Taiwan and France Smart Grid Exchange Symposium

Taiwan’s Energy & Smart Grid Development Perspective

Prepared by Dr. CHEN, Yenhaw
Presented by Prof. TSAI, MenShen

Taiwan Smart Grid Industry Association

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Agenda

1. The Global Energy Supply and GHGs Reduction Trend
2. Taiwan's Energy Supply and Current Status of GHGs Reduction
3. Taiwan's New Energy Policy & Implementation Plan
4. The Smart Grid Technology Development in Taiwan
I. The Global Energy Supply and GHGs Reduction Trend

- The agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to **well below** 2°C.
- The Paris Climate Change Agreement entered into force on 4th Nov. 2016.

<table>
<thead>
<tr>
<th>Long-term Goal</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The target of keeping the rise in temperature is <strong>below 2°C</strong> and should <strong>aim for 1.5°C</strong>.</td>
</tr>
<tr>
<td></td>
<td>Emissions should <strong>peak</strong> as soon as possible and the countries will aim to achieve carbon neutrality in the second half of the century.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Review Mechanism</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In 2018, Parties will collectively <strong>take stock of countries’ emissions</strong> reductions, and then update their NDCs or submit new ones by 2020.</td>
</tr>
<tr>
<td></td>
<td>After 2020, a <strong>regular “Global Stocktake”</strong> will take place every five years starting in 2023 to review all aspects of Agreement implementation, including mitigation, adaptation, finance and support.</td>
</tr>
<tr>
<td></td>
<td>Parties will then <strong>submit new NDCs every five years</strong>, informed by these Global Stocktakes.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Support</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The developed countries will continue to support climate action to reduce emissions and build resilience to climate change impacts in developing countries.</td>
</tr>
<tr>
<td></td>
<td>Developed countries intend to continue their existing collective goal to mobilise <strong>USD 100 billion per year by 2020</strong> and extend this until 2025.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mechanism for Loss and Damage</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Decides on the continuation of the Warsaw International Mechanism for Loss and Damage associated with <strong>Climate Change Impacts</strong>, following the review in 2016;</td>
</tr>
</tbody>
</table>

資料來源：United Nations FCCC/CP/2015/L.9 (2015)；台經院整理
The Global Development of Renewable Energy

- To every investor’s astonishment, in 2014, half of the global new installed capacities went to renewable energy. Renewable energy has become a mainstream energy.

- Due to the strong carbon reduction policies in international community, it is projected that, from 2015 to 2040, 60% of the electricity investment will directly link to the renewable energy. The leading countries will be China, the EU, the US and India. Renewable energy will continuously take the dominant position.

Source: 2015 world energy outlook, IEA, REN21 2015
The Global Energy Transition is Ongoing

- Due to the **carbon reduction policies** eagerly adopted among international communities, together with the trend that the **decline of costs in renewable energy**, mainly Solar PV and Wind Power, **the global energy transition is ongoing**.

- To increase the share of renewable energy, each country expects the reinforcement of the application among **demand side management**, **renewable energy, storage and smart grid**, as well as establishes the **regional system of smart energy management and supply**.

- It is every country’s common will to **promote the necessary technology of the energy transition both pragmatically and economically**, to reach final goal.

Source: Gou-Chung Chi, Yenhaw Chen, The Role of Smart Grid to Constructing Green Energy Supply System in Taiwan, TIER, 2017
II. Taiwan's Energy Supply and Current Status of GHGs Reduction
Current Power System in Taiwan

- Large centralized power system
  - Source of power: thermal (natural gas, coal, oil), nuclear power, hydro, renewable energy.
  - Power pumped and stored during non-peak hours
  - Natural gas-based power generation to support power consumption during peak hours
- Centralized load, growing demand for electricity on a yearly basis

<table>
<thead>
<tr>
<th>Year</th>
<th>2005</th>
<th>2010</th>
<th>2014</th>
<th>2020 (F)</th>
<th>2025 (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load during peak hours (MW)</td>
<td>30,943</td>
<td>33,023</td>
<td>34,821</td>
<td>37,377</td>
<td>39,529</td>
</tr>
</tbody>
</table>

Source: 2005 ~ 2014 Energy Statistics
Installed Capacity and Power Generation Mix in Taiwan

Power supply in Taiwan is mainly supported by fire power plants, among which coal-fired power plants are the majority. Power generated by coal-fired power plants in 2015 accounted for 44.58% of the overall power supply, followed by 31.38% from gas-fired power plants then 14.13% from nuclear power plants.

<table>
<thead>
<tr>
<th>2015</th>
<th>Gross installed capacity (GW)</th>
<th>Capacity factor (%)</th>
<th>Power generated by TaiPower (100 million kWh of electricity)</th>
<th>Power generation cost of TaiPower (NT$/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal-Fired Power Plant</td>
<td>16.8</td>
<td>88.87</td>
<td>1,150.16</td>
<td>1.21</td>
</tr>
<tr>
<td>Gas-Fired Power Plant</td>
<td>16.13</td>
<td>46</td>
<td>809.56</td>
<td>3.18</td>
</tr>
<tr>
<td>Oil Power Plant</td>
<td>3.7</td>
<td>24</td>
<td>120.74</td>
<td>4.03</td>
</tr>
<tr>
<td>Nuclear Power Plant</td>
<td>5.1</td>
<td>94</td>
<td>364.71</td>
<td>1.15</td>
</tr>
<tr>
<td>Renewable energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV</td>
<td>0.8</td>
<td>12</td>
<td>8.76</td>
<td>9.44</td>
</tr>
<tr>
<td>Wind power</td>
<td>0.6</td>
<td>32</td>
<td>15.25</td>
<td>2.50</td>
</tr>
<tr>
<td>Hydroelectric power (including routine and pumping/storage)</td>
<td>4.7</td>
<td>24</td>
<td>78.62</td>
<td>1.70</td>
</tr>
<tr>
<td>Biomass</td>
<td>0.1</td>
<td>22</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Waste</td>
<td>0.6</td>
<td>55</td>
<td>3.57</td>
<td>--</td>
</tr>
<tr>
<td>Total</td>
<td>48.7</td>
<td>--</td>
<td>2,580</td>
<td>1.95</td>
</tr>
</tbody>
</table>

