RE Grid Integration: Thailand’s Perspective

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Thailand Electricity Supply Industry Structure

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  - SPPs
  - EGAT
  - IPPs
  - Import

- Power Purchaser, System Operation, And Transmission
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    - System Operation
    - Transmission
    - Bulk Power Supply

- Distribution Retail Supply
  - PEA
  - MEA
  - Direct Customer
  - End User

- REGULATOR
Thailand Electric Power Development Plan 2010-2030: PDP 2010 (1)

• Projects during 2010-2020

1. EGAT owned power plants 4,821 MW
2. IPP 4,400
3. SPP 3,539
4. VSPP 2,335
5. New Combine Cycle PP (LPG) 800
6. Purchase from neighbors 5,699
Thailand Electric Power Development Plan 2010-2030: PDP 2010 (2)

• Projects during 2021-2030

1. NEW EGAT owned power plants (RE) 97 MW
2. (NG) 13 X 800
3. (CC) 8 X 800
4. (Nuclear) 4 X 1000
5. Purchase from SPP 3,800
6. Purchase from VSPP 1,745
7. Purchase from neighbors 6,000
PDP 2010 Total Capacity

- **Total Installed Capacity 2009**: 29,212 MW
- **Total Added Capacity 2010-2030**: 54,005
- **Total Retired Capacity 2010-2030**: (17,671)
- **Grand Total Capacity (end 2030)**: 65,547
- **Minimum Reserve Margin (%)**: 15.0

**Assumption in the Formulation of PDP 2010**
1. System Reliability
2. Clean Energy and Efficient Utilization
3. Load Forecast
**RE for Electric Power**

<table>
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<tr>
<th>Type</th>
<th>Biomass</th>
<th>Biogas</th>
<th>Solar</th>
<th>MS W</th>
<th>Wind</th>
<th>Small Hydro</th>
<th>Total</th>
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<td>E.2009</td>
<td>663.04</td>
<td>49.04</td>
<td>9.23</td>
<td>10.82</td>
<td>3.07</td>
<td>18.33</td>
<td>753.52 (2.6%)</td>
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<td>E.2022</td>
<td>2272.04</td>
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<td>159.32</td>
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<td>3023.04</td>
<td>176.04</td>
<td>1107.23</td>
<td>183.32</td>
<td>1321.07</td>
<td>281.33</td>
<td>6101.02 (9.3%)</td>
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*Power Generation Sector released 0.546 Kg of CO₂/Kwh in 2009, goal of PDP 2010 is to have lower emission rate at 0.368 Kg of CO₂/Kwh in 2030*
### Status of Thailand Cogeneration and Renewable Energy

#### Status of VSPP & SPP in Thailand (As of June 2009)

<table>
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<tr>
<th>Fuel Type</th>
<th>Implement</th>
<th>Existing</th>
<th>Total</th>
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<tr>
<td></td>
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<td>Approved</td>
<td>Contacted</td>
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<tr>
<td>Biomass</td>
<td>933.78</td>
<td>759.40</td>
<td>530.45</td>
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<tr>
<td>Biogas</td>
<td>70.11</td>
<td>43.75</td>
<td>67.91</td>
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<tr>
<td>Wastes</td>
<td>120.10</td>
<td>91.45</td>
<td>70.86</td>
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<tr>
<td>Wind</td>
<td>1,242.79</td>
<td>85.80</td>
<td>1.50</td>
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<td>Hydro</td>
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<tr>
<td>• &lt;50 kW</td>
<td>-</td>
<td>-</td>
<td>0.03</td>
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<tr>
<td>• 50-200 kW</td>
<td>-</td>
<td>-</td>
<td>0.18</td>
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<td>• &gt; 200 kW</td>
<td>-</td>
<td>5.04</td>
<td>1.07</td>
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<tr>
<td>Solar</td>
<td>819.57</td>
<td>356.56</td>
<td>998.54</td>
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<td>Total</td>
<td>3,186.35</td>
<td>1,342.00</td>
<td>1,670.54</td>
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## Adder Rate for SPPs ad VSPPs Using RE

