Energy System Integration

— Distributed Energy Management for Sustainable Energy Demand and Supply —

June 18th, 2014

Kazuhiko OGIMOTO

Center of Energy Engineering, Institute of Industrial Science, The University of Tokyo
1. Impact of Energy Scenario Selection
2. Variability : issue of balancing capability
3. Flexibility : Challenge to variability
   - Generator, Demand, Transmission, interconnection, System operation, Market-
     3.1 Demand Activation – auto-DR-
4. Power Market Issues
5. Energy System Integration
6. R&D
7. Beyond Energy
1. Impact of Scenario Selection

Japan’s Energy Supply Prospect (METI 2010)

After the quake, in order to revise the Basic Energy Plan, there are broad discussions on the future energy mix of Japan including nuclear scenarios in several government committees and among various non-governmental entities.

Primary Energy Supply (G litter)

- **2007 (Practice)**
  - Coal: 60 (23%)
  - Natural Gas: 105 (19%)
  - Oil: 344 (39%)
  - LPG: 18 (5%)
  - Nuclear: 60 (10%)

- **2030 (Projected)**
  - Coal: 88 (23%)
  - Natural Gas: 81 (21%)
  - Oil: 141 (39%)
  - LPG: 18 (5%)
  - Nuclear: 122 (30%)

- Half of the import fuel is targeted to be from owned source. (About 70%)

Self-supply (About 40%)

Generation (100GWh)

- **2007 (Practice)**
  - Nuclear: 2,638 (26%)
  - Oil: 1,356 (13%)
  - LNG: 2,822 (28%)
  - Coal: 1,131 (11%)
  - Zero emission Supply(70%)

- **2030 (Projected)**
  - Nuclear: 5,366 (53%)
  - Oil: 205 (2%)
  - LNG: 1,357 (13%)
  - Coal: 1,131 (11%)
  - Zero emission Supply(70%)

- Half of the import fuel is targeted to be from owned source. (About 70%)

Zero emission Supply (34%)
Assumption for the analysis

◆ Analysis Period: 2011-2030
◆ Base Line toward 2030
◆ Assumptions of Generation facilities and operation
  Power Supply Plans of Power utilities
  Demand: variation according to ambient temperature, EV, HPWH and Batteries
  Coal and NG Power Plants: 40 year life, expansion with reserve margin criteria
  Oil fired power plants: No addition, no retirement excluding announced ones
  PV and, wind: Hourly variation of generation, reduced implementation cost for PV
  Hydro: Monthly variation of generation
  Interconnection: No expansion, fixed operation
  Fuel cost: assumed to be stable at the level in January, 2011
◆ Analysis tool: ESPRIT
### Assumed Nuclear Scenarios

<table>
<thead>
<tr>
<th>No.</th>
<th>Scenario</th>
<th>Shape in 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>2010 Plan</td>
<td>The outlook before 3.11 disaster, which is based on the long-term energy outlook in 2008 and the basic energy published Plan in 2010.6. The nuclear development of fourteen units are assumed by 2030 with 90% utilization factor.</td>
</tr>
<tr>
<td>2a</td>
<td>Continued Development</td>
<td>Continued Nuclear development with some delay. PV80GW, Wind 28GW</td>
</tr>
<tr>
<td>2b</td>
<td>Continued Nuclear Development, 40 year life</td>
<td>Continued Nuclear development with some delay. Existing nuclear units are demolished after 40 year operation. PV80GW, Wind 28GW</td>
</tr>
<tr>
<td>3a</td>
<td>No Nuclear Development, 40 year life</td>
<td>No new nuclear development. Existing nuclear units are to be demolished after 40 year operation. PV of 80GW, Wind of 28GW</td>
</tr>
<tr>
<td>4a</td>
<td>Abolition in 5 years</td>
<td>No new construction. Existing nuclear units are to be demolished in 5 years. PV80GW, Wind 28GW</td>
</tr>
<tr>
<td>4b</td>
<td>Abolition in 5 years and aggressive thermal development</td>
<td>No new construction. Existing nuclear units are to be demolished in 5 years. 37.5 GW coal and NG fired power plants are additionally developed to compensate the reduction of nuclear. PV of 80GW, Wind of 28GW</td>
</tr>
<tr>
<td>4c</td>
<td>Abolition in 5 years and aggressive PV and Wind development</td>
<td>No new construction. Existing nuclear units are to be demolished in 5 years. PV of 160GW and wind of 160GW to compensate the reduction of nuclear.</td>
</tr>
</tbody>
</table>

