Application of Wide Area Monitoring and Control in CSG

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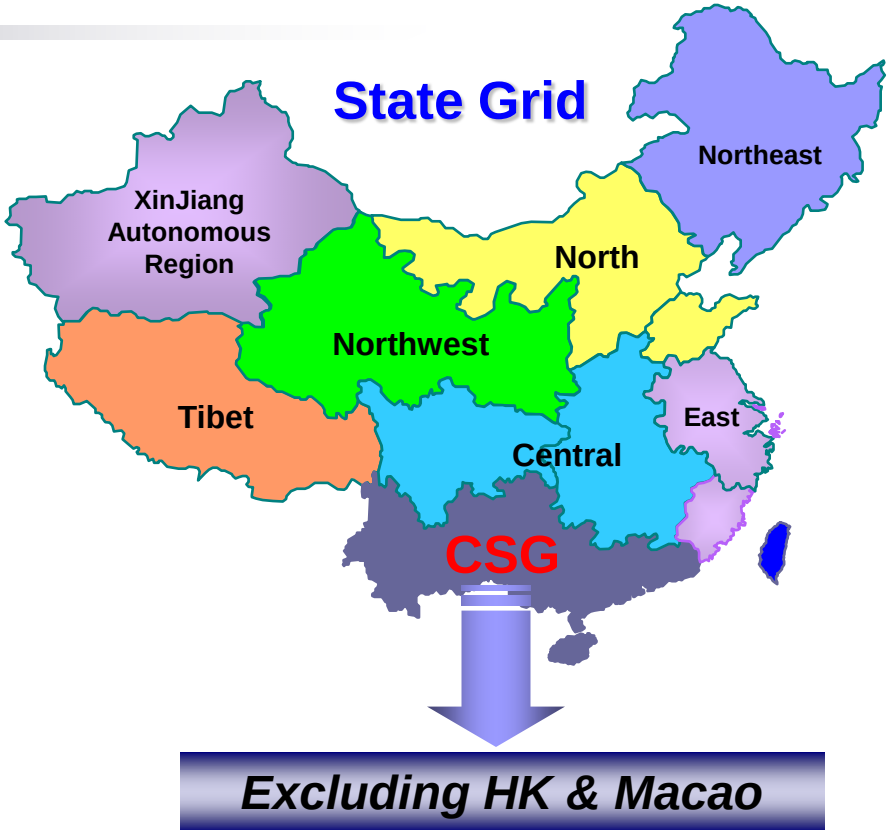
Outline

- Overview of China Southern Grid (CSG)
- Application of PMU in CSG
- Challenges of PMU application in CSG
- Conclusions

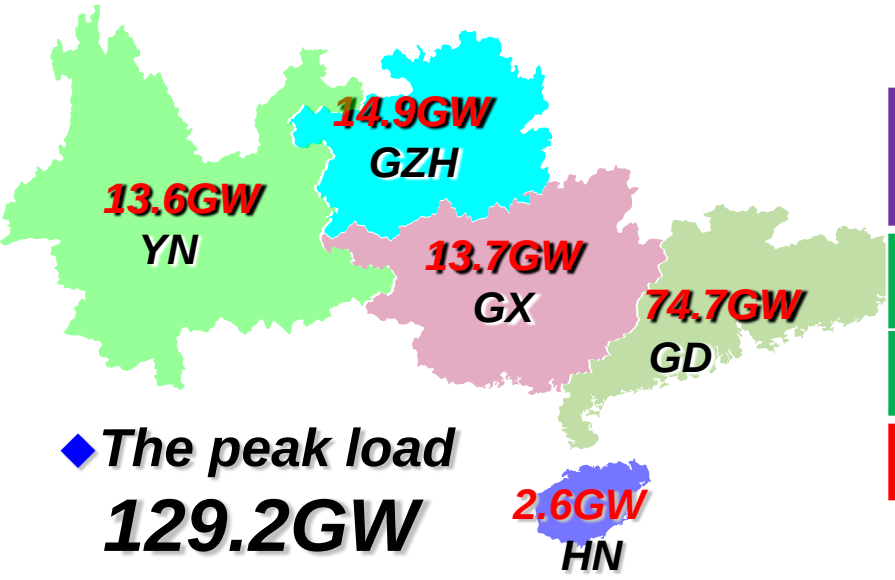
Overview of CSG

中国南方电网 CHINA SOUTHERN POWER GRID

- Established on Dec 29th, 2002
- **Main Business**: Power transmission, distribution and supply in Southern China including Guangdong, Guangxi, Yunnan, Guizhou and Hainan, covering 1 million km^2.
- **Serving Population**： 230 million, about 17.8% of the national population
- **Revenue**: 379.4 billion RMB in 2011, ranked 149th in Fortune Global 500



