Development of Smart Grid in Taiwan

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Outline

- Current Status of Taipower System
- Master Plan of Smart Grid in Taiwan
- National Energy Program - Phases I-II: Smart Grid General Project
- Penghu Smart Grid Demonstration Project
- Automatic Demand Response Demonstration Project
- Virtual Power Plant Demonstration Project
- AC Microgrid Demonstration Project
- Development of Smart Grid Industry in Taiwan
Current Status of Taipower System
Power System in Taiwan

TPC Power System

Installed Capacity in Year 2013: **41,181 MW**

<table>
<thead>
<tr>
<th>Source</th>
<th>Installed Capacity</th>
<th>MW</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Taipower</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclear</td>
<td>5,144</td>
<td>12.45</td>
<td></td>
</tr>
<tr>
<td>Thermal</td>
<td>22,132</td>
<td>53.80</td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>3,325</td>
<td>8.00</td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td>8,200</td>
<td>21.30</td>
<td></td>
</tr>
<tr>
<td>LNG</td>
<td>10,607</td>
<td>25.60</td>
<td></td>
</tr>
<tr>
<td>Hydro</td>
<td>4,353.60</td>
<td>10.5</td>
<td></td>
</tr>
<tr>
<td>Conventional Hydro</td>
<td>1,792</td>
<td>4.20</td>
<td></td>
</tr>
<tr>
<td>Pumped storage Hydro</td>
<td>2,602</td>
<td>6.30</td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td>287</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>PV</td>
<td>18</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td><strong>Subtotal of Taipower</strong></td>
<td>32,508.06</td>
<td>78.50</td>
<td></td>
</tr>
<tr>
<td><strong>IPP</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal</td>
<td>7,707.10</td>
<td>18.60</td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td>3,097.1</td>
<td>7.50</td>
<td></td>
</tr>
<tr>
<td>LNG</td>
<td>4,610.0</td>
<td>11.20</td>
<td></td>
</tr>
<tr>
<td>Hydro</td>
<td>289.10</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td>236.10</td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>PV</td>
<td>350</td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td>CoGeneration</td>
<td>622.00</td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td><strong>Subtotal of IPP</strong></td>
<td>8,892.60</td>
<td>21.5</td>
<td></td>
</tr>
<tr>
<td><strong>Total Installed Capacity</strong></td>
<td>41,181</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Substation No.</th>
<th>MVA</th>
<th>ckt-km</th>
</tr>
</thead>
<tbody>
<tr>
<td>EHV</td>
<td>29</td>
<td>56000</td>
</tr>
<tr>
<td>Primary</td>
<td>264</td>
<td>68450</td>
</tr>
<tr>
<td>Secondary</td>
<td>295</td>
<td>20728</td>
</tr>
</tbody>
</table>

Remark 1: In 2014, peak load is 34,821MW.
Remark 2: In 2015, installed capacity of RE is 3.8GW (9%).
Remark 3: In 2015, power generation is 219,224GWh in which RE is 4%.
User Profile of Taipower in 2013

Customers (13,184 Thousand)
- Residential: 11,759 (89.4%)
- Industrial: 210 (1.6%)
- Commercial: 996 (7.5%)
- Others: 189 (1.4%)

Sales (201,945 GWh)
- Residential: 40,891 (20.2%)
- Commercial: 33,525 (15.6%)
- Others: 17,504 (8.7%)
- Industrial: 312,031 (59.5%)

Power Outage Duration and Frequency

<table>
<thead>
<tr>
<th>Year</th>
<th>Duration of Power Outage (min./cus./Yr)</th>
<th>Frequency of Power Outage (Freq./cus./Yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>0.264</td>
<td>18.086</td>
</tr>
<tr>
<td>2012</td>
<td>0.298</td>
<td>19.050</td>
</tr>
<tr>
<td>2011</td>
<td>0.204</td>
<td>18.224</td>
</tr>
<tr>
<td>2010</td>
<td>0.196</td>
<td>17.663</td>
</tr>
<tr>
<td>2009</td>
<td>0.238</td>
<td>19.246</td>
</tr>
</tbody>
</table>

Line Loss
- 2009: 4.86%
- 2010: 4.66%
- 2011: 4.76%
- 2012: 4.42%
- 2013: 4.25%
# Nuclear Power Plants in Taiwan