---

**National Energy Plan before the quake**

53GW PV, 10GW Wind in 2030

Fukushima Daiichi and Daini units are out of operation excluding Scenario 1.
1. Impact of Scenario Selection

Assumed Nuclear Scenario

1. Impact of Scenario Selection

Assumption of Cost of PV and Wind

- PV deployment was assumed by existing and new houses, and large-building integration and Mega-solar.
- The cost of PV in 2030 is assumed to be 100 k¥/kW for new houses assuming building integration, 200 k¥/kW for existing houses including installation cost of 100 k¥/kW, for commercial buildings and mega-solar.
- The cost of wind generation is assumed to be constant at 150 k¥/kW for wind assuming balance of cost reduction of equipment and cost increase due to site condition.
- The distribution of PV and Wind deployment among power system is assumed based on power demand for PV and resource availability for wind.

<table>
<thead>
<tr>
<th>系統</th>
<th>1</th>
<th>2a-4b</th>
<th>4c</th>
<th>4d</th>
</tr>
</thead>
<tbody>
<tr>
<td>北海道</td>
<td>0.6</td>
<td>1.8</td>
<td>10.1</td>
<td>2.0</td>
</tr>
<tr>
<td>東北</td>
<td>3.2</td>
<td>9.1</td>
<td>51.9</td>
<td>9.7</td>
</tr>
<tr>
<td>東京</td>
<td>0.4</td>
<td>1.0</td>
<td>5.8</td>
<td>3.3</td>
</tr>
<tr>
<td>中部</td>
<td>0.4</td>
<td>1.0</td>
<td>5.8</td>
<td>2.0</td>
</tr>
<tr>
<td>北陸</td>
<td>0.7</td>
<td>2.0</td>
<td>11.5</td>
<td>2.2</td>
</tr>
<tr>
<td>關西</td>
<td>1.2</td>
<td>3.3</td>
<td>18.7</td>
<td>4.4</td>
</tr>
<tr>
<td>中国</td>
<td>0.8</td>
<td>2.3</td>
<td>13.0</td>
<td>2.7</td>
</tr>
<tr>
<td>四国</td>
<td>0.5</td>
<td>1.3</td>
<td>7.2</td>
<td>1.5</td>
</tr>
<tr>
<td>九州</td>
<td>2.1</td>
<td>5.8</td>
<td>33.2</td>
<td>6.5</td>
</tr>
<tr>
<td>沖縄</td>
<td>0.2</td>
<td>0.5</td>
<td>2.9</td>
<td>0.6</td>
</tr>
<tr>
<td>全国計</td>
<td>10.0</td>
<td>28.0</td>
<td>160.0</td>
<td>35.0</td>
</tr>
</tbody>
</table>

Assumption for thermal and nuclear

- The development cost of thermal power plants: 250000 yen/kW for coal fired, 150000 yen/kW for NG fired
- The fuel cost of NG and coal: constant at the levels of January 2011. The price increase in the future is not included. (In the Japan government’s Cost Verification Committee has adopted the fuel prices from the scenarios of World Energy Outlook 2011.)
- The fuel cost of nuclear: 1 yen/kWh

1. Impact of Scenario Selection

Power Supply Capacity and Generation

- The figure of Supply Capacity indicates the assumed supply capacity scenario.
- When the nuclear generation decreases, thermal generation takes the major substitute, due to the limited contribution of PV, wind of around 15% share in scenario 2a through 4a.

Japan’s Power Supply capacity in 2030

- PV 53GW, Wind 10GW
- PV 80GW, Wind 28GW
- PV 160GW, Wind160GW

Japan’s Generation in 2030

- Share of PV and wind is around 15%.

1. Impact of Scenario Selection

Security: Supply reliability and stable operation

- The indicators of Expected unserved energy (EUE) and Loss of Load Probability (LOLP) show the unsecured situation when nuclear plants are stopped within 5 years.