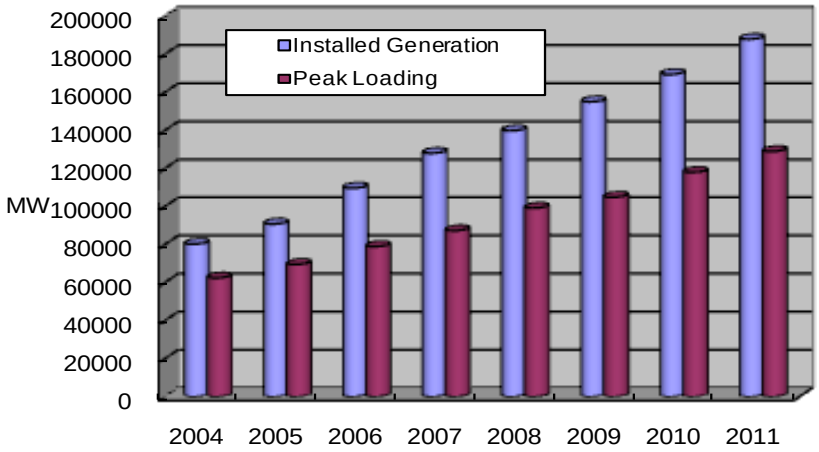
Overview of CSG

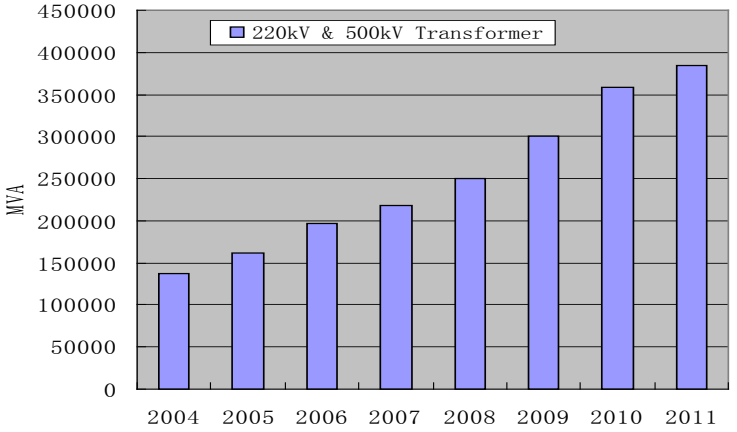


- **The peak load**

129.2GW

	Transmission line (km)	Transformer capacity (GVA)
220kV	56,401	234.98
500kV	30,629	148.25
Total	87,030	383.23





