Operational Experience and Challenges of UHV Grid in ECG

EAST CHINA DISPATCHING CENTER

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Outline

1. Brief Introduction of ECG
2. Operational Condition of UHV systems in ECG
3. Outlook of Further UHV Construction in ECG
4. Opportunities and Challenges brought by UHV Systems

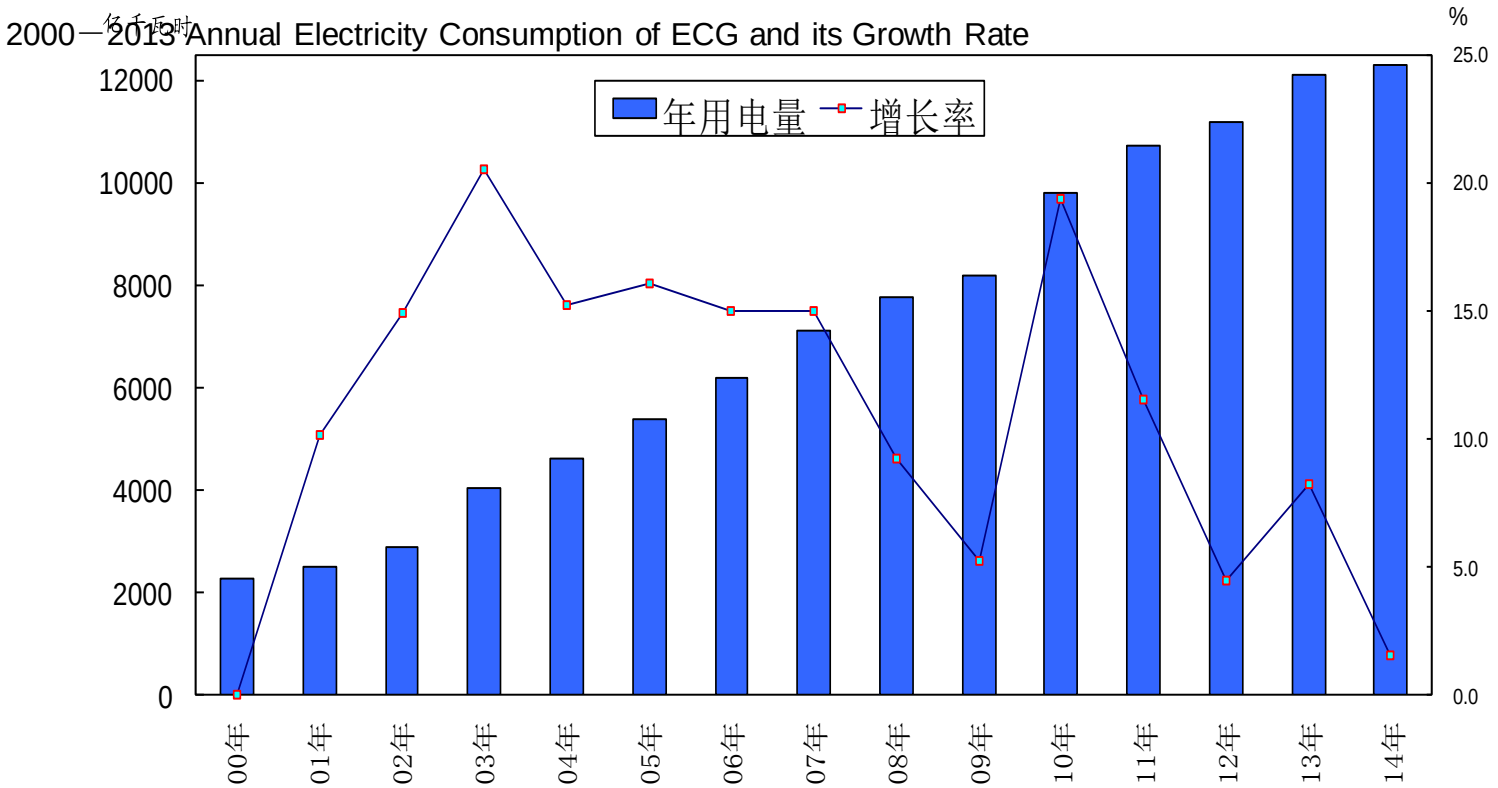
East China Grid

4 Provinces + 1 Municipality

Power Supply Area	**480000 km^2**
Population	**250 million**
GDP	**17380 billion RMB**