- The difficulties in demand-supply balancing of a power system operation will cause a part of RE generation curtailment, which reduces the benefits of RE deployment.

Even with the assumed penetration of PV and Wind, reduced nuclear generation will cause a substantial increase of fuel cost for increased coal, natural gas, and oil.

The total cost of fuel and annualized capital shows the pessimistic economy for aggressive RE penetration in 2030.

Kazuhiko Ogimoto, Kazuto Kataoka, Takashi Ikegami, Yusuke Udagawa, Makoto Akai: Study of Best Mix of Long-Term Power Demand and Supply(2), JSER Annual Conference, 1-1 (2013)
Outlook of Power System: CO2 Emission

- The CO2 emissions, indicating almost the same trend as that of fuel cost, increase between 50Mt-CO2/year and 250Mt-CO2/year in Scenarios 2a, 2b, 3a, and 4a for the year 2020.

- In 2030, as compared to Scenario 4a, Scenario 4b with reinforcement of thermal power plants shows no major improvement in emissions. CO2 emissions decrease drastically in Scenario 4c with huge RE deployment under the expense of the RE capital cost.

Kazuhiko Ogimoto, Kazuto Kataoka, Takashi Ikegami, Yusuke Udagawa, Makoto Akai: Study of Best Mix of Long-Term Power Demand and Supply(2), JSER Annual Conference, 1-1 (2013)
1. Impact of Scenario Selection

Self-sufficiency ratio of Generation

- RE and nuclear being indigenous and semi-indigenous, the self-sufficiency ratio of primary energy for power production decreases when the nuclear generation decreases from scenario 1 through 4a.

- The self-sufficiency of the total energy supply is far more smaller.

Self-sufficiency ration of power generation in 2030

Kazuhiko Ogimoto, Kazuto Kataoka, Takashi Ikegami, Yusuke Udagawa, Makoto Akai: Study of Best Mix of Long-Term Power Demand and Supply(2), JSER Annual Conference, 1-1 (2013)
1. Impact of Scenario Selection

Long-Term Planning

- Demand and Generation option identification and analysis
- Transmission and distribution option identification and analysis including power system interconnection
- Demand activation option identification and analysis
- Re-Confirmation of the Energy Policy, S+3E.
- Establishment of executable plan
2. Variability: Issues of balancing capability

The Implication by an Extreme Case

- Image of equivalent system demand under PV penetration of 4, 8, 12, 16, 20% of the assumed total generation of 2030

- The variation of RE generation brings about the issue of demand-supply balance.

- The countermeasures for the issues are more sophisticated operation existing and new technologies in operation and new asset portfolio.
2. Variability: Issues of balancing capability

Variable Nature of RE Generation

PV generation has a variable nature due to time and changes of weather, although the variation is predictable to a certain extent.

Fig. 24hour PV output variation in 90 days in summer

Fig. PV output variation at 14:00 in 90 days in summer
Two Factors of Reduced Balancing Capability

- The ultimate impact of PV Penetration on a power system is the difficulty of supply and demand balance.

- Increased variation under reduced regulation capability and Increased variability are the two risk factors of the stable power system operation.

Hourly system load, PV generation, and an equivalent load
2. Variability: Issues of balancing capability

Net Load Analysis

- Wind power 28 GW in Japan,
  9.1 GW in Tohoku System, 1.0 GW, Tokyo System
- PV 80 GW in Japan,
  7.7 GW in Tohoku System, 26.5 GW in Tokyo System

Kazuto Kataoka, Takashi Ikegami, Yusuke Udagawa, Kazuhiko Ogimoto, Takashi Oozeki, Tetsuo Saitou: Analysis and evaluation of variable renewable generation and demand, IEEJ Workshop, FTE-12-52, MES-12-23 (2012)
2. Variability: Issues of balancing capability

Impact of Large Ramp

- Based on the current n-1 criteria, the severest variability of net load is with the failure of the maximum generation capacity of 1.35

- Under a large weather change in a broad area variable RE has a possibility of large ramp down of its generation, which may cause a critical impact on a power system operation.