Ratios of different types of power supply in Taiwan in 2015

- Coal, 44.58%
- Gas, 31.38%
- Nuclear Power, 14.13%
- Oil, 4.68%
- Wind Power, 0.59%
- Solar Power, 0.34%
- Biomass, 0.14%
- Waste, 1.26%

Source: 2015 Energy Statistics, Bureau of Energy, Ministry of Economic Affairs, sorted out by the Taiwan Institute of Economic Research
National Energy Demand Trends in the Future

Taiwan’s Energy consumption can be divided into seven sectors, which are: energy sector own use, industrial, transportation, agricultural, services, residential and non-energy consuming sector. In 2014, the industrial accounted for 37.73% and became the primary consumption sector. Followed by the transportation sector (11.63%), the services sector (10.92%) and the residential sector (10.78%).

It is estimated that Taiwan’s energy demand will grow on average due to the improvement of the living quality in the future as well as the value upgrade of the industry.

<table>
<thead>
<tr>
<th>Department</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>It is estimated that the annual energy demand will grow 0.81% on average between 2013 and 2030.</td>
</tr>
<tr>
<td></td>
<td>For the steel industry, electricity consumption accounts for a majority while for the petrochemical industry, natural gas grows the most quickly.</td>
</tr>
<tr>
<td></td>
<td>For the electronic, electrical, and mechanical (EEM) industries, on the other hand, primary consumption of energy comes from electricity.</td>
</tr>
<tr>
<td>Transportation</td>
<td>It is estimated that the annual energy demand will grow 1.54% on average between 2013 and 2030.</td>
</tr>
<tr>
<td></td>
<td>The demand for automobile gasoline is the biggest while the growth in the demand for electricity is the fastest. Railway electrification is the trend.</td>
</tr>
<tr>
<td>Residential and services</td>
<td>It is estimated that the annual energy demand will grow 0.85% on average for household and 1.895% on average for business between 2013~2030.</td>
</tr>
<tr>
<td></td>
<td>The demand for electricity is the biggest while the growth in natural gas is the fastest, demonstrating the generally improved economic growth and quality of family life.</td>
</tr>
</tbody>
</table>
Taiwan Energy-saving and Carbon Reduction Goals and Current Strategies

- In June 2015, the Legislative Yuan approved the "Greenhouse Gas Reduction and Management Act" stipulating that the greenhouse gas emission has to drop below 50% of the 2005 level by 2050.
- Most nuclear power units that are currently operating were built in the 1970s and the 1980s. Their decommissioning will peak between 2020 and 2030. Once they are decommissioned, both safety and environmental impacts will be major challenges. As such, it is necessary to prepare for a rainy day.
- It is worth discussing how to make up for the electricity supply gap caused by decommissioning of the nuclear power units.

The existing reduction proposal helps only achieve short-term goals. To fulfill the 2020 goal, it is required to apply additional reduction proposals.

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Current proposals at the Bureau and the Ministry

<table>
<thead>
<tr>
<th>Current proposals at the Bureau and the Ministry</th>
<th>Reduction outcome in 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in energy efficiency by 2.0% each year</td>
<td>76.1</td>
</tr>
<tr>
<td>Extended use of natural gas</td>
<td>16.0</td>
</tr>
<tr>
<td>Promotion of renewable energy</td>
<td>5.2</td>
</tr>
<tr>
<td>Commissioning of Nuclear Power Plant 4 and decommissioning of Nuclear Power Plant 1</td>
<td>28.7</td>
</tr>
<tr>
<td>Increased power generation efficiency</td>
<td>2.8</td>
</tr>
<tr>
<td>Forest carbon sink</td>
<td>1.0</td>
</tr>
<tr>
<td>Purchase of external carbon credit (gap)</td>
<td>32.0</td>
</tr>
<tr>
<td>Gap</td>
<td>1.2</td>
</tr>
<tr>
<td>Total</td>
<td>163</td>
</tr>
</tbody>
</table>

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Source: "Nationally Appropriate Mitigation Actions - Presidential Office Keynote Report", Environmental Protection Administration, Executive Yuan, May 17, 2010; calculated and sorted out by the Taiwan Institute of Economic Research
## Nuclear Power Plants in Taiwan

The installed capacity of Taipower’s three nuclear power plants is 5,144 MW (10.61% of total installed capacity) and the electricity generation is 42,389 GWh (16.3% of total power generation) in 2014.

<table>
<thead>
<tr>
<th>NPP</th>
<th>Unit</th>
<th>Capacity (MW)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Jinshan Nuclear Power Plant</td>
<td>1</td>
<td>636</td>
<td>Decommission in 2018</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>636</td>
<td>Decommission in 2019</td>
</tr>
<tr>
<td>2nd Kuosheng Nuclear Power Plant</td>
<td>1</td>
<td>985</td>
<td>Decommission in 2021</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>985</td>
<td>Decommission in 2023</td>
</tr>
<tr>
<td>3rd Maanshan Nuclear Power Plant</td>
<td>1</td>
<td>951</td>
<td>Decommission in 2024</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>951</td>
<td>Decommission in 2024</td>
</tr>
<tr>
<td>4th Lungmen Nuclear Power Plant</td>
<td>1</td>
<td>1350</td>
<td>Mothballed</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1350</td>
<td>Suspended</td>
</tr>
</tbody>
</table>

Taiwan’s Future Electricity Demand and Supply Shortage

The analysis on national energy supply in 2011 shows that, given the zero-nuclear energy supply, there will be a power gap of 16.7%. By year 2030, the energy consumption will grow 1% on average annually, which will create the energy shortage of 185TWh.

