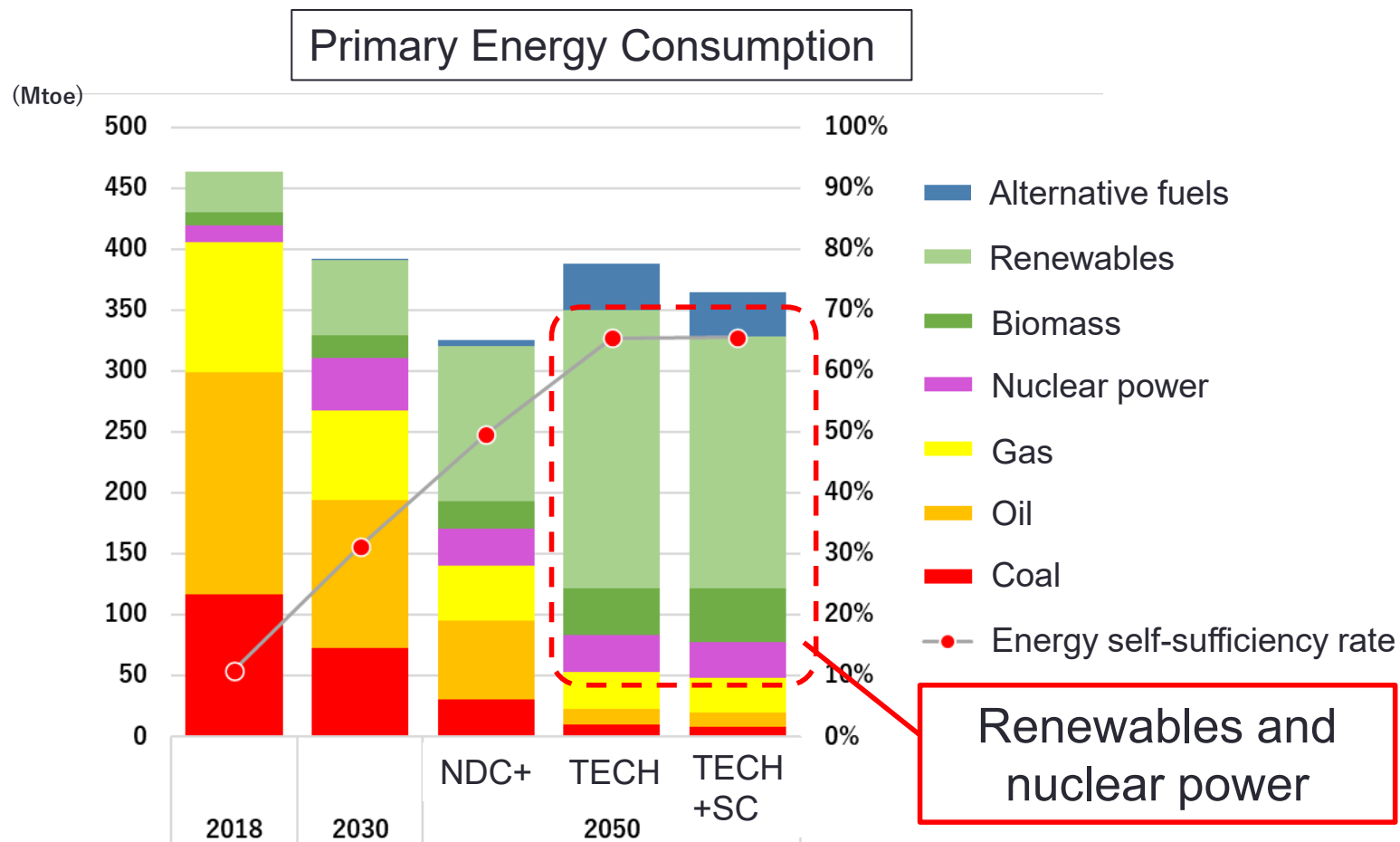
- **Application of Artificial Intelligence (AI) and Machine Learning (ML)** to analysis of electricity consumption data

- Development of **electricity monitoring and power billing system in NIES**

Demand

Decarbonization requires large penetration of renewables

- Net-zero emissions in Japan require a major shift from fossil fuels, currently 80% of primary energy supply, **to decarbonized energy, especially to renewable energy of ~70% by 2050.**



Conflicts between renewables and local communities

- Large-scale renewable penetration may **cause conflicts with local communities** – cause of mudslides, birds/bats and wind turbines, and degradation of natural resources.

