Introduction of Micro-grid R&D at CSG

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Outlines

- Drivers for micro-grids
- Key technologies of micro-grids
- Research on micro-grids at CSG
- Demo projects of micro-grids
- Further steps
- Conclusion
Drivers for micro-grids -1

To improve safety and stability of power systems
To improve asset utilization and management
To improve energy efficiency and customer service
To optimize allocation of power resources and their utilization
To develop a resource-conserving and environment-friendly society

Vision

Distributed generation and micro-grid technologies are the key in smart grid development at CSG.

Objectives
Drivers for micro-grids -1

- Friendly integration of DGs
- Diversify power resources and improve customer service
- Energy efficiency and CO2 emission reduction
- Improvement of power reliability and quality
- Emergency supply
- Part of smart grid

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Drivers for micro-grids -2

Need for urbanization

- Electricity consumption will increase dramatically during urbanization, which encourages energy supply innovation and development of micro grids.

- Expansion and development of power networks enables friendly integration of DGs (wind, PV, bio, and etc.).

- Demand side micro-grid is the core for DG absorption locally, and thus increases energy efficiency and power reliability.
By 2015, the total installed PV capacity will reach 35GW
- 10GW increase per year between 2013-2015 (6.5GW by the end of 2012)

Explore domestic distributed PV market, to ease the burden of PV manufacture industry, and encourage lowering PV installation cost. More policies were published recently to
- Encourage development of BIPV and BAPV systems at industrial and commercial enterprises, industrial parks where the electricity price is high.
- Develop 100 demo districts, 1000 demo towns and villages for PV application.
- CSG published “Guidance for further support of PV and other renewable energy application” in 08/2013, and more actions will be taken soon to encourage PV application in its service territories.

Demand side micro grids are expected.
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Key technologies of micro-grids

Expectations on micro grids

- Friendly integration of DGs and energy storage devices.
- High reliability, efficiency, and high power quality
- Seamlessly change between islanding and interconnection, without disturbance on the distribution systems
- Technically and economically feasible to apply micro grids on different CSG distribution systems.
Elements for DG and Micro Grid Integration

DGs
- Fuel Cells
- CHP
- Energy Storage
- PV
- Wind
- Micro Turbines

Interconnection
- PCS
  - Power Conversion
  - Power Quality
- Breaker, PIC
  - Protection
  - Source and load control
  - Auxiliary services
  - Communication
  - Metering

Power systems

Load

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Technologies for Micro Grid Application

Key 1: MG planning and design

Key 2: MG protection, instrument and control

Key 3: MG operation and energy management

Key 4: MG simulation and testing

Key 5: MG devices

(Sorce: Tianjin Univ)
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MG R&D is still at early stage, and expects to speed up along with key R&D and demo projects.
Research on micro-grids at CSG

Policy and Tech Support

Lab and Demos

Stds and Specs

R&D
## Key R&D Projects

<table>
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<tr>
<th>Project</th>
<th>Focus Areas</th>
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<tr>
<td>Modeling and simulation of DG and MG devices</td>
<td>DG/MG/analysis/control/EMS</td>
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<tr>
<td>Development of wind power forecasting system</td>
<td>Renewable energy analysis/ICT</td>
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<tr>
<td>Roadmap of renewable energy R&amp;D at CSG</td>
<td>Renewable energy planning</td>
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<tr>
<td>Impact of wind farm integration on Guizhou power grid</td>
<td>Renewable energy planning/analysis</td>
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<tr>
<td>Micro grid demo project with wind/PV/diesel/fuel cell/energy storage</td>
<td>DG/MG/analysis/PIC/EMS/ICT</td>
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<tr>
<td>Research of micro grid integration and demonstration with CHP</td>
<td>DG/MG/analysis/PIC/EMS/ICT</td>
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<tr>
<td>Power quality analysis of Zhuhai grid with offshore wind farms</td>
<td>DG/MG/analysis/PIC/EMS/ICT</td>
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<tr>
<td>Application of distributed energy resources at CSG</td>
<td>DG/MG/analysis/PIC/EMS/ICT</td>
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<tr>
<td>R&amp;D of micro grid at Dong’Ao Island</td>
<td>DG/MG/analysis/PIC/EMS/ICT</td>
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<tr>
<td>Development of micro grid lab</td>
<td>DG/MG/analysis/PIC/EMS/ICT</td>
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</tbody>
</table>

- **Proposed systematic solutions for an island micro grid, including strategy of micro grid dispatching, steady state and dynamic control, and protection configuration.**
- **Developed MGCC (micro grid central controller) and MG EMS.**
Research on micro-grids at CSG

62-node CSG Distribution System Use Case

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Test technical specification for equipment connecting micro grid with power grid (Drafting)

Functional specification for control systems connecting distributed resources with power grid (Draft)

Technical rule for distributed resources connected to power grid (Draft)

Technical rules for grid-connected wind power forecasting systems (Draft)

Technical rule for photovoltaic power station connected to power grid (Draft)
Demand side micro grid system:
- The vertical axis wind turbine: 2kW (1), 0.5kW (1)
- Mono crystalline silicon PV modules: 2.73 kWp
- Polycrystalline silicon PV modules: 2.4 kWp
- BESS: 10kWp/20kWh
- Super capacitor: 10kW/10s
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Demo projects of micro-grids