- It is important to analyze the net load and to forecast a critical Ramp.

Kazuto Kataoka, Takashi Ikegami, Yusuke Udagawa, Kazuhiko Ogimoto, Tetsuo Saito: Preliminary Analyses of Wind Power and Residual Load Ramps, IEEJ Annual Conference, 6-143,pp259-260 (2013)
2. Variability: Issues of balancing capability

Sort Term Variability of Wind

- Based on the analysis of aggregated wind power generation data of 13 wind firms (292 MW) in Tohoku, the difference between maximum and minimum data is more than 20% (or ±10%) of the installed capacity.

- The current reserve capacity for load frequency control of 2% of the load is ±0.16 GW at the minimum load of 8GW.

- When the wind capacity is 9GW the short-term variation of ±0.9GW is far beyond the current reserve. This situation suggests the difficulty of stable operation of the power system.

Short-term variation of wind in Tohoku

Kazuto Kataoka, Takashi Ikegami, Yusuke Udagawa, Kazuhiko Ogimoto, Tetsuo Saito: Preliminary Analyses of Wind Power and Residual Load Ramps, IEEJ Annual Conference, 6-143, pp259-260 (2013)
2. Variability: Issues of balancing capability

**Issues of Balancing Capability: Common issues in Low Carbon Energy Supply**

- Reduction of fossil fuel utilization for sustainable energy supply, the share of power in the energy demand and supply and the share of non-dispatchable power supply in a power system will increase.

- The requirement for additional supply-demand balancing resources in a power system is universal in all the countries in the world.

Source of figures: CoolEarth Innovative Energy technology Program
3. Flexibility: Challenge to variability

Enhancement of Flexibility

From now to the future, a series of enhancement measures should be applied under the estimation of needs and possibilities of now and the future:

- **The maximum usage of the traditional generation**:
  - Increased ramp rate and reduction of minimum load and start-up time
  - New operation of pumped storage and variable speed technology
  - Enhanced operation of hydro power

- **Aggressive usage of variable RE generation**
  - Active power control for output limit, ramp rate limit, primary and secondary and tertiary frequency control
  - Reactive power control

- **Activation of demand (auto-demand response)** including houses and commercial buildings, and vehicles/batteries.

- **Strengthening of distribution system, transmission lines and interconnections** for holistic optimization of flexibility resource usage

- **Improvement of system operation** including the *generation forecast* of variable PV and wind and evolution of the system
4. Flexibility Resources

Optimum Integration of Flexibility Resources

3. Distributed Energy Management and Demand Activation

Power and Information Network

Physical Law

Rule and Market

Balancing

3. Energy storage

2. Optimum Deployment and operation of RE

1. Existing Generation

4. Flexibility Resources

4. Upgrade and Interconnection

5. Sophisticated Operation

1. Existing Generation
3. Flexibility: Challenge to variability

Thermal Power

- The number of operational thermal units reduces under the decline of a net load due to variable RE penetration.
- The thermal units are expected to have the following features for the increase of balancing capability:
  - Increase of ramp rate
  - Reduction of minimum load
  - Reduction of start-up time

Features of Flexibility of a generation Plant

3. Flexibility: Challenge to variability

**Demand Activation by Distributed EMS**

The power supply/demand balance is currently regulated by centralized EMS using major generators. When RE penetrates into the system, distributed EMS will take a part of the balancing capability at the demand side through demand activation, or auto-demand-response.

- **Current control of supply/demand balance**
- **Control of supply/demand balance through storage batteries**
- **Additional adjustments at existing generation facilities**
- **Control of supply/demand balance through storage batteries and more active control on demand side**
- **Should storage batteries become economically feasible, the supply/demand balance could be adjusted via optimal allocation of storage equipment**
- **If the demand side can take on part of the regulation of the supply/demand balance, economy can grow while reducing the use of resources**

Diagram:

- Green arrows: Stabilization
- Red arrows: fluctuation

©2011 Ogimoto Lab.
✓ HEMS and BEMS, distributed energy management systems, are the appropriate hub for the demand activation because they can totally pursue three targets:
1) enhancement of quality of life and work environment in buildings,
2) reduction of cost and environmental footprints, and
3) balancing capability for a power system in harmonization with centralized EMS.

