

Netherlands-Japan Horticulture Webinar

Sustainable and profitable greenhouse business:

Potential of Regional Horticultural Clusters and Opportunities for Japan-Netherlands Cooperation

Thu 12 October 2023

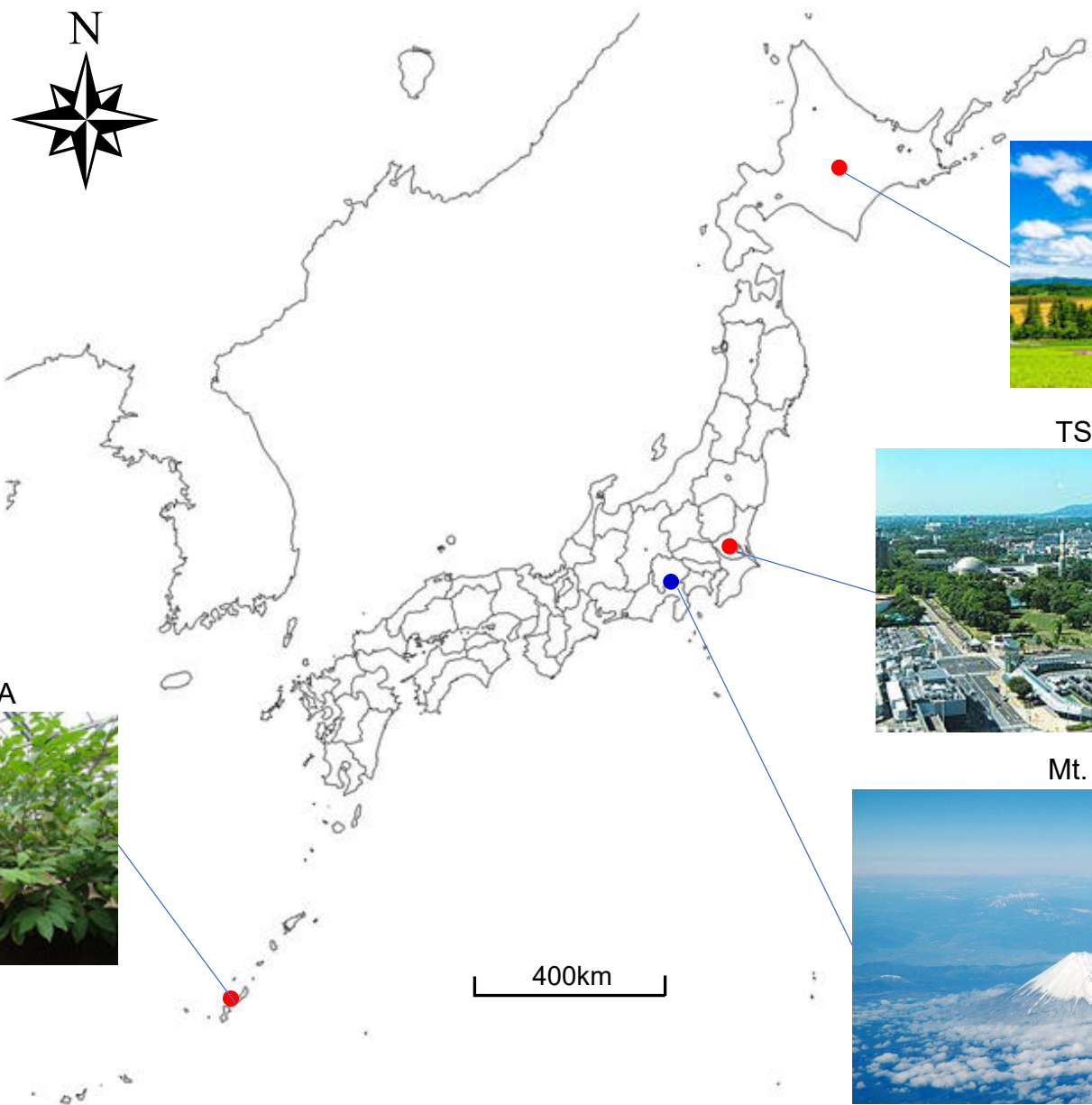
Research and Development of Village Energy Management System (VEMS) and Net Zero Energy Greenhouse (ZEG) for Carbon Neutrality in Rural Area

**Institute for Rural Engineering,
National Agricultural and Food Research
Organization (NARO)
Masahisa Ishii, Ph.D.**

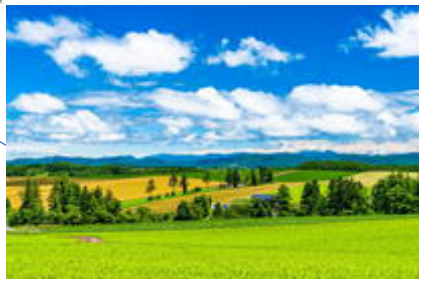
Research and development projects being carried out by the National Agriculture and Food Research Organization (NARO)

- 1. Development of village energy management system (VEMS) to contribute RE100 in rural areas**
- 2. Pilot research project for realization of decarbonized agriculture.**
- 3. Development and demonstration of a net zero energy greenhouse (ZEG) for contributes to the decarbonization of horticulture.**

Geographical Location within Japan



HOKKAIDO



TSUKUBA



Mt. Fuji



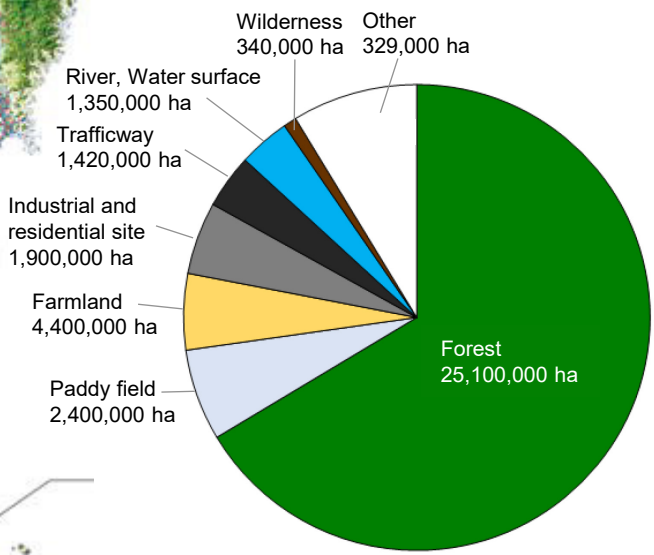
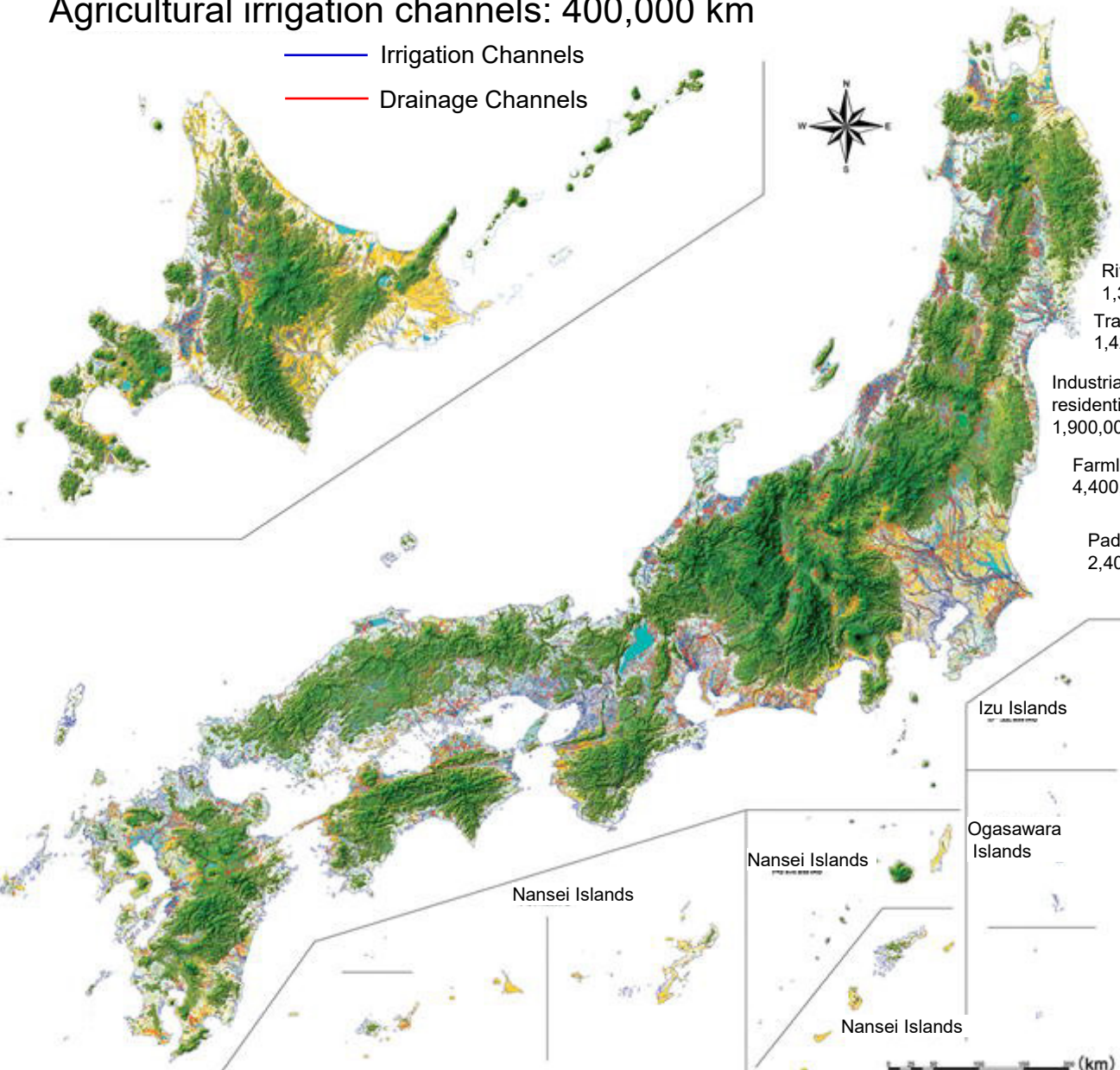
OKINAWA



