Island-Type Smart Community Demonstration in Miyakojima City

Eco-Island Promotion Division, Planning Department, Miyakojima City
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Miyakojima is an island located approximately 2,000km from Tokyo, approximately 300km from Naha, and midway between Japan and Taiwan.
It is a flat island surrounded by the ocean on all four sides and formed by raised coral reefs. There are no large rivers, and it has a harsh natural environment that is easily affected by typhoons and draughts.

Population: Approx. 55,000 people
Area: Approx. 205km² (of that, 80% is Miyakojima)
Climate: Subtropical climate
Temperature: Annual average of 23.3°C
Rainfall amount: Annual average of 2,000mm
Humidity: Annual average of 79%

Scenes of Miyakojima City

Higashihennazaki (government-designated site of scenic beauty)

Spring water from a mountain river

Maehama Beach

Sugarcane field
Miyakojima is in a harsh natural environment, and in the past it has suffered heavy damage from things such as droughts. Therefore, we are aiming to break away from waterless agriculture by using its abundant underground water, and we have built water storage dams by using underground water-stopping walls made of Ryukyu limestone, which is very permeable, and we have developed water resources. (Construction began in 1987 and was completed in 2000 and 2002.)
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Overview of the project
For the purpose of making the most efficient use of the island’s renewable energy such as solar power and wind power, we are aiming to clarify the state of the entire island’s demand for electricity, to build a system that will bring about faceted management of energy by doing things such as making electricity consumption visible and controlling demand for electricity, and at the same time to build a system by which it will be possible for regions to be the main parties conducting operations throughout the future.

Project period: Fiscal 2011 – fiscal 2017  * Operation began in October 2013

Implementation system: Implementing body: Okinawa Prefecture
Consigned party: Miyakojima City (overall control)
Re-consigned party: SMA ECO Co. (promotion of commercialization, system development, etc.)
Promotion committee: Professor Kenji Iba, Meisei University (committee chairperson)
Professor Hitoshi Aida, The University of Tokyo
Associate Professor Junpei Baba, The University of Tokyo
Professor Tomonobu Senju, University of the Ryukus
(1) Overview of the Miyakojima City entire-island EMS verification project
～Island-type smart community demonstration project～

Overview of the system

Home sector: 200 households

Business place sector: 25 business places (Places of large-scale demand: 5 business places; places of small and medium-scale demand: 20 business places)

Agricultural sector: 19 pump buildings (places containing underground dam water pumps)

Commonly-used name: “SMA ECO Project”: Let’s live on the island in a smart way.

Entire-island EMS

AMI system
advanced metering infrastructure

MDMS server
Meter Data Management System

Integrated BEMS server
Building Energy Management System

CEMS: Local energy management system

Agriculture EMS server

Collection of performance information
Prediction → Planning functions

Existing water management system

Measurement device

Tablets

Places of large-scale demand
5 business places

Small and medium-scale monitors
20 business places

Terminal that makes things visible

Pump buildings:
Places holding pumps

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(2) Purposes of the demonstration project (SMA ECO project) ~Entire-island EMS demonstration project~

**Purposes of the project**

① Reduction of the degree of reliance on energy from outside the island
   = Security measure

   • Reduction of the total amount of energy consumption
   • Maximum use of renewable energy

② Reduction of social costs for energy supply
   = Stabilization of citizens’ daily lives
   = Reduction of daily life costs

③ Creation of a business model for social implementation
Structure of supply costs

~Reasons why electricity supply costs are high on remote islands~

- Fuel costs
  (influenced by the consumption amount)
  - On Miyakojima, diesel power generation is dominant.
  - Heavy oil C, which is more expensive than coal, is the main fuel.
  - Transport costs are necessary.
  - There is a significant influence by the cost of crude oil.
- Facility costs (peak times have an influence)
  - Because it is a small-scale system, reserve power is made comparatively large.
  - Economy of scale does not work, and it is difficult to recover facility costs.

However, because it is universal service, it is a state in which independent operation by remote island areas is difficult.

⇒ In comparison, the effects of introducing renewable energy are high.
⇒ It is possible to build a cooperative relationship with Okinawa Electric Power Company! ?

⇒ This will be the first example of a smart community that coordinates supply and demand (the real thing)!!

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State of demand (fiscal 2011 results)

- Electricity demand peak: **Approx. 52MW (summer)**
- Electricity demand bottom (daytime): Approx. 22MW (winter)
  * Application of 30-day rule → 25.6MW
- Total amount of annual electricity consumption: 262,419 MWh
* The peak is around 8 p.m. (civilian demand)

State of power generation facilities (as of March 31, 2015)

- DEG power generation (heavy oil C): 65MW (7 facilities)
- GT power generation (heavy oil A): 15MW (3 facilities)
  ● Thermal power generation total: 80MW
- Wind power generation: 4.8MW
- Solar power generation: 4MW (mega-solar)
- Sunlight on the demand side: 19.71MW (connectable amount)
  ● Renewable energy facility total: Approx. 28.5MW

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Calculation of RE ratio

* Calculation based only on ordinary use ratios
  - Sunlight 12%
    \[23.7 \times 8760 \times 12\% = \text{Approx. 25,000MWh}\]
  - Wind power 25%
    \[4.8 \times 8760 \times 25\% = \text{Approx. 10,500MWh}\]

RE total / Total amount of consumption

Approx. 35,500 / Approx. 262,500MWh

RE ratio 13.5\%
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① Reduction of the degree of reliance on energy from outside the island (expansion of renewable energy)

On the island, there is increasing introduction of large amounts of PV through FIT, and a situation is near at hand in which, in times of clear weather in the winter, the cost of reducing the amount of production of power plants’ diesel generators will be eliminated.