The options to make up the energy shortage could be 1) Energy-saving, 2) Exploitation of renewable energy, 3) Increase LNG usage (Implementation of the CCS technology).
Current Status of Taipower and Energy Policy of Taiwan

(1) Current Status of Taipower
a. Due to an extreme lack of indigenous energy resources, Taiwan relies on imported energy resources for 98% of its needs.
b. Fossil fuels play a major role in the energy supply structure, having a tendency of excessive concentration.
c. As an isolated power system, Taiwan Power network has not yet been connected to other power systems.
d. Under the government’s policy, flat electricity prices have been failing to reasonably reflect the costs.

(2) Energy Policy of Taiwan
a. Steadily Reducing Nuclear Dependency
   a) No extension to life spans of existing plants, and the decommissioning plan should be launched as planned.
   b) The security of the 4th Nuclear Power Plant must be ensured prior its commercial operation.
b. Replacing Nuclear with LNG for Base Load
   a) LNG total installation capacity is expected to reach 26,532 MW (accounting for 40% of total capacity of power installations) by 2030.
c. Promoting Renewable Energy Extensively
   a) Under the campaign of “one thousand wind mills” and “one million sunshine roofs”, the installed capacity of renewable energy is expected to reach 28,500 MW (accounting for 50% of total power installations) by 2025.
      (2025 installation capacity 20 GW about more than 1 GW each year, Wind installation 2025 capacity 4.2 GW)
III. Taiwan's New Energy Policy & Implementation Plan
2025 Energy Policy Target

- To reach the balance among energy security, environmental sustainability and green economy, while constructing an energy demand and supply system with security, stability, efficiency, and tidiness as well as initiating the value of sustainability in order to go towards to nuclear free homeland by 2025.

- The policy goal of nuclear free homeland by 2025 that the energy mix will be 30% by coal, 50% by gas and 20% by renewables.

<table>
<thead>
<tr>
<th>2025</th>
<th>51.5(TWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar PV</td>
<td>Wind</td>
</tr>
<tr>
<td>25 (TWh)</td>
<td>14 (TWh)</td>
</tr>
</tbody>
</table>

(1 TWh=10億度)
The Goal of Renewable Energy Policy

- **Strategic Directions:** To achieve nuclear-free homeland and greenhouse gas reduction targets, the new government will increase the installation of the renewable energy, especially solar photovoltaic energy and offshore wind power. Additionally, it will accelerate the deployment of the smart grid and the AMI.

- **Objectives:** To promote solar PV 20GW (roof 3GW / ground type 17GW), wind power 4.2GW (onshore 1.2GW, offshore 3GW), till 2025 renewable energy will achieve 53.1% of generation capacity, 18.5% of the total generating capacity. And 8 million livelihood users build link to smart grid and smart meters.

<table>
<thead>
<tr>
<th></th>
<th>2015 Installed Capacity (MW)</th>
<th>2015 Power Generation (100 GWh)</th>
<th>2020 Installed Capacity (MW)</th>
<th>2020 Power Generation (100 GWh)</th>
<th>2025 Installed Capacity (MW)</th>
<th>2025 Power Generation (100 GWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV</td>
<td>842</td>
<td>11</td>
<td>8776</td>
<td>110</td>
<td>20000</td>
<td>250</td>
</tr>
<tr>
<td>Onshore Wind</td>
<td>647</td>
<td>16</td>
<td>1200</td>
<td>29</td>
<td>1200</td>
<td>29</td>
</tr>
<tr>
<td>Offshore Wind</td>
<td>0</td>
<td>0</td>
<td>520</td>
<td>19</td>
<td>3000</td>
<td>111</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0</td>
<td>0</td>
<td>150</td>
<td>10</td>
<td>200</td>
<td>13</td>
</tr>
<tr>
<td>Biomass</td>
<td>741</td>
<td>54</td>
<td>768</td>
<td>56</td>
<td>813</td>
<td>59</td>
</tr>
<tr>
<td>Hydro</td>
<td>2089</td>
<td>46</td>
<td>2100</td>
<td>47</td>
<td>2150</td>
<td>48</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>0</td>
<td>0</td>
<td>22.5</td>
<td>2</td>
<td>60</td>
<td>5</td>
</tr>
<tr>
<td>Ocean</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4319</td>
<td>127</td>
<td>13537</td>
<td>273</td>
<td>27423</td>
<td>515</td>
</tr>
</tbody>
</table>

The PV Promote Situation in Taiwan

Bureau of Energy’s PV promotion targets is 20 GWp accumulative capacity in 2030. but how to find out sufficient area for PV installation, the power grid connect capability, and the regulation issues such as the electricity act, renewable energy act will be the challenge of this policy. PV 2 years project will install 1.5 GW before 2018.

The PV Promote Situation in Taiwan

PV Feed-in Tariff upper bound
Promotion Goal and Strategy in Taiwan Offshore Wind Power

Strategy: Offshore wind farms are built in from shallow ocean regions under “Offshore Demonstration Incentive Program” to deep sea regions via a district-based development model gradually.

- **National Project**
  - **2016**
    - Taipower / SENERG
      - 5MW * 2 (demo turbines)
      - Water depth: 15-26 m
      - Distance to shore: 7-9 km
  - **2020**
    - Taipower / SENERG
      - 108-110 MW (18-30 units) (demonstration wind farm)
  - **2025**
    - 3GW
    - Developing & planning
  - **2030**
    - 4GW

- **Private Project**
  - **2016**
    - TGC
      - 4MW * 2 (demo turbines)
      - Water depth: 20-45 m
      - Distance to shore: 8-12 km
  - **2020**
    - TGC
      - 4MW * 28 units (demonstration wind farm)
  - **2025**
    - Formosa I Wind Power
      - 4MW * 30 units (demonstration wind farm)

8 MW demonstration turbines will be operated commercially at the end of this year.

Data Source: Taiwan Institute of Economic Research (TIER), Research Division 1.
# Progress of Offshore Demonstration Wind Farm Met Mast

Domestic offshore wind farm developers have completed the Met Mast respectively in 2015, and continue to measure the meteorological data and establish the meteorological database.