✓ The distributed EMS such as HEMS and BEMS autonomously control demand, energy storage and others.

✓ Area EMS will be effective to enhance the control capability of demand side with more resources in the area.
3. Flexibility: Challenge to variability

Harmonization of centralized and distributed energy management

3.1 Demand Activation

Activation of Heat Pump Water Heater

- Under the dynamic pricing reflecting the variation generation and generation forecast of RES, the operation of heat pump water heaters can be optimized to minimize power cost.

- Sophisticated control of HPWH can contribute to level the residual power system load to minimize the total system cost without disturbing the hot water use of houses.

**Table: Original, residual, and new loads**

<table>
<thead>
<tr>
<th>Heat demand</th>
<th>Power Purchase Price</th>
<th>Purchased power</th>
<th>Charge</th>
<th>Power Storage</th>
<th>System Demand(GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Graphs:**

- Power Purchase Price
- Purchased power
- Charge
- Power Storage
- Heat Storage
- Heat Production
- Heat demand
- System Demand(GW)

**Notes:**

PV: 17GW PV systems of 3 to 4 kW, 3.4 kW on average, are deployed in a power system.

Battery: 7.5GW-30GWh Battery systems of 1 to 2 kW, 2 to 12 kWh, 1.5kW and 6kWh on average, with the round trip loss of 2 15 to 20%, 16% on average

HPWH: 20 GW HPWH of rated Heat output of 3, 4, and 12 kW, 4 kW on average, with a hot water tank of 200 L for 3kW system and 370 L for others.

3.1 Demand Activation

**Activation of EV Charging**

- Under the dynamic pricing reflecting the variation generation and generation forecast of RES, the charging of EVs can be optimized to minimize charging cost.
- **Sophisticated control of EV charging** can contribute to level the residual power system load to minimize the total system cost without disturbing the EV use for driving.

- Simulate 10 million EVs with a battery of 24 kWh, 3.0 kW. EVs are assumed to drive on an average speed of 21 km/h with power use of 10 km/kWh.

*Figures showing system load, marginal cost, and ratio of EV on duty.*

3.1 Demand Activation
Balancing Capability Enhancement

- Generation is scheduled to meet the system demand including variable generation of PV and wind, and activated demand by one-day ahead scheduling.

- Additional balancing capability from demand activation can be useful as well as all the other countermeasures such as generators, energy and storage so as to minimize generation curtailment of PV and wind.

Scenario 2b  Tohoku-System, Max generation of PV+Wind, w/ and w/o Battery
3.1 Demand Activation

Expansion of Scope of Smart Grid

- An **existing Power System** is structured by generation, transmission, distribution and in-active demands with uni-directional power flows.

- The increase of controllable distributed loads, generations, EVs and batteries has been activating the demands and make the power flows bi-directional.

- The harmonization of centralized/decentralized energy management will increase the flexibility to accommodate carbon-free and low carbon energy supply.

- The demand activation brings about availability of new data and information which enables new energy services, new energy-related and non-energy-related services, and new products.

- However, the information and data for new services and products requires **higher specification** with a new ICT infrastructure than original energy requirements.
3. Flexibility: Challenge to variability

System Operation: Sophistication

- The committee, run by The National Policy Unit (NPU) which reports directly to the prime minister, verified the demand-supply balance of Japan’s 9 power systems in which all the nuclear plants are stopped due to the nuclear failure in the Great East Japan Earthquake and the following tsunami.

- The Various countermeasures including Energy Efficiency, demand curtailment, demand response, cooperation of demand sector, restart of old generators, utilization of interconnections were verified quantitatively.

Demand-Supply Balance including Pumped Storage (Kansai System)

Report of the Demand-Supply Verification Committee
In the future low carbon power system, where REs and nuclear increase and dispatchable thermal decreases, system operation will change including demand activation.

The current power system operation of Japan and all the foreign systems will have to change gradually according as the change of demand-supply structure. In order to realize RE penetration advanced system operation including the analysis of variation feature, development of generation forecast, management of numerous demand, best use of RE power curtailment is important.