Agricultural irrigation channels in Japan

Agricultural irrigation channels: 400,000 km

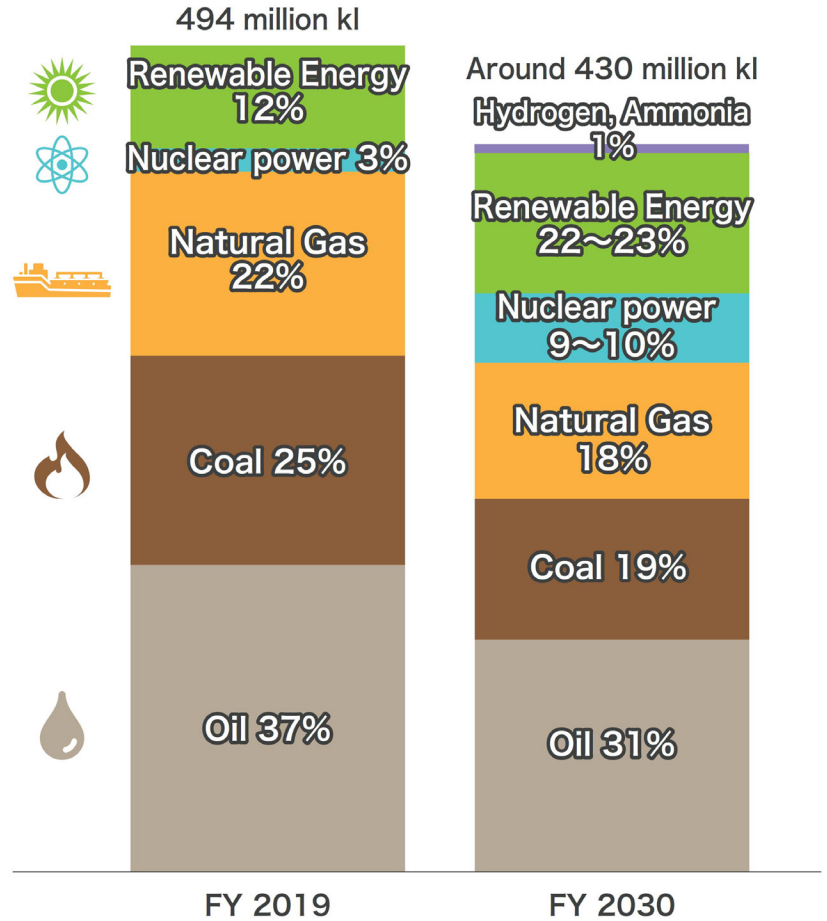
— Irrigation Channels
— Drainage Channels



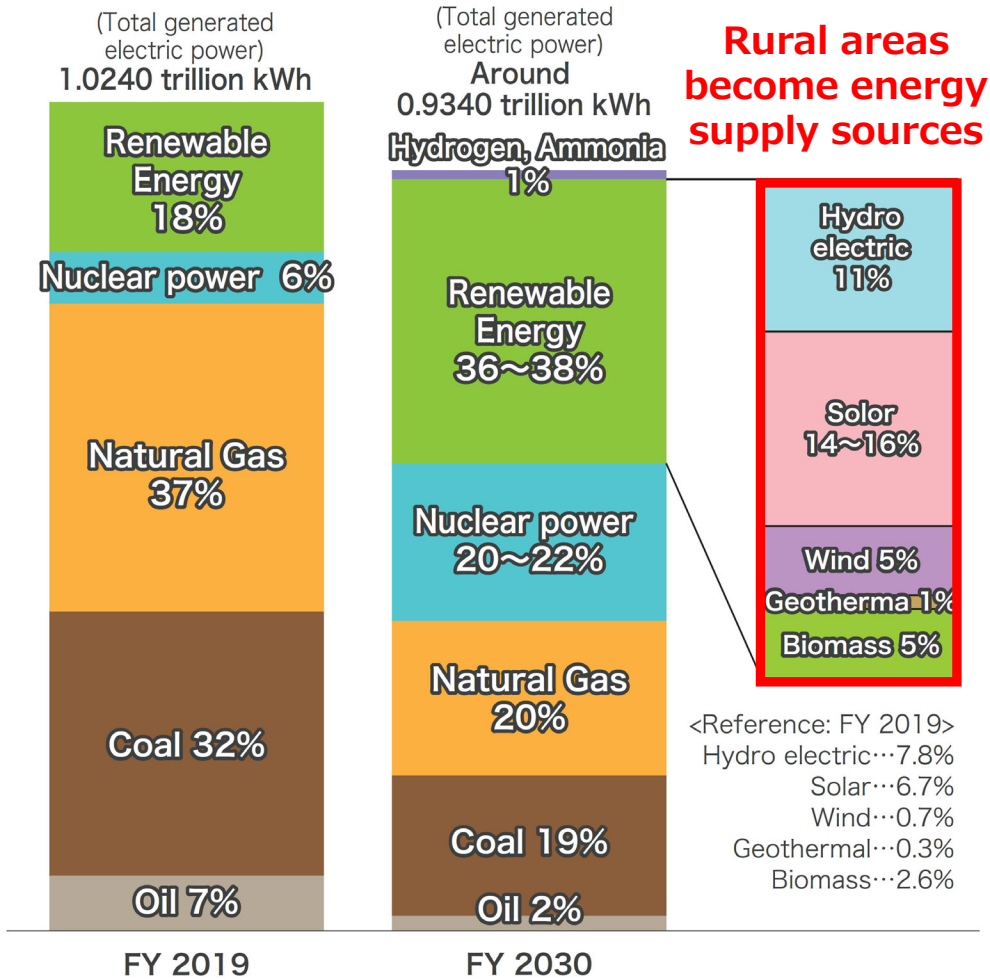
Land Area 37,800,000 ha

Direction of energy policy in Japan

Primary Energy Supply



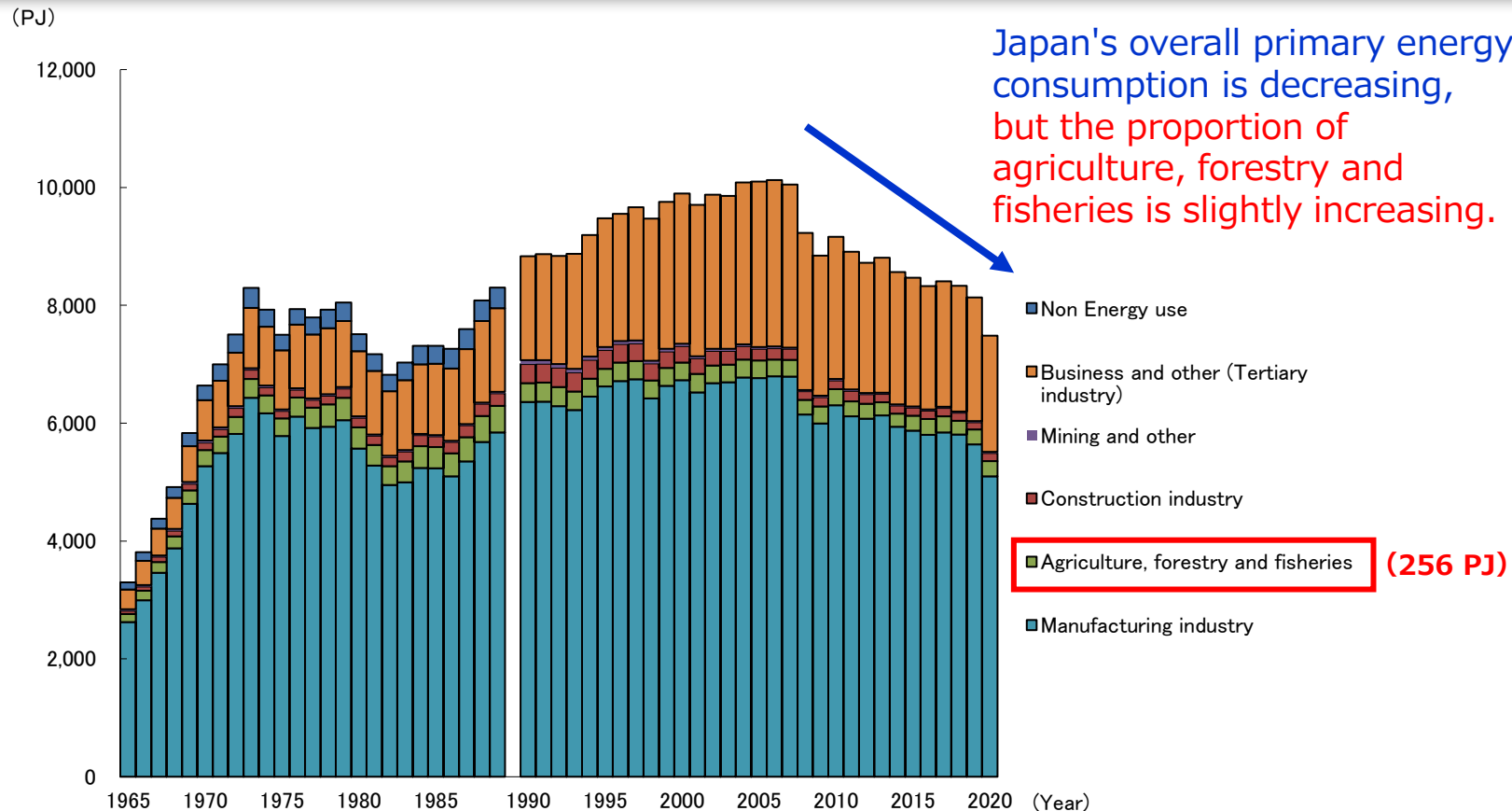
Power Generation Mix



The outlook for energy supply and demand in FY 2019-2030 (energy mix).