Daytime load: Approx. 25.6MW
In contrast,
PV connectable amount: 19.71MW
(announced by Okinawa Electric)
It is not possible to reduce DEG more than this.

The problem of connection hold for solar power generation
The need to increase daytime demand in the winter
⇒ It is not possible to use it wastefully. ⇒ A demand shift is necessary.
Doing the following for the timing of drawing up water:
- Shifting from the peak hours of the entire island’s electricity demand
- Shifting to the hours of solar power generation

Summer: There is a lot of use of water, and it is necessary to operate them within the extent that they do not become empty.

Winter: There is little use of water, and it is necessary to operate them within the extent that they do not overflow.

Watering fields through natural downward flow
① Reduction of the degree of reliance on energy from outside the island (expansion of renewable energy)

As a result of demonstration, it was found that because there are limits to expansion of the connectable amount, it is necessary to control facilities for which a demand shift (accumulated energy) is possible for equipment on the demand side.

From now on, we will proceed with various types of investigations and reviews in order to bring about energy management that utilizes things such as the following:

- HP-type water heaters
- Electric automobiles
② Reduction of social costs for energy supply

As a result of simulations, it became clear that, in aiming to reduce social costs for supply, measures for cutting use at peak times are effective and lead to bottom-up power generation cost reduction.

Power generation costs are lowered by realizing load leveling through coordination of timely and appropriate demand and improving system load factors.
(3) Progress of the demonstration project (SMA ECO project) ~Entire-island EMS demonstration project~

② Reduction of social costs for energy supply

As a result of demonstrating demand response thus far, it was revealed that because ordinary homes and business places do not have facilities by which large load control is possible, even if we have them respond to requests by e-mail, etc. it is difficult to obtain valid effect size.

From now on, we will proceed with various types of investigations and reviews in order to bring about energy management that utilizes things such as the following:

- HP-type water heaters
- Electric automobiles

In the same way as with measures for the connection hold problem, popularization of controllable load and realization of remote control will be important tasks from now on.
③ Creation of a business model for social implementation

Sustainable social system
(≒ Creation of business)

Energy benefits
(1) Tasks for DR implementation
   (Supply and demand cooperation)
(2) Tasks for service
   (Energy services)

Non-energy benefits
(3) Tasks for service
   (Added-value services)
Overview of the business model
By conserving energy and realizing DR by making energy visible through entire-island EMS, we aim to create a business model and form a social system.

a) Energy conservation services by making electricity consumption visible for parties on the demand side = Lower effects
   A service model developed by obtaining counter value for energy conservation services such as making the energy consumption situation visible to the demand side and conducting energy diagnoses

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Entire-island EMS company

Service charges

Energy conservation services through creation of visibility (Lower effects)

Electricity charge reduction service through cutting use at peak hours

Home sector

Business place sector

Agricultural sector
b) Optimization of supply and demand through demand response (DR) = Upper effects

Through electricity consumption adjustment requests (demand response = DR) to the demand side, we will realize optimization of supply that includes efficient use of renewable energy, and ensure initiatives for effects (upper effects) for electricity businesses.
③ Creation of a business model for social implementation

Concluding an MOU with an EMS business

In the future, concluding an MOU with SMA ECO Co., which is an EMS business that is responsible for business. We will participate in a project promotion system from now on and conduct things such as the following:

- System operation and evaluation
- Overall consideration of business models
- Scheme for popularizing controllable loads
- Addition of functions to control systems
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Project overview
With the purposes of ensuring energy security and contributing to reduction of CO2 emissions by building a “use model” that uses renewable energy in the most efficient ways in local areas, we aim to install solar power generation and local storage cell facilities on the demand side and build a “model of a remote island with 100% renewable energy” that will combine with the wind power generation data of Miyakojima’s existing facilities to cover all consumed power on the island with renewable energy. **Project period:** Fiscal 2011 – fiscal 2016  
* Operation began in January 2014.