<table>
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<tr>
<th>Energy Source</th>
<th>Countrywide Except 3 Most S.P. (c/kWh)</th>
<th>The 3 Most S.P. (c/kWh)</th>
<th>Area Using Diesel Engines (c/kWh)</th>
<th>Subsidized Period (Years)</th>
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<tr>
<td>Biomass</td>
<td>1-1.8</td>
<td>4.5-5.0</td>
<td>4.5-5.0</td>
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<tr>
<td>Biogas</td>
<td>1-1.8</td>
<td>4.5-5.0</td>
<td>4.5-5.0</td>
<td>7</td>
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<tr>
<td>Small, Micro &amp; Mini</td>
<td>2.7-5.0</td>
<td>6-8.4</td>
<td>6-8.4</td>
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<td>Waste</td>
<td>8.4-12</td>
<td>12-15</td>
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<td>7</td>
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<td>Wind Energy</td>
<td>12-15</td>
<td>17-20</td>
<td>17-20</td>
<td>10</td>
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<td>Solar Energy</td>
<td>27</td>
<td>31.5</td>
<td>31.5</td>
<td>10</td>
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</table>

Source: NEPC, 3/2009
About PEA

Operating Environment
Supply Area: 510,000 sq km (73 provinces)
Customers: ~14.6 Millions

Max Demand
System: 14,127 MW (Coincident Demand)

Annual Sales:
~89,602 GWh
SPP, VSPP connected to PEA's Network: ~3 Gw

Overhead Lines
HV system: ~8,701 km
MV system: ~289,328 km
LV system: ~450,424 km

Underground Cables
Transmission: 1,269 km
Distribution: 18,228 km

Supply Voltage Level
HV: 115, 69 kV, MV: 22, 33/19 (L-N), 11 kV
LV: 400/230 V

Supply Substations
Total Substation: 631 s/s
(451 s/s owned by PEA)
(180 s/s owned by EGAT)
Distribution Trt (Total): xxxx units

Source: PEA annual report 2008
• PEA is the Distribution Section

PEA: (Provincial Electricity Authority)

Responsible for providing electricity supply to provincial areas outside MEA service area. PEA was assigned to handle the Rural Electrification Programme in Thailand

Vision:
PEA is a leading organization of international standard, doing business in energy, services and related businesses.
The PEA’s three major objectives are:

1. To continue to improve its provision and distribution of electric energy for customers
2. To optimize its business and operations in order to be more profitable and thereby achieve sufficient revenues to facilitate further development
3. To develop its organizational structure, man power and resources management in order to achieve the highest level of efficiency and effectiveness
PEA understanding in “Smart Grid”
PEA understanding of “Smart Grid”
Smart Grid Domains

- Smart Grid implies close cooperation between the utilities and the customers
- The Smart Grid activities are cross-cutting over different domains
Observations

• The Grid does not become smart just by adding AMI, DER, and Demand Response
  ➢ The Grid is smart when it digitally performs monitoring and dynamic optimization of its operations including AMI, DER, and Demand Response

• The Smart Grid will not be a revolution.
  ➢ It will be a gradual transformation of the systems that have served us for many years into a more intelligent, more effective and environmentally sensitive network to provide for our future needs.
Smart Grid Business Drivers

- Greenhouse Gases
- Operational Efficiency
- Renewable Resources & PHEVs
- Aging Workforce
- Demand Response
- Condition-Based Maintenance
- Reliability & Quality of Supply
- Aging Infrastructure
- Supply Reliability
- Power Quality

Carbon Footprint
Productivity Improvement
Vision of Smart Grid Components in High Level
Smart Grid application at all level
Smooth Deployment need right architecture and concerned area need to be address
Conceptual view of distribution smart grids