Source: "Comprehensive energy statistics of Japan"; 2019 confirmed figures published by the Agency for Natural Resources and Energy, outlook for energy supply and demand in FY2030 (related materials)

Trend of the energy consumption of enterprise, business establishment and other sections



Trends in Energy Consumption in Companies, Offices and Other Sectors

Source: FY2021 Energy White Paper (Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry)

- Agriculture, forestry and fisheries accounts for approximately 3.4% of the approximately 7483 PJ of energy consumption by Japanese companies, office and other sectors.
- The main energies consumed in the agriculture, forestry and fisheries are heavy oil, kerosene, light oil, gasoline, and electric power.
- Heavy oil is consumed by the internal combustion engines of fishing boats and the heating of greenhouse horticulture.

Current status of greenhouse heating in Japan



- The area of greenhouse horticulture in Japan is 40615 ha. There are 16936 ha of greenhouses with in heating equipment. The combustion heating systems use A heavy oil in 90%.
- Biomass fuels (wood pellets, chips, rice husks, etc.) and natural energy uses (geothermal heat and solar heat) are being promoted as renewable energy uses, but they are not becoming more widespread.
- After the rise in fuel prices, heat pumps were introduced to reduce heating costs, but the air heat source method suffers from the problem of frost formation on the outdoor heat exchanger, which prevents it from becoming more widespread. Another issue is the high implementation cost.

New Energy and Industrial Technology Development Organization (NEDO) Advanced Research Program for Energy and Environmental Technologies (FY2021-FY2022)

Development of Village Energy Management System (VEMS) to Contribute RE100 in Rural Areas

Representative institution:

- National Agricultural and Food Research Organization (NARO)

Collaborating institutions:

- Mitsubishi Electric Corporation
- Chiba Ecological Energy Inc.
- Geosystem Co., Ltd.
- Holt Plan LLC
- National Institute of Advanced Industrial Science and Technology (AIST)
- Faculty of Science and Technology, Keio University
- Faculty of Science and Engineering, Waseda University
- Institute of Industrial Science, The university of Tokyo
- Graduate School of Engineering and Faculty of Engineering, Kyoto University

Project management:

- Smart Community and Energy Systems Department, New Energy and Industrial Technology Development Organization (NEDO)

Renewable energy in agriculture, forestry, and fisheries region

- Rural areas have diverse renewable energy candidates such as solar power, hydro power, wind power, wave power, biomass power, etc.
- We need a business model that enables local production and local consumption of renewable energy in rural areas, even after FIT program has relinquished.



Solar Power generation



Solar power generation on the farmland



Hydro power generation



Wind Power generation



Wood biomass power generation



Methane gas power generation by livestock manure



Methane gas power generation by food residue

Energy demand group in the district of agriculture, forestry, and fisheries

- In rural areas are various consumer groups that require electricity and heat, such as greenhouses, livestock barns, rice-drying facilities, storage facilities, processing facilities, distribution facilities, offices, and residences.
- Currently, the cost of energy consumption is flowing out of the region



Greenhouse



Petroleum hot air heating



Petroleum hot water heating



Air-source heat pump



livestock barn



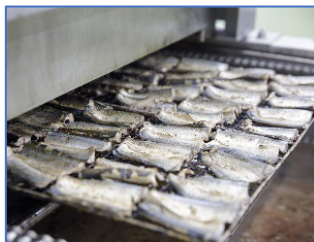
Food processing facility



Rice-Drying/Storage facility



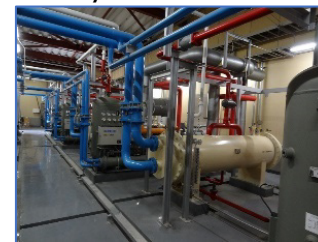
Office



Seafood processing facility



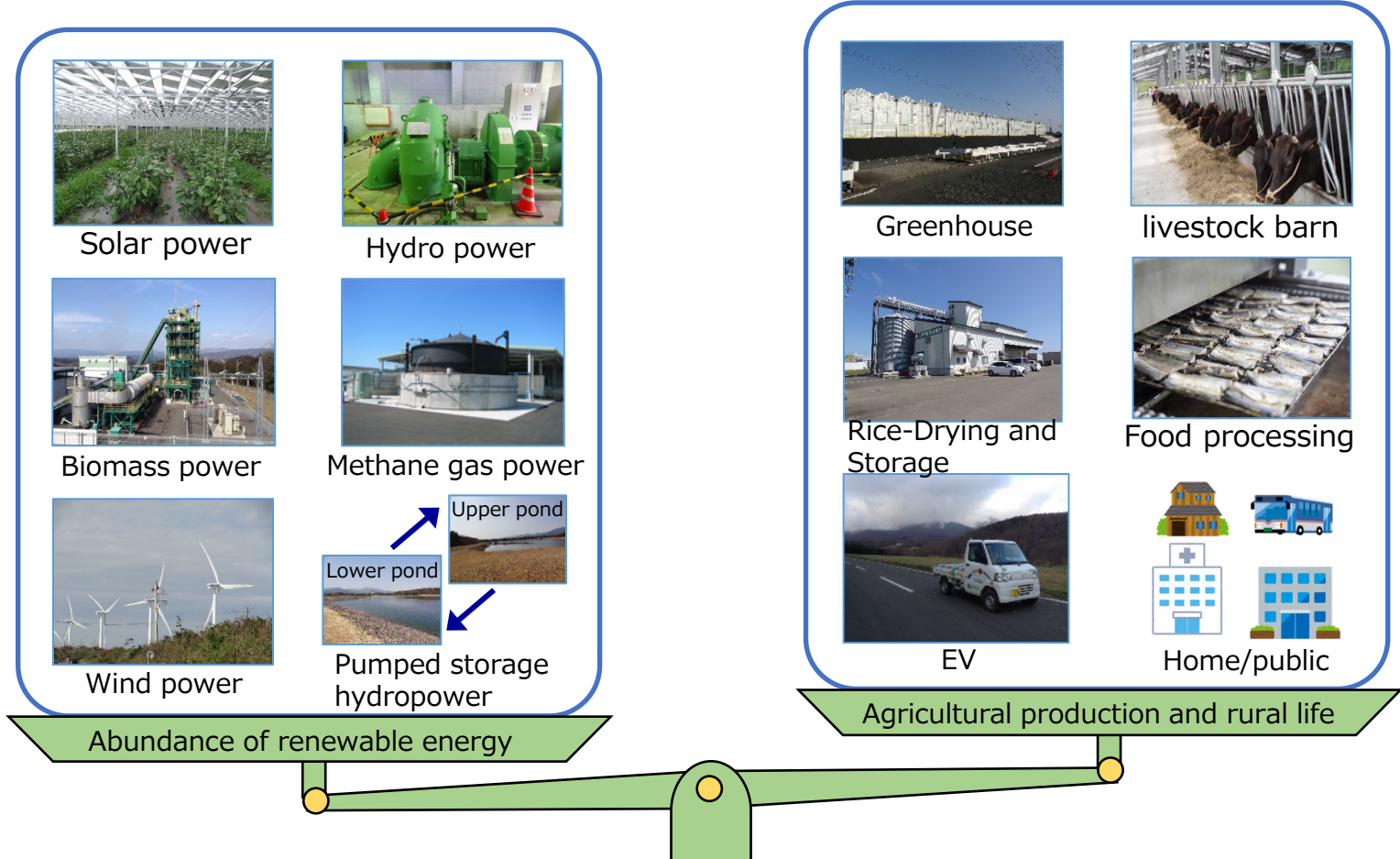
Freezing storage facility



Refrigerator



Cooling tower



Village Energy Management System, VEMS

Measuring and optimally managing the demand and supply of renewable energy in agricultural production and rural life