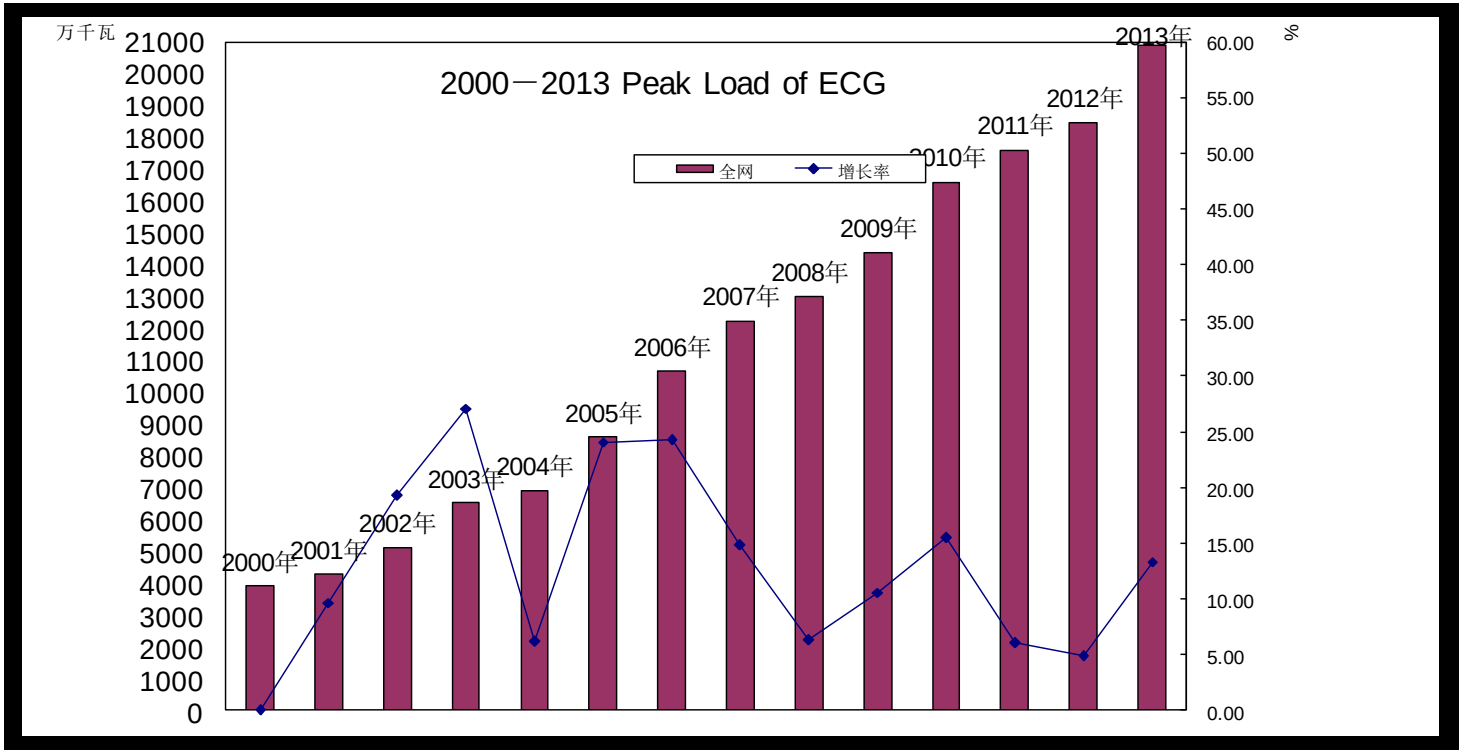
Development of ECG Over the Last Decade

Power Consumption Nearly Tripled



Development of ECG Over the Last Decade

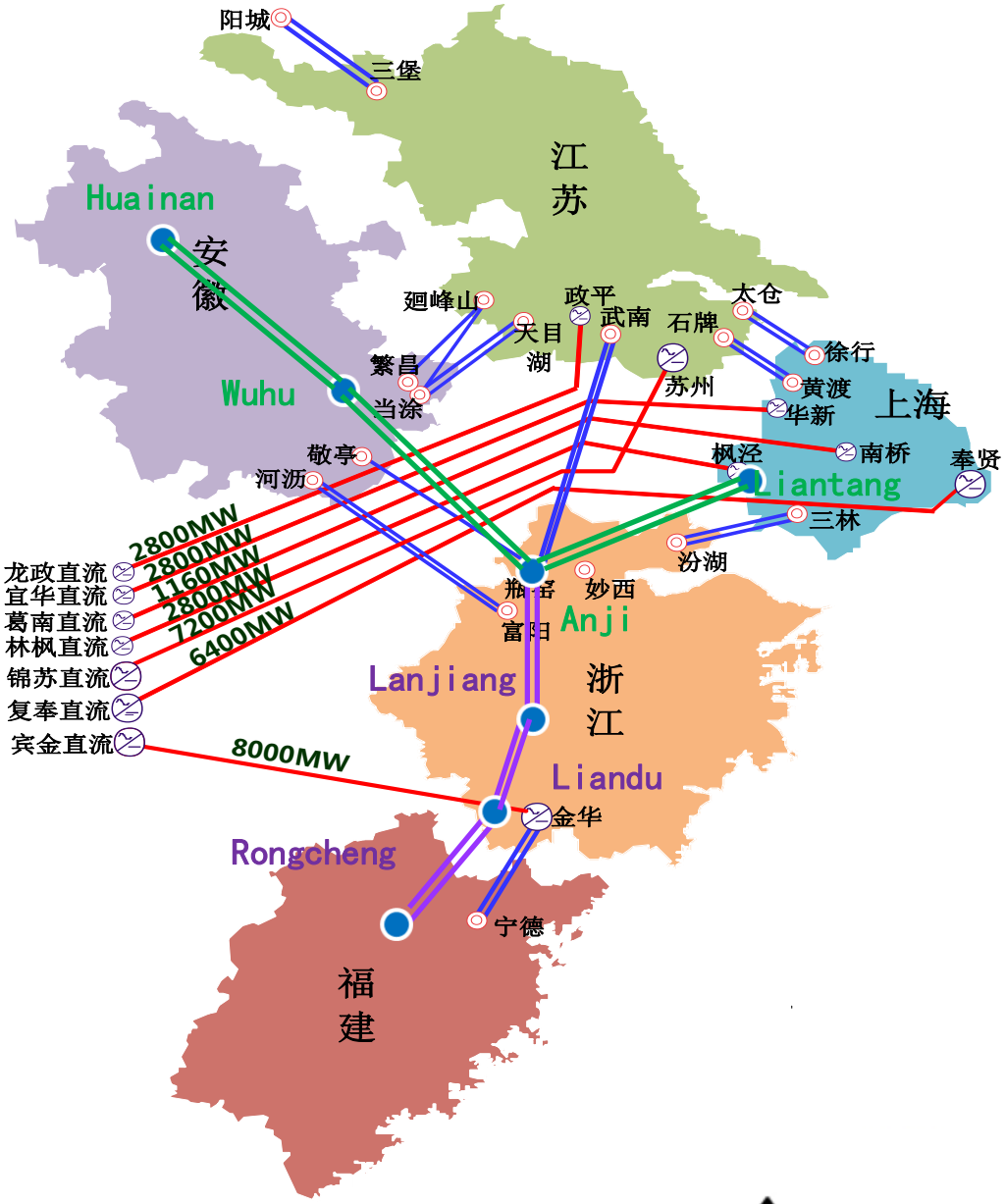
Peak Load and Grid Scale Tripled



Grid Scale of 500kV and above	2000	2005	2010	2014
Substations and Plants	23	70	150	200
Transformers	30	102	216	303
Substation Capacity （10k kVA）	2045	7990	18165	29195
AC Transmission Lines	40	163	351	489
Total Length （km）	3978.6	11691.7	21450	31048.7