Mudslides and PVs



↑ 土砂崩れ被害

PVs on Wetlands in Hokkaido



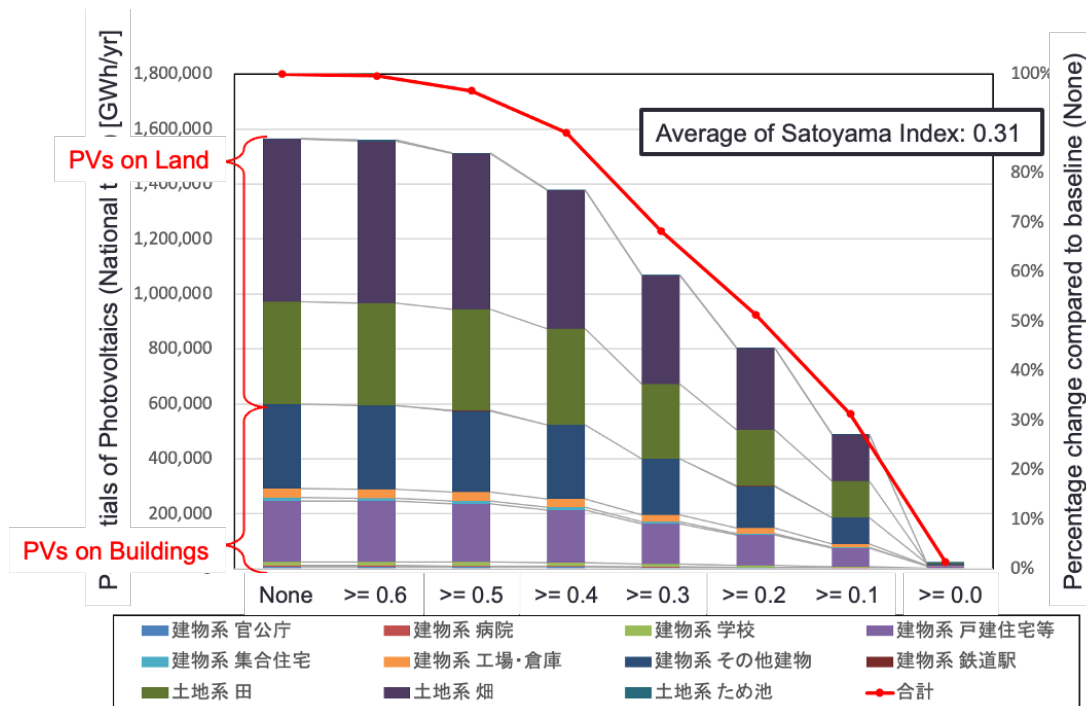
Source: Ministry of Economy, Trade and Industry (METI),
https://www.meti.go.jp/shingikai/sankoshin/hoan_shohi/denryoku_anzen/newenergy_hatsuden_wg/pdf/014_01_00.pdf

Source: https://kumamori.org/topics/kumamori-news/20221223_1.html

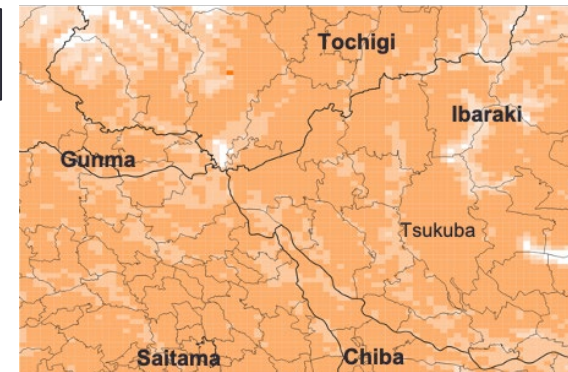
Protection of biodiversity and renewable potentials

- **Satoyama Index (SI)*** is used as a level of biodiversity. High SI means the area has high heterogeneity of land use.
- **Exclude points with a SI value of 0.3 or higher** will reduce the total potential to 1,070 TWh, **around 70% of baseline case.**