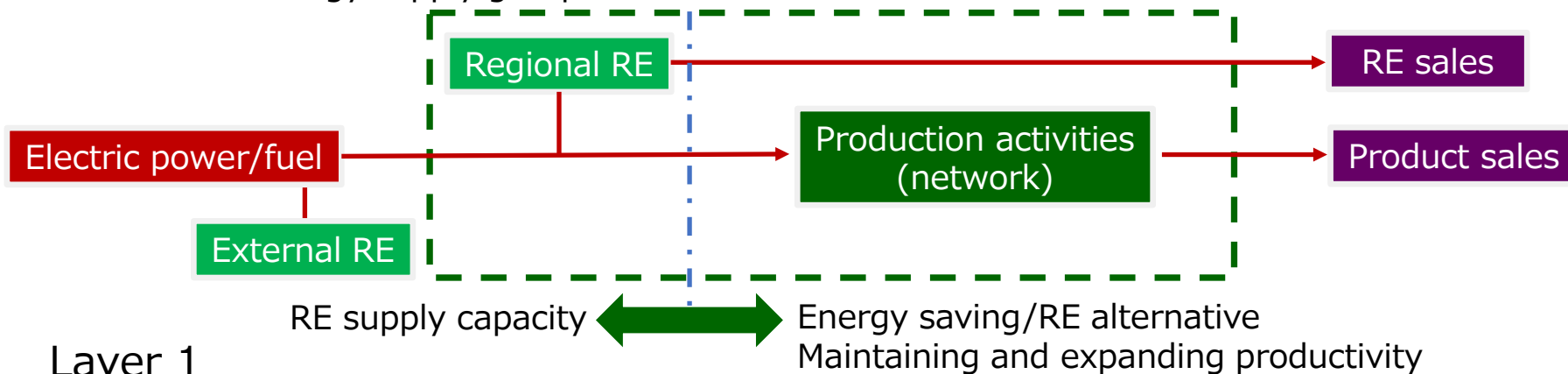
Two-layer structure and network model of VEMS

Concept of rural design

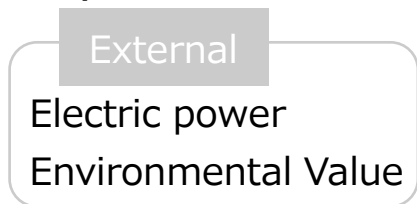
Aggregate

Energy supply group

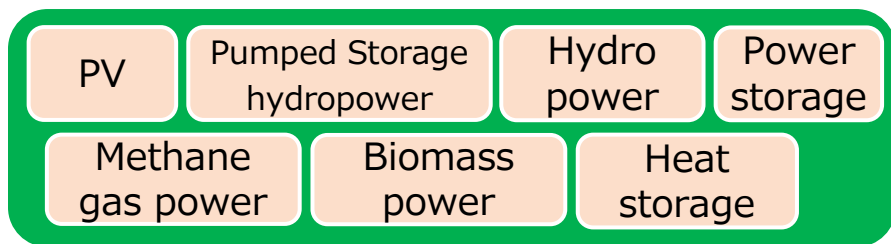
Production activities and energy demand groups



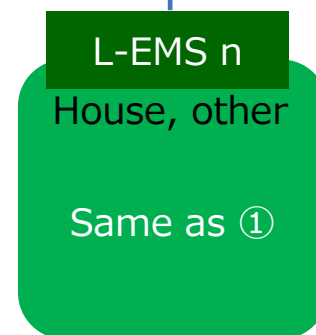
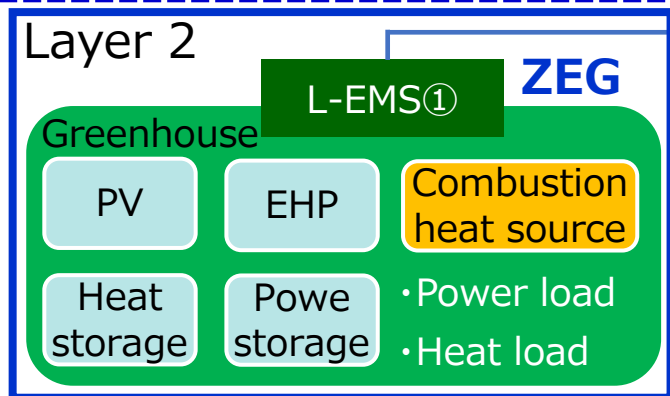
Layer 1



A-EMS








Layer 2



Installation purpose, control target and demand characteristics of VEMS

Comparison item EMS type	Purpose					Composition of energy supply and demand					Player size			
	Main target			Environmental	Regional activation	Energy source					Local production and consumption	Demand control	Consumer	Business company
	Primary industry	Secondary industry	Tertiary industry			Generator	RE	cogeneration	Heat source	Heat pump				
EMS for electric power business		○	○			○						Small	Multiple	Single
BEMS/ FEMS/ other	○	○	○			○	○	○	○			Small	Single	Single
VEMS	○	○	○	○	○	△	○	○	○	○	○	Large	Multiple	Multiple

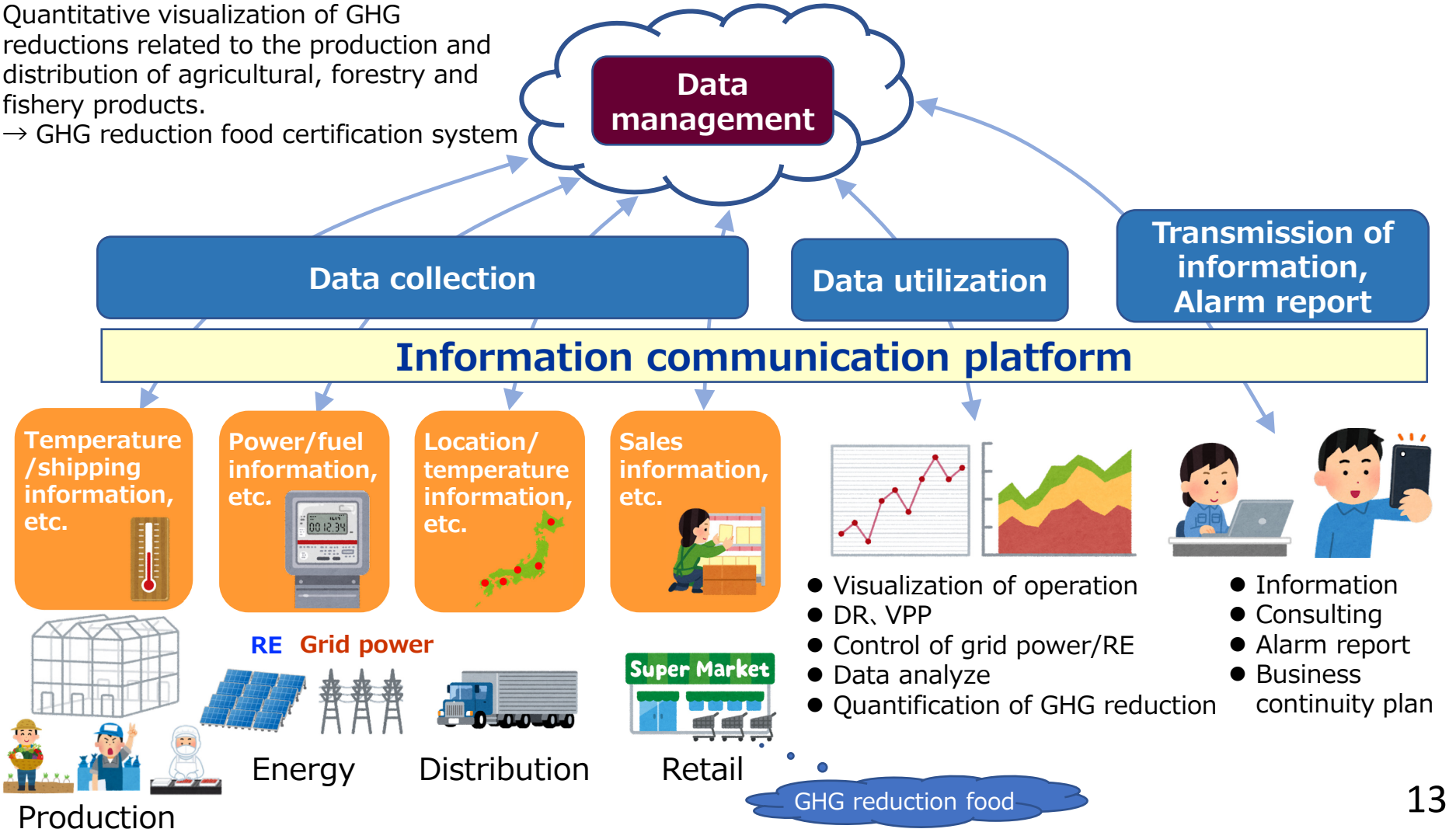
Explanation of terms

-  Main target | Primary industry: agriculture and fishery, secondary industry: processing, tertiary industry: service and sales
VEMS is expected to integrate and create a new sixth industry.
-  Environmental | Include environment-related indices (CO2 emissions, etc.) in EMS control targets (or objective functions).
-  Regional activation | Added value given to locations where EMS is introduced.
-  Local production and consumption | Extent of energy distribution inside and outside the EMS installation site. Local production for local consumption minimizes the flow of energy with the other areas.
-  Demand control | Differences in energy demand by year, season, month, and day

Advantage of visualization of energy for district of agriculture, forestry and fisheries

Visualization of production information related to agriculture, forestry and fisheries, and product tagging (added value)