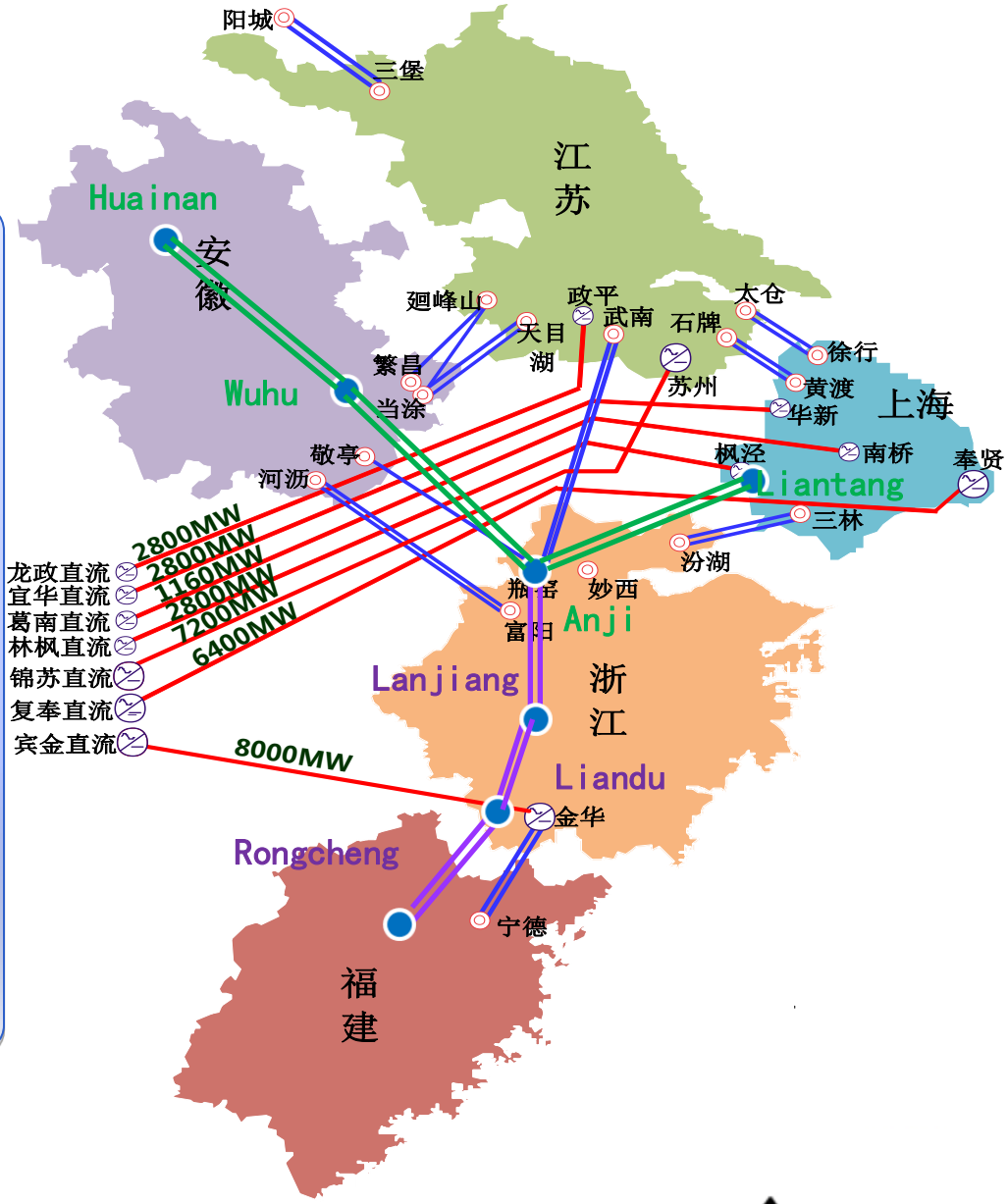
Grid Structure of ECG in 2014

- Receiving end power grid centered around Yangtze River Delta
- Receiving power from 7 DC projects
- Shanghai: enlarged double ring grid
- Jiangsu:3 horizontal + 4 vertical transmission corridors
- Zhejiang: vertical double ring grid
- Anhui: 1 UHV + 3 transmission corridors (west, middle, east)



Characteristics of ECG in 2014

- 2 UHV AC systems, 3 UHV DC systems
- Characteristic of wet and dry period
- Light load at night。
- Load flow distribution shift
- Short-circuit current exceeding problem



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2 **Advantages of UHV Systems in Operation**

3 **Difficulties from Operation of UHV Systems**

4 **Steps We Took to Ensure the Safety of UHV**

Brief Introduction of UHV Systems in Operation

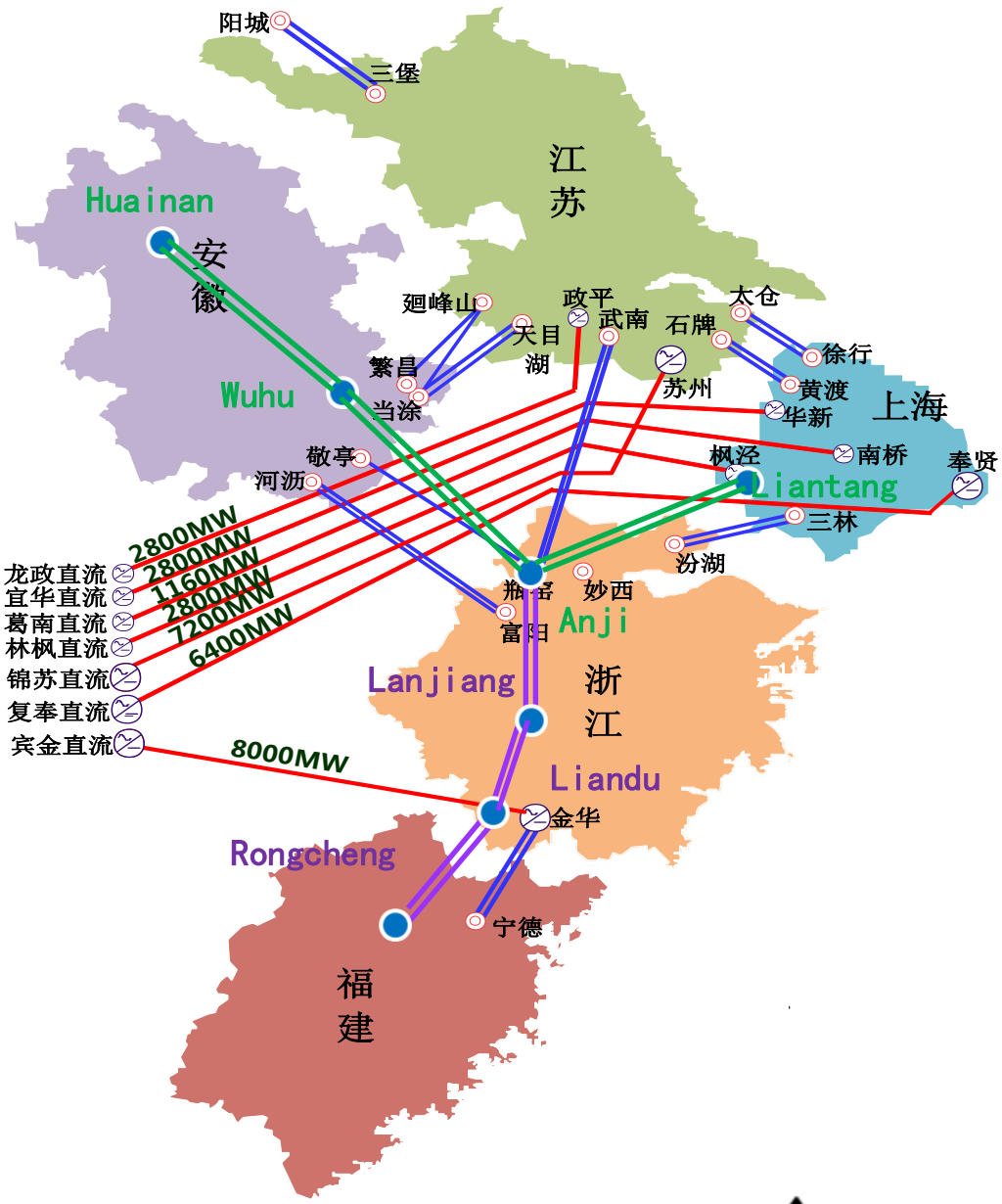
■**UHV AC :**

Huaihu from Anhui to Shanghai (2013.09)

Zhefu from Fujian to Zhejiang (2014.12)

■**UHV DC :**

- **±800kV Fufeng 6.4 GW (2010.07)**
- **±800kV Jinsu 7.2GW (2012.12)**
- **± 800kV Binjin 8 GW (2014.07)**