Overview of CSG

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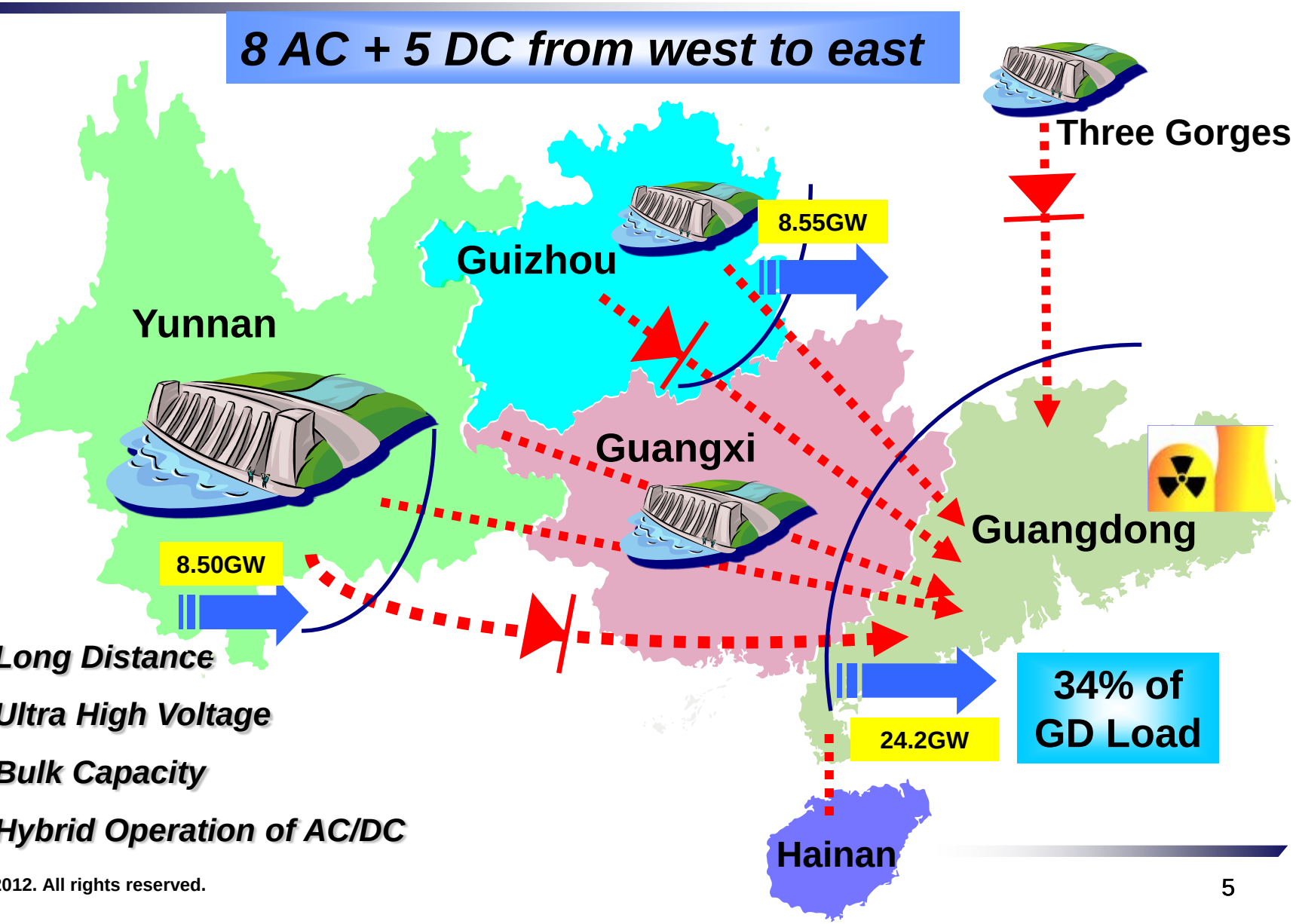

- *Long Distance*
- *Ultra High Voltage*
- *Bulk Capacity*
- *Hybrid Operation of AC/DC*