The institutions should be reformed where necessary to support the change.
4. Power Market Issues

Operation of Thermal Generation

- The penetration of variable RE generation and their prioritized dispatch reduce the production of the utilization of traditional thermal units and their market prices.


Decline of thermal operation hours in Spain

Euelectric, “RES Integration and Market Design: are Capacity Remuneration Mechanisms needed to ensure generation adequacy?” (2011)

4. Power Market Issues

Base load price in Western Central Europe Market

- In the first quarter of 2013, the market price of base load in Germany have reached its bottom in the last seven years due to reduction of coal price and abundant generation of wind power.

- In Germany, on March 24th, the negative market price, which occurred only during night before the end of 2012 occurred during day time.

Energy is essential for all the human activities. The constraints of energy directly affect our economy and quality of life.

For the sustainable society, energy system should sustainable according to multiple criteria such as economy, stability and environment, and stability. And uncertainties such as fuel price, environmental constraints, technology development and socio-economic conditions should be considered.

For the sustainable energy system, it is important to integrate all the options of technology, institution, and life style.

For the evolution of energy system, broad and long-term perspective is important including R&D and deployment of technology and human development.

There being variety of conditions and constraints in the real world, the path of the energy system evolution is diversified and uncertain.

Through envisioning the future, the Energy System Integration, or the maximum optimization of possible options is the key for the success.
By considering the total structure of energy system, we can expand our optimization scope: from a house, a community, a grid, a nation, to the world, from supply side to supply and demand sides including network, from electric power, all the kind of energies such as power, gas, oil, to all the utilities.

However, there are various constraints:
1) Technological: distribution/transmission system, interconnections
2) Institutional: Tariff, codes, operation condition, balancing
3) Security: Robustness to natural disasters, failures, and malicious attacks

Demand activation in a house, a community, which is realized by distributed energy management, is the key to the future energy system.

It is important to include lessons learned from the quake.

Furthermore, it is important to recognize that what we need is not energy itself, but services such as well-conditioned space.
 Practices of Energy Technology Strategy (2004-)
In 2005, METI formulated the "Energy Technology Vision 2100" as a navigating tool for strategic planning and implementation of energy technology.

The vision, being developed by back-casting the technology portfolio from the year 2100, consists of roadmaps of Residential/Commercial, Transportation, Industry, Transformation sectors.

**Source:** Energy Technology Vision 2100, Institute of Applied Energy and METI (2005)
6. R&D

Energy Technology Map for RES and Distributed System

Objective | Class | Energy Technology | Technology
---|---|---|---
③New Energy Development and Dissemination | | | 
Cross Cutting Technology | | | 
21 Energy Management | 1211F HEMS | 1213F Area Energy Management | 
22 高効率送電 | 1212F BEMS | | 
55 熱輸送 | 1221S 超電導高効率発電 | | 
56 蓄熱 | 1222S 大容量送電 | | 
11 高効率内燃機関 自動車 | | | 
New Power Supply System Power storage system | | | 
50 New Power Supply System | 3051F Demand system Technology | | 
54 Power storage system | 3502B Distribution system Technology for DG interconnection | | 
3543M ニッケル水素電池 | 3503K Transmission system Technology for DG interconnection | | 
3544M Lithium Ion Battery Technology | | | 
3545M キャパシタ | | | 
3546O 揚水発電 | | | 
3547F 超電導電力貯蔵 | | | 
3548K 壓縮空気電力貯蔵(CAES) | | | 

Source: METI technological strategy map (2009)
Based on the series of studies of energy technology strategy, Cool Earth energy technology innovation plan was established to 21 energy technologies.