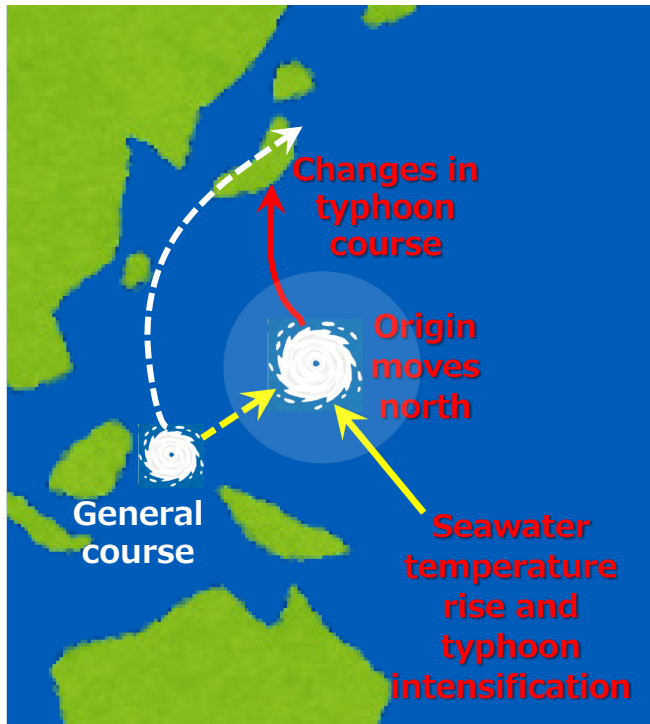
Quantitative visualization of GHG reductions related to the production and distribution of agricultural, forestry and fishery products.
 → GHG reduction food certification system



Strengthening energy resilience in the district of agriculture, forestry and fisheries by VEMS

Energy resilience:

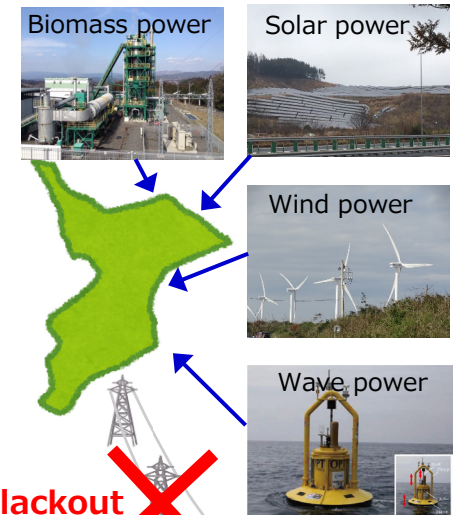
In normal times, the required energy is stably supplied to society, including consumers. Safety and robustness in terms of hardware and software before and after the occurrence of a disaster etc., in order to reduce the impact on human life, assets, economic activities, and society in the event of an energy supply disruption due to a natural or man-made disaster, etc. and ability to recover quickly from an outage.



Larger typhoons due to sea temperature rise



Power outage damage caused by huge typhoon No. 15 in 2019
Source: METI

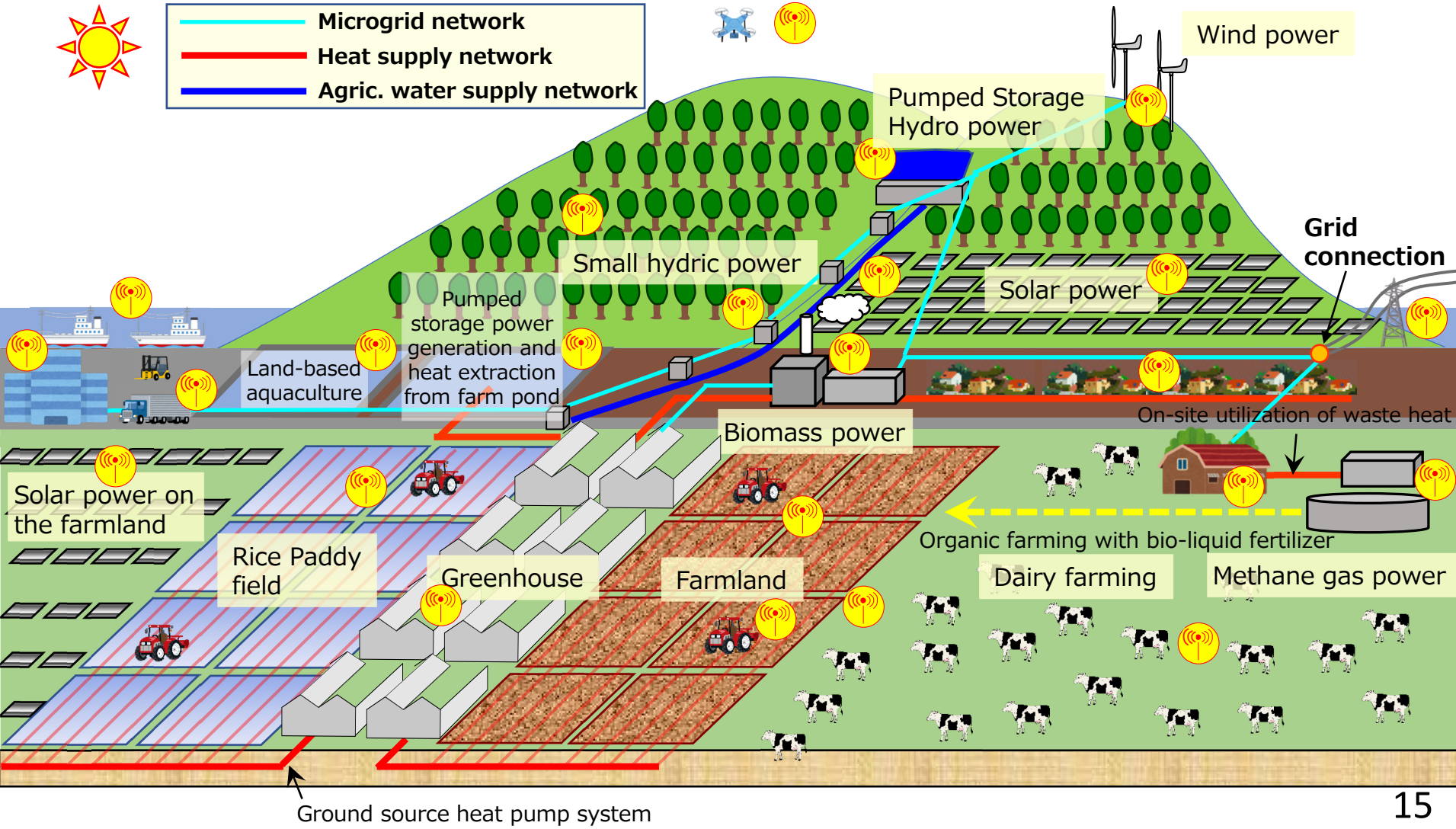


Rural areas have high potential for renewable energy and high energy resilience.

Village Energy Management System, VEMS NARO

National Agriculture and Food Research Organization

- A system that manages the electricity and heat supply and demand from facilities such as solar power, small hydroelectric power, wind power, biomass power, and infrastructures such as farmland and agricultural water etc. in rural areas.



Commissioned Research Project
Ministry of Agriculture, Forestry and Fisheries (MAFF)

Pilot Research Project for Realization of Decarbonized Agriculture

Representative institution:

- National Agricultural and Food Research Organization (NARO)

Collaborating institutions:

- Tochigi Prefectural Agricultural Experiment Station
- Agricultural Research Department, The Hokkaido Research Organization (HRO)
- National Institute of Advanced Industrial Science and Technology (AIST)
- Faculty of Science and Technology, Keio University
- Faculty of Science and Engineering, Waseda University
- Graduate School of Engineering and Faculty of Engineering, Kyoto University
- Holt Plan LLC

Project management:

- Agriculture, Forestry and Fisheries Research Council, Ministry of Agriculture, Forestry and Fisheries (MAFF)

Overview of research project

Aiming for environmentally friendly agriculture

Management



- GHG reduction effect by deploying decarbonization technology in rural areas
- Elucidation of agricultural management improvement effects, environmental improvement effects, and impact levels
- Creating a role as rural green infrastructure

Greenhouse

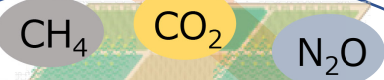
- Reducing GHG emissions with renewable energy heat pumps
- Reducing fossil fuels with the latest horticultural energy-saving technology