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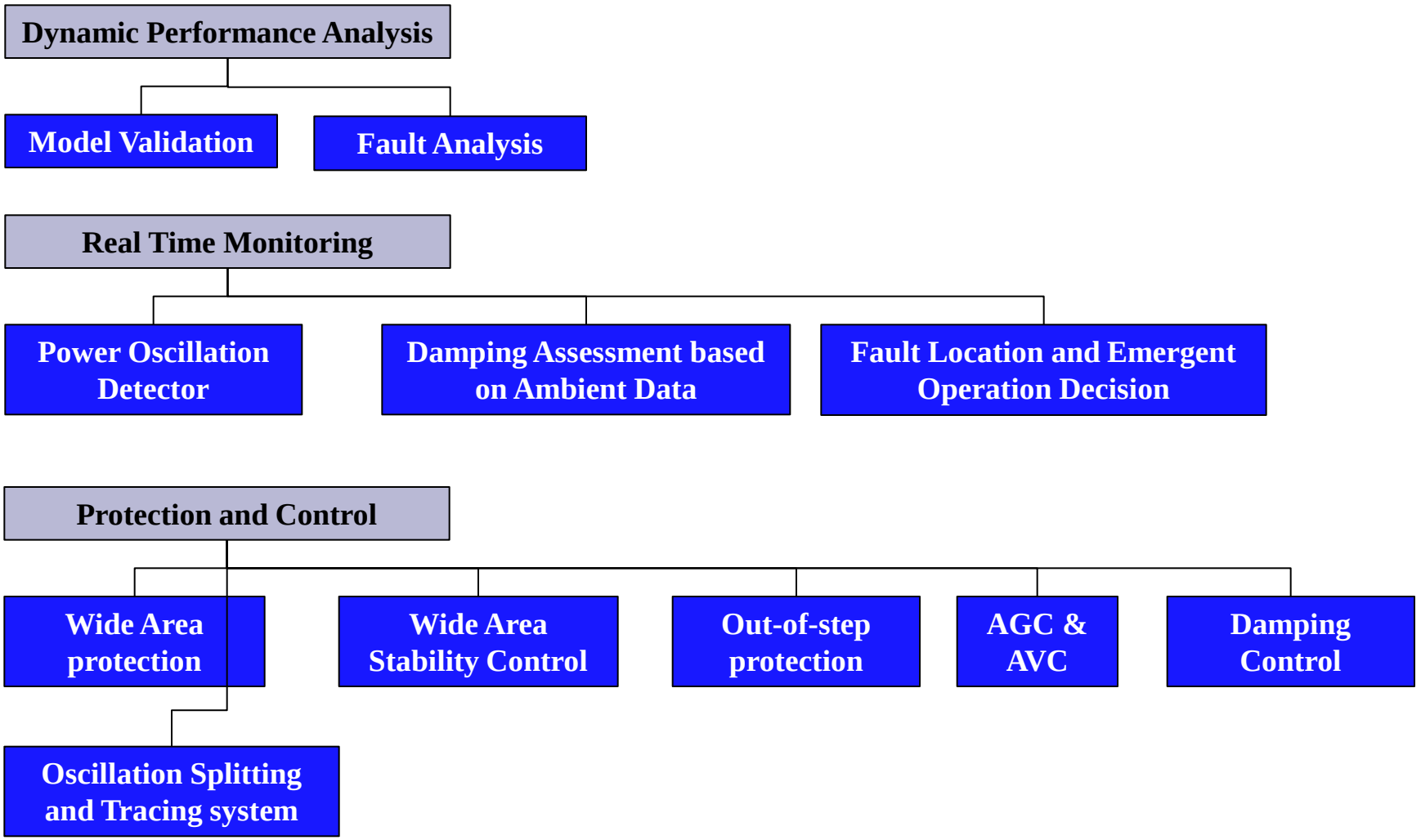
PMU in CSG

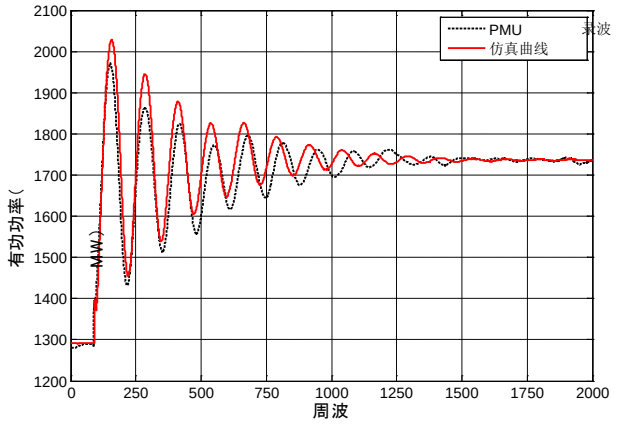
- **>340 stations and plants installed PMU.**
  - All 500 kV stations and plants
  - Part of 220kV stations and plants
- **All signals from PMUs are sent to EMS in control center with the frequency of 100Hz.**