Power Delivery & Customer Services Operations
- WMS
- MWF
- CIS
- DMS
- Data Collection
- Ops Data Mart
- EMS
- DMS, DSM
- SCADA
- Billing & Settlements
- Forecasting & Scheduling

AMI Back-end SG Front-end
- Asset Mgmt System
- Operations & Solution Architecture

T&D Field Devices, Sensors & Comms Equipment
- Backhaul Comms
- Web Access
- Substations
  - Substation Automation
  - Condition Monitoring
  - Distribution Automation

Distributed Resources
- Local Comms
- Renewable Resource
  - Demand Response & Enhanced Automation
- Distributed Generation

ISO & Energy Markets
- Stakeholders
Smart Grid Enabling Demand Response

Designation & Certification to Encourage Manufacturers to Develop DR-Ready Products

Barriers: Standards for DR Interface & Market Transformation to Embed DR Interface
Smart Grid development challenge
The Standard Landscape

Source: EPRI
Standard – Transmission and Substations Communications and information management

- Common Information Model – Middleware requirements and application integration
  - IEC 61968 and 61970
  - Generic Interface Definition
- Substation Communications
  - IEC 61850 or DNP3 (IEEE Std 1379) migrating to IEC 61850
  - IEEE Std 1646 – 2004 (Performance)
- Substations IED Configuration
  - Substation Configuration Language (61850-6)
  - DNP XML Schema for configuration
- SCADA – DNP3, IEC 60870-5, IEC 60870-6, IEC 61850
- IEC 61850 approaches for distribution communications
- Phasor Measurement Units – IEEE C37.118-2005
- NERC CIP Requirements for cyber security
- IEC 62351 security guidelines
  - TCP/IP, VPN, IEC 61850
  - DNP3 specifications for secure authentication
- Hardened substation devices
  - IEEE 1613-2003
  - IEC 61850 Part 3 & 5
- Time Synchronization
  - DNP embedded method – supports to +/- 5mSec (adequate for feeder devices in most applications)
  - NTP/SNTP – supports to +/- 10uS
  - GPS – supports to +/- 1 uS (adequate for substation devices in most applications today)
  - IEEE 1588-2002 – supports to +/- 100 nS
  - Future upgrade to IEEE 1588 Ver 2.0 (will be increasingly required for substation devices in the future)
- COMTRADE and PQDIF for data exchange
  - IEEE C37.111-1999 – COMTRADE
  - IEEE 1159.3 - PQDIF

IEEE SCC21 1547 Series of Interconnection Standards


P1547.5 Draft Technical Guidelines for Interconnection of Electric Power Sources Greater Than 10 MVA to the Power Transmission Grid

Guide for Impacts – 2009 start

P1547.4 Draft Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems


DP Specifications & Performance (includes modeling)

(publisher year in parentheses; P1547.X are under development; other topics are under consideration by SCC21 work group members)
Smart Grid benefit

- Ability to monitor and manage their power delivery down to the home or business in real time
- Can offer multiple rate structure to manage demand peak
- Allow utilities to manage outage more effectively by using real time information and advance control system
- Allow utilities to delay the construction of new plants and transmission lines and better manage their carbon output through implementing measures such as demand response and time-based rates to more actively manage load
- Allow utilities to provide real-time information to their customers and in utility operations
- Key new drivers:
  - Integration of renewables (intermittent resources)
  - Distributed resources, microgrids
  - Facilitating customer participation in markets
  - New technologies (PHEV, storage, smart loads)
Utility smart grid Roadmap

- **Smart Grid Roadmaps**
  - Define vision, evolutionary pathway and multi-year investment strategy for individual utilities
  - Tools for evaluating costs and benefits of smart grid applications

- **Interoperability standards**
  - An industry architecture (a tightly coupled suite of standards) that enables interoperable systems
  - Common language

- **Effective security requirements, policies and technologies**

- **Technology assessments and applications**
  - Based on real world applications