<table>
<thead>
<tr>
<th>Developer</th>
<th>Location</th>
<th>Distance (km)</th>
<th>Depth (m)</th>
<th>Numbers</th>
<th>Capacity (MW)</th>
<th>Support Vessel</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuhai (TGC)</td>
<td>Offshore Fangyuan, Changhua</td>
<td>8~12</td>
<td>20~45</td>
<td>30</td>
<td>120</td>
<td>CSBC Huadian 1001</td>
<td>Met Mast has been completed in Aug 2015.</td>
</tr>
<tr>
<td>Formosa (Swancor)</td>
<td>Offshore Chunan, Miaoli</td>
<td>2~6</td>
<td>15~35</td>
<td>32</td>
<td>128</td>
<td>Domestic Platform Barge</td>
<td>Met Mast has been completed in Aug 2015.</td>
</tr>
<tr>
<td>Taipower</td>
<td>Offshore Fangyuan, Changhua</td>
<td>5~8</td>
<td>15~25</td>
<td>22~36</td>
<td>108</td>
<td>HongYu No.1</td>
<td>Met Mast has been completed in Nov 2015.</td>
</tr>
</tbody>
</table>

Data Source: National Energy Program-Phase II-Offshore Wind Power and Marine Energy Focus Center
Demonstration Wind Turbines by Swancor

- Swancor has installed two demonstration wind turbines in October 2016.
- 22th February 2017, first offshore wind turbine started to operate and feed the power into the grid.
- This two are the first case on offshore wind energy in Taiwan and Asia.
AMI, Demand Bidding & Aggregator Mechanism

- In 2010, the Executive Yuan began the “AMI Promotion Project”, the project has completed over 24,123 high voltage AMI systems and 10,000 low voltage AMI, which controls 60% of Taiwan’s power consumption. Taipower will start the installation of 200 thousands low voltage AMI in 2017, 800 thousands in 2018, by 2020 finish 1 Million, by 2024 3 Million, low voltage AMI installation.

- Due to the tight power supply, in order to lower the peak load and ensure the reliability of power supply, Taipower has introduced the “Demand Bidding Schema” in May, 2015. The target audiences are the high voltage users who’s contract capacity is 100MW and above, and the lowest bidding price is 50kW power usage, which are government agencies, commercial buildings, hypermarkets and etc. Taipower asked the participants to save power over 50kW or above each hour, and will have an incentive of NTD$10 per kWh.

- In 2017, Taipower introduce the Aggregator Mechanism for peak load clipping. Each year, it could provide 200MW power usage reduction for 100 hours during the peak hours and increase 0.5% of Percent Operating Reserve.

Source: Hideo Ishii, WASEDA University, 2015
Amendment to Electricity Act

- Amendments to the Electricity Act passed their third and final reading in the legislature on 11th Jan 2017.
- The Electricity Act have been held up for 20 years, and their passage marks a significant milestone in Taiwan’s development of green energy sources.
  - Set a goal to make Taiwan nuclear-free by 2025
  - Prioritize the development of green energy, with an eye to expanding renewable energy and creating a green, eco-friendly country.

Source: Legislature passes amendments to reform energy market and fund long-term care, Executive Yuan, 2017-01-12
Amendment to Electricity Act – New Power Industry Sector

**Generation**
- Non-Utility (2)
- Unclear and 2MW Hydro limited to Public, others open private investment

**Transmission & distribution**
- Utility (5)
- One Public Company (5)
- Concurrently running Public Retail business by allowance

**Retail**
- Utility (2)
- Take over the power supply responsibility (47)

**Traditional Generation**
- Only sell power to Public Retail or Transmission & distribution

**Renewable Generation**
- sell power to customer by wheeling or direct power supply (45)

**Renewable Retail**
- Non-utility (2)
- trade only Renewable Energy (2)

資料來源：台電公司企劃處整理
Amendment to Electricity Act – Power Industry Sector

First step

- **Renewable Energy**
- **Existed Traditional Generation** (include Taipower and IPP)
- **New Install Generation** (include Taipower and IPP)

Second step

- **Electricity Industry Regulator**

**Generation** (open)

**Transmission & Distribution** (台電專營)

**Retail** (open green energy generation and retail)

**Customer** (open access)

**Transmission & Distribution (Taipower)**

- **Green Energy Retail**
- **Public Retail (Taipower)**
- **Private Retail**

**Non-controlled Tariff**

- Pricing by electricity price equation and committee

**Controlled Tariff**

**Retail Obligation**

- Carbon intensity control
- Reserve capacity

**Note:**
1. 自用發電設備以自用為主，若有餘電時，得售予發電業及售電業
2. 電業管制機關，評估長期電源供需、監管電力市場運作、爭議調處、確保用戶權益、各類電價及收费費率審議
Amendments to the Electricity Act – Market Structure

- **Traditional Generation**
- **Renewable Generation**
- **Self-Generator**

**Tariff without control**
- **Public Retail**
- **Grid (Auxiliary Service)**

**Tariff under control**
- **Customer supply directly or by wheeling**

**Self-usage by wheeling**
- **Renewable Electricity Retail**

資料來源：台電公司企劃處整理
The New Business Chance for Green Energy under Amendment of Electricity Act 2017

- **Current Green Energy Business (Renewable Energy Development Act)**
  - Renewable *self-generator* sell electricity to Taipower with Feed-in Tariff

- **New Green Energy Business Scenario (Electricity Act 2017)**
  1. Renewable Generation Company could sell electricity with *bilateral contact* and supply directly or by wheeling to green energy end user. (large scale renewable power plant)
  2. Renewable Generator could sell electricity to *green energy retail company* (small scale renewable generator)
  3. Renewable Generation Company and End User could invest & install renewable generation equipment together and supply directly or by wheeling to end user himself.
IV. The Smart Grid Technology Development in Taiwan