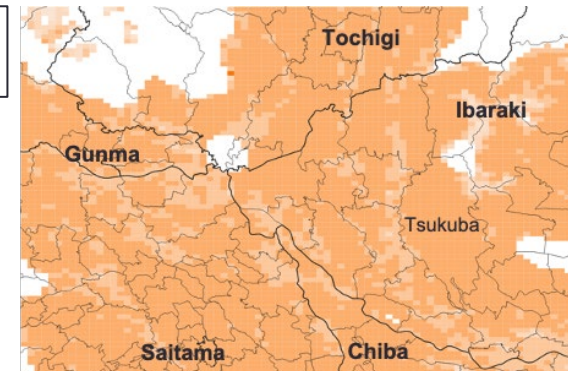
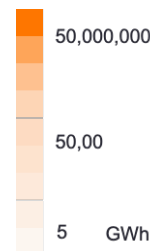
Changes in PV potentials (Total over Japan, GWh/yr)



Baseline
(None)



Excludes
SI >= 0.3



*More detailed about Satoyama Index:

Yoshioka, A., Kadoya, T., Imai, J., and Washitani, I. (2013) Overview of landuse pattern of Japanese Archipelago with biodiversity-conscious landuse classification and Satoyama Index. Japanese Journal of Conservation Ecology 18:141-156
Kadoya T., and Washitani I. (2011) The Satoyama Index: a biodiversity indicator for agricultural landscapes. Agriculture, Ecosystems and Environment, 140: 20-26.

Simplified Excel Tool for Local Decarbonization Scenario

- **Simplified excel tool** is developed for local decarbonization scenario analysis **assuming use by officials and policymakers.**
- The tool applied to all (1,741) municipalities in Japan.

Snapshots of the tool (for Tsukuba city)

Calculation flow in the tool

Energy balance table
(baseyear, by municipality)

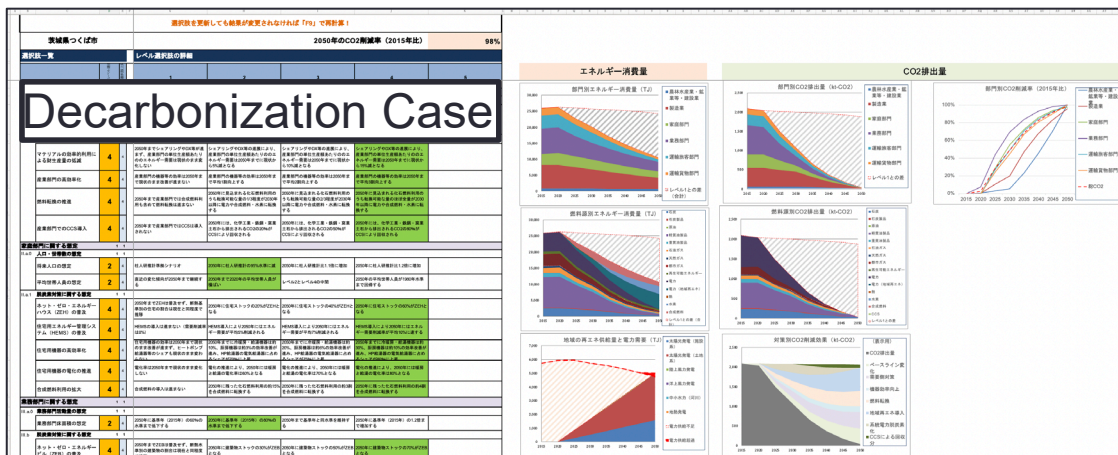
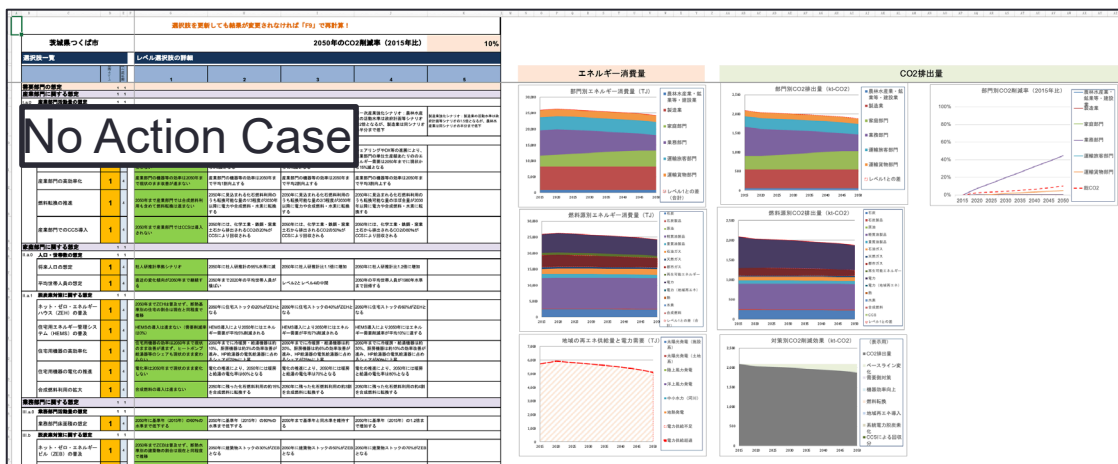
(1) Baseline change
(Only includes socio-economic changes)

