Seminar on Renewable Energy Technology implementation in Thailand
Experience transfer from Europe

co-organised by
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PV Performance: Impact to the grid

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1. Introduction
2. Current status of Thailand’s ESI
3. Evolutionary challenges on renewable energy policies
4. EGAT’s practices for grid impact assessment
5. PV performance and its impact to the grid
6. Proposed optimal path to integrating solar generation
1. Introduction

- Reduction of CO₂ Emission
- Growing demand for green energy from new and renewable resources
- More distributed generations (DG) and integration of intermittent renewable energy onto the power system
- Maintaining the power system ‘reliable and stable’ in long-run in use of high energy efficiency manner
2. Current Status

### Generation
- SPP (7%)
- IPP (39.6%)
- EGAT (46.6%)
- Import (6.7%)
- VSPP (<1%)

### Transmission
- PEA (68%)
- MEA (30%)
- Direct Customer (2%)

### Distribution
- Customers

Note: Reference on 31 July 2012

4 October 2012
2. Current Status

Installed Capacity (August 2012) 32,184.7 MW
Peak Demand (26 April 2012) 26,121.1 MW

Combine Cycle 17,548.0 MW 55%
Thermal 8,589.7 MW 27%
RE 5,622.6 MW 17%

Gas Turbine & Diesel 124.4 MW 0.3%
Renewable Energy 5,622.6 MW

TNB (HVDC) 300.0 MW 1%

Domestic 3,738.0 MW (12%)
Laos 1,884.6 MW (6%)

Thai Hydro 3,436.2 MW 61%
Laos Hydro 1,884.6 MW 34%
Biomass 297.3 MW 5%
Others 4.5 MW 0.1%
2. Current Status

**Installed: 3,364.67 MW**
Peak: 2,606.35 MW
Export EDL: 291.50 MW

### System Voltages (kV)

<table>
<thead>
<tr>
<th>No.</th>
<th>Tx. Rating (MVA)</th>
<th>Transmission (cct.-km.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>11</td>
<td>20,849.99</td>
</tr>
<tr>
<td>230</td>
<td>70</td>
<td>49,560.04</td>
</tr>
<tr>
<td>115</td>
<td>130</td>
<td>14,598.74</td>
</tr>
<tr>
<td>132</td>
<td>-</td>
<td>133.40</td>
</tr>
<tr>
<td>69</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>300 (HVDC)</td>
<td>-</td>
<td>388.02</td>
</tr>
</tbody>
</table>

**Note:** Reference on July 2012

**Installed Capacity:** 31,450.72 MW
Peak Demand: 26,121.10 MW

**Note:** Reference on 26 April 2012
3. RE Policy Challenges

Alternative Energy Development Plan (AEDP 2012-2021)
(targeting @ 9,198 MW by 2021)

15-year Renewable Energy Development Plan (REDP 2008 - 2022)
(targeting @ 5,608 MW by 2022)

Renewable Portfolio Standard (RPS 2004)
### 3. RE Policy Challenges

<table>
<thead>
<tr>
<th>Type</th>
<th>Biomass</th>
<th>Solar</th>
<th>Wind</th>
<th>Hydro</th>
<th>Biogas</th>
<th>MSW</th>
<th>Tides &amp; Waves</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>As of 2011</td>
<td>747</td>
<td>138</td>
<td>3</td>
<td>31</td>
<td>106</td>
<td>21</td>
<td>2</td>
<td>1,048</td>
</tr>
<tr>
<td>Additional (2012-2030)</td>
<td>2,602</td>
<td>3,802</td>
<td>1,974</td>
<td>705</td>
<td>46</td>
<td>353</td>
<td>-</td>
<td>9,482</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td>3,349</td>
<td>3,940</td>
<td>1,977</td>
<td>736</td>
<td>152</td>
<td>374</td>
<td>2</td>
<td>10,530</td>
</tr>
</tbody>
</table>

**Total Capacity at the end of 2030**: 10,530 MW

- **Biomass**: 3,349 MW
- **Solar**: 3,940 MW
- **Wind**: 1,977 MW
- **Hydro**: 736 MW
- **Biogas**: 152 MW
- **MSW**: 374 MW
- **Tides & Waves**: 2 MW
- **AEDP**: 6,000 MW
- **Other**: 4,000 MW

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**Graph**

![Graph showing RE capacity growth from 2012 to 2030](image)
4. EGAT’s Practices

Solar power plant:

- **Contracted capacity**: 55 MW
- **Connecting point**: 115 kV Chai Badan Substation
- **Test run**: 8 MW – on 22 Dec. 2011
  7 MW – in Mar. 2012
- **COD**: March 2012 (EP + adder)

only EP
1) **Power flow study**
   - Normal operation with Solar Project
   - N-1 (115 kV TTK-CBD tripped)
   - N-1 (115 kV CBD-LB2 tripped)

