Smart Grid and beyond

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What’s NEDO

• Japan’s public R&D management Organization
• Promoting R&D in the industrial, energy and environmental technologies.
• Established on October 1, 1980
• Chairman: Mr. Seiji Murata
• Personnel: About 1,000
• Budget: Approximately $2B
Character of Electricity and AC

• **Character of Electricity**
  – Generated by many power source
    • E.g. Coal, Oil, Natural Gas, Nuclear, Hydrogen, Renewable (solar, wind, etc)
  – Difficulty for storage as electricity

• **Character of Alternating Current (AC)**
  – Commercial Generation by AC started from 1890s
    • NO ICT in 1890s
  – Principally, just watch a frequency (60Hz/50Hz), and control the power supply depend on the demand
    • If demand > supply, then frequency will be down.
    • If demand < supply, then frequency will be up.
ICT and Electricity

• Traditionally, ICT was introduced mainly to the supply side, such as transmission and distribution line and the power station. In Demand side, ICT was introduced only for the customer services.
  – In Japan, ICT was also introduced in the distribution line. However it was mainly limited to supply side.
What’s Smart Grid

• “Smart Grid” is today used as marketing term, rather than a technical definition. For this reason there is no well defined and commonly accepted scope of what “smart” is and what it is not.

• However smart technologies improve the observability and/or the controllability of the power system.

• Thereby Smart Grid technologies help to convert the power grid from a static infrastructure to be operated as designed, to a flexible, “living” infrastructure operated proactively.

• SG3 defines Smart Grids as the concept of modernizing the electric grid. The Smart Grid is integrating the electrical and information technologies in between any point of generation and any point of consumption.

IEC Smart Grid Standardization Roadmap (Prepared by SMB Smart Grid Strategic Group (SG3) June 2010; Edition 1.0)
What’s the key drivers behind Smart Grid solutions

• **Supply side**
  – Sustainability and Security Reliability under;
    • Need for more energy (especially in developing countries)
    • Ageing infrastructure and workforce (especially in developed countries)
  – **Increased usage of renewable energy resources**
    • Wind power might be cause for the unbalance of power supply and frequency problem.
    • Solar power in roof top might be cause for the distribution voltage problem.
  – Competitive energy prices and services

• **Demand side**
  – Saving energy and Saving money        Cf. Demand response
  – Improving customer services          Cf. Tele-metering and Tele-switching
  – New energy related service

• **Industrial Policy**
  – Create infrastructure for EVs
  – Create new services, new industry and new job
Supply Reliability

Average Outage Time for each customer

minuets/(customer x year)

France
Germany
England
USA
Japan
Korea
Italy
Spain
Sweden
Australasia
OECD Average

2000 2001 2002 2003 2004 2005 2006 2007
In Japan, “Smart grid” means a transmission and distribution grid to promote the stability of electric power supply by using ICT while introducing huge amount of renewable energy.

After the introduction of renewable energy, home electrification and EV to the home, electricity supply-demand system might be changed. Potentially, the demand side could play an adjustment function role with energy suppliers.

Energy can be used more efficiently if the demand side manages to distribute power supply locally, i.e. “local production for local consumption”.

Example of energy utilization on demand side

- **Sunny**
  - Solar battery
  - Perception
  - Home server
  - Control
  - Boiler
  - Washing machine
  - Electric vehicle etc.
  - The amount of power generation is large.
  - Charge a large amount of hot Waters.
  - Washing begins automatically.
  - The charge begins automatically.
  - The storage battery supplies it to the home.

- **Rain or cloudy**
  - Solar battery
  - Perception
  - Home server
  - Control
  - Boiler
  - Washing machine
  - Electric vehicle etc.
  - The amount of power generation is small.
  - Use hot water kept warm before.
  - It doesn’t wash.

Image of energy management in the regions
Challenges of “Smart Grid” in Japan

- In case of the huge amount of renewable energy introduced to the grid, “Smart grid” might provide one of the solutions,
  - Increase in voltage limit violations, instability on frequency and uncertainty of balancing
- The solution might be not only the technology also in the regulation.

NEDO has begun creating a forecast of needs for grid connection technology related to renewable energy

Increase in voltage limit violations

Increase in voltage limit violations from grid voltage rising

Year 2010
4 GW PV

Year 2020
34 GW PV

Year 2030
100 GW PV
Technology Demonstration Project

Ota City Demonstration Site

- Number of PV-equipped houses: 553
- Total PV capacity: 2,129 kW
- Average capacity per house: 3.85 kW

Wakkanai Demonstration site

- Wakkanai site
  - 5 MW: Most PV cells are crystalline.
  - NaS battery: 1500 kW-7.2hrs

Demonstration Project on Grid-interconnection of Clustered PV Power Generation Systems (FY2002-FY2007)

Verification of Grid Stabilization with Large-scale PV Power Generation Systems (FY2006-FY2010)
Introduction of Smart Grid differs depending on each country’s situation.