## Nuclear Power Plants in Taiwan

<table>
<thead>
<tr>
<th>Station</th>
<th>Set</th>
<th>Capacity (MW)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Jinshan Nuclear</td>
<td>1</td>
<td>636</td>
<td>Retire in 2018</td>
</tr>
<tr>
<td>Power Plant</td>
<td>2</td>
<td>636</td>
<td>Retire in 2019</td>
</tr>
<tr>
<td>2nd Kuosheng Nuclear</td>
<td>1</td>
<td>985</td>
<td>Retire in 2021</td>
</tr>
<tr>
<td>Power Plant</td>
<td>2</td>
<td>985</td>
<td>Retire in 2023</td>
</tr>
<tr>
<td>3rd Maanshan Nuclear</td>
<td>1</td>
<td>951</td>
<td>Retire in 2024</td>
</tr>
<tr>
<td>Power Plant</td>
<td>2</td>
<td>951</td>
<td>Retire in 2024</td>
</tr>
<tr>
<td>4th Lungmen Nuclear</td>
<td>1</td>
<td>1350</td>
<td>Operate after 2017?</td>
</tr>
<tr>
<td>Power Plant</td>
<td>2</td>
<td>1350</td>
<td>Operate after 2018?</td>
</tr>
</tbody>
</table>

Regional Power Congestion

The regional supply capacity and peak load of northern, middle and southern Taiwan in 2013

Peak load in northern, middle and southern

Power supply capacity in northern, middle and southern
The Future Power Supply Environment in Taiwan

- Estimation based on analysis of overall power supply and demand shows that under the circumstances of Nuke 4 came to a halt, Nuke 1, 2 and 3 will decommission on schedule, the newly planned coal-fired and natural gas power generation will be completed on schedule, and the outdated facilities will be eliminated on schedule:
  - Calculation based on normal power consumption scenario (power consumption growth rate is 2%), starting from 2018, Taiwan will face the risk of power shortage. (idea case)
  - However, if the renewed coal-fired, natural gas power generation facilities are inoperable and Nuke 1, 2 and 3 can’t reconnected to the grid due to any reason, Taiwan will face the risk of power shortage in 2016 the earliest. (current situation)
  - The risk of power shortage is a serious and unavoidable subject that all the citizens will face.

When Electricity reserve rate is lower than 15%, the chance of electricity rationing will increase, it has happened to be lower than 10% multiple times in 2015, and it was 3.88% on April 29th, 2015.
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. Taipower is owned by the government. 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 28.5 GW (PV 20GW, WTG 3GW) by 2025 (accounting for 50% of total power installations).
Master Plan of Smart Grid in Taiwan
Master Plan of Smart Grid in Taiwan (2011~2030)

Smart Generation and Dispatch
- Increase of renewables
- Increase for the reliability & efficiency in power plants

Smart Transmission
- High efficiency in transmission
- Increase of the security in transmission

Industries for Smart Grid
- Develop key systems & facilities
- Introduce the service opportunities for smart grid

Smart Consumers
- Establishment of end-users’ information
- Advanced planning of end-users’ service

Smart Distribution
- Enhancement of security for distribution
- Enhancement of integration in DG

Task Forces:
- Ministry of Science and Technology (MOST)
  - Ministry of Economic Affairs (MOEA)
    - Bureau of Energy
    - Bureau of Standards
    - Industrial Development Bureau
    - Department of Industrial Technology
- Taiwan Power Company
- Institute for Information Industry
- Institute of Nuclear Energy Research
- Industrial Technology Research Institute
- Taiwan Institute of Economic Research
- Taiwan Smart Grid Industry Association
<table>
<thead>
<tr>
<th>Benefit</th>
<th>Objective</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security &amp; Reliability in Power Grid</td>
<td>System average interruption duration index</td>
<td>21min/</td>
<td>16min/</td>
<td>15.5min/</td>
</tr>
<tr>
<td></td>
<td>(SAIDI)</td>
<td>customer · year</td>
<td>customer · year</td>
<td>customer · year</td>
</tr>
<tr>
<td>Energy Efficiency</td>
<td>Efficiency in thermal power plants</td>
<td>42.52%</td>
<td>44.73%</td>
<td>(2023 44.95%)</td>
</tr>
<tr>
<td>Renewable (Including Hydro Power)</td>
<td>Percentage of installed capacities</td>
<td>4.7% (2GW)</td>
<td>(2015 9%, 3.8GW)</td>
<td>(2025 50%, 28.5GW)</td>
</tr>
<tr>
<td>Carbon Reduction</td>
<td>Carbon Oxide reduction</td>
<td>(CO2 emission: 276</td>
<td>35.99 million tons</td>
<td>114.71 million tons</td>
</tr>
<tr>
<td></td>
<td></td>
<td>million tons, 12 ton</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>per person)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
National Energy Program-Phases I-II: Smart Grid General Project
National Energy Program-Phase I: Smart Grid General Project