(4-1) The Overview of Smart Grid Technology in Taiwan
(4-2) The Micro Grid Technology Development in Taiwan
(4-3) The Virtual Power Plant Technology Development in Taiwan
(4-1) The Overview of Smart Grid Technology in Taiwan
National Energy Program-Phase II: Smart Grid Focus Center Project Framework (2014~2018)

A  Smart Energy network and energy saving control Technology

B  AMI Value-added service and integration technology

C  Distribution Power Control Technology development

D  Isolated Microgrid Technology development

E  Grid-connected High Power Converter development

F  EV charging station manager strategy

G  Advanced Wide-area Measurement System (WAMS) and control technology

H  Transmission System Power Quality improvement and wheeling technology development

I  Smart Grid and AMI Standard Development

J  Smart Grid Industry Development Project

K  Penghu Smart Grid Demon Site Construction (Low Carbon Island)

L  Integrated Applications of Demand Response, Distributed Generator, and Energy Storage System (VPP Demo Site)

M  Taiwan Power Company Smart Grid Installation & International Market

Source: Faa-Jeng, Lin, NEPII- Smart Grid and Advanced Metering Infrastructure General Project  MOST 106-3113-F-008-002 -
Smart Grid Demonstration Sites in Taiwan & Overseas

- Lead by Smart Grid Focus Center of Phase I and II of the National Energy Program and Ministry of Economic Affairs’ Development of Energy Information and Communication Technology, domestic industry, university and academy have either set or involved in various smart grid demonstration sites in Taiwan and overseas.

- Aforementioned demonstration sites can be divided into 3 categories which are 1) Smart Metering and User Energy Management Systems, 2) Smart Transmission and Distribution and Micro Grid Systems, 3) Virtual Power Plant Integration Systems.

- There are 11 demonstration sites in Smart Metering and User Energy Management Systems, those can be further divided into (1-1) Smart Metering and Energy Management and (1-2) Energy Saving Management, each with 6 and 5 sites respectively.

- There are 19 demonstration sites in Smart Transmission and Distribution and Micro Grid Systems, those can be further divided into (2-1) Advanced Transmission and Distribution and (2-2) Micro Grid, each with 5 and 14 sites respectively.

- There are 10 demonstration sites in Virtual Power Plant Integration Systems, those can also be further divided into (3-1) Demand Management and (3-2) Green Energy Generation and Demand Integration, each with 4 and 6 sites respectively.

Source: Faa-Jeng, Lin, Yenhaw CHEN, NEPII, 2016 The Development of Smart Grid Industry and Technology in Taiwan
1) Smart Metering and User Energy Management Systems

(1-1) Smart Metering and Energy Management

- Demonstration of Smart Meter Reading in a Metropolitan Setting in Min-Shen Community in Taipei
- Tatung University Smart Grid Control Center and Smart Home Demo Room
- Tatung Smart Home Energy Management System
- NCKU Smart Home (Building) Energy Management System
- Renjian Qingjing Community Smart Meter System and Home Energy Management System Demonstration Area in Tainan
- Delta Americas Headquarters – Smart EV Charging Station with Energy Management for Workplace Parking
- Convenience Store Energy Conservation Management System
- Hypermarket Energy Conservation Management System
- Optimizing Control System For A High-Tech Plant Ice Water System

(1-2) Energy Saving Management

- Wastewater Treatment Plant Power Equipment Monitoring And Energy Conservation Management System
- ITRI-Zhongxing District Smart Building Energy Conservation Demonstration Area

Source: Faa-Jeng, Lin, Yenhaw CHEN, NEPII, 2016 The Development of Smart Grid Industry and Technology in Taiwan
2) Smart Transmission and Distribution and Micro Grid Systems

(2-1) Advanced Transmission and Distribution

Zhongfeng Distribution Substation Transformer: Remote Realtime Monitoring System

Advanced Distribution Automation Demo System (TaiPower Shulin TPRI Lab)

Penghu Smart Grid Demonstration System (Cimei Township, Penghu)

Zhongfeng Distribution Substation Transformer: Remote Realtime Monitoring System


Source: Faa-Jeng, Lin, Yenhaw CHEN, NEPII, 2016 The Development of Smart Grid Industry and Technology in Taiwan
2) Smart Transmission and Distribution and Micro Grid Systems

(2-2) Micro Grid System

- INER Autonomous Hundred-kW level Microgrid Demonstration System
- Smart Micro Grid Demonstration Zone in Linbian Township, Pingtung County
- Yulon Motors Micro-grid and Electric Vehicle Demonstration Site
- Penghu Dongjiyu Microgrid Small Power Supply System
- Fumei Farm Agricultural Greenhouse Smart Microgrid Demonstration System
- Disaster Preventive Micro Grid System in Wulai District
- CHEM Smart AC / DC Hybrid Micro-Grid Demonstration System
- NTHU Highpower Gridconnected Converter Development
- Offshore Micro Grid System in Taiping Island
- Offshore Micro Grid System in Dongsha Island
- Independent Photovoltaic and Pumping System in Myanmar
- NCCU Smart DC Power System Educational Demonstration House
- Independently Complementary Wind and Solar Micro Grid System in Czech Republic
- Independent Photovoltaic and Atmospheric Water Generator in Dubai

Source: Faa-Jeng, Lin, Yenhaw CHEN, NEPII, 2016 The Development of Smart Grid Industry and Technology in Taiwan
3) Virtual Power Plant Integration System

**3-1 Demand Management**
- Demonstration of Virtual Power Plant Application in New Taipei City
- Trial Automated Demand Response project for Airconditioning
- NCU Smart Meter Reading & Demand Response System
- Taiwan Power Research Institute Shulin District Smart Energy Use Demand Side Management Demonstration Site