(2) Demand Reductions
(Lifestyle changes etc)

(3) Efficiency Improvement
(Installation of EE technologies)

(4) Fuel shifts in demand side
(Electrification, alternative fuels)

(5) Fuel shifts in supply side
(Renewables, alternative fuels)

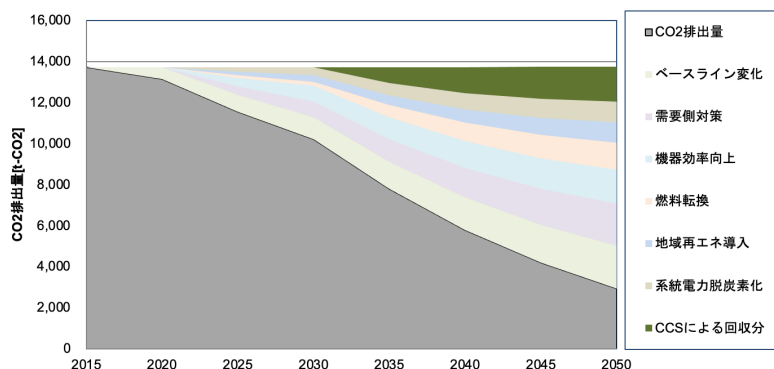


Example of Pathways toward Local Decarbonization

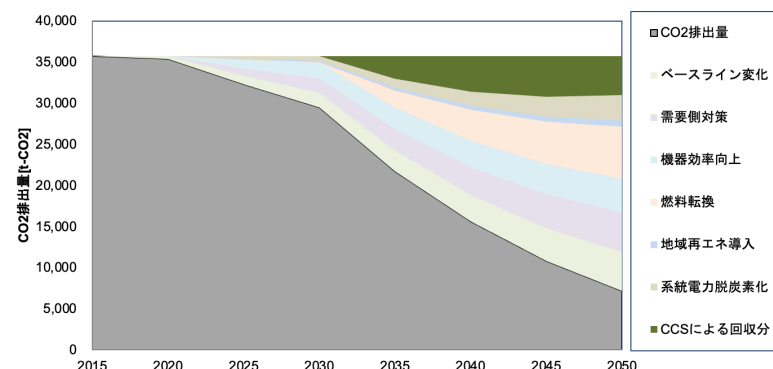
- Taking actions set in AIM's net-zero scenario for Japan, many municipalities will reach over 90% reduction of CO₂ emissions, but **pathways and contributions by actions differ area by area.**

Example of results derived from the developed tool

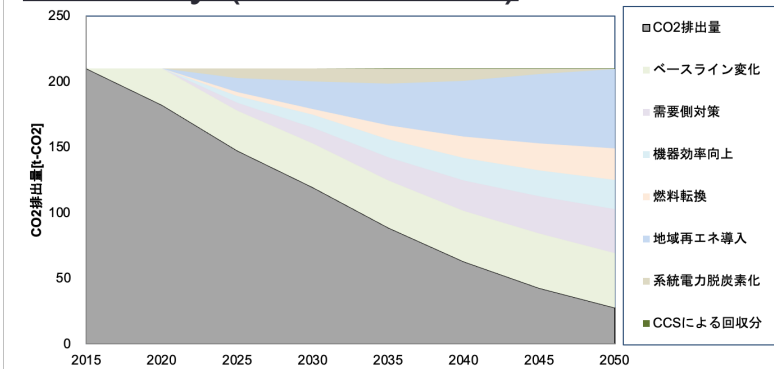
Kita-kyushu city (Industrial area)



