## Smart Grid and Power Quality Development in China

The 14<sup>th</sup> Annual PQSynergy International Conference and Exhibition Monday May 19<sup>th</sup>, 2014 Chiang Mai, Thailand

# Power Grids in China

### **Key Statistics**

- Generation capacity: ~1,145GW
- Peak load: ~669GW
- Annual energy consumption: 4,959TWh
- Ultra-High Voltage transmission: ±800kV/±1100kV DC, 1000kV AC
- Distribution max voltage: 110kV
- Two large trans. owers: SGCC and CSG

## Challenges

- Rapid economic growth
- Imbalanced generation/demand distribution
- Pressures over sustainability and environment





# State Grid Corporation of China Profile

#### 国家电网公司 STATE GRID CORPORATION OF CHINA

### Geographic coverage

• 88% of China's territory

### Customers

• Over 1.1 billion(83%) of China's population

## Core business

Power grid construction and operation

## **Overseas business**

- National Grid Corporation of the Philippines
- National Energy Network of Portugal
- SG Brazil Holdings
- South Australia's ElectraNet

## Fortune Global 500

• 7th in 2013







# **Overview of CSG**

### Date of Establishment

• December 29, 2002

#### Services

 Power transmission, distribution, and supply in Guangdong, Guangxi, Yunnan, Guizhou, and Hainan, a total area of 1.02 million square kilometers

## **Population Served**

• A total population of 230 million, accounting for 17.8% of the national population

#### Assets

• As of the end of 2013, 562.9 billion yuan, ranked 134 in Fortune Global 500







## Strong & Smart Grid

- Smart grid is a highly integration of strong network and smart technologies
- large scale access of clean energy such as wind power and solar power, etc.
- Realize two way interaction with users
- Enhance flexibility and security of power grid

## **A New Modernized Power Grid**







## Strong & Smart Grid Initiative



#### UHV AC & DC Transmission Projects:

- Highest operating voltage
- Longest transmission distance
- Largest transmission capacity



UHV AC & DC projects in operation

#### Smart Grid:

- Automated, ICT-based, interactive
- Covering Generation, Transmission, Transformation, Distribution, Consumption and Dispatching



National Wind/Solar/ Energy Storage/ Smart Grid Demonstration Project



## Smart Grid Pilot Projects

- Since 2009, launched 313 pilot projects
- > 269 pilot projests completed so far
- > 32.6 billion Yuan invested totally





Year	2009	2010	2011	2012	2013
Investment (mil. Yuan)	3,900	13,230	8,470	10,330	230



# **Development of Renewable Energy**



#### Wind Power Planning

Year	2015	2020
Large-scale wind power bases	80GW	140GW
Offshore wind power	5GW	30GW
Distributed wind power	5GW	15GW



#### Solar Power Planning

Year	2015	2020
Large-scale PV power	10GW	20GW
Distributed PV power	10GW	27GW
Solar thermal power	1GW	3GW



# Why Ultra-High Voltage Transmission in China?

- The imbalanced allocation of generation resources and consumption centers
- North China & West China: 2/3 coal, wind, solar energy
- Southwest China: 4/5 hydro energy
- East China & Central China:
  2/3 energy demand
- Distance: 1,500-3,000km
- Forming large scale, long distance, large capacity transmission pattern





# **UHV DC Technology**



- Cost efficient and technically mature
- Capable of long distance delivery of renewable energy
- Effective backup for energy security
- Environmentally friendly



# Southern Hami-Zhengzhou UHV DC Project

- World's largest and longest UHV DC project
- The first "Xinjiang power transmission" UHV DC project, transmits thermal power bundled with wind power
- Providing an effective solution for hazy weather in China

#### Main Data

Rated voltage	±800kV
Rated current	5,000A
Rated capacity	8000MW
Transmission distance	2,210km(1,373 miles)
Commercial operation	Jan 27, 2014







# China Transmission Grid Planning 2020





# Vision of Central Asia-Europe Transmission





## **Direct transmission**





## Future Outlook

> With European Supergrid:

Renewable Electricity→UHV Power Grid→European Supergrid→Countries in Europe

With breakthroughs in energy efficiency, new materials and energy storage: Transmit massive renewable power from Central Asia, Middle East, and North Africa to Europe