**3-2 Green Energy Generation and Demand Integration**
- Smart Building Energy Management System for Integrated Distributed Energy Resources (DER) - Taipei City XingLong Public Housing Area 1
- Collaborative Virtual Power Plant Demonstration between Finland and Taiwan
- Dongkeng Smart Grid Demonstration Project
- Sunshine Siaolin Village Community Electricity Storage System Demonstration Site in Kaohsiung
- Integrated Distributed Energy Resource Management System – Taipower Research Institute, Shulin District

Source: Faa-Jeng, Lin, Yenhaw CHEN, NEPII, 2016 The Development of Smart Grid Industry and Technology in Taiwan
(4-2) The Micro Gird Technology Development in Taiwan
Taiwan’s Remote Islands

- Green Island
- Orchid Island
- Chi-Mei Island
- Wang-An Island
- Hu-Jing Island
- Dong-Ji Island
- East Chu Island
- West Chu Island
Frequency of Extreme Typhoon Rainfall

The Leading 30 extreme Typhoon events over Taiwan: 1970 ~2009

- 2000~2009: 14 extreme Typhoon events
- 1990~1999: 6 extreme Typhoon events
- 1980~1989: 6 extreme Typhoon events
- 1970~1979: 4 extreme Typhoon events
Institute of Nuclear Energy Research Microgrid

- The establishment of an autonomously-controlled microgrid demonstration system, and completion of seamless, stable switching of microgrid between grid-connected and islanding operating modes.

- INER are developing Microgrid & EV Integration Technology

1. Reduce EV charging grid connection impact;
2. Improve the renewable energy usage efficiency
3. Vehicle to Grid (V2G) for Load Shifting

Source: Institute of Nuclear Energy Research for 21st APEC Automotive Dialogue
Energy Storage System Cost and Domestic Energy Storage Market Trends

- **High Voltage**
  - Emergency backup on remote island & Community
  - The user of photovoltaic Self-consumption / quality maintenance

- **Low Voltage**
  - Storage of energy System cost
    - $940/kWh
    - $710~$1000/kWh
    - $430/kWh
    - $550~$830/kWh
    - $400~$660/kWh
    - $250~$480/kWh

- **User end**
  - Emergency backup
  - Combination of wind power generation/integration of renewable energy
  - Combination of photovoltaic power generation/distribution quality maintenance
  - remote island application of microgrids/outlying and power supply bottlenecks

**Development conditions**
- 2015: The high cost of diesel power generation on remote islands
- 2020: The risk of power shortage started in 2018
- 2025: Demand and user groups Mature mechanisms
- 2030: 2021~2030 Mature power distribution service mechanism

- The amount of renewable energy generation accounts for 50% of national power generation (Taipower 30%)
- Offshore wind capacity target 4GW, solar photovoltaic target 20 GW

**Notes:**
- The energy storage system does not include storage systems besides pumped hydro and compressed air
- In 2018, the price of flow batteries of US ViZn Energy Systems will drop to $200/kWh.
- If the EV Market grows up continuously, the battery price will reduce 50% each 5 years.

Demonstration of Microgrid Remote Islands

- Microgrid could be divided into two modes, grid-connected and stand-alone. In Taiwan, grid-connected microgrid is applied to remote islands, for example, Tai-Ping Island, Dong-Keng Community, Kinmen County, and Dong-Ji Island, Penghu County. Stand-alone microgrid is otherwise applied mainly in urban and rural areas, for example, the public housing in Taipei City and Siaolin Village No.2, respectively.
- The function of microgrids in remote islands are to increase the penetration of renewable energy and lower cost of power supply.
- If our new government is planning to enhance the use of renewable energy, microgrids with energy storage system will then be given multiple characteristics in these areas, such as renewable energy, power loads, backup power and even cooperate with the power grid.

**Microgrid in Tai-Ping Island**

With a 40 kWp solar PV system and a 612 kWh energy storage system, the microgrid in Taiping Island could be integrated with the existing 120 kWp solar PV system and 4 diesel generators. It is estimated that the microgrid could generate around 190 thousands kWh per year.

**Smart Energy Storage System in Dongkeng Community, Kinmen County**

With 45.9 kWp solar PV system, 3 kW wind turbine, 5 kW fuel cell, and 140 kWh secondary battery energy storage system, Smart Energy Storage System in Dongkeng Community could generate 200 kWh per day, and provide to 16 households. This is a demonstration site of how to stabilize the power supply in communities by using renewable energy, energy storage system, and load management.

**Microgrid in Dong-Ji Island, Penghu County**

Dong-Ji Island has existing diesel generator, solar PV system, and energy storage system, but was unable to be connected together. It is expected to connect these equipment using the microgrid and energy management system, and to enhance the quality and stability of power supply in Dongji Island.

Source: Tatung Company, National Chung-Shan Institute of Science and Technology, Chung Hsin Electric & Machinery Mfg. Corp. Ltd., organized by TIER
Demonstration of Microgrid - Rural and Urban Areas

- Stand-alone microgrids are applied to rural and urban areas, we already have related demonstration sites such as Guangtsai Wetland in Pingtung County, Siaolin Village No.2 in Kaohsiung City, and Public Housing in Taipei City.
- While in main island of Taiwan, the function of microgrids is to provide backup power when in emergency.

**Microgrid in Guangtsai Wetland, Pingtung County**

The power supply in Guangtsai Wetland is based on renewable energy, mainly from 78 kW solar PV and 10 kW wind power generation system, along with energy storage system and modern smart energy management system. By using these systems, it is expected to achieve real-time management of power supply and demand, and 100% of self-sufficiency in power supply.

**Smart Energy Storage System in Siaolin Village No.2, Kaohsiung City**

NCSISI has established a Smart Energy Storage System in Siaolin Village No.2, Kaohsiung City in April, 2016. It is expected to promote the system in remote mountains, and further, to overseas.