Pilot Projects and Preliminary Collaborating Firms

1. AC Microgrid Pilot
   - CHEM, ABB, CAEC, AIDC, Allis, RICH ELECTRIC, ADX Corporation, 源鼎, AC POWER
   MicroGrid for more renewable energy penetration and better power quality

2. Advanced Metering Infrastructure (AMI) Pilot Project
   - Tatung, AcBel, Arch Meter, JosephTec, Delta, MOXA
   Meter is the interface between customer loads and energy management systems and the grid

3. Advanced DAS Pilot Project
   - Hsiang Cheng, Connet, Allis, Ximple
   Billing/Customer service Distribution automation Energy Management Outage management

4. Smart Home (Building) Energy Management System Pilot Project
   - NETVOX, Microtime, Panasonic, Megawin, CHTTL, Raydium, SPIROX, ABB, AIRONE, 源鼎, ITRI/GEER, ITRI/IC, III, TATUNG
   Improve of building energy efficiency and public energy saving conscious

5. Research on DC Smart Microgrid
   - SYSGRATION, EtasisElectronics, tehtai, CSIST, LiteOn, GLW, ATE, CSC, Delta, CTE

6. Advanced Wide-area Measurement System (WAMS) Applications Pilot Project
   - ADX, TATUNG

7. Transmission System Power Quality Monitoring and Control Technology Development and Applications Pilot Project
   - ADX, APPA, TAYA, INER

   - TAIPOWER, TBKC, Archmeter, SAC, LOCK, KBUS, ITRI/GEER, DELTA, AC POWER

9. Smart Grid And AMI Standard Establishment
   - CHEM, CHT, DELTA

10. Virtual Power Plant Pilot Project
    - ADX, APPA, TAYA, INER

11. Smart Grid Demo Site in Penghu
    - Hsiang Cheng, Connet, Allis, Ximple
There are currently 18 Smart Grid Demonstration Sites in Taiwan.
Smart Grid Demo Sites in Taiwan-2

Advanced Distribution Automation Demo System

100 kW Autonomous Micro-grid Demonstration System

Smart DC Power System Educational Demonstration House

Smart AC/DC Hybrid Micro-Grid Demonstration System

Micro-grid and Electric Vehicle Demonstration Site

Dongkeng Smart Grid Demonstration Project

Penghu Smart Grid Demonstration Site

Furnace Optimized Operation Demonstration System

Optimizing Control System for a High-tech Plant Ice Water System
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

Sponsored by National Science Council
The Integrated Application of Demand Response, Distributed Generator, and Energy Storage System (NCKU)


Development and Application of Standalone Microgrid System Technology
Development and Application of Autonomous Power Control and Management Technology for a Distributed Power System Institute of Nuclear Energy Research, Longtan (2014–2016)

NEP-II Smart Grid Focus Center – Research Projects and Test Fields

Development of High Power Grid-Connected Converters
NTHU, Hsinchu (2014–2016)

Key Technology Development of Energy Saving Control And System Integration for Smart Grids
Industrial Technology Research Institute, Hsinchu (2014–2016)

Penghu Smart Grid Demonstration Project (ITRI)

EV charging station manager strategy
NSYSU, Kaohsiung (2014)

Research and Development of Wide-Area Monitoring and Control Technologies (NTU)
The Commercialization and Implementation of Smart Grid Technology Project (Taiwan Institute of Economic Research)
Smart Grid Interfacing Consumers' Standards and Their Test Specifications (Bureau of Standards, Metrology & Inspection, M.O.E.A.) (2014–2016)
NEP II - Penghu Smart Grid Demonstration Project
Penghu Smart Grid Demonstration Project

• Penghu archipelago (48km from Taiwan, inhabitants 100,000, average load 40MW, peak load 72MW in 2014)

With 161kV/200MW and completed in the end of 2016
Smart Grid Master Plan was announced in 2012.
Some technologies need detailed action plans and technology verification.
Penghu Island is proposed as the demo site of Smart Grids technologies.