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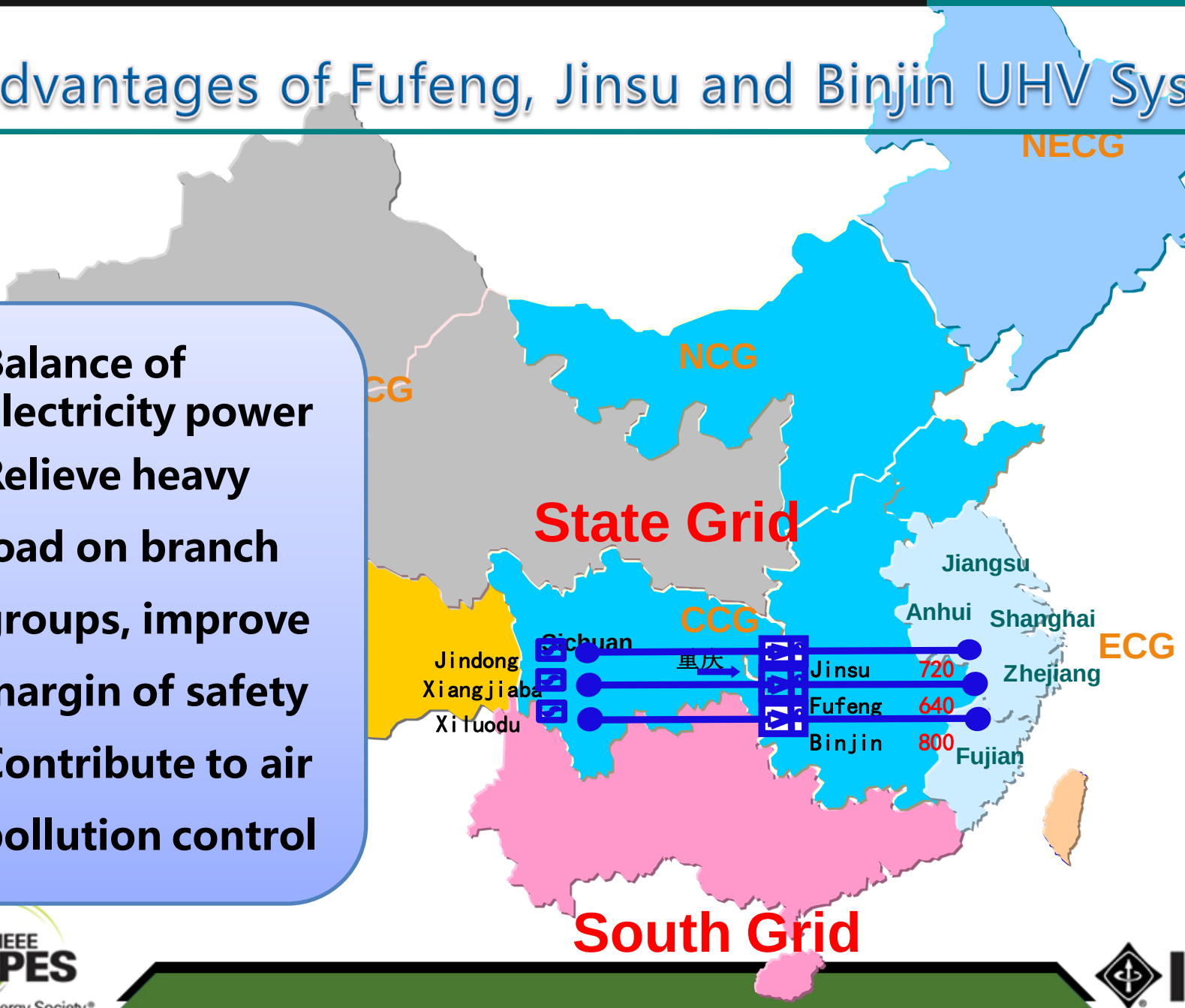
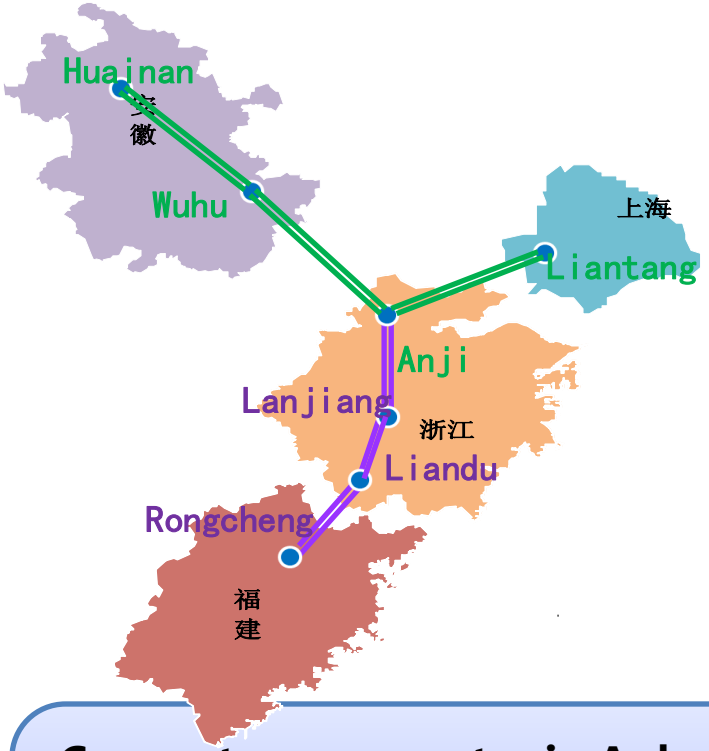
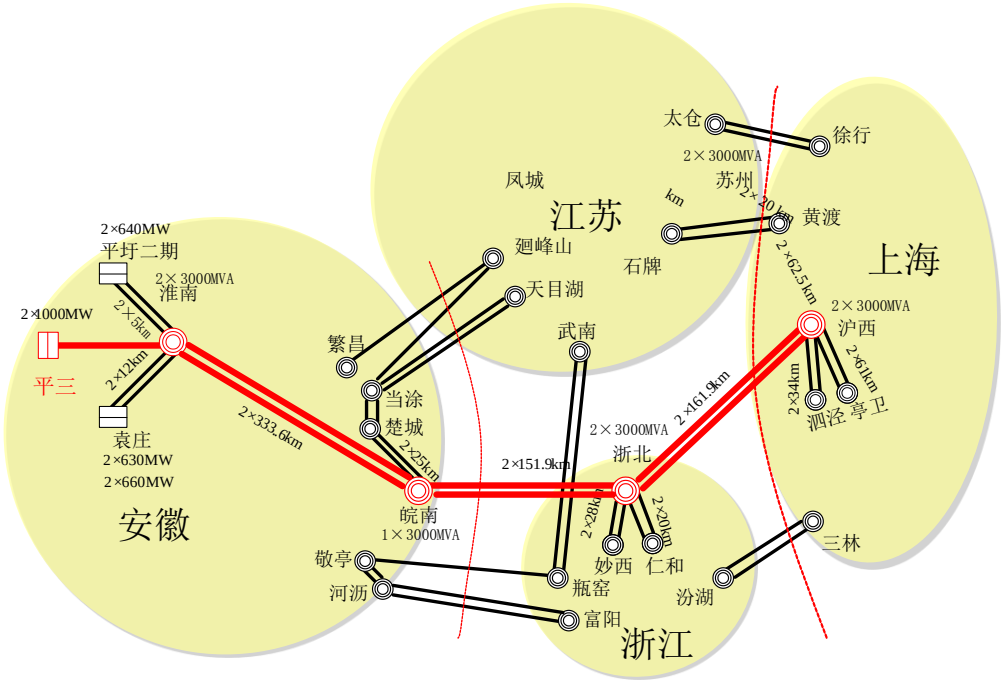
Advantages of Fufeng, Jinsu and Binjin UHV Systems