**Green Microgrid for Public Electric Facilities in Taipei City**

The concept of this microgrid is to integrate solar PV system, diesel generator, and energy storage system into a mix power supply system. When in emergency, the building could maintain its power supply by activating the energy storage system and diesel generator, therefore increasing the stability of power supply in it. Other than that, the microgrid could also soothing congestion problem by dispatching power supply to nearby loads.

Source: Tatung Company, National Chung-Shan Institute of Science and Technology, Prof. Hong-Tzer, Yang, organized by TIER
Current Status of Promoting Microgrid in Overseas

The microgrid industry in Taiwan has already promote the system to rural areas overseas, for example, the microgrid in rural areas in Myanmar, establishing by Tatung Company, and the microgrid system of Fu-Mei Farm in Chongming Island in China, establishing by Chung Hsin Electric & Machinery Mfg. Corp. Ltd.

**Microgrid in Myanmar-Rural Area**

Tha-Yet-Pin and Pe-Taw-Gon, rural areas near Naypyidaw, Myanmar, have installed microgrids, including 10 kW solar PV system and 6 kW pumping system. The microgrid is used to integrated the energy storage system, diesel generator, wind turbine, to monitor and control the whole system, providing drinking and irrigation water. If there is any extra power generation, it could also be consumed by home appliances. Since there were no power infrastructures before, the microgrid has already improved the health and living conditions greatly in these areas.

**Chung Hsin Electric & Machinery Mfg. Corp. Ltd**

The green house landscaping of Fu-Mei farm has established a microgrid system, including 50 kW solar energy, 50 kW two-way intelligent inverter and 150 kWh energy storage system. The farm could maintain the quality of power supply by installing the energy storage system and the energy management system. The microgrid is expected to be completed at the end of 2016.

Source: Tatung Company, Chung Hsin Electric & Machinery Mfg. Corp. Ltd., organized by TIER
Microgrid in Dong-Ji Island Penghu County

- The annual sunshine condition of Dong-Ji island is about 2,181 hours and is very suitable for PV.
- 2011 January, 85kW PV with battery system was installed as the disaster prevention system. This system was improved to connect PV, battery and diesel generation in 2015.
- This system could be switched between grid-tie or isolated mode. Normally, the grid will be operated in grid-tie mode. The existed diesel generator will be the base load power source. The combination with PV & battery system could increase the renewable energy usage rate and reduce the fuel cost.
- If the grid fail, by the switch of ATS (automatic transfer switches), PV & battery system will become the backup power of Marine National Park Headquarters.
- Dong-Ji Microgrid includes 200 kW diesel generator, and Smart Energy Management System (SEMS), 90kW inverter, 750 kWh lead-acid battery.
- During daytime, SEMS will adjust the inverter according to the PV generation and battery condition to meet the load. During the nighttime, SEMS will adjust the output of inverter and supply power to the grid. Dong-Ji Microgrid system could devise the energy source and reduce the usage & transports of fuel.
The TPC’s first Remote Community backup Microgrid

- Usually, typhoon will cause serious disaster in remote community located in mountain area. Due to road interruption caused by extreme rainfall Taipower can not accurate the power supply recovery process.
- Fu Shan Village experienced no power supply for 17 days last year.
- So, the first village backup microgrid was set up by Taiwan power company in January 2017 in Wulai, Fu Shan Elementary School.
- This microgrid system could be operated in isolated mode at least 2 weeks.

Source: Taipower
(4-3) The Virtual Power Plant Technology Development in Taiwan
Motivation for Developing Virtual Power Plants

- **Difficult to increase large power plants capacity**: nuclear power, firepower, large land-based wind power, endless protest & opposition.
- **Increasing numbers of power congested areas**: it is uneasy to add or change transmission and distribution lines and substations, while electricity demand increases year by year, the power supply scheduling is difficult and the economic losses caused by power instability are difficult to estimate.
- **Change in power usage structure**: the percent of power used by production users has decreased and the percent of power used by consumers has increased, power supply congestion areas are mostly in densely populated metropolitan areas.
- **Reward small-scale renewable energy**: small-scale solar energy and wind turbine grid power generation has increased, but the lack of a scheduling mechanism affects the quality of the power supply grid.
- **High-valued new energy and energy saving industries**: integrate demand response and photovoltaic, wind, energy storage, fuel cell equipment industry and transform them into a high value-added power supply service system.

The above problems are not unique to Taiwan, but Taiwan's people, industrial restructuring, and policy encouragement has accelerated the occurrence. International response has been to develop "virtual power plant solutions" which are based on communication technology, and the construction includes four elements: transmission and distribution network intelligence, user terminal decentralized energy management system, automatic demand response systems, and user demand markets. Since Taiwan has the foundation of the ICT industry, it has development advantages compared to other competing countries.

Source: Energy National Science and Technology Program — Smart grid and advanced meter reading project NSC 102-3113-P-008-010
The Structure of VPP Energy Supply Service Technology

Smart grids are the backbone of virtual power plants, through a combination of distributed power generation equipment, energy storage devices, demand management technology and powerline communication network systems, the most effective or the best use of the environment is achieved during construction of regional energy to enhance the efficiency and reliability of power system degrees.

Source: Energy National Science and Technology Program — Smart grid and advanced meter reading project NSC 102-3113-P-008-010
The Connection between Taiwan VPP Promotion and Energy Market

- The concept of VPP enables distributed energies, demand response and others with lower capacity to be part of energy market, despite the limitation of ISO financial model and real facility model.
- The VPP technology coordinating with energy market liberalization attract enterprises to integrate demand response, distributed energies such as solar energy, wind energy, power saving facilities, fuel cells, CHP, etc., to join energy generation industry, make up for the future capacity gap caused by steady decreasing nuclear power usage, and encourage green industry along with new energy industry development.

資料來源: 陳彥豪、盧思穎、林法正, 虛擬電廠概念與運作模式介紹, 電力電子雙月刊, Vol.11, No.4, 46-53頁, 2013年7月。
Regional Power Usage Character and Renewable Resource

- **North Taiwan**
  Power transmits from South to North during the peak time. North area is large power demand center. Demand management could create North VPP and become system dispatch resource.