Heat Pump

Fertilization use of organic materials

- Reducing GHG emissions with precision water management



Paddy field

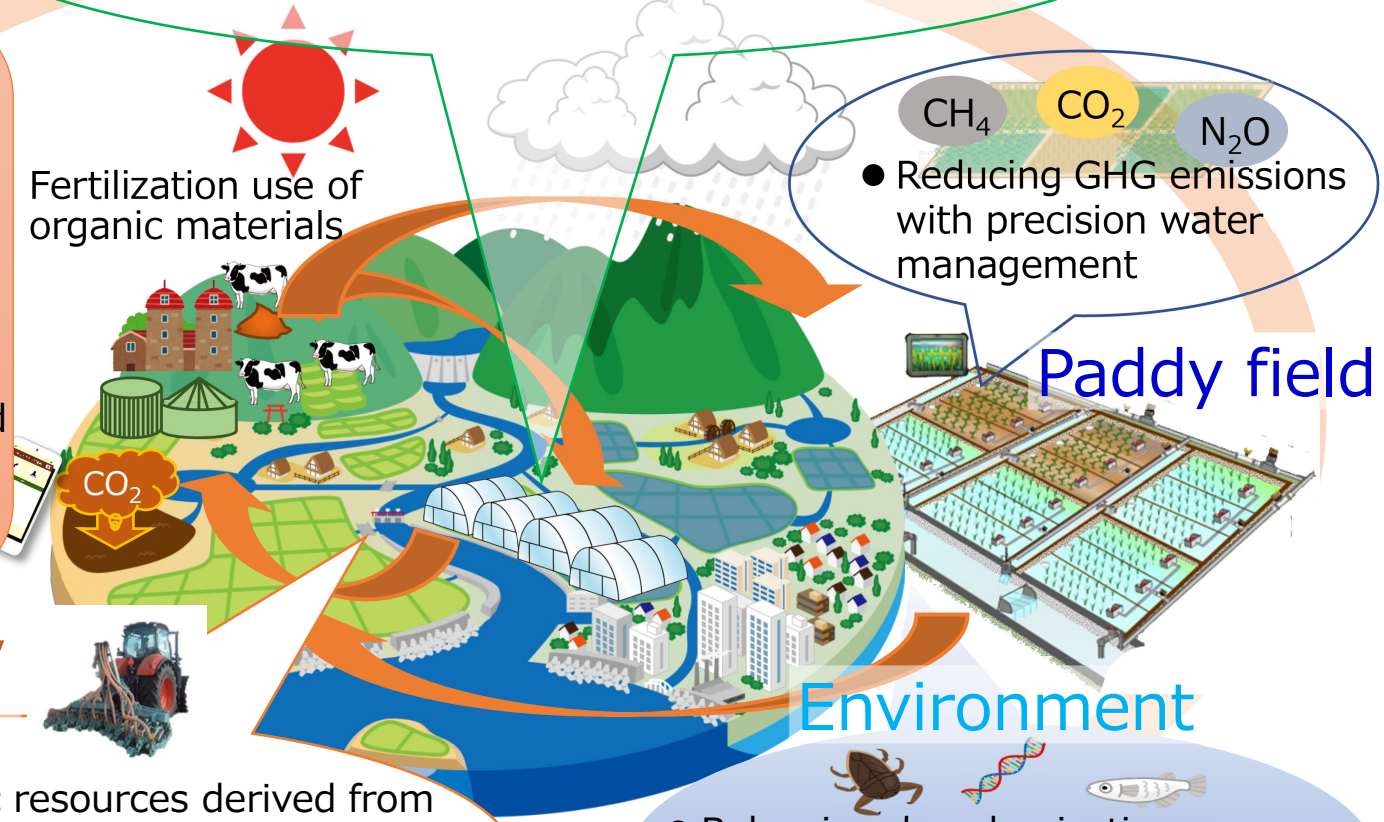
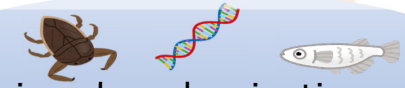
Dairy farming/ Field farming

- Utilization of organic resources derived from biogas power generation
- Reducing GHG emissions through fertilization alternatives and carbon storage

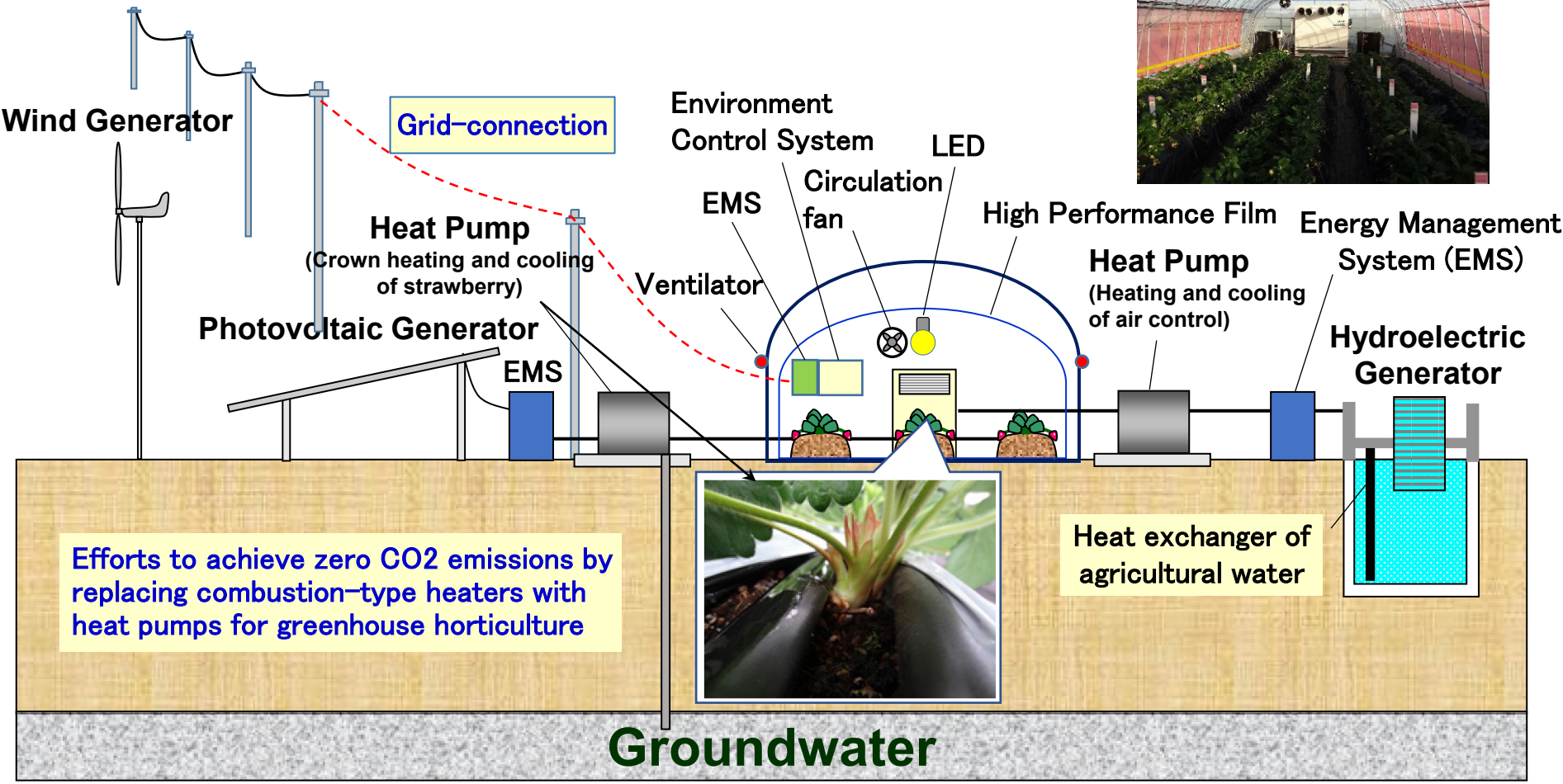


Environment

- Balancing decarbonization measures and biological habitat
- Use of organic materials and water environment conservation



Greenhouse



Demonstration test of new heat pump system in tomato production greenhouse



Exterior of demonstration greenhouse



Interior of demonstration greenhouse



New heat pump system



Groundwater heat exchanger

The Ministry of the Environment (MOE), Japan, selected six applications for the "FY2022 Technology Development and Demonstration Project for Regional Symbiosis and Cross-Sectoral Carbon Neutrality (Second Round)."

Development and demonstration of a net zero energy greenhouse (ZEG) for contributes to the decarbonization of horticulture

Representative institution:

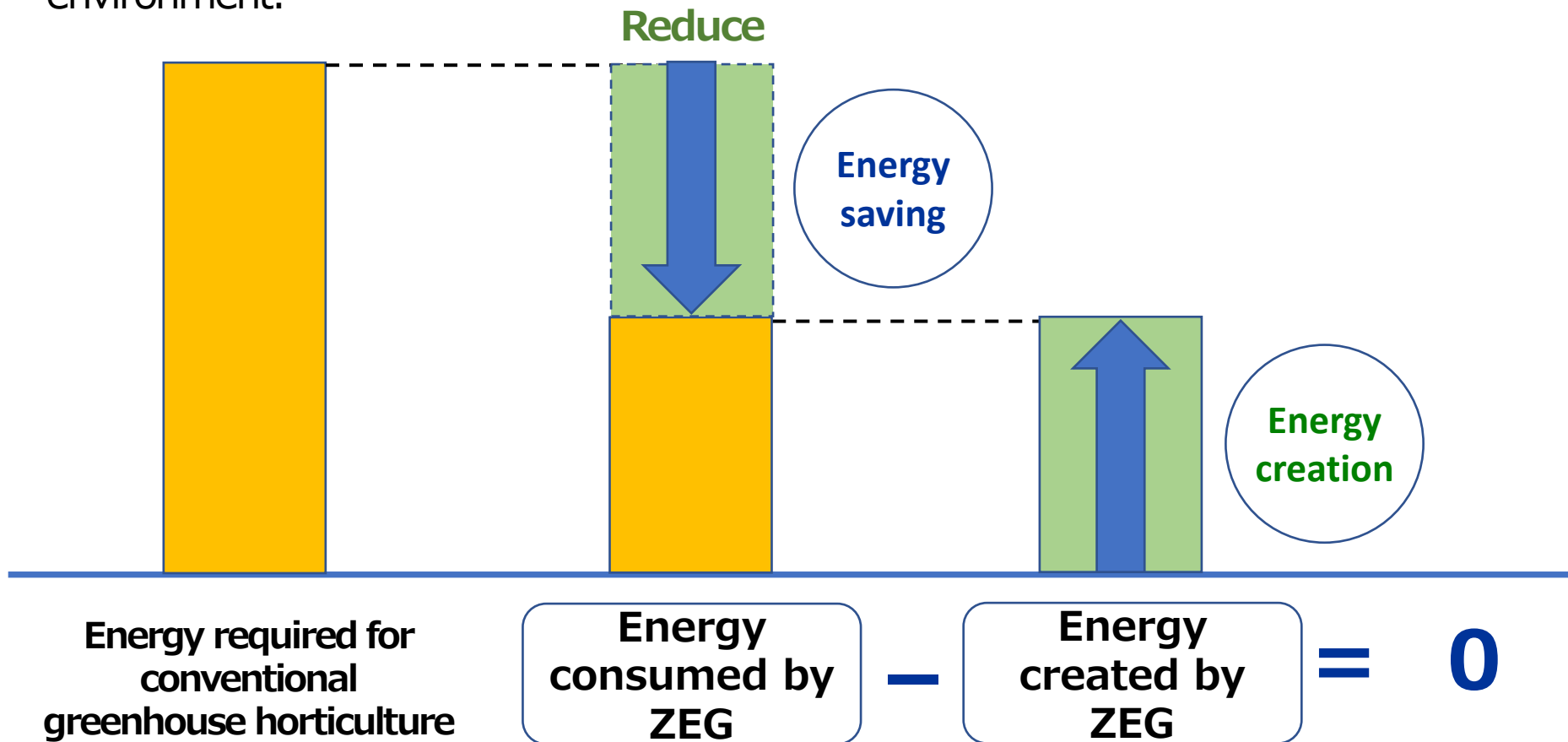
- **National Agricultural and Food Research Organization (NARO)**