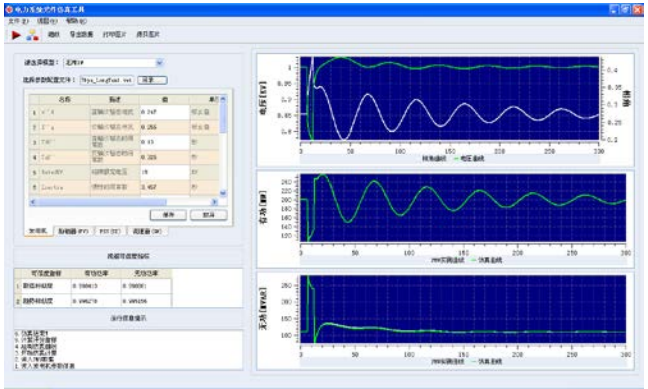
PMU Applications in CSG



Model Validation based on PMU

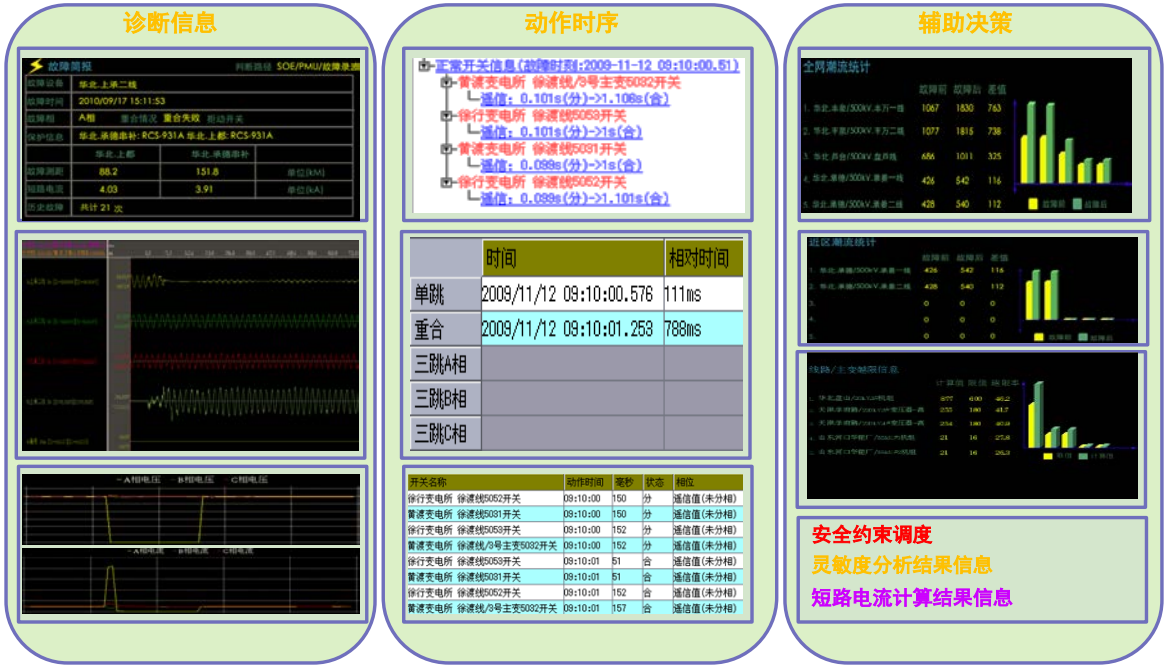
- PMU record is used to be compared with simulation results after each fault manually, to validate the model.
- CSG developed a system to validate model of each generator automatically, through record of PMU and hybrid simulation, and the system commission in 2011.





Fault Location and Emergency Operation Decision based on PMU

- There are so many information from protection and control system during fault, and how can operator locate the fault ASAP?
- CSG launch the project to locate the fault automatically with the help of PMU and other fault record systems.