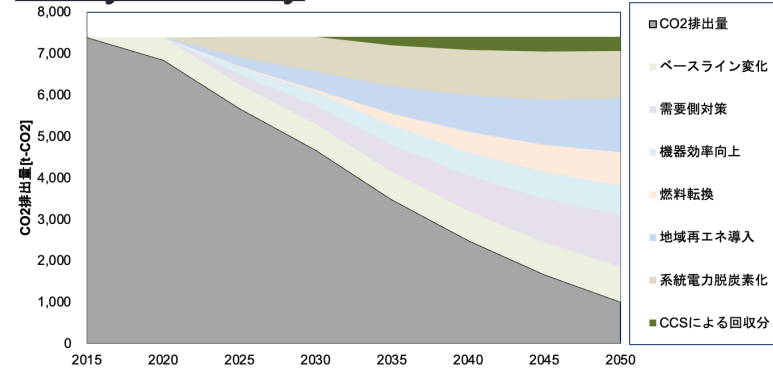
Kurashiki city (Industrial area)



Goto city (Islands area)



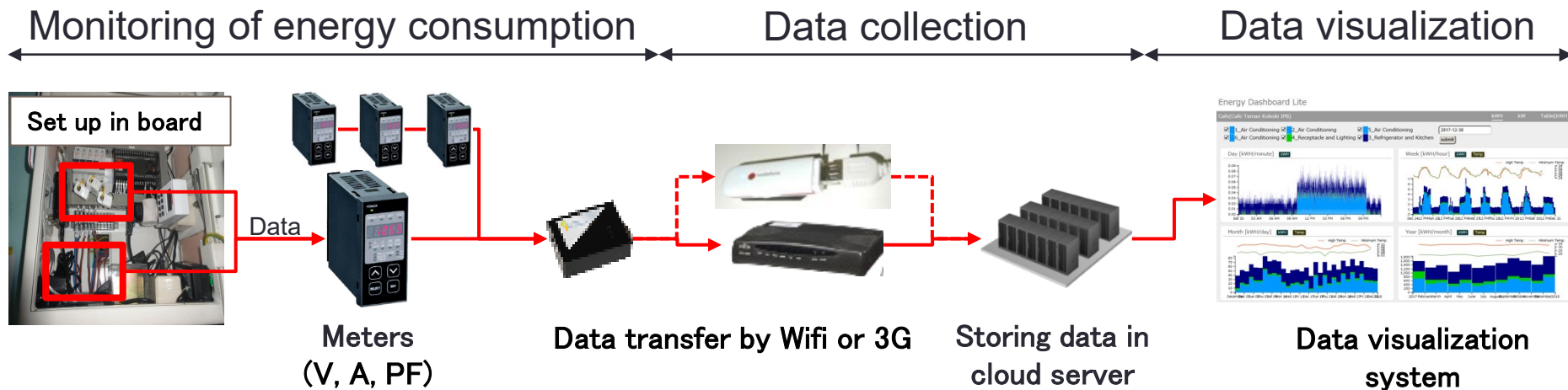
Okayama city



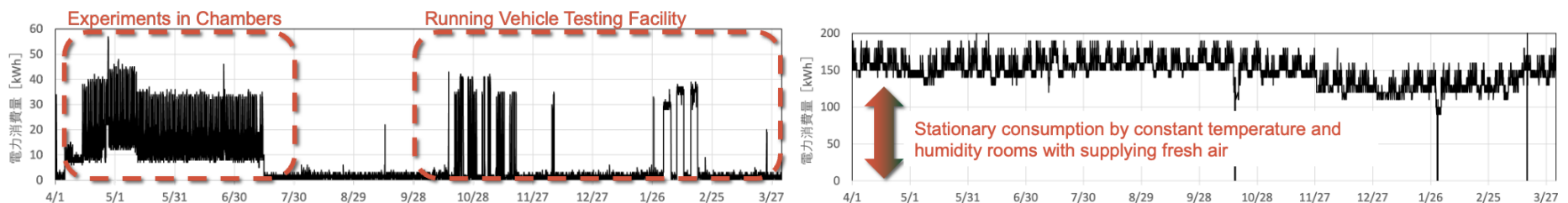
Monitoring of Electricity Consumptions

- NIES set up electricity monitoring system in NIES, Shinchichi town in Fukushima Prefecture, and Bogor (joint work with IPB team).
- We have around **90 mil. data for Shinchichi town (FY2012-), 330 mil. data for Bogor, 50 mil. data for NIES (FY2009-).**