Collaborating institutions:

- **TOYOBO Co., Ltd.**
- **Holt Plan LLC**
- **Inochio Agri Inc.**
- **Faculty of Science and Engineering, Waseda University**
- **Faculty of Science and Technology, Keio University**
- **Faculty of Horticulture, Chiba University**
- **Saitama Agricultural Technology Research Center**
- **Kokubunji Orchids Co., Ltd.**

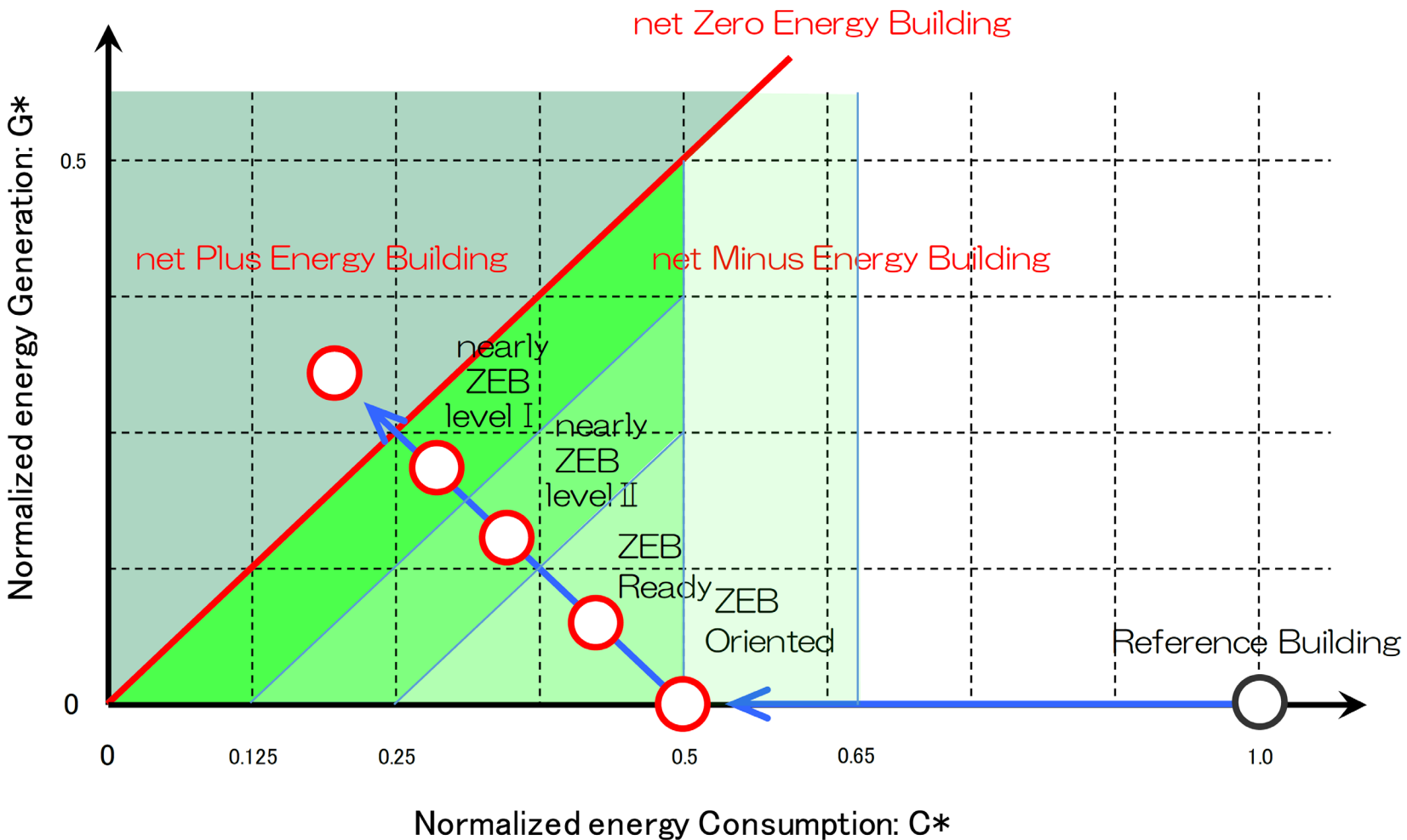
What is a Zero Energy Greenhouse (ZEG)?

- Abbreviation for net Zero Energy Greenhouse, we called “ZEG”
- ZEG aims to reduce the annual primary energy consumption of greenhouses to zero while achieving highly efficient horticultural production and a comfortable greenhouse environment.

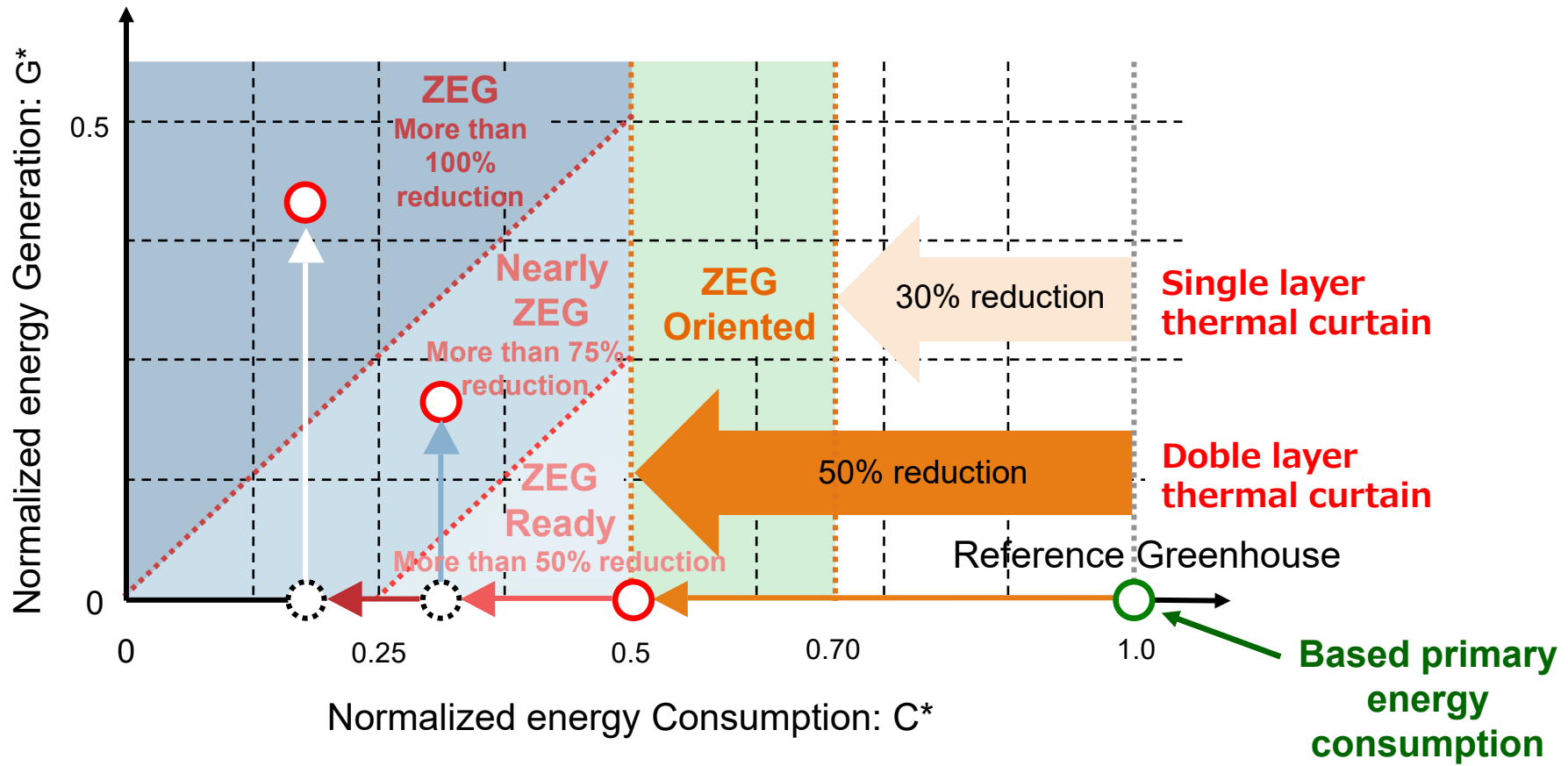


Source: Excerpt from NEDO research report “Development of village energy management system (VEMS) to contribute RE100 in rural areas” (2022)

Evaluation of ZEB (net Zero Energy Building)