- **Field experience with large-scale deployment and integration of smart grid systems and technologies**

Source: EPRI
Road Map for smart Grids implementation

- Regulatory strategy – *cost recovery and regulatory alignment*
- Holistic approach – *operation and business surrounding system planning, power delivery and customer services*
- Business case Justification – *cost benefit associate with technologies and business transformation*
- Enabler and foundational capabilities – *and also people and process are the critical to the long-term success*
- Interoperability standard – *adopting interoperability standards and developing and architectural framework for data, system and technology integration is an important step for smart grids implementation*
- Practical, Balanced and leveraged Solutions - *The future models for the smart grids have to meet changes in technology, and accommodate public values related to the environment and commerce*
PEA – Ongoing and existing IT Project
(related to Smart Grid components)
PEA’s Ongoing Project

- Transmission and Substation Development Project, 8th stage (2005-2012)
- The Power Distribution System Reinforcement Project, 6th stage (2004-2010)
- Rural Household Electrification Project, 3rd stage (2003-2009)
- Submarine Cable Extension to Electrified Islands (2005-2009)
- Distribution System Dispatching Center Project, 2nd stage (2008-2012)
- Distribution System Reliability Improvement Project, 2nd stage (2006-2010)
- Underground Cable Development in Large Town Project* (2005-2009)
- The GIS Development Project, 2nd stage* (2005-2010)

* Were adjusted to long term plan
System Management Center (in operation in Y2005)

1st Stage Area Distribution Dispatching Center (in operation since Y2005)

2nd Stage Area Distribution Dispatching Center (Ongoing-Project)
PEA-DDC.1 Project

SMC (Bangkok)

Communication Backbone: (Optical Fiber)

- ADDC-C1
- ADDC-C2
- ADDC-C3
- ADDC-N3
- ADDC-S1
Area Distribution Dispatching Center (ADDC)

Capacitor Bank

Automated Voltage Regulator

GSM Modem

Optical Fiber, TDMA, DMRL, Leased Line

Substation

Remote Controlled Switch

Line Recloser

UHF

DDC.1 Project
PEA-DDC.1 Project Benefit (i.e. System reliability index)

- SAIDI index
DDC.2 Project (Ongoing)
Communication Channels at Head Office

Ethernet Port Connection Diagram

Gigabit Ethernet Port
Throughput = 130 x 4 Mbps
= 520 Mbps
Communication Channels for SCADA system

Ethernet Port Connection Diagram

Throughput = 12 x 2 Mbps = 24 Mbps
Next Step for PEA
Review existing IT system (i.e. DDC.1 project)

**DMS Master Station**
- Basic SCADA
- DMS applications
- Interlink with OMS, AMR, Distributed Generation, and Geospatial Information System
- Inter center co-ordination
- Enterprise / corporate applications

**Communication System**
- Fiber Optic backbone with SDH
- UHF MARS radio network
- Protocol
- Data concentration and data distribution

**Substation and Field Device**
- SRTU or CSCS
- FRTU:
  - Pole top switches
  - Automatic Voltage Regulator
  - Capacitor bank controller
  - Line recloser switch
  - Communication infrastructure

An integrated approach to evaluate overall performance in terms of efficiency, reliability, and availability
Outline of strategy for implementing the Smart Grid Concept in PEA

