Smart Grid for Future System

Dr. Suthep Chimklai
Director, System Planning Division, EGAT
Pattaya, Chonburi
September 29, 2011
EGAT’s System

- Generation System
- Transmission System
- System Control and Operation

**Technologies for EGAT’s System:**
SCADA (Supervisory Control And Data Acquisition)
Modern Protection System.

**Communication System:**
Two – way communication.

Currently, EGAT’s System is being developed to be Smart Grid
Examples: EGAT’s Smart Grid

- SCADA System

- Communication System:
  
  - Power Line Carrier: Communication is sent via Line Trap / Wave Trap
  
  - Optical Fiber in Overhead Ground Wire: Optic Fiber is integrated into the Overhead Ground Wires of transmission lines, namely OPGW (Optical Fiber in Overhead Ground Wire)
• **Global Warming and Climate Change** due to the emission of Green House Gas, GHG to atmosphere, then Smart Grid is initiated to enhance and support for the solution in energy sector
US Policy on Smart Grid

• “We’ll fund a better, smarter electricity grid and train workers to build it…”
  President Barack Obama

• “To meet the energy challenge and create a 21st century energy economy, we need a 21st century electric grid…”
  Sec. of Energy Steven Chu

• “A smart electricity grid will revolutionize the way we use energy, but we need standards…”
  Sec. of Commerce Gary Locke

American Recovery & Reinvestment Act (ARRA) of 2009

Smart Grid Investment Grant (SGIG)
- 100 projects
- $3.4 billion

Smart Grid Demonstration Projects (SGDP)
- 32 projects
- $600 million

Smart Grid Workforce Training
- 54 programs
- $100 million
US Grant on Smart Grid

<table>
<thead>
<tr>
<th>Category</th>
<th>$ Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated/Crosscutting</td>
<td>2,150</td>
</tr>
<tr>
<td>AMI</td>
<td>818</td>
</tr>
<tr>
<td>Distribution</td>
<td>254</td>
</tr>
<tr>
<td>Transmission</td>
<td>148</td>
</tr>
<tr>
<td>Customer Systems</td>
<td>32</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>26</td>
</tr>
<tr>
<td>Total</td>
<td>3,429</td>
</tr>
</tbody>
</table>

18 million smart meters
1.2 million in-home display units
206,000 smart transformers
177,000 load control devices
170,000 smart thermostats
877 networked phasor measurement units
671 automated substations
100 PEV charging stations

Reference: Presentation at EGAT 7 January 2011 Nonthaburi, Thailand By Dr. Manisa Pipattanasomporn
Smart Grid

• What is Smart Grid? ¹/

From Generator to Customer, all parties can access to the energy management

- **Power Management**
- **Two – way Communication**

Hardware and Software to connect Generation System, Transmission System, Distribution System and Customer

---

¹/ EGAT’s Working Group on Smart Grid for the Future System
What part of the system relates to Smart Grid?

**Generation and Transmission**
- Renewable Energy Integration
- Data Access at the Enterprise
- System Modeling and Simulation
- Relays & Control
- Wide-Area Measurement
- Condition – Based Management
- Volt/VAR Management
- Peak Load Management

**Distribution**
- Feeder Outage Management
- Relays & Controls
- Data Access at the Enterprise
- Integration Automation
- Condition - Based Maintenance
- Peak Load Management
- Volt/VAR Management

**Customer**
- AMI
- Demand Response
- Smart Homes
- Electric Vehicles
- Real-Time Pricing

What make it smart: **two-way communication; real-time monitoring & control**
**Driver Factors for Smart Grid for Future System**

**Electricity Network:**
- High use of renewables - 20%-35% by 2020
- Distributed generation and microgrids
- Bi-directional metering - selling local power to the grid
- Distributed storage
- Networked sensors and automated controls throughout the grid

**Customer participation:**
- Smart meters that provide near real-time usage data
- Time of use and dynamic pricing
- Smart appliances communicating with the grid
- Energy management systems in homes as well as commercial and industrial facilities linked to the grid
- Growing use of plug-in electric vehicles
Concerned Levels for Smart Grid

From Generator to Refrigerator

- Power Plant
- Transmission
- Distribution
- Home Business
- End-use Appliances
Issues on Smart Grid for Future System

1. Standards
2. Technologies
3. Cyber Security
4. Legislation & Regulation
5. Education, Training and Awareness
1. Technical Issues and Technology on Smart Grid for Future System

- Based on Generation, Transmission, and Control System
- EGAT applies SCADA System and Protection System
- New Technologies being applied:
  - Digitized Substation
  - Wide Area Monitoring System (WAMS)
  - Special Protection Scheme (SPS)
  - Automatic Fault Analysis (AFA)
2. Benefits from Smart Grid on Future System

**Investment**: - High efficiency on Generation and Transmission  
- Reduction of O&M Cost

**Stakeholders**:  
- High Performance Organization  
- Environmental Friendliness due to decreasing Greenhouse Gas

**Internal Process**: System Performance Indicator (SPI) is improved

**Learning and Growth**: Learning organization to sustainably move forwards
3. EGAT’s Readiness for Smart Grid

EGAT continues to develop generation/transmission/control and communication system for Monitoring and Controlling to make EGAT’s System Automated and Integrated.