**Improved efficiency**
1) Highly efficient, natural gas thermal power plant
2) Highly efficient coal-fired thermal power plant
3) Carbon capture and storage
4) Innovative solar power plant
5) State-of-the-art nuclear power plant
6) Superconductive power distribution
7) ITS
8) Fuel-cell cars
9) Plug-in hybrids, electric cars
10) Alternative fuels for vehicles using biomass energy
11) Innovative materials, manufacturing and processing technologies
12) Innovative steel-making processes
13) Energy-efficient housing/buildings
14) Next-generation super-efficient lighting
15) Stationary fuel cells
16) Super-efficient heat pumps
17) Energy-efficient IT equipment and systems
18) HEMS/BEMS/ regional EMS※
19) High-performance electric power storage
20) Power electronics
21) Generate, transport, store hydrogen power

**Low carbon**

Source: METI Cool Earth energy technology innovation plan report
The project, “National Project on Optimal Control and Demonstration of the Japanese Smart Grid for Massive Integration of Photovoltaic Systems”, consisting of 4 groups of distribution system control, a new inverter, home energy management, and centralized energy management of a system level, deals with issues associated with mass penetration of photovoltaic power generation systems.
The project, “National Project on Optimal Control and Demonstration of the Japanese Smart Grid for Massive Integration of Photovoltaic Systems”, consisting of 4 groups of distribution system control, a new inverter, home energy management, and centralized energy management of a system level, deals with issues associated with mass penetration of photovoltaic power generation systems.

HEMS group, located in a laboratory area of the University of Tokyo, takes charge of development of methodology for optimum control of customer’s equipments according to demand-supply balance of a whole utility grid with a large amount of PV.
Based on the platform of building, appliances, ICT, control system with external information of atmosphere, power system, prediction and others, we are trying to realize the HEMS with the following three axes:

**Energy Efficiency and Environment axis**
- Energy System contribution axis
- HEMS
- Smart meter
- Solar heat water heater
- Battery
- Home basic performance improvement: high airtightness, high thermal insulation, ventilation and lighting function improvement
- Air conditioner
- Solar power generation
- Medical health
- Education monitoring
- Crime prevention and disaster prevention
- Electricity visible
- Water and gas visible
- Electric vehicle
- Air conditioning control etc.

**QoL Axis**
- Comfort and convenience
- Fun
- Energy saving and reduced lighting fees
- An 대한 정보
- Animal calorimeter
- Window opening and lighting
- Solar hot water heater
- Battery
- Home basic performance improvement: high airtightness, high thermal insulation, ventilation and lighting function improvement
- Air conditioner
- Solar power generation
- Medical health
- Education monitoring
- Crime prevention and disaster prevention
- Electricity visible
- Water and gas visible
- Electric vehicle
- Air conditioning control etc.

**System Contribution Axis**
- Need adjustment
- Peak cut
- Other homes
- Cloud data center
- Electric forecast
- Weather forecast • solar radiation forecast • generation forecast

Based on the platform of building, appliances, ICT, control system with external information of atmosphere, power system, prediction and others, we are trying to realize the HEMS with the following three axes:
COMMA House: UT Demonstration Smart House
Envisioning Residence in 2020

- COMMA House is a demonstration smart house jointly developed by the University of Tokyo and LIXIL Corporation in Komaba Research Campus.
- Underlying concept of the COMMA House is simultaneous achievement of comfort, energy efficiency and maximum use of renewable energy.
- Features of COMMA House includes: 1) Architectural structure for air tightness, thermal insulation and earthquake resistance, 2) Adjustable opening to control wind, light and heat, 3) Coordinated control and operation of appliances from multiple vendors, 4) Integration of architectural features with energy technologies, 5) Combination of automated control with active involvement by inhabitants for comfort and energy usage optimization utilizing (HEMS).

*1) HEMS (Home Energy Management System): センサー や IT を活用し、住宅のエネルギー管理を行うシステム

【本件に関するお問い合わせ先】
http://www.commahouse.iis.u-tokyo.ac.jp/
7. Beyond Energy

Sustainable Society: Vision of Future Energy System and Community

- Optimization of energy sector and maximization of service level, economy and security through maximum rational utilization of renewable/unused energy and rational energy use.
- In urban area, energy and utility system will be established and operated by building and area management system in optimized and harmonized manner.
- Networks of various energies and utilities and will be managed through monitoring, controlling, and optimizing.

 Establishment of Smart Utility System.
Thank you

Ogimoto Laboratory, Institute of Industrial Science, the University of Tokyo
http://www.ogimotolab.iis.u-tokyo.ac.jp/

In related contents are available in English and Japanese.
http://nippon.com/en/in-depth/a00302/

The description of “1. Impact of Scenario Selection” is available in this book which is just published July, 2012.