- Balance of electricity power
- Relieve heavy load on branch groups, improve margin of safety
- Contribute to air pollution control



Advantages of Huaihu UHV AC Project



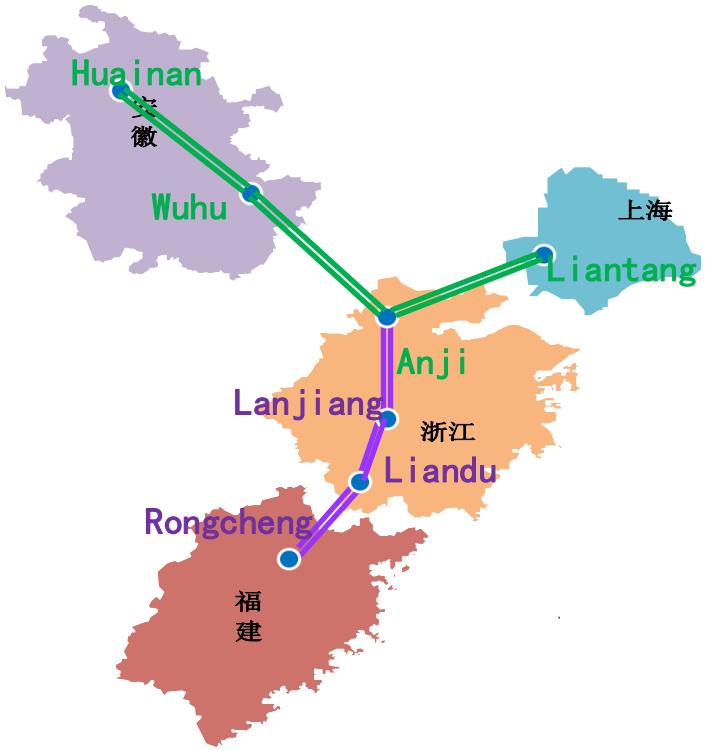


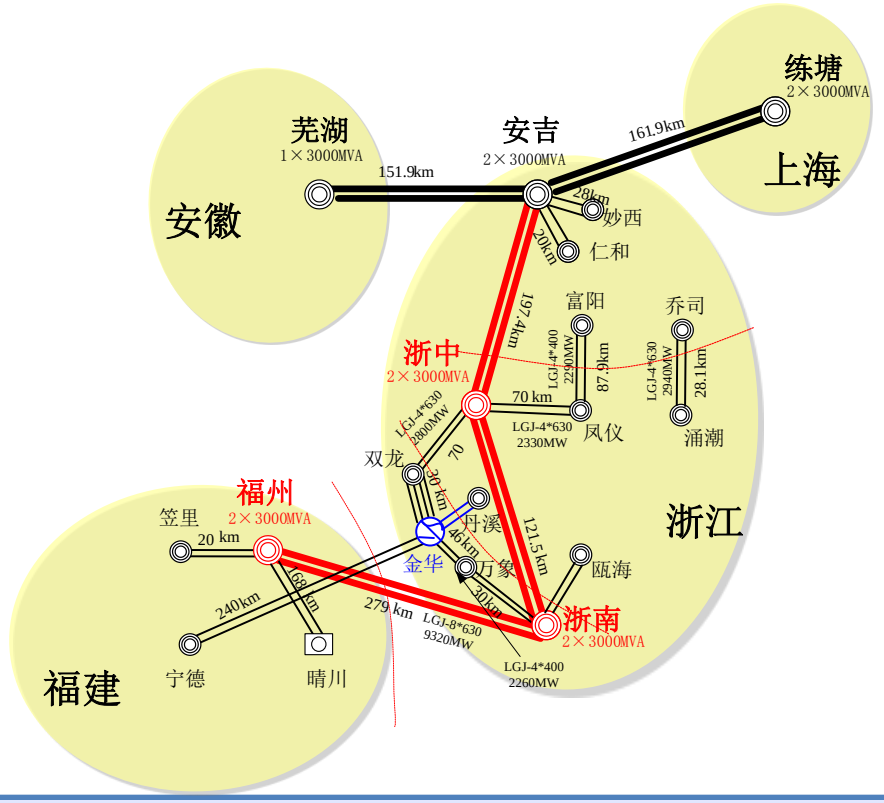
Connect power center in Anhui and load center in Shanghai :

- **Increase sending capability of Anhui, 7.5 GW to 13 GW**
- **Improve receiving ability of Shanghai 6 GW to 8.5 GW**
- **Strengthen ECG's ability against DC bipolar blocking**

Max power 4.08 GW , Accumulated power 26880 GWh

Advantages of Zhefu UHV AC Project





Connects power plants in Fujian province with load centers on ECG

- Relieve Fujian sending branch groups, Zhejiang interchange branch groups, Qiantang river branch groups
- Improve the ability to consume power from Binjin project
- Resist the risk of DC bipolar blocking on Binjin。

Max power 7.16 GW

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Difficulties Encountered and Solved

- **Strong DC, weak AC。**
  - 7 DC systems(3+4), 2 AC systems
  - DC bipolar blocking
- **Received electricity grows, peak regulation becomes harder**
  - Power shortage to power surplus
  - DC electricity does not participate in peak regulation
  - Heavy load on transmission lines near DC converter stations
- **Low level of stability at initial stage, need power system stability control system**
  - Few UHV AC transmission lines now
  - Security and stability control system
  - Disconnect generators during DC blocking

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Steps We Took to Ensure the Safety of UHV

- **Conducting 2 to 3 years rolling analysis**
  - Sort problems existed in current power grid
  - Coordinate power grid planning and dispatch operation
  - Transit from 500kV power grid to UHV power grid
- **Analyze system characteristic, establish all kinds of regulations**
  - Regulation of dispatching operation
  - Voltage control strategy
  - Protection setting scheme
  - Emergency response plans
- **Optimize outage schedule, implement device startup work。**
  - Reduce impact to the minimum
  - Sending dispatchers to work site
- **Optimize resources among grid, establish reserve sharing mechanism**
  - Automatically arrange supporting power during DC blocking