Deployment Items:
1. Smart PV inverter test site
2. Smart Substations (Magong & Huhsi S/S)
3. Advanced DAS with FDIR in two feeders
4. 2,000 smart meters
5. 100 smart users with HEMS
6. Micro-EMS demo system
Penghu Smart Grid Demonstration Project

An information integration platform accesses data with substation, ADAS, MDMS, DRMS and DER through MicroEMS.

- Substation: UPdating intelligent electronic device
- ADAS: 2 feeders and lateral automation
- MDMS: 2000 smart meters
- DRMS: 100 HEMS
- DER: Smart Inverter/Energy storage system

ADAS: advanced distribution automation system
MDMS: metering data management system
DER: distributed energy resource
Penghu Smart Grid Demonstration Project

Show Room of Penghu Smart Grid Demonstration Project

Scenario of smart home, computer room for information integration platform, model of smart grid system, monitoring power generation and transmission of Penghu island
Penghu Smart Grid Demonstration Project

website http://smartgrids.tw
Inverter – Role in PV Plants?

PV inverter converts DC energy from solar modules into AC energy and interface the PV system with electricity grid.

Traditional Inverter
- Harvesting maximum power from PV array
- Matching plant output with grid voltage and frequency
- Providing unintentional islanding protection

What is Smart Inverter?
- Inverter that can modify its real and reactive power output to provide grid support
- Can respond autonomously to V/F changes or can respond to communicated signal
Voltage Violation (w/o smart inverter)

- May 2012 (267,864 points)
  - 3.0% of points exceed +5% limit
Voltage after Power Factor Adjustment

January 2013 (267,382 points)
• < 0.1% of points exceed +5% limit
Active power feed-in control with smart inverter

\[ \Delta P = 20 \frac{P_M \cdot 50.2 \text{Hz} - f_{\text{mains}}}{50 \text{Hz}} \]

for 50.2 Hz \( \leq f_{\text{mains}} \leq 51.5 \text{Hz} \)

Where:

- \( P_M \) : the power generated at the time of exceeding 50.2 Hz;
- \( P \) : the power reduction;
- \( f_{\text{mains}} \) : the mains frequency.

There are no restrictions for frequencies of 47.5 Hz \( \leq f_{\text{mains}} \leq 50.2 \text{ Hz} \).

Disconnection from the network is required for \( f_{\text{mains}} \leq 47.5 \text{ Hz} \) and \( f_{\text{mains}} \geq 51.5 \text{ Hz} \).
Demonstration of Smart Inverter in Penghu

Makong Primary School
PV=355kWp

Aimen Primary School
PV=60kWp

1km

5.84km
Monitoring and Control of Grid-connected PV System

Distribution Mapping System

PV inverter
(EnerSolis 12KW)

Advanced Distribution Automation System

WiFi

PV system

Renewable Energy Management System
Communication Architecture of Renewable Energy Management System

Field Equip:
1. Inverter
2. Solar Irra.
4. Smart meter

PV system#1
- RS485
- RF
- Gateway
- COMM.Node

PV system#N
- RS485
- RF
- Gateway
- COMM.Node

Radio station (AP)
- Wireless
- TCP/IP

Database Server
- Wireless
- TCP/IP
- TDS
- HTML5 support

Master station
- TCP/IP
- HTTP
Field Test of Smart Inverter
(Makong Primary School, 2015/06/25-10:30AM)
Field Test of Smart Inverter
(Makong Primary School, 2015/06/25-10:30AM)
Enhancement of PV penetration by power factor control of smart inverters

- Taipower distribution feeder:
  - length=8.5KM
  - total existing PV installation=2646KWp
- A new PV installation with smart inverter
Maximum capacity of PV integration
(W/O violating the constraint of voltage variation 2.5%)

- Conventional PV Inverter (PF=1.0)
  - PV capacity of 3200 KWp (Maximum PV capacity:3200 KWp)