1. Determine the needed changes to optimize the future operations (the CAN DO)
2. Determine the needed changes in the DMS hardware and software to accommodate the expected penetration of new technology (the MUST DO)
3. Estimate the benefits and cost of the defined changes
4. Develop a Smart Grid Road Map (implementation plan) based on the findings
5. Develop conceptual designs of:
   - Application upgrades justified in the feasibility study
   - IT system upgrades and integration to support the upgraded applications, such as:
     • GIS
     • CIS
     • OMS
     • WMS
     • AMI data management system
     • Demand Response management system
     • DER Management system
     • PEV management system
     • Cyber Security system
   - Smart Meters meeting the requirements of the upgraded applications (to use not only for billing, but support of applications)
   - Hardware upgrades
   - Communications upgrades including interoperability standards
6. Determine upgrades of the distribution system to accommodate the Smart Grid requirements
   – Optimize the location of controllable switches
   – Optimize the location and sizes of reactive power sources and voltage regulators
   – Prioritize the implementation of AMI and Demand Response to maximally benefit from integration with DA
7. Develop design and functional requirements for the
   – Upgraded DA applications
   – IT systems
   – Hardware
   – Smart Meters
   – Communications
Potential of the Smart Grids

-Allowing the seamless integration of renewable energy sources like wind
-Enabling nationwide use of plug-in hybrid electric vehicles
-Ushering in a new era of consumer choice
-Making large-scale energy storage a reality
-Exploiting the use of green building standards to help lighten the load
-Making use of solar energy 24 hours a day

Source: US DoE
## Benefits of Smart Grids

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<tr>
<th>Without Smart Grids</th>
<th>With Smart Grids</th>
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<tr>
<td>- &lt;13% variable renewables penetration</td>
<td>- &gt;30% variable renewables penetration</td>
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<tr>
<td>- 5% demand response</td>
<td>- 15% demand response</td>
</tr>
<tr>
<td>- &lt;1% consumer generation used on the grid</td>
<td>- 10% consumer generation used on the grid</td>
</tr>
<tr>
<td>- 47% generation asset utilization</td>
<td>- 90% generation asset utilization</td>
</tr>
<tr>
<td>- 50% transmission asset utilization</td>
<td>- 80% transmission asset utilization</td>
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<tr>
<td>- 30% distribution asset utilization</td>
<td>- 80% distribution asset utilization</td>
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Initial PEA Grid Roadmap

Reconceptualization & Strengthening
2009-2013
- Demand 17,243 MW
- Re-Conceptualization: Planning, Engineering, Service
- Setting up: Power & ICT Integration, DG Connection, Premium Power, Automation
- EV
- AMI initiative

Preparation & Development
2014-2018
- Demand 22,796 MW
- Program Implementation: Power & ICT Integration
- Human Resource: Modern Power & ICT
- Knowledge Management: R&D Center

Realization of Smart Grids
2019-2024
- Demand 30,395 MW
- AMI era
- Web-Based Energy Management
- Advanced Distribution Management
- IT Service/Provider
Initial Timeline Of PEA Smart Grids

**Development**

- Review Traditional Concepts
- Define PEA Smart Grids
- Set up Planning Criteria, Engineering Criteria & Service Criteria
  - Conceptual Design
  - Technology Selection & Development
  - Field Testing
  - Pilot Project
  - SCADA Improvement

- Integration of Technologies (e.g., SCADA, OMS, CRM, GIS, AMR etc)
- Integration and Exploitation of DGs and Renewable Energy Resources
  - Large-Scale Projects
    - Underground
    - Voltage Levelization
    - Reliability-Base Action

- The Beginning of SmartGrids Era
- Further Development of the PEA Smart Grids

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<th>2567</th>
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<td>Define, Design, Testing</td>
<td>Implementation</td>
<td>Sustentation</td>
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Conclusions: 4C Critical Success Factors

- **Customers**: Smart Grid Development must create value added to both internal and external customers
- **Collaboration**: 2 types of collaboration
  (a) Stakeholders collaboration
  (b) Technology and System Collaboration
- **Communication**: Between equipment and systems, personnel communication
- **Continuity**: Shared Visions, Long term policy and strategy
Acknowledgement and References

• Electricity Generating Authority of Thailand: Summary of Thailand Power Development Plan 2010-2030, System Planning Division, April 2010

• Weerachai Koykul, Deputy Governor (Network Operation), Provincial Electricity Authority (PEA)

• National Science and Technology Development Agency (NSTDA), Thailand