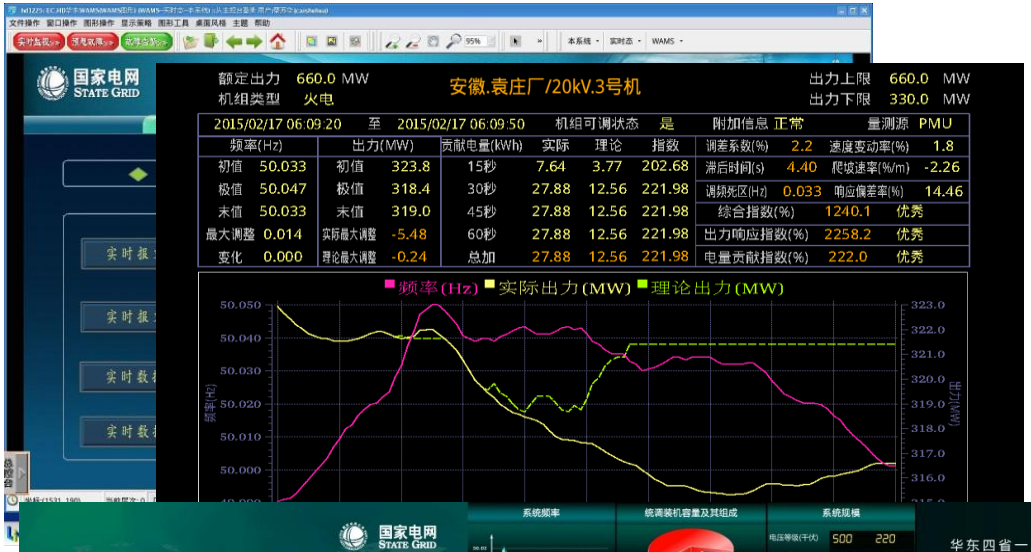
Steps We Took to Ensure the Safety of UHV

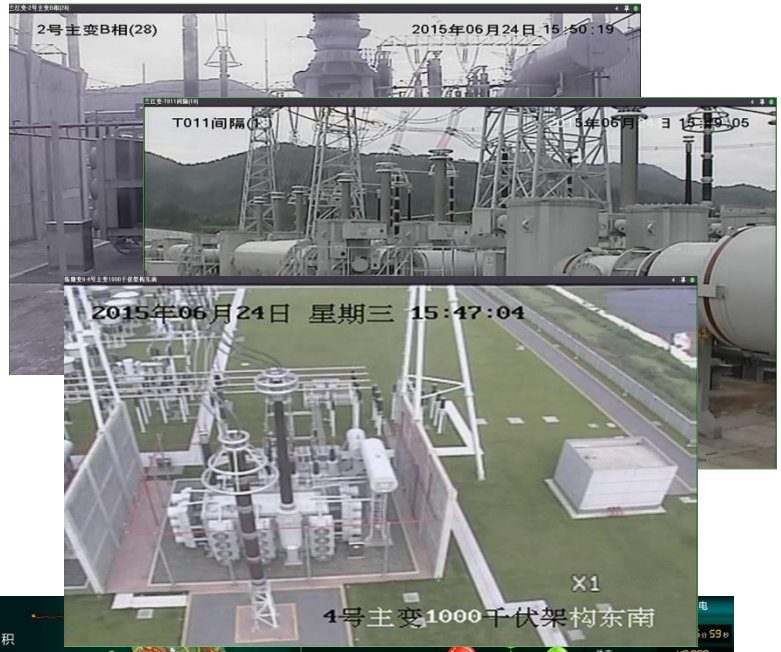
- **Coordinated safety control technology in UHV grid**

- **Integrated intelligent alarm system**
- **Real-time stability calculation and evaluation**
- **Real-time analyze on low frequency oscillation**
- **Multi-level coordinated control system**

Steps We Took to Ensure the Safety of UHV

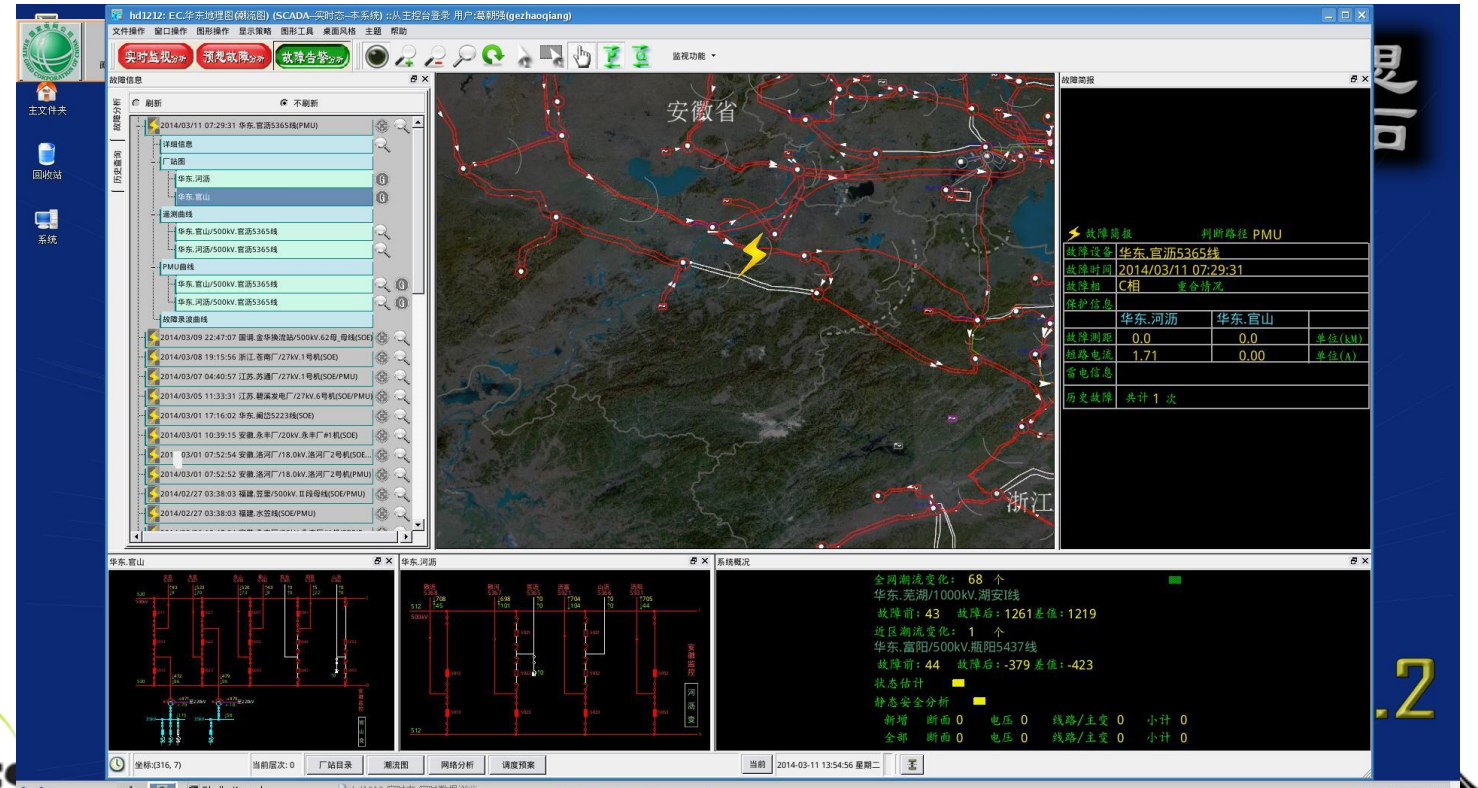
- **Video access of UHV substations**
- **Implementation of PMU device (Installed in 165 sub-stations or plants)**
- **Power grid display and monitor system**