- Smart Inverter (operating with PF=0.9)
  - Maximum PV capacity:5434 KWp

- Conclusion
  - The maximum capacity of PV integration is increased by 2234 KWp when the smart inverters are applied for the large PV farm.
NEP II – Automatic Demand Response Demonstration Project
Automatic Demand Response (ADR)

Demand Response (DR) is a set of actions taken to reduce load when electric grid contingencies threaten supply-demand balance or market conditions occur that raise electricity costs. Automated demand response consists of fully automated signaling from a utility, ISO/RTO or other appropriate entity to provide automated connectivity to customer end-use control systems and strategies. Open Automated Demand Response (OpenADR) is a research and standards development effort for energy management led by North American research labs and companies. The typical use is to send information and signals to cause electrical power-using devices to be turned off during periods of high demand. OpenADR provides a foundation for interoperable information exchange to facilitate automated demand response.
Taipower Research Institute Test Site – ADR

1. **Control Center** transmits DR Event with “Reduction Level” to ADR VEN
2. **ADR VEN** transmits DR event to responsible client according to DR event and client (simple or smart client)
3. **Smart Client** negotiates EMS system to schedule demand reduction accordingly
4. **EMS System** manages and controls load according to demand reduction schedule

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Storage Connected with TPC Grid
- Consumption Analysis
- Over-Capacity Warning
- Demand Management

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TPC Control Center

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Demonstration of ADR Using Large Chiller

Shizi-MinChuan Feeder Region:
(1) 60 Chiller over 100RT
(2) Both HV & LV Consumers

Investigation:
OpenADR VEN / VTN Operations with PULL / PUSH Mode

Project Focus:
1. Establish AC ADR SOP
2. VEN installation and integration on Consumer Side
3. ADR Architecture Design
4. ADR Benefit/Cost Analysis
5. ADR Programs Design

Project Term:
Feb. 2015 ~ Jan. 2017
NEP II - Virtual Power Plant Demonstration Project
The Structure of VPP Energy Supply Service Technology

Coal-fired, oil power plants

Nuclear Power Plant

Natural Gas Power Plant

Smart transmission technology development

Pumped hydroelectric power

Conventional Hydro Power

Two-way exchange of electric power network

Advanced Smart Distribution System Development

Cogeneration

Wind power

Solar power generation

Energy storage systems (including electric vehicles)

Virtual Power Plant (VPP)

Electricity and communications network systems integration

On-site Production

Energy-saving technology

Smart user energy management system

New energy technology

The VPP in distribution level can solve the power supply bottleneck problem and to achieve high renewable energy penetration. The VPP can be achieved by the integrated applications of demand response, distributed generator including PV, WTG, micro turbine and diesel generator, and energy storage system.
Virtual Power Plant Demonstration Project

- **Dynamic Electricity Market/Ancillary Services Market Mechanisms**
  - Analyze related international VPP and DR experiences, and propose suitable model for Taiwan

- **Comm. Control Interface Standard**
  - Research and development of comm. Interface
  - CAN Bus / DNP3 / IEC 61850

- **Supervisory Control and Data Acquisition (SCADA)**
  - Software and Hardware Developments
  - Human Machine Interface (HMI)

- **DER Energy Management System (DER-EMS)**
  - Forecasting system, optimal EMS algorithms, reactive and real power demand dispatching

- **Comm. and Control Interface of Energy Conversion System**

- **Distribution System Mathematical Model Simulation**
  - Power system and DER models simulation and analysis

- **Testing System Demonstration**
  - Taiwan Power Research Institute
  - BEMS, DER, and DR integration

- **Communication and control interface: active and reactive power control/voltage and frequency regulation**

- **Dynamic electricity market**

- **DER dispatching optimization**

- **Comm. standard and interface integration**

- **Power quality analysis and load transfer control: load forecasting/system dynamic analysis/active and reactive power compensation**

- **Distribution system EMS**

- **DER-EMS**

- **DR data center**

- **Demand Response BEMS**

- **HEMS**

- **Renewable Energy**

- **Energy Storage**

- **CHP, Micro Gas Turbines, Distributed Generation Techniques Assessment**
Taipower Research Institute Test Site