1. The micro-grid with distributed energy, Foshan City, Guangdong
2. The micro-grid demo, Yunnan power S&T park, Kunming, Yunnan
3. The micro-grid, Weizhou Island, Guangxi
4. The micro-grid demo at Wanshan islands, Zhuhai, Guangdong
5. Demand side micro-grid demos at five sites, CSG
Demo 1: Foshan, Guangdong

Sponsored by National High Technology Research and Development Programs (863 program)

Location: Foshan City, Guangdong Province

Objectives: To develop a micro grid with CCP, whose maximal power output is 1100 kW.
Demo 1: Objectives

✓ Develop a demo micro grid with CCP distributed energy
✓ Resolve a series of key technical issues in micro grid implementation
✓ Develop modeling and simulation tools for micro-grid analysis
✓ Develop relay protection and control devices suitable for micro grids
✓ Define micro grid related standards
✓ Guarantee the replicability over CSG

✓ 2009-2012
## Demo 1: Results

### Protection and power quality
- New principles of islanding detection based on the high-frequency impedance measurement
- Protection, automation and integration solution for micro grid
- Analysis and improvement of micro-grid related power quality

### Digital simulation
- Steady-state analysis software for distribution system with micro-grids
- Transient and stability simulation system for micro grids
- Physical simulation system for micro grids

### EMS of Micro-grid
- Data acquisition
- Historical data storage
- Optimization and decision-making

### Standards for Micro-grid
- Operation and maintenance procedure for distributed energy supply system
- Technical regulations for micro grid interconnected with power grid
- Acceptance test regulations for micro grid interconnected with power grid
Demo 1: Results
Demo projects of micro-grids

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Demo 2: Kunming, Yunnan

Location: Kunming City, Yunnan Province

- Micro grid demo is located at Yunnan power S&T park.
- Includes: 200kWp PV, 20kW wind turbine, 505kW diesel generator, 248kWh lithium battery, and 100kW super capacitor.
- AC and DC hybrid micro grid
Demo 2: Objectives

- Develop a demo micro grid with multi types of distributed energy resources
- Develop tools for micro grid modeling, analysis, simulation and control
- Study hardware-in-the-loop simulation technology of micro grid
- Dynamic simulation laboratory platform of the distribution system with high penetration of DGs
Demo 2: Results

- 200kW Solar Power
- 248kWh Li-ion Battery
- 100kW Super capacitor
- 20kW Wind Power
- 505kW diesel generator
Demo projects of micro-grids

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Demo 3: Weizhou Island, Guangxi

Location: Weizhou Island, Guangxi

Sponsored by National High Technology Research and Development Programs (863 program)
Demo 3: Objectives

- Develop a islanded micro grid demo with multiple types of distributed energy resources
- Develop the integrated energy utilization mode including wind, solar, natural gas and wave energy
- Satisfy certain demand of cooling, heating and fresh water
- Improve power reliability
Demo 3: Status

Sketch map of the new power system in Weizhou Island

- Micro-grid energy management system
- Photovoltaic generation
- Power storage device
- Gas power generation
- Wave energy generation
- Wind power generation
- Smart power utilization
- CCHP power plant
- Bi-directional communication of the IT line
- Distribution line
- Line of communication
- Small distribution automation system
- Traditional load

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Demo projects of micro-grids

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Guishan Offshore wind farm will be put into service in 2014.
Demo 4: Objectives

- Develop three islanded micro grids. The micro grid at Dong’ao Island will be the largest micro grid of this kind at CSG.
- Improve power reliability
- Develop micro grid related standards
- Guarantee the replicability over CSG
Demo 4: Micro grid at Dong’Ao Island

- **EV charging station (1MVA), which can satisfy 5 medium-size buses and 20 cars**
- **35kV Dong’ao substation 2×8MVA (To be developed)**
- **Distributed resources (Done)**
  - Wind turbine 2.25MW
  - Diesel generator: 1.2MW
  - PV: 1MWp
  - BESS: 2MWh
- **Distribution network (Done)**
  - 10kV distribution transformers 14.52MVA
  - 10kV overhead lines 9.5km
- **MW Level Smart Grid Test Center**
Demo projects of micro-grids

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Demo 5: Demand side micro-grid demos

Site 1: Residential/community
Guangzhou, Subtropic

Site 1: Residential/community
Kunming, Temperate mountain plateau

Site 2: Industrial Parks (2)
Dongguan, Subtropic

Site 3: Commercial building
Shenzhen, Subtropic

Sponsored by National High Technology Research and Development Programs (863 program)
Demo 5: Objectives

- Develop five demand side micro grids, mainly with PV integration.
- Explore business models of demand side MGs to meet needs during urbanization.
- Develop typical design and configurations of demand side MGs.
- Explore domestic PV market
- Develop demand side micro grid related standards
- Guarantee the replicability over CSG
## Demo projects of micro-grids - Summary

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<th>Project 2</th>
<th>Project 3</th>
<th>Project 4</th>
<th>Project 5</th>
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<td>Islanded</td>
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<td>Grid-connected</td>
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<td>BESS</td>
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<td>Multi- ES</td>
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<td>Electric vehicle</td>
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Further Steps

- Suitability
- ROI and cost
- Technology maturity and standards
- Business model and stakeholder interests
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Conclusion

- Distributed generation and micro grids are the core elements of smart grid.

- Integration of distributed energy resources needs flexible micro-grids

- Micro grid techniques are simple and complex.

- CSG will develop micro grids through R&D, standards, pilots and demos, and gradually approach our goals: a smart, efficient, reliable and green grid.
Thank you!

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