Typical Configuration of Energy Monitoring System



Examples of Monitoring data (case of NIES)

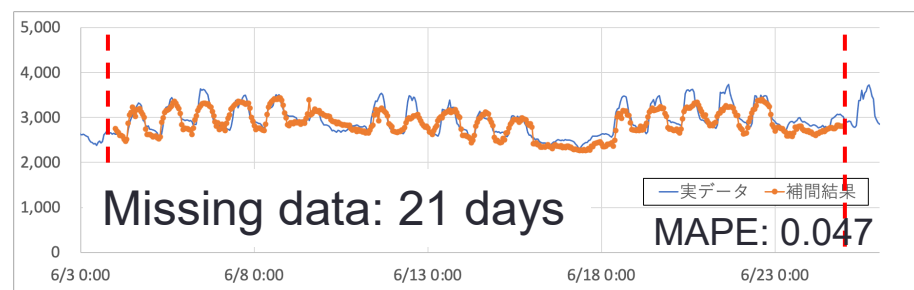
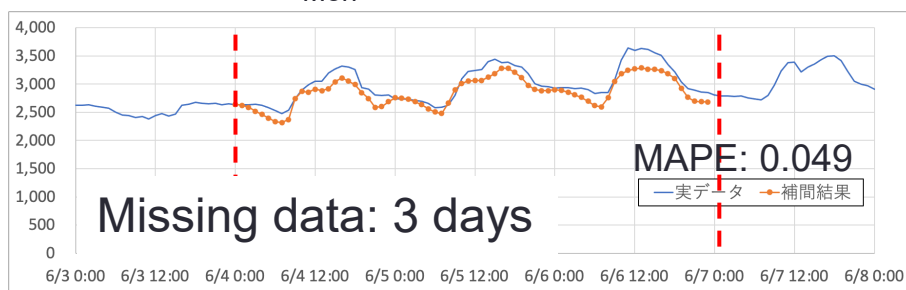
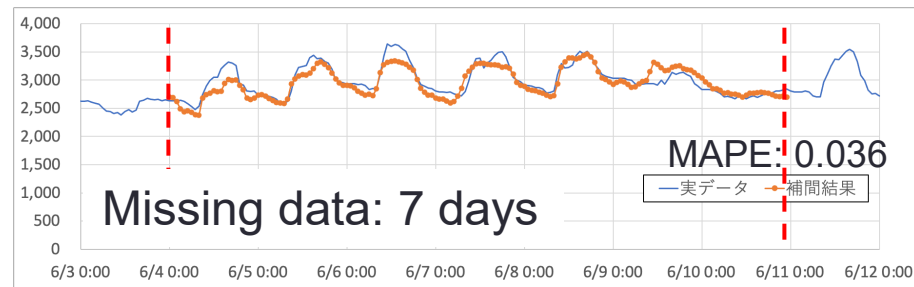
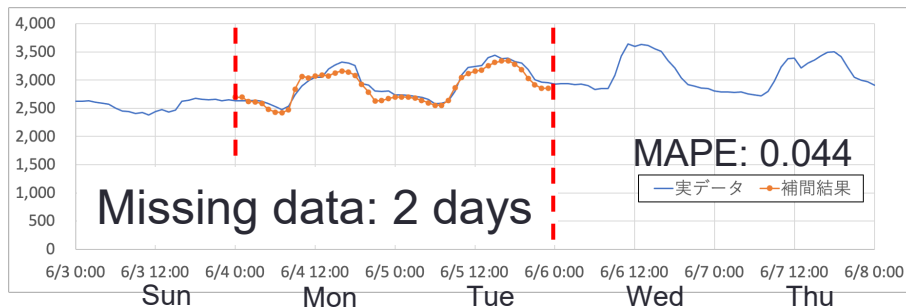


Application of AI/ML: Interpolation of missing data

- Numerical experiment is conducted for interpolation of monitoring data by using AI/ML.
- **Short-term reproducibility is relatively high**, but generally smooth results.
- Random and high power consumption factors (large facility operations) seem not be captured well.