- Over 3,000 utilities, 1 Federal regulator and 50 State regulators
- Vulnerable transmission infrastructure and insufficient investment for new power plants and transmission line
- Need for efficient supply by the demand response
- Need for enhancing the reliability of electricity supply through ICT
- Creation on new business through utilizing demand information

- Set the target of “20-20-20” by 2020
- Introduction of huge amount of wind power invite the need for the security reliability
- Development of EV charging infrastructure
- Deployment of smart meter for billing and efficient use of energy.

- Rapid growth of energy demand due to economic boom and needs for higher QOL. Construction of energy infrastructure is inevitable.
- Development of urban city including energy infrastructure such as Tianjin Eco-city.
Next subject of the Smart Grid

- Not only in technology

- Business Model
  - Who will play the aggregator?

- Standardization
  - Interoperability
  - Big meter or Small meter?
  - Even in case of small meter, what kind of information might be collected and transferred?

- Regulation
  - Who will pay the investment for the Smart Grid?
  - Demand response is very important. But how? Mandately or Voluntarily?

- Customer Understanding
  - Regulator’s activity might be depend on the customer understanding.
  - What’s the merit of customer?
  - Data access for third party
Beyond the “Smart Grid” toward “Smart Community”

- Maximize the use of renewables, such as PVs, wind power, and micro hydraulic
- In order to absorb fluctuation caused by renewables in the community, share energy with homes and office in the region
- Utilize EV and EB as part of energy infrastructure by managing their location and battery status

Control Center for optimizing energy demand/supply

Utilize Electric Car As a part of energy infrastructure

Shortage: EV → House
Excess: House → EV

Smart House

- Photovoltaic Cell
- LED Light Television
- Smart Meter
- Home Area Network
- Home Gateway
- Air Conditioner
- Heat Pump Water Heater
- Dryer/Washer
- Dish Washer

Original Visual Image made by Mitsubishi Heavy Industries

- Li-Ion Battery (Replaceable)
- Li-Ion Battery (Fixed)
- Motor
- AC Inverter
- Quick Charging Station

Quick Charging Station

- 80% charge in 30 minutes
- Electric Bus (works like LRT when connected)
- Battery Replaceable Bus / Works like LRT by connecting multiple buses

Power Line Free LRT

LRT with Battery
- At the station: Charge to battery
- Between stations: Move by battery

Utilize Electric Car

- Nuclear Power Plant
- Thermal Power Plant
- Wind Power
- Mega Solar
- Micro Hydraulic Plant

- ITS
- Smart Building
- Electric Car
- Electric Bus
- Quick Charging Station
- Large Energy Storage
- Home Gateway
- Li-Ion Battery (Fixed)
- Li-Ion Battery (Replaceable)
Japan’s Smart Community Roadmap

To address the 3Es simultaneously, it is important to realize the best mix of power sources by introducing large-scale RE utilizing storage. This roadmap illustrates a future social system Japan is aiming at, concentrating on regional EMS and lifestyle changes, under such an energy supply structure.

(3E (Environment ・ Energy Security ・ Economy) )

<table>
<thead>
<tr>
<th>Today - Year 2020</th>
<th>2020 - 2030</th>
<th>2030 -</th>
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</thead>
<tbody>
<tr>
<td><strong>Relation between regional EMS and entire grid</strong></td>
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<tr>
<td>• Solar panel prices will decrease significantly due to large-scale introduction of panels to houses as well as commercial buildings.</td>
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<tr>
<td>• Measures to maintain the quality of electricity while the large-scale introduction of PV will be carried out mainly for the grid side. Storage cells will be installed at substations.</td>
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<tr>
<td>• As regional EMS are further demonstrated, technology and know-how will be accumulated.</td>
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<tr>
<td>• The cost of storage cells will go down due to technology development and demonstration.</td>
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<tr>
<td>• Due to a decline in PV prices, more PV systems will be installed at houses.</td>
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<tr>
<td>• Regional EMS, which contribute to effective use of RE generated at houses, will become more important.</td>
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<tr>
<td>• Regional EMS will be realized as storage cells become cheaper and are further disseminated.</td>
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<tr>
<td>• Distribution and transmission networks that enable two-way communication between demand side and grid side will be actively established.</td>
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<tr>
<td>• Cost competitiveness of RE will improve as fossil fuel prices increase by more than double. Use of RE will be prioritized and nuclear power will be used as a base.</td>
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<tr>
<td>• EMS that can provide an optimized balance in terms of economy and security between regional EMS and grid will be established.</td>
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<tr>
<td>• EMS that creates demand by charging EVs at the time of excessive RE, and supplies energy to grid at high demand, will be used.</td>
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<tr>
<td><strong>Houses</strong></td>
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<tr>
<td>• Remote reading using smart meters will start.</td>
<td></td>
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<tr>
<td>• HEMS will be disseminated. Some houses will install home servers. Demand response demonstration will start.</td>
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<tr>
<td>• Demonstration of EVs will start.</td>
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<tr>
<td>• HEMS and regional EMS will be integrated. All power generated at houses will be used optimally.</td>
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<tr>
<td>• Various services using home servers will be disseminated.</td>
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<tr>
<td>• EVs will be used for power storage as well.</td>
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<td></td>
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<tr>
<td>• A fully-automated HEMS will be realized.</td>
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<tr>
<td><strong>Buildings</strong></td>
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<tr>
<td>• ZEB introduction will start.</td>
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<tr>
<td>• ZEB will be realized at new public buildings.</td>
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<tr>
<td>• ZEB will lead to a greatly reduced level of emissions for all new buildings as a group.</td>
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</table>
The “Japan Smart Community Alliance,” a public-private consortium, consists of a broad range of Japanese organizations, companies, has founded in April 2010.