- To Build DER-EMS System and Technical Verification

**Distributed energy resources**

- P,Q output control

**Power conversion interface**

- ESS
  - 250kW

- DG
  - PV, WTG, Diesel generators, Steam turbines

**DER-EMS optimal decision-making platform**

- IEC 61850-7-420
- IEEE P2030.2

**AMI**

- OpenADR 2.0 for ADR

**Smart building energy management system**

- H(B)EMS
  - DR control
  - Load saving control

**Electricity market programs**

- Substation-EMS
economic dispatch
decision-making platform

- Taipower side

- Diesel-Engine Generator
- PV
- ESS
- Wind-turbine

**IEC 62056**

- IEC 61968

**Advanced DNP**

- IEC 61850
Taipei’s residential policy would like to build 50,000 public residence in 8 years. Public residences will be the permanent assets of Taipei city government, and the government is planning to establish a Taipei real estate company which is responsible for rental, maintenance etc.

- Shinlong Public Housing, Jiankang Public Housing, Dongming Public Housing and Young-adult Public Housing are currently negotiating with Taipower about AMI implementation.
- Public housings are planning PV installation to provide basement and public area lighting. Power charging facilities are reserved for EVs.
Singlong 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
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。
NEP II - AC Microgrid Demonstration Project
DOE: Definition of a MicroGrid

A group of interconnected loads and distributed energy resources (DER) with clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid and can connect and disconnect from the grid to enable it to operate in both grid connected or island mode.

Typical Microgrid Requirements

■ Grid Connected Capabilities
  – Optimization for Economic Operation
  – Support Integration of Renewables
  – Support for DER Market Participation

■ Islanding Capabilities
  – Emergency Islanding Support
  – Managing Critical/Non-Critical Loads to Available Generation
  – Island Operations with High Penetrations of Renewables
  – Optimized Island Operation for Longevity (Fuel, Maximizing REs)

■ Secure Operations
  – Cyber Secure Communications Network
  – Distributed and Resilient Architecture
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
Target: Developing power control and management technology for low voltage side of microgrid with three zones in which 20% of total energy comes from renewable energy. Microgrid EMS can be used to perform seamless transition control between grid connected and stand alone operation successfully.
470 kW Microgrid Test Field

MG Test Field

25 kW wind

100 kW HCPV

150 kW wind

100 kW HCPV

150 kW wind

Photo Direction

Control Room

250 kW ES

65 kW x3 MT

MG Test Field
470 kW Microgrid Test Field
TPC Distribution Feeder

Point of Common Coupling (PCC)

Microgrid Test Field

Overhead Line (700 m)
Underground Line (35m)
TPC’s FDCC issue islanding operation command to INER’s Microgrid

1. Issue Command
2. Acknowledge
3. Complete

20 km, 4 sec
Islanding Operation on Building

- 20~30% RE Penetration
- PV still active
- MT load following
- ES floating charge
- Islanding
- MT on
- PV off
- PV on
- MT off
- Grid connected
100 hrs Islanding Operation
Taiwan’s Remote Islands

Green Island
Orchid Island
Chi-Mei Island
Wang-An Island
West Chu Island
Hu-Jing Island
Easet Chu Island

Taiwan’s Remote Islands

Green Island
Orchid Island
Chi-Mei Island
Wang-An Island
West Chu Island
Hu-Jing Island
Easet Chu Island
Demonstration of Microgrid Remote Islands

- Microgrid could be divided into two modes, grid-connected and stand-alone. In Taiwan, stand-alone microgrid is applied to remote islands, for example, Tai-Ping Island, Dong-Keng Community, Kinmen County, and Dong-Ji Island, Penghu County. Grid-connected 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.

**Microgrid in Tai-Ping Island**

With a 40 kWp solar PV system and a 612 kWh energy storage system, the microgrid in Tai-Ping 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**

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.
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.

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.

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.

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.
Microgrid on Dongji Island
Microgrid on Dongji Island

■ Goals
  ➢ Increase the electricity generation of renewable energy.
  ➢ Reduce electricity generation from fuels.
  ➢ Enhance the power supply quality on offshore islands.
  ➢ Pave the way for zero-carbon electricity generation.

■ Method
  ➢ Implementation of Microgrid Power Management Systems on Offshore Island.