G^* : Normalized energy generation = energy generation of target building/ energy consumption of reference building
 C^* : Normalized energy consumption = energy consumption of target building/ energy consumption of reference building



G^* : Normalized energy generation = energy generation of target building / energy consumption of reference greenhouse
 C^* : Normalized energy consumption = energy consumption of target building / energy consumption of reference greenhouse

Source: Excerpt from NEDO research report "Development of village energy management system (VEMS) to contribute RE100 in rural areas" (2022)

Development and demonstration of a net zero energy greenhouse (ZEG) for contributes to the decarbonization of horticulture

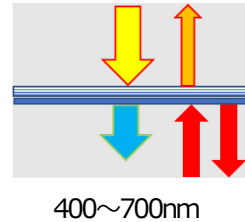
Overview of Demonstration New Technologies

Technical element 1. New Heat Pump System



Ground Source
New Heat Pump System

Technical element 2. New Thermal Curtain by Nanotechnologies



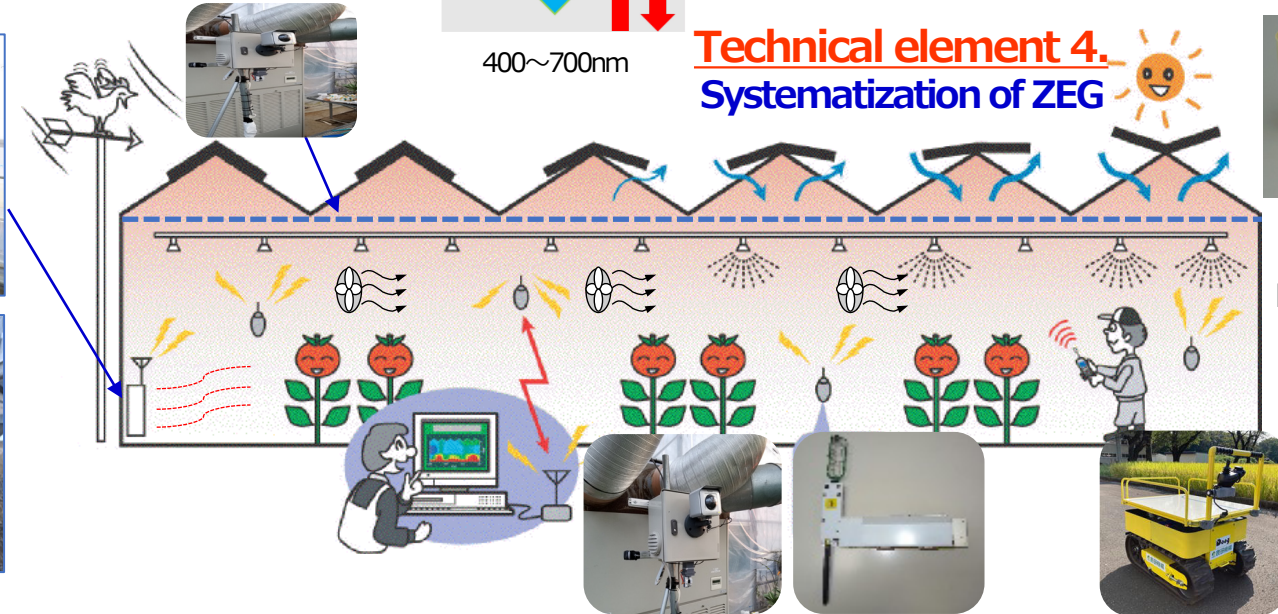
400~700nm

- Selectively transmits wavelengths from 400 to 700 nm, which are effective for photosynthesis
- Controls the reflection of near-infrared light

Technical element 4. Systematization of ZEG



Wavelength
Selective
Laminated Film



New Sensor Network System Autonomous Robot

Technical element 3.

High-precision Environmental Measurement and Control Equipment/ EMS/ Sensor Network

1. Development of high-efficiency new heat pump system using renewable energy in greenhouse.
2. Development of a new curtain material that maximizes crop photosynthesis, minimizes energy loss.
3. Development of high-precision environmental measurement and control equipment, EMS and sensor networks that maximize the effects of new heat pump systems and new material curtains.
4. Systematization and standardization of ZEG.

Development and demonstration of a net zero energy greenhouse (ZEG) for contributes to the decarbonization of horticulture

Overview of Demonstration New Technologies

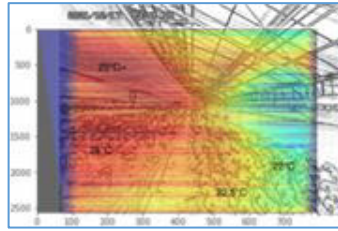
Heating capacity: 2.8kW



Heating capacity: 28kW



Development and improvement of new heat pump system (NARO)

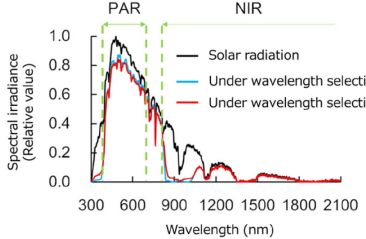
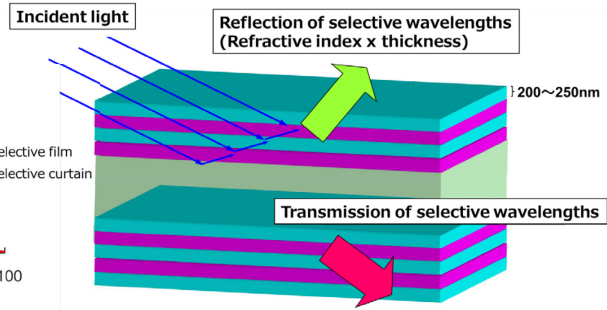


High-precision environmental measurement/control equipment/sensor network (Keio Univ., Holt Plan, NARO)

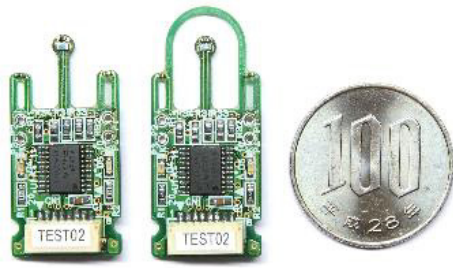


Utilizing multiple reflections of specific wavelengths due to optical path difference interference in each layers

Reflection phenomenon that specifically appears at 1/4 thickness of one layer



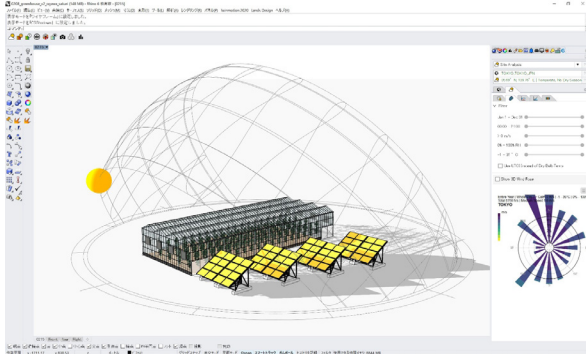
Development of a laminated wavelength selective film (TOYOBO)



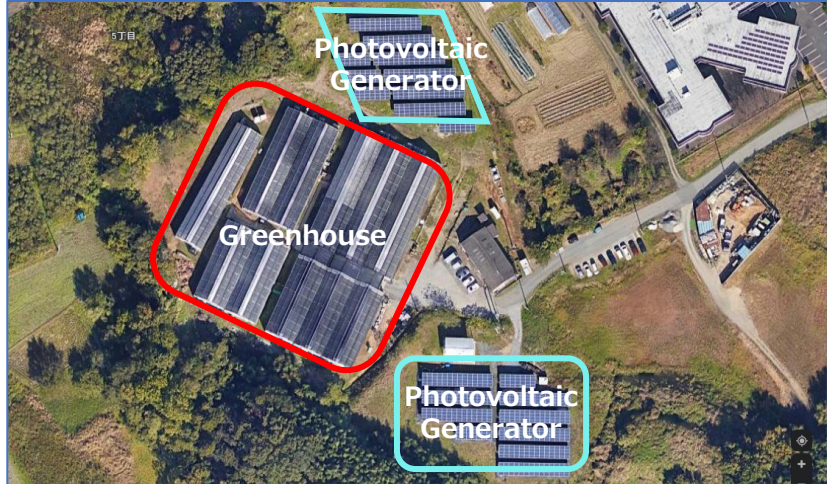
Environmental measurement sensor module (Holt Plan, NARO)



Autonomous electrical robot (NARO)



Environmental and Energy Simulator for ZEG(Waseda Univ., NARO)



On-site demonstration of ZEG specification greenhouse (Inochio Agri, Saitama Agric. Tech. Res. Cent., Chiba Uni., Kokubunji Orchids)

Acknowledgments

This presentation is based on the results obtained from the following projects:

1. The New Energy and Industrial Technology Development Organization (NEDO) Grant Number (JPNP14004)/Title: Advanced Research Program for Energy and Environmental Technologies/Development of village energy management system (VEMS) to contribute RE100 in rural areas.
2. Ministry of Agriculture, Forestry and Fisheries (MAFF), Commissioned project study (Grant Number JPJ009819)/Title: Pilot research project for realization of decarbonized agriculture.
3. The Ministry of the Environment (MOE), Japan, selected six applications for the "FY2022 Technology Development and Demonstration Project for Regional Symbiosis and Cross-Sectoral Carbon Neutrality (Second Round)."/ Title: Development and demonstration of a net zero energy greenhouse (ZEG) for contributes to the decarbonization of horticulture.