It carries out various work for development of roadmaps or dissemination of information to promote international standardization, and strengthening collaboration.

Members: 453 (As of September 14, 2010)

JSCA has members from the electric power, gas, automobile, information and communications, electric machinery, construction and trading industries as well as the public sector and academia.
Thank you very much.

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Initiatives for international cooperation

- **Project base**
  - Each technology was proven at the research project level.

- **Local deployment**
  - Micro Grid project
  - Smart Community project
  - Still its impact is limited.

- **Global deployment**
  - Western countries
  - BRICs
  - Contribution to the world though cooperations
Research will be carried out at five sites in the State of New Mexico. NEDO participates in research in Los Alamos and Albuquerque projects as well as collective research on the overall project.

State of New Mexico, NEDO, Los Alamos National Laboratory (LANL), Sandia National Laboratories (SNL), New Mexico State University, Intel

Collective Research on Overall Project

- Power storage demonstration
- Home demand response demonstration

- Demand response in industrial or commercial buildings

- Smart meter
- Real time pricing
- Direct load control

- Wind farm demonstration
- Stable supply test with power grid

- μ-grid concept in New Mexico State Univ.

New Energy and Industrial Technology Development Organization

- Data management
- Cyber security
- Evaluate effect of Smart grid introduction

Site
Taos
Los Alamos
Albuquerque
Roosevelt
Las Cruces

U.S. partners
Los Alamos County, LANL
PNM, SNL
NEDO demonstration research
NEDO demonstration research
Okinawa and Hawaii shares many similarities.

- Island, Subtropical to tropical climate
- Energy structure (fossil fuel: Hawaii 91%, Okinawa 99%)
- Proactive to renewable energy

Maximum synergy is expected by sharing best practices between the two.

Establishment of a smart community
Introduction of next generation vehicles (e.g. EV)
Promotion of energy efficiency (e.g. ZEB for subtropics)
Development of REs
Overseas Deployment of Smart Community

- Overseas demonstrations are planned in parallel with domestic projects.
- JSCA has been organized to promote domestic and overseas Smart Grid projects.
- Different types of systems will be developed:
  - Urban type (Domestic projects and New Mexico project),
  - Remote island type (Okinawa-Hawaii project),
  - Emerging country type (India).

- Japan—China
  The ‘Smart Community’ Plan includes not only energy project but also water, recycle, transportation system projects.

- Japan—India
  The ‘Smart Community’ Plan materialized after prime minister visit in Dec 2009. JETRO-DMICDC has concluded a MOU. (Mitsubishi, Hitachi, Toshiba, JGC and other major companies have joined)

- Japan (Okinawa)—U.S. (Hawaii)
  Japan - U.S. Clean Energy Technologies Action Plan (November 2009)
  Evaluate the achievements of clean energy projects in both islands to enable the islands to be energy independent, including micro-grid projects, etc.

- Japan—U.S (New Mexico)
  High-level technological tests by the United States National Research Institute and NEDO. About 31 companies (Toshiba and Kyocera etc.) are participating. (Total investment is about 7 billion yen.)
Smart Community Projects
– Four large scale pilot projects started in 2010 –

**Kyoto Keihanna District**
(Kyoto Prefecture, Kansai Electric Power, Osaka Gas Power, KANSAI SCIENCE CITY, Kyoto Univ.)
CO2 ▲ 20%: houses, ▲ 30%: transportation (from 2005)
● ‘Smart tap’ which visualizes energy consumption controls home energy usage.
● ‘Electric power virtual coloring’ technology actualizes total home energy management.