- **Centre Taiwan**
  Full of onshore and offshore wind resource which is suitable to develop wind power and integrate as Centre VPP.

- **South Taiwan**
  70% PVs are installed in south area, combined with storage system could be South VPP.

- **East Taiwan**
  Full of geothermal and Ocean Current, could become local power resource and avoid the power transmit issue from West to East.
The Vision of Smart Grid Promotion in Taipei City

Setting **Smart City, Smart Government, Smart Service and Smart Field** as core, integrate city government’s current promotion policies on power saving, power creating and industry, expand the utilization of green energy, enhance power usage efficiency and the willingness to save power, lower the risk of power shortage, invigorate **smart economy**, build the **future energy planning benchmark for the city**.
Promotion Structure for Smart Grid

**Power creating public facilities and Zero Energy Consuming Buildings Demonstration (Smart Government)**

- Smart Gov.
- Smart Campus
- PV Power Plant

**Energy Information Cloud Center (Smart Service)**

- Energy Information Cloud Center
- Info. Center
- Aggregator

**Power Consumption & Creation Big DATA Aggregator Business Model (Smart Economy)**

- Big DATA Aggregator
- Business Model
- Public Utility

**Low Energy Consuming Industrial Park (Smart City)**

- Low Energy Consuming Industrial Park

**Zero Energy Consuming Housing Complex Demonstration (Smart Field)**

- Zero Energy Consuming Housing Complex
- Smart Commercial Building
- PV Power Plant

**Single-family Housing & Smart Appliances**

- Single-family Housing
- PV Power Plant

**PV Power Plant**

- PV Power Plant
Expansion of Public Power-creating Facilities & Housing, Enhance Green Energy Self-generation Rate

- **Encourage the installation of renewable energy generation facilities, enhance energy self-generation proportion.**

  Encourage the New Energy Integration Wholesale System”, use existing buildings, public facilities to fully promote photovoltaic generation, the total power-creation covers 10% of the total electricity consumption (Needs confirmation).

- **Promote Green Housing’s Public Power Consumption Demonstration**
  - Buildings/Complex, public power consumption’s contract capacity is around 30~45kW
  - Demonstrate small-scaled energy storage microgrid technology as public energy management system, provide backup power supply for lighting, elevator and emergency communications equipment.
Illustration of Small-scaled Public Microgrid for Common Buildings

- **Public power consumption**: includes elevators, pump motors, lightings of public stairs, roads and basements, other public facilities power consumption, power and charging for EV or electric scooters.
- **Hardware equipment**: power consumption monitoring equipment (AMI), smart inverter, energy management system and energy storage equipment.
- **Pros**: available for blackout lighting, elevator backup power and emergency use, utilize energy storage facilities to lower the contract capacity, easier to split the bill for public power consumption. Can switch to microgrid system steadily and provide emergency power use, enhance power supply reliability.
Residential Power Consumption Cloud Service in Taipei

Build cloud service for residential power consumption, visualize power consumption and provide data, enhance the willingness to save power.

- **Easy Access To Power Consumption Info:** 15 mins or an hour as base unit, provide residential power consumption info hourly, daily, quarterly and yearly.
- **Analyze Power Consumption Info:** use the cloud platform to analyze and demonstrate the status of residential power consumption.
- **Provide Power Saving Strategies Based On Types:** provide power saving strategies based on different types of residential power consumption.

Visualize Power Consumption Data and Build the Base of Power Consumption Data

Average Power Consumption in this area
Users Average Power Consumption

Digitalize User Power Consumption Info in Taipei

TPC AMI
Common Residential

Source: TIER, 2015
Xing Long Public Housing 1st Block Smart Grid Phase Zero Project

1. **Smart Building/House Energy Management System (B/HEMS)** - Set up monitoring station to integrate the individual HEMS, and be able to reduce energy usage during peak hours through the demand response (DR) program.

2. **Green Public Electricity Microgrid** – Install & integrate photovoltaic (PV) system and Energy Storage System (ESS).

3. **Smart EV Charging Integration Management System**

4. **Advanced Metering Infrastructure (AMI)**

Source: Department of Urban Development, Taipei City Government, NCKU, TIER and TaiPower, Suggestions for Smart Grid Promotion in Taipei City - Xing Long Public Housing, Oct. 2015
Building Energy Management System User Interface (1/6)

1. Real Time Info of Surroundings
2. Solar Energy and Utility Power Info
3. EV Charging Station, ESS, and Diesel Power Info
4. Overall Building Power Info

Source: Department of Urban Development, Taipei City Government, NCKU, TIER and TaiPower, Suggestions for Smart Grid Promotion in Taipei City - Xing Long Public Housing, Oct. 2015
Xinglong Public Housing 2nd Block Smart Grid Project

- Pictures of Xinglong Public Housing 2nd Block
- Project Scope and number of Household
  - Building B1 & B2
  - Smart grid Experiment 144 Households (6 Stories)
    - HEMS & AMI Installed
  - Control Group 144 Household
    - Only AMI Installed
In the past, only Taipower work on the promotion of demand side management. In the future more Energy Service Companies will be involved in this business.

The Promotion of demand respond in urban area, could reduce the peak load in urban area.

Taipei City Government and Taiwan Power Company could encourage residential or commercial customers to joint demand side biding under the smart community demonstration.

Source: Taiwan Power Company, 2016
Xinglong Public Housing Joint Taipower Demand Side Biding Concept

Because of the limited household numbers with EMS and battery capacity in Xinglong Public Housing 1st block, we will introduce a CEMS to integrate Xinglong Public Housing 1st & 2nd, modify backup diesel generator, so that Xinglong Smart Community could become a VPP and Joint Taipower Demand Side Biding program.
Thank you!

Contact : +886 2 25865000 # 905,  yenhaw@msn.com

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