**Implementation system:** Implementing body: Okinawa Prefecture  
Consigned party: Miyakojima City (promoting party and overall control)

System (re-consigned party): SMA ECO Co. (evaluation verification, consideration of expansion models)
Overview of Kurimajima

- Population: Less than 200 people (less than 100 households)
- Electricity demand: More than 200kW at the summer peak, approximately 50kW at the winter bottom

System overview

- Power generation facility: Solar power generation system of approx. 380kW
- Storage cell facilities: 100kW - 176kWh × 2 sets
- Current measurement / Kurima EMS

Kurimajima RE 100% self-support demonstration project

~ Island-type smart community demonstration project ~

Realization of local production and local consumption through cooperative initiatives

Realization of 100% independence

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(2) Progress of demonstration
~Kurimajima RE 100% self-support demonstration project~

![Renewable energy 100% self-support demonstration](image)

### Solar power generation only

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Capacity</th>
<th>Ratio of facility use</th>
<th>Power generation cost</th>
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<td>PV: 2.0MW</td>
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<td>Storage facility</td>
<td>Lead storage battery: 7.5MWh</td>
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### Solar power generation + Wind power generation

<table>
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<th>Ratio of facility use</th>
<th>Power generation cost</th>
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<td>Power generation facility</td>
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<td>JPY 89.1</td>
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<td>WT: 245kW</td>
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<tr>
<td>Storage facility</td>
<td>Lead storage battery: 6.0MWh</td>
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On remote islands that have extremely small-scale independent systems and remote islands that are supplied by ocean floor cables, it is thought that power generation costs will become more expensive, and therefore we are conducting technical verification of systems in which supply is not hindered even if there is no internal-combustion power and, in light of the trend of cost reduction for solar power generation and storage cells, we are continuing to consider expansion to small-scale remote islands.
(2) Progress of demonstration
~Kurimajima RE 100% self-support demonstration project~

In the case of aiming for 100% by sunlight alone:
PV2000kW (existing 380kW + 1620kW)
Lead storage battery: 7.5MWh
(2) Progress of demonstration

~Kurijima RE 100% self-support demonstration project~

- In the case of aiming for 100% by sunlight + wind power:
  - PV1000kW (existing 380kW+620kW) 245kW
  - One tilting wind mill
  - Lead storage battery: 6.0MWh

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Using microgrid simulation software (HOMER) that can conduct optimization analysis for 8,760 hours a year, we input the previously mentioned data for demand on the island, solar radiation amount data, and wind speed data, and conducted simulation analyses.

For solar power generation we set ordinary specifications, and for wind power generation we set 245kW tilting wind mill specifications.

For storage cells, we used 15% charge and discharge loss by lead storage batteries.

As a result, the facility composition that is necessary for 100% independence are the regions enveloped in red and written in red numbers.
Verification of facilities’ optimal capacity

Regarding introduction costs, for the scale of each facility we calculated JPY 400,000/kW for solar power generation, JPY 200,000,000 per mill for 245kW tilting wind mills, and JPY 100,000,000/MWh as system counter value for storage cells.

<table>
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<tr>
<th>PV (kW)</th>
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<th>Storage cell (MWh) (JPY 100,000,000)</th>
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We set twenty years as the number of operation years for all facilities, and 1% of construction expenses per year for maintenance costs, and then calculated electricity generation costs.

Electricity generation costs = (Construction expenses (no subsidies) + Operation costs (1% of construction expenses for twenty years)) ÷ ((PV scale * PV facility use ratio + WT scale * WT facility use ratio) * 8760 * 20 years)

The things that will become inexpensive within the scope of 100% independence are PV2MW + storage cell 7.5MWh or PV1MW + WT245kW + storage cell 6.0MWh.

If electricity generation costs by ordinary diesel electricity generation are set at JPY 50/kWh, it can be appraised that the regions enveloped in green and written in red numbers have economical efficiency.
As a result of simulations, for the surplus power that cannot be absorbed even by storage cells we made allocations in accordance with each output scale of solar power generation and wind power generation. That resulted in a reduction of the facility use ratio.

In the case of solar power generation, PCS output control is technically possible, but because special specifications are necessary we think that under current standard technology it is desirable to realize 10kW-PCS unit number control (ON-OFF).
As a result of simulations, for the surplus power that cannot be absorbed even by storage cells we made allocations in accordance with each output scale of solar power generation and wind power generation. That resulted in a reduction of the facility use ratio.

In the case of wind power generation, it is assumed that output control will be conducted by pitch control.

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  Entire-island EMS demonstration project
- Overview of the demonstration project
- Purpose of the demonstration project
- Progress of the demonstration project

Kurima RE 100% self-support demonstration project
- Overview of the demonstration project
- Progress of the demonstration project
- Direction from now on
By demonstrating renewable energy 100% independence, the difficulties and possibilities of efficiently using renewable energy become clear as actual data.

Costs are expensive for 100% renewable energy, but because the supply cost per kWh is extremely high on remote islands that have a smaller scale than Miyakojima and that have independent systems and on small-scale remote islands that conduct supply by ocean floor cables, there is a possibility that future cost reductions for solar power generation systems and storage cell systems will generate competitive edges for expanding this model to such small-scale remote islands.

Because Kurmajima’s system is connected to Miyakojima, there is little risk of things such as power outages due to the effects of demonstration, and because it is possible to measure the interconnected line current, it is an environment in which, after conducting maximum introduction of RE, it is possible to conduct verification based on actual changes of seasons and solar radiation, as well as residents’ actual daily life environments. We think that there is value in utilizing such characteristics as a base for researching and demonstrating the many independent system remote islands that exist in Okinawa Prefecture.
Thank you for your attention.