**Yokohama City**
(Yokohama City. Toshiba, Panasonic, Meidensha, Nissan, Accenture, etc.)
CO2 ▲ 30% by 2025 (from 2004)
● Energy management system which integrates HEMS, BEMS, EV
● PV (27000 kW) Use of heat and unused energy
● 4000 Smart houses, 2000 EVs

**Kitakyushu-City**
(Kitakyushu City, Fuji Electric, GE, IBM, Nippon Steel) CO2 ▲ 50% (from 2005)
● Real-time management in 70 companies and 200 houses
● Energy management by HEMS, BEMS
● Energy system which integrates demand-side management and high energy system.

**Toyota City**
(Toyota City. Toyota, Chubu Electric, Toho Gas, Toshiba, Mitsubishi Heavy, Denso, Sharp, Fujitsu, etc.)
CO2 ▲ 20%: houses, ▲ 40%: transportation
● Use of heat and unused energy as well as electricity
● Demand response with more than 70 home 3100EV, V2H, V2G
Yokohama City, Kanagawa

**Planned action**

- Large-scale deployment of renewable energy (27,000 kW photovoltaic system)
- Introduction of smart house/building technology (at 4,000 households/establishments)
- Coordinated control of regional energy (e.g., electricity, heat) complementary to a large network
- Diffusion of the next-generation transport system (2,000 next-generation vehicles)
- Lifestyle innovation through visualization
- Enhanced promotional structure through the establishment of a business alliance

**Proposal outline**

- Construct a new social system by bringing together in Yokohama the wisdom of companies for reducing CO2 emissions and increasing national wealth and promote its deployment overseas.
- In doing so, make the utmost use of Yokohama’s excellent assets and opportunities, such as civic power, diverse geographical features, and APEC meetings
- To make the project sustainable, construct a system in an existing urban district where people actually live
- Establish an entity responsible for overall decision making, investments, and publicity to organize a promotional structure involving energy companies and users
- Seek to reduce CO2 emissions by 30% by 2025 compared to the 2004 level

**Partner**

- TOSHIBA
- Accenture
- Tokyo Gas
- NISSAN
- Panasonic
- MEIDEN

**MinatoMirai district**
Planned action

- Efficient use of energy in households (70 or more households)
- Efficient use of energy based on communities
- Establishment of a low-carbon transport system (diffusion of 3,100 next-generation vehicles)
- Lifestyle innovation through support to encourage consumers to change their action patterns and verification of its effect as an incentive (to reduce social costs)
- Development of strategy for global deployment (global deployment and international standards)

Proposal outline

- Focus on the household sector (homes and cars) and aim to construct a low carbon social system through joint efforts of global companies, leading local firms, and the local government in cooperation with consumers
- Demonstrate the efficient use of a mix of different energy sources (electricity, heat and unused energy) and the construction and linkage of low carbon transport systems, while restricting social costs
- Make standardization and other efforts emphasizing international competition
- Seek to reduce CO2 emissions by 20% in households and 40% in transport
Installation of photovoltaic systems in 1,000 households
Building “nano-grids” in homes and buildings to intelligently control power generation systems (e.g., solar cells, fuel cells) and electrical storage systems through “computerized” management of energy
Active deployment of EVs and construction of a network of charging stations
Proposal of a regional energy economy model based on “Kyoto eco-points”
Establishment of a model for local energy production for local consumption by integrating the above actions
Experiments to demonstrate complementarities between a regional nano-grid and the national grid

Control energy by visualizing energy flows in homes and offices as well as those through EVs (a “nano-grid” project) in Kansai Science City, which aims to study and demonstrate sciences for a sustainable society and create new industries based on them
By doing so, confine fluctuations in demand arising from human activity patterns and the instability of natural energy sources, and aim to establish a stable and efficient regional energy system and create new industries
Seek to reduce CO2 emissions by 20% in households compared to the 2005 level and 40% in transport by 2030
Planned action

- Creation of a city block where new energy, including that from industry, accounts for 10% of energy consumption
- Deployment of energy conservation systems for an entire town (e.g., real-time energy management for 70 companies and 200 households using smart meters)
- City block energy management through a regional energy saving station
- Development of communities and transport systems based on energy infrastructure
- Establishment of a system to transfer the outcomes to other parts of Asia

Proposal outline

- Aim for regional energy management in which citizens and all other community members participate, by building a smart grid based on the local new energy infrastructure (solar power, hydrogen, etc.) and community infrastructure of the Yahata Higashida district, which has been pursuing an eco-friendly community under the leadership of the private sector, and eventually create a society with 50% less CO2 emissions
- Disseminate the outcome across the city by incorporating it in the city’s community development policy and expand it to Asia through networking with other Asian cities
- Seek to achieve, in addition to the current target of reducing CO2 emissions by 40% by 2030 and 70% by 2050 in the residential/commercial and transport sectors), an additional 10% reduction (80% reduction instead of 70% by 2030, 80% reduction instead of 70% by 2050)