4. Smart Grid with SPP and VSPP

Two-way communication via Smart Grid to integrate SPP and VSPP as Single Grid.
Effects of DG Integration

- Performance and Controllability of Different Types and Sizes of DGs

- Different Load Control Algorithms and Communication Protocols

- System Security Under Diverse Operations
5. Future Implementation for Smart Grid

Interoperability Standard for Smart Grid is required to be discussed for future compatibility development of the Power System.
Effects of Renewable Energy Integration

Fluctuation in Wind Resources (Texas Data)

Wind Forecasting Errors (Oregon Data)

BPA forecast and actual wind power output
May 19, 2010
Load Curve and Load Duration Curve (EGAT’s System)

- Peak: 24,010 MW
- Energy: 160,113 GWh
- Plant Factor: 76%
Hourly Generation by Solar Power
(Sirindhorn 1.012 MW, Pha Bong 0.504 MW)

- **Total Capacity**: 1.516 MW
- **Total Energy**: 2.243 GWh
- **Plant Factor**: 16.9%

Daily Profile

1 Jan 2010 – 31 Dec 2010
Hourly Generation by Wind Power
(Lam Takhong: 2.5 MW)

- Maximum: 3 Nov. 2010 7.00 am
- Total Capacity: 2.5 MW
- Total Energy: 3.319 GWh
- Plant Factor: 15.2%

Average: 0.379 MW
Min: 0 MW
Max: 2.478 MW
StDev: 0.506 MW
Effects of Electric Vehicle (EV)

EV Effects on Transmission System

**EV**: EV cars will be charged their electric power when they are parked at home, then the large amount of power consumption will start at the same time and results in transmission line overloading or tie - transformers (230/69 kV or 230/115 kV) normally overloading or N-1 overloading

**Facts**: - Quick Charging with Battery of 25 kWh requires 120 kW (0.12 MW) for 10 minutes

- If there are 120,000 EV cars by 2016 (or earlier), and 100,000 EV cars are charged for electric power at the same time (7.00 pm.), the power consumption approximately increases for **12,000 MW**
Charging EVs can overload transmission and distribution transformers

Household load (kW) w/ PHEVs

- Charge type: Quick charge
- Charge power: 3.84 kW

Target: Peak Load Reduction and Load Factor Improvement
EV Charging Station
EV Charging Station (Cont’d)

3-5D PHV and PHV Charger

Type I

Type II

Type III

© Hitachi, Ltd. 2010. All rights reserved.
Pilot Project

Pilot Project in Thailand:

- To be implemented to verify the energy efficiency management of Smart Grid

- To demonstrate the Home Energy Management (HEM) for Smart Grid

- To apply and enhance the technologies domestically developed in Thailand for Sustainable Energy
Home Energy Management (HEM)

Scheme: Grid ➔ Substation ➔ Customer ➔ End-use equipment control by HMS
Smart Community (SC)

The concept of a smart community

- To create a bold image of the whole-city task-solution system that copes with worldwide problems, and to promote technological development, standardization, and reform of social systems in order to realize the system.

- Control center
  - Control center that optimizes supply and demand of energy for the region

- A new transport infrastructure integrated with the energy network
  - Drastically lowering carbon emissions and providing solutions for traffic accidents and traffic jams, by exchanging information between EVs and electric buses.

- Smart houses
  - Solar energy generation
  - LED lighting
  - TV
  - Energy-saving air conditioner
  - Heat pump water heater
  - Electric car

- Electric buses
  - Electric bus (to be changed into streetcars in the future)
  - Electric buses with replacement-type batteries. Multiple buses will be connected to become a streetcar in the future.

- Smart buildings
  - Power storage device
  - Wind turbines
  - Large-scale solar energy generation
  - Rapid charging station

- Streetcars
  - ITS
  - Small-scale hydropower generation

- Power storage device
  - Nuclear power plant
  - Thermal power plant

- ITS
  - Streetcars
  - Large-scale solar energy generation
  - Rapid charging station
Pilot Project – Japan

3-4 Pilot Trial at Rokkasho Village

This project evaluates system functionality and energy optimization which equivalent the said Step2 and Step3 by using closed grid at specially authorized by Japanese Government.

Futamata Window Power Generation Site (JWD)

Surveillance and Control Information Exchange

Heat Pump Control

PHV (Plug-in Hybrid Vehicle)
PCH (Power Conditioning System)

PHV Charger

EV&PHV (Smart Center)

Smart House (Panasonic)
Smart House (JWD)
Smart House (Toyota)

Multi family housing

NAS Battery (NCK)

Hub Battery (250kW)

Photovoltaic (Hitachi)

Grid Side Supply and Demand management and control includes Power generation and Storage

Grid Side Supply and Demand management and control includes Power generation and Storage

© Hitachi, Ltd. 2010. All rights reserved.
Conclusion

1. Cost/Benefit for Smart Grid
   Hardware (Smart Meter, Communication, etc)
   Software (Energy Management, etc.)

2. Interoperability Standard for Smart Grid

3. Smart Grid with SPP and VSPP
   Uncertainty of Generation of Renewable Energy (Wind and Solar) into the system, the need for communication system and generation forecasting (Wind Velocity, Solar Radiation) for efficiently dispatching is considered

4. Human Resource Training for Smart Grid