DESERTEC-EUMENA



European Supergrid



# Microgrid Pilot Project

### **Project Overview**

- Location: Beihai city, Guangxi province
- Supported by National High-Tech R&D Program(863 Program)
- Power supply using microturbines, rate capacity is 8MW
- Peak load in 2009 is 2.1MW, and more than 15MW in 2013

## Main Objectives

- Construct a pilot project of island microgrid with multiple types of distributed energy
- Develop isolated island microgrid demo system
- Develop the integrated energy utilization mode including wind, solar, natural gas and marine energy
- Improve the reliability of power supply of islands







# Microgrid Pilot Project(Cont'd)





# Multi-terminal VSC-HVDC for wind farms integration

## Wind farms in Nan'ao island

- By 2011, total capacity is 143MW
- In 2013, more than 25MW;
- In 2015, offshore 50MW(Tayu)

## Multi-terminal VSC-HDVC

- Three sending converter stations, one receiving inverter station
- Rated DC voltage: ±160kV
- Rated capacity: 200MW
- Distance: 20km
- Commissioning: 2013







# STATCOM for Power System Stability Improvement

- For the Pearl River Delta region, CSG has constructed many HVDC transmission grid. Therefore, dynamic reactive power demand and voltage stability are paramount to ensuring the supply of electrical energy to this region
- The STATCOM can enhance transmission system control, reliability and operation, and improve system power quality.
- Connected to the 35kV bus instead of the 10kV bus to reduce the output current required and the losses
- The construction and operation of the ±200Mvar STATCOM project has resulted in remarkable and comprehensive benefits







## STATCOM operation curve after lightning fault





# EV Charging and Battery-swap Service Networks

- At the end of 2013, SGCC has built 400 charging and battery-swap stations and 19,000 charging spots
- > By 2012, CSG has built 18 charging station and 3,229 charging spots





Intercity interconnection project between Suzhou, Shanghai and Hangzhou



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# Tesla in China

- Delivered the first cars in China at customer events in Beijing and Shanghai last month
- Shanghai government's announcement that Model S drivers in the city will be entitled to free license plates
- > Tesla plans are to install a large supercharger network in China



China Deliveries Event



Supercharger Station



## Tesla's Supercharger Network in China



Open now



Coming soon



# SMEPC PQ Monitoring and Management System

### Shanghai Municipal Electric Power Company(SMEPC) at a glance

- SMEPC is a branch company of SGCC
- SMEPC provides transmission and distribution in Shanghai
- Generation capacity: 12GW
- Number of substations: 941
- Shanghai population: 16 million
- Peak load(2013): 29,400MW
- Customer number: over 8.5 million





# **Overview of PQMS**

- > PQ Monitor installation begun in 2007
- > PQMS extent as of December 2013
  - PQ monitors: 368
  - Other sensors including SCADA and smart meter: 3,770
- Monitored Voltages:
  - 380V to 500kV
- Monitor Locations include the Shanghai Expo park and Disney resort





# **Power Quality Monitoring Report**



#### 上海电网电能质量监测简报

2009.02

#### 上海市电力公司技术与发展中心

#### 上海电网电能质量监测周报

2010-04-30(周五)~2010-05-06(周四)

#### 1 监测点

监测系统包括监测中心、通信网和监测终端,共设入运行 281 个监测终端。 监测终端分布表如下表所示。

公司	超高压	市南	嘉定	青浦	松江	金山	市北	市区	浦东	泰贤	合计
数量	136	14	9	2	10	2	24	26	55	3	281

#### 2稳态电能质量

本周全网稳态电能质量较好,但一些站点某些指标超标。频率偏差无超标站 点,超标情况主要集中在电压偏差、三相电压不平衡度、电压谐波总畸变率、谐 波及长时间闪变,超标站点及情况说明如下表所示:

公司	站点	监测母线	超标指标	本周合格率
	干练站	220kV 侧电压	三相电压不平衡度	25. 32%
	高东站	1 号主变	电压总谐波畸变率	38. 72%
	高东站	1 号主变	7 次谐波电压含有率	33.83%
超高压	瑞全站	1 号主变 110kV 电压	电压总谐波畸变率	88. 32%
	瑞全站	1 号主变 110kV 电压	11 次谐波电压含有率	92.83%
	瑞全站	110kV 一般	电压总谐波畸变率	88.86%
	瑞全站	110kV 一段	11 次谐波电压含有率	93.27%
凝毀	齐贤站	10千伏二段母线	电压总谐波畸变率	94. 38%
A.1.	松隐站	35kV 副母	电压总谐波畸变率	83. 26%
20	松隐站	35kV 副母	5 次谐波电压含有率	79.09%
浦东	浦明卢浦站	太阳能发电接入点	长时间闪变值	93.72%
青浦	崧輝站	10KV - 段母线	长时间闪变值	0.35%



# Expo 2010 Shanghai China

- From May 1 to October 31, Shanghai World Expo was the largest World's Fair site ever at 5.28 square km
- Participant countries: 192 countries
- Participating International Organizations: 50
- > By the end of the expo, over 73 million people had visited







# PQ Monitoring and Analysis at Shanghai Expo Park

- Monitoring Shanghai Expo Park substation using 76 PQ monitors
  - Monitored Voltages: 10kV to 220kV
- Employing visual display monitoring center
- Providing steady-state and transient PQ measurement, statistics and analysis

#### Monitored locations at expo site

Name	EHV	Urban	City East	Total	
Monitors	37	13	28	78	
Substations	7	6	6	19	





## **Power Quality Visualization Analysis Software**









# Specific Problem after Expo Opened

## Harmonic Distortion

- The Ruijin 110kV bus station in May 2010 showed a voltage total harmonic distortion voltage passing rate of 72.11%. The 11th harmonic voltage was 83.76% compliant.
- Voltage Fluctuation Plt
  - The Puminglu 10kV substation in May 2010 showed Plt compliance rate of 66.67%.

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	电压等级: 10kV 基础相电压: 5773.50V 时间选择: 2010-6- 快度方法: 上月 上原间值: 下限阈值: 1、PMS经	Y -9 -2010-6-10 ▼ 	



## The 11<sup>th</sup> Voltage Harmonic at Ruijin Substation

瑞金站1号主变110kV侧(110kV一段)-11次谐波电压含有率变化趋势图

时间范围: 2010-6-25 0:00:00--2010-6-29 0:00:00





# Solar Power Monitoring at 10kV Substation

浦明卢站(10kV一段)-长时间闪变值变化趋势图

#### 时间范围: 2010-5-1 0:00:00--2010-6-1 0:00:00





# Voltage Sag Propagation



Voltage Level	Events	Sag mag
0.4kV	1	85.7%
10kV	45	70.8%~89.4%
35kV	46	65.9%~89.2%
110kV	21	62.7%~87.4%
220kV	39	57.1%~85.8%

Events Time: March 27, 2011 11:49:02

Cause: 960 meters away from the Yanghang substation, Gaohang 5109 transmission line phase A foreign short leading to discharge



## **PQView Users in China**



- Beijing Electric Power Company
- Hebei Electric Power Company
- Henan Electric Power Company
- Shanxi Electric Power Company
- Shandong Electric Power Company
- Shanghai Municipal Electric Power Company
- Fujian Electric Power Co., Ltd.
- Jibei Electric Power Company

### **?** CSG

- China Southern Power Grid
- Guangdong Power Grid
- Guangxi Power Grid
- Yunnan Power Grid
- **?** CLP Power Hong Kong
- Macau Electric Company (CEM)



# The Key Technologies of Smart Substation

- Data collection, transmission, sharing and utilization through high speed communication
- ➢ Equipment life cycle management: condition monitoring→fault diagnosis→condition based maintenance
- Advanced applications:
  Automatic control, smart regulation, co-operation...
- ✗ Smart substation:

Digital substation + Condition monitoring + Advanced applications









# Power Quality Monitoring for Smart Substation



### Hightlights

- ECT/EVT, MU and PQ monitor sampling: 512 samples/cycle
- PQ Monitor modeling based on IEC 61850 standard:
  - Real-time measurements: MMS/Logical Nodes
  - Historical data(Trend) and Event data: IEEE Std 1159.3 PQDIF/IEC 61850 file services





Thank you for your attention!