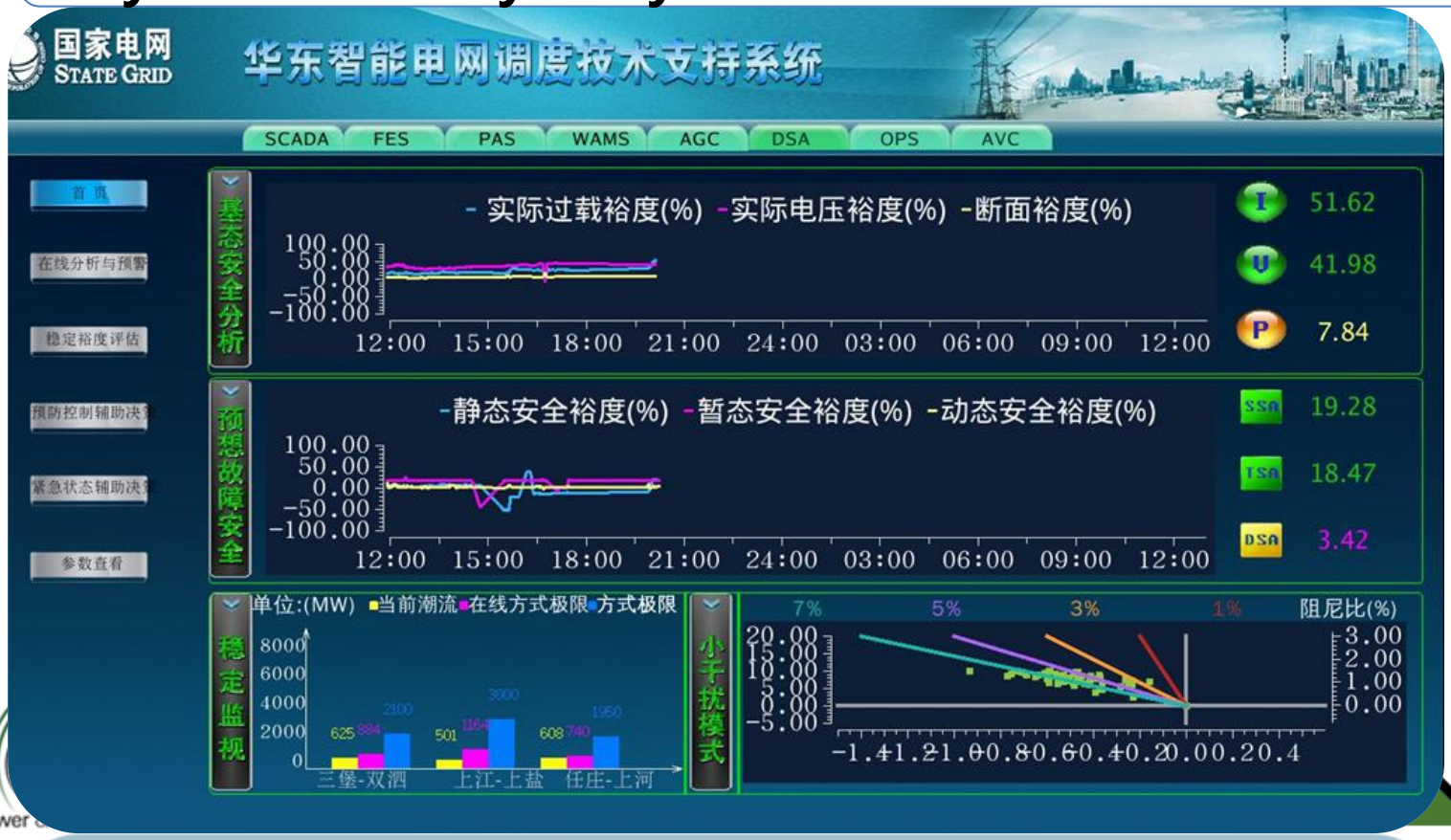
Integrated Intelligent Alarm System

- Identify and classify contingencies
- Provide suggestions of response action
- Shorten perception time (minutes to seconds)



Dynamic Stability Analysis

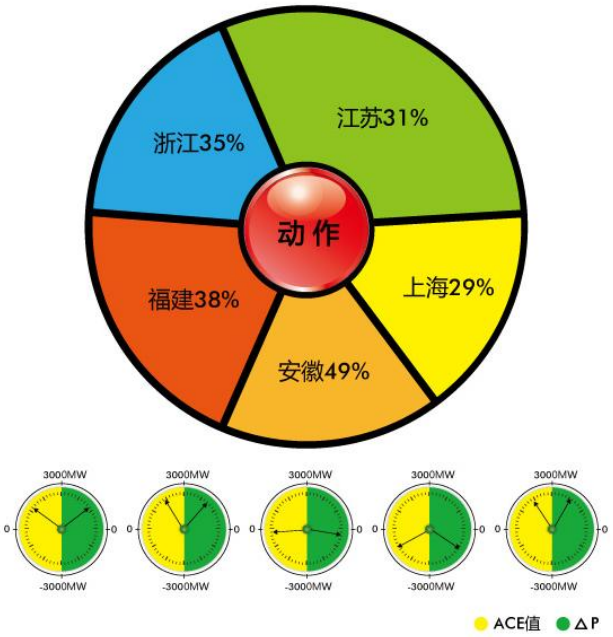
- Steady stability analysis
- Contingency analysis
- Stability limit analysis on branch groups
- Dynamic stability analysis