■ Functions
  ➢ Power generation forecasts
  ➢ Load forecasts ➢ Remote monitoring
  ➢ Energy distribution ➢ Demand control
  ➢ Unbalanced three-phase power control
Microgrid on Dongji Island

Achieves the coordinated control of PV and DG:
- PV serves as the primary power supply, while DG as the secondary power supply. The target is to generate electricity without fuels.
- Achieves the coordinated control of PV and DG to improve the stability of power supply on offshore islands.
- Increase Penghu’s popularity by establishing international case of offshore island which the power generation is mainly supplied by renewable energy.
Development of Smart Grid Industry in Taiwan
Global Development of Smart Grid Market

The construction development of smart grid around the world has begun, and the output value of smart grid global market will continue to grow sustainably.

- Whether grid update projects of developed countries or grid infrastructure installation of developing countries, all will continue over 20 years or more.

- According to the analysis done by international research institute GMT, the total output value of smart grid global market will generate over $400 billion with 8% of compound average growth rate (CAGR). It can be expected that the output value of smart grid global market will continue to grow sustainably in the future.

Source: 2013 ~ 2020 over output value of smart grid (Source: GTM 2013)
Vision of Smart Grid Industry in Taiwan

With power, electrical electronics & IT industries’ power combined, the output value of Smart-Grid Industry in Taiwan is estimated to reach NT$70 Billion in 2020, and NT$170 Billion in 2030.

- **Traditional Power Equipment Industry**: Generator, Electric Motor, Micromotor, Transformer, HV&LV Panel, Circuit Breaker

- **Smart-Grid Power Equipment Industry**: HV&LV Single-Phase Smart Meter System, Smart Substation, Feeder Automation, H(B)EMS

- **Smart-Grid IT Equipment Industry**: MDMS, Communication Module, Sensors

<table>
<thead>
<tr>
<th>Year</th>
<th>Employment</th>
<th>Population</th>
<th>Output Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>28,000</td>
<td>28,000</td>
<td>NT$57.7 Billion</td>
</tr>
<tr>
<td>2007</td>
<td>28,000</td>
<td>29,000</td>
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<td>2008</td>
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<td>NT$52.4 Billion</td>
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<tr>
<td>2010</td>
<td>32,000</td>
<td>29,000</td>
<td>NT$51.5 Billion</td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
<td>NT$9 Billion</td>
</tr>
<tr>
<td>2012</td>
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<tr>
<td>2030</td>
<td></td>
<td></td>
<td>NT$170 Billion</td>
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</table>
Taiwan Smart Grid Industry Association (TSGIA) was officially established in September 2009 for the purpose of facilitating the development of the smart grid industry in Taiwan.
Results of Smart Grid Industry Survey in Taiwan

According to the surveys that were conducted in 2012 and 2014, the result shows that the total sales of Smart Grid related products continue to grow steadily and have a Compound Annual Growth Rate (CAGR) of 51.71%. 2012, 2013 domestic sales growth lower than expected, mainly due to Taipower’s reduce or postpone of investment in transmission and distribution sector, companies more actively developing overseas markets. Overall, nearly six years, domestic and foreign markets showing stable growth trend.

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic</th>
<th>Overseas</th>
<th>Total Sales</th>
<th>Domestic</th>
<th>Overseas</th>
<th>Growth Rate</th>
<th>CAGR</th>
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<tbody>
<tr>
<td>2009</td>
<td>$14.98</td>
<td>$6.10</td>
<td>71.07%</td>
<td>28.93%</td>
<td>$21.09</td>
<td>-</td>
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<tr>
<td>2010</td>
<td>$28.18</td>
<td>$26.91</td>
<td>51.15%</td>
<td>48.85%</td>
<td>$55.09</td>
<td>161.25%</td>
<td>51.71%</td>
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<tr>
<td>2011</td>
<td>$59.03</td>
<td>$32.08</td>
<td>64.79%</td>
<td>35.21%</td>
<td>$91.12</td>
<td>65.41%</td>
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<tr>
<td>2012</td>
<td>$82.20</td>
<td>$42.04</td>
<td>66.16%</td>
<td>33.84%</td>
<td>$124.24</td>
<td>36.36%</td>
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<tr>
<td>2013</td>
<td>$79.11</td>
<td>$58.54</td>
<td>57.47%</td>
<td>42.53%</td>
<td>$137.65</td>
<td>10.79%</td>
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<td>2014</td>
<td>$91.22</td>
<td>$78.28</td>
<td>53.82%</td>
<td>46.18%</td>
<td>$169.5</td>
<td>23.14%</td>
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</table>
Thank You for Your Listening!