2) **Short-circuit study**
   - 3-phase faults
   - Single-line to ground fault

3) **Transient stability study**
   - 3-phase faults at 115 kV CBD + Faults cleared
   - 3-phase faults at 115 kV CBD + 115 kV CBD-LB2 tripped
   - 3 Phase Faults at 115 kV CBD + 115 kV CBD-TTK tripped

**Note:** Faults clearing-time is 140 ms. (7 Cycles)
4.1) Power Flow Study

- Normal operation with Solar Project (system peak 2012)
4.1) Power Flow Study

- Normal operation with Solar Project (system peak 2015)
4.1) Power Flow Study

- N-1, when 115 kV TTK-CBD is tripped. (system peak 2012)
4.1) Power Flow Study

- N-1, when 115 kV TTK-CBD is tripped. (system peak 2015)
4.1) Power Flow Study

- N-1, when 115 kV CBD-LB2 is tripped. (system peak 2012)
4.1) Power Flow Study

- N-1, when 115 kV CBD-LB2 is tripped. (system peak 2015)

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4.2) Short-circuit study

- 3-phase fault at CBD
4.2) Short-circuit study

- Single-line to ground fault at CBD
4.3) Transient study

- 3-phase fault at 115 kV CBD + Fault cleared (System Peak 2012)
4.3) Transient study

- 3-phase fault at 115 kV CBD + Fault cleared (System Peak 2015)

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4.3) Transient study

- 3-phase fault at 115 kV CBD + 115 kV CBD-LB2 tripped (system peak 2012)
4.3) Transient study

- 3-phase fault at 115 kV CBD + 115 kV CBD-LB2 tripped (system peak 2015)
4.3) Transient study

- 3-phase fault at 115kV CBD + 115kV CBD-TTK tripped (system peak 2012)
4.3) Transient study

- 3-phase fault at 115kV CBD + 115kV CBD-TTK tripped (system peak 2015)
5. PV performance and its impact to the grid

5.1 PV performances
5.2 Its impact to the grid
5.1 PV Performance

*Fig. 1* Variation of solar power plant demonstrating through its generation profile over one year observation

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5.1 PV Performance

Fig. 2 Chronological variation of solar power plant demonstrating throughout its generation profile over one year observation

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Summary of dependable capacity factor of RE power plants within EGAT system

<table>
<thead>
<tr>
<th>Fuel Types</th>
<th>Plant Factor (%)</th>
<th>Dependable Capacity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>12 months (8,760 hr.)</td>
</tr>
<tr>
<td>Solar</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Wind</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Biomass</td>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td>Biogas</td>
<td>22</td>
<td>7</td>
</tr>
<tr>
<td>Municipal Solid Waste</td>
<td>43</td>
<td>32</td>
</tr>
<tr>
<td>Mini-hydro</td>
<td>50</td>
<td>27</td>
</tr>
</tbody>
</table>

*Note: System peak-time is at 14:00 -15:00 hr. during March – May of the year*
5.2 Impact to the Grid

- Impacts of high penetration of solar PV generation onto power grid
  - voltage and power flow fluctuation
  - Frequency fluctuation
  - Difficulty of demand-supply management
5.2 Impact to the Grid

Example of voltage fluctuation — before and after having the transmission system reinforcement in order to improve the system voltages and to enhance system reliability.
Example of power fluctuation — before and after having the transmission system reinforcement in order to improve the system voltages and to enhance system reliability.
6. Proposed optimal path to integrating the solar generation

6.1 System criteria to follow
6.2 Countermeasures to consider
6.3 Methodology for long-term power system planning
6.1 System criteria

- Economic efficiency
- Environmental compatibility
- System reliability/parameters:
  - load demand in multiple years
  - adequacy of energy
  - capacity credits of RE power plants
  - availability / outage rate
- Robustness of energy security
6.2 Countermeasures

- Improvement of load following capability
- Reduction of minimum operation of existing and new thermal / hydro power plants
- Improvement of RE forecast
- Demand activation
- Utilization of energy storage, e.g.
  - Hydro pumped storage power plant,
  - Battery storage,
  - Etc.

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6.3 Proposed methodology

- Data of each observation point
  - Available current and future load, assets, and other conditions
  - Generation analysis, including smoothing effect

- Load frequency control analysis and other analysis

- Probabilistic production analysis, using Load Duration Curve (LDC)
  - Time series load dispatch analysis, using Time Series Load Curve

- Generation and Transmission Expansion Analysis
  - Operation Cost Analysis
  - Operation Constraints Evaluation

- System expansion planning / system reinforcement planning
THANK YOU!

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