Dynamic Area Control Error Module

- **Reserve sharing**
- **Frequency recovery**

$$ACE' = \Delta P' + K\Delta f = (\Delta P - \Delta P_s) + K\Delta f$$



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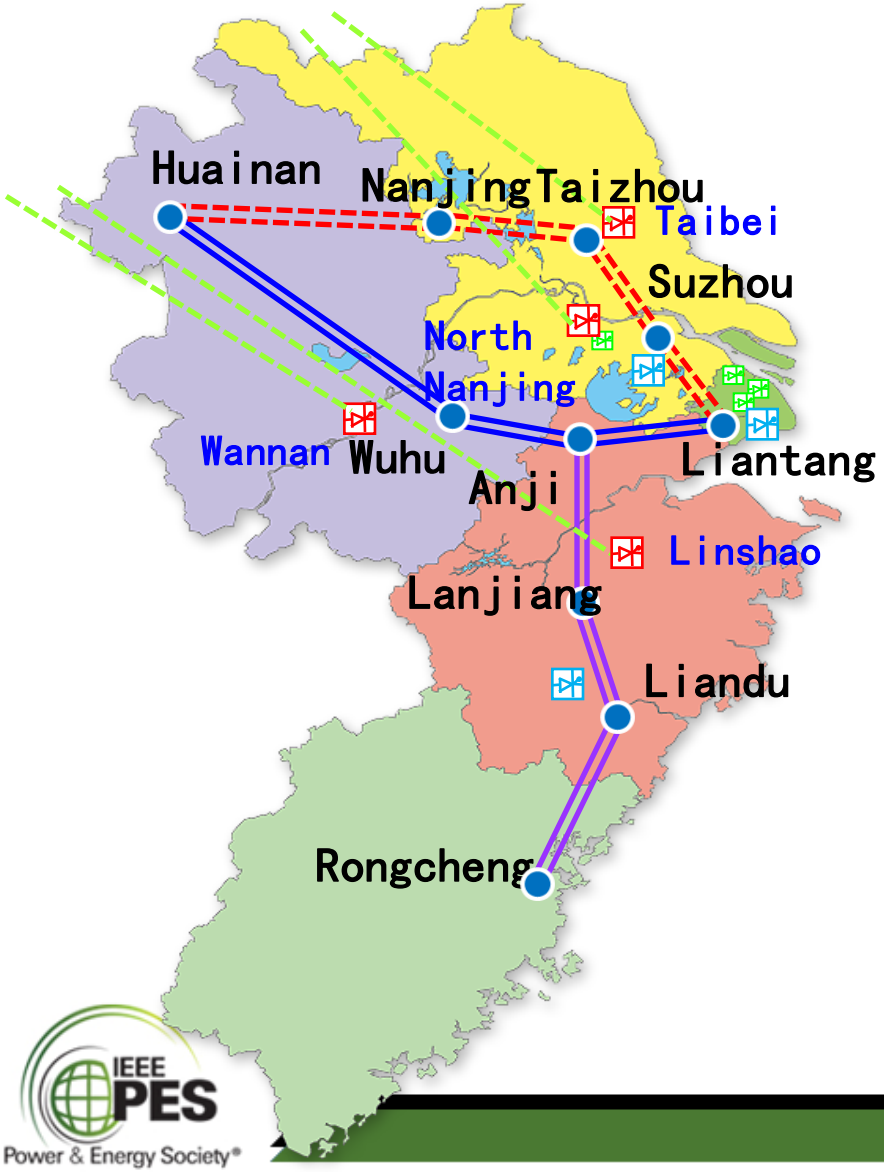
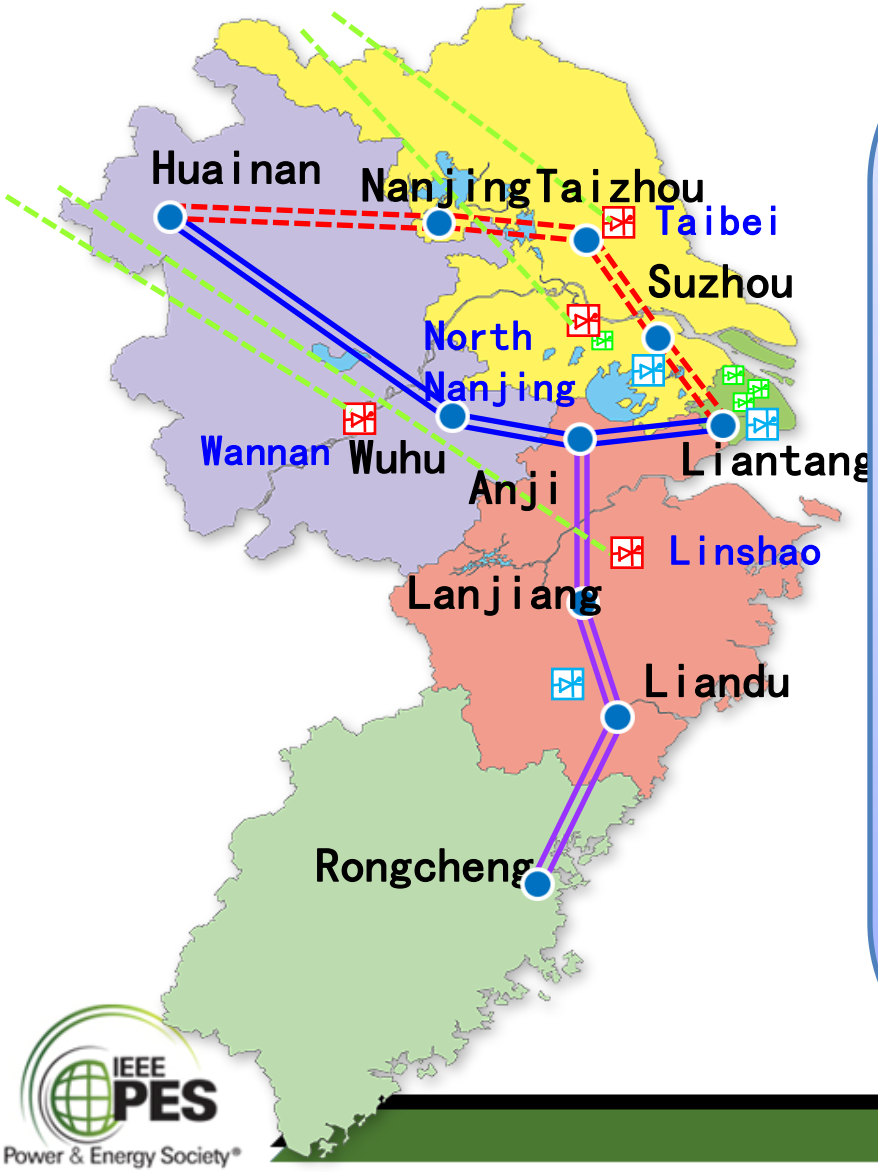
Further construction of UHV systems in ECG



- North Rim UHV AC project (2016)
- ±800kV Ningshao UHV DC project (8 GW, 2016)
- ±800kV Ximen to Taizhou UHV DC project(10 GW, 2017)
- ±800kV Shanxi to Nanjing UHV DC project(8 GW, 2017)
- ±1100kV Zhundong to Wannan UHV DC project (12 GW, 2018)
- By 2018, 3 UHV AC projects, 7 UHV DC projects

Advantages and Challenges



Advantages:

- **Complete UHV ring grid**
  - **External power**
  - **Internal exchange**
- **Margin of power balance**

Challenges:

- **UHV DC with hierarchical access**
  - **Lack of experience**
- **Peak regulation**
  - **DC and AC system interaction**
  - **Power consumption**

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Advantages of DC and UHV AC Projects

Advantages of UHV in nationwide

Reverse allocation of power source and load center

- **Long transmission distance**
- **Large transmission capacity**
- **Low line loss**
- **Less land use**
- **Clean power consumption**
- **Solving short-circuit exceeding problem**

Advantages of UHV AC and DC Projects

Advantages of UHV in ECG

1、 Fundamentally alleviate the tension of power shortage

Power shortage to power surplus

By 2018, incoming power 69.7 GW

2、 Substantially improve ECG's ability of optimal resource allocation

Preliminary network of UHV power grid is formed

Closer connection between provincial grids

Shorter electrical distance

3、 Beneficial to clean power consumption and air pollution control

Most power sources of the follow-up UHV systems are hydropower and wind power

Challenges of UHV AC and DC Projects

1、Stability level of UHV power grid needs to be improved

Few UHV transmission lines, rely on security and stability control systems 。

2、Interaction between AC and DC systems

Fast construction of DC projects

3、Impact of single contingency increases

Large transmission capacity of UHV DC projects

4、Peak regulation

Clean power grow

Peak power insufficient

Single province to whole region

5、Power grids of different level

500kV grid slows down

Safety of power flow near DC converter substation

Coordinated development between power grids of different level

Wuhu UHV sub-Station

Thank you

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