Results of numerical experiment of data interpolation with NIES data

Explanatory variables: date, holiday dummy, temperature, humidity, rain falls, solar radiation, wind speed, discomfort index

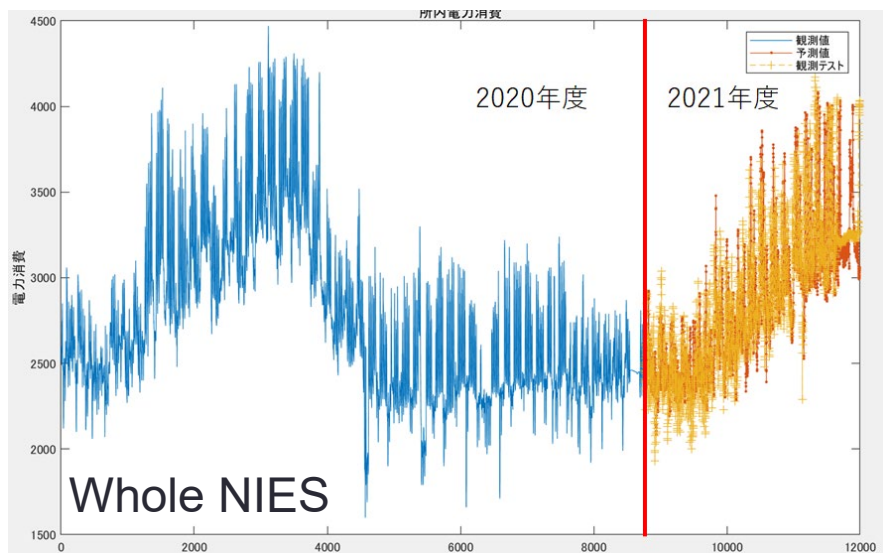


MAPE: Mean Absolute Percentage Error

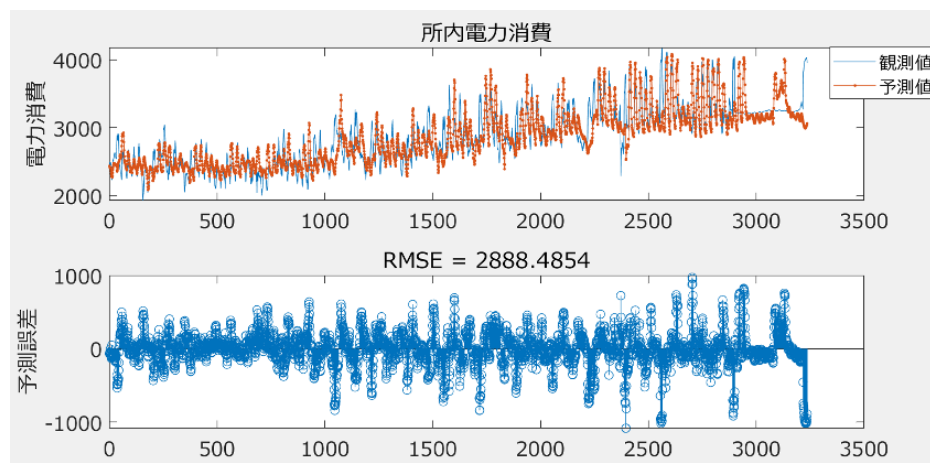
Application of AI/ML: Forecast of future consumptions

- We constructed an **LSTM*-based electricity consumption forecasting model**, using FY2020 data of NIES as a training set; Numerical experiments are conducted to forecast electricity consumptions in FY2021.
- Results seem to show a similar trend of actual situation.
- We will develop a methodology and **try to identify effects of energy saving actions by using monitoring data**.

Results of numerical experiment



Impacts of forecasting period and RMSE**



**RMSE: Root Mean Squared Error

*LSTM: Long Short-Term Memory, a kind of Recurrent Neural Network (RNN)