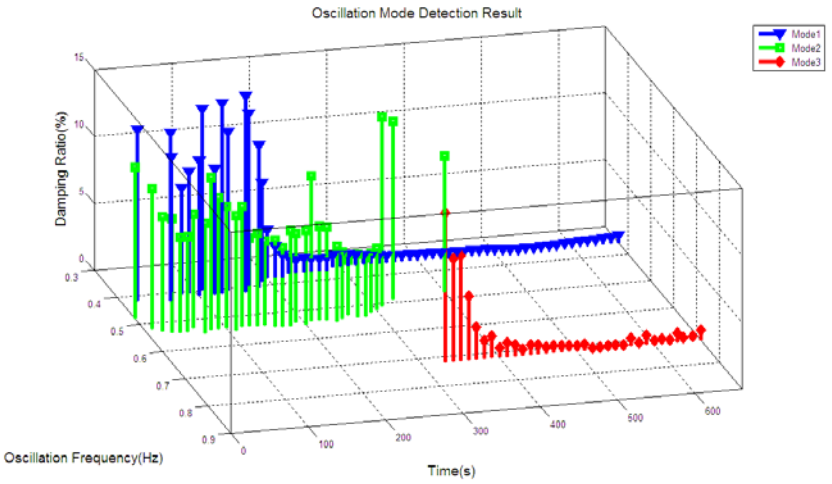


Oscillation Detector based on PMU

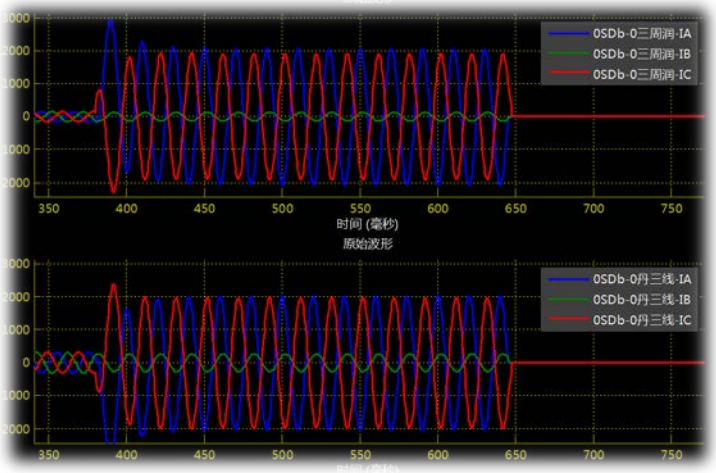
- Power oscillation detector is one of the most successful application of PMU in CSG.
- In the past five years, oscillation detector captured more than twenty oscillation events and promote the application of PSS and other damping tech.

Damping Assessment based on PMU

- Traditionally PMU data only be used after the fault.
- How to take the pulse of power system 24*365?– to explore the ambient data of PMU!
- Ambient data analysis is used to estimate the inherent oscillatory modes of the power system when the main source of excitation of the system modes are random load variations resulting in a low amplitude stochastic time series (ambient data).
- CSG developed the damping assessment tech. based on ambient data from PMU, and the system commissioned in 2011.



Wide area protection based on PMU



The concept of Wide Area Protection was first proposed in 1997 by IEEE journal paper named ‘Wide Areas Protection Against Voltage Collapse’

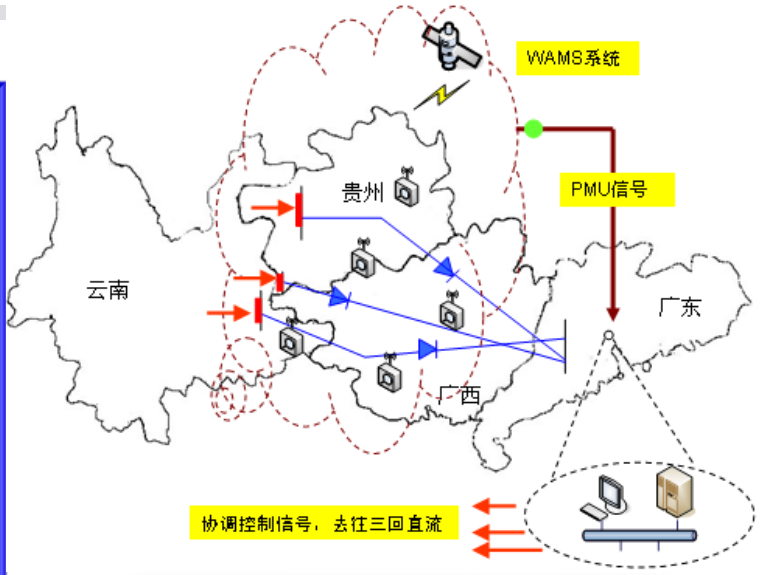
CSG developed wide area protection since 2008. The first wide area differential protection commissioned as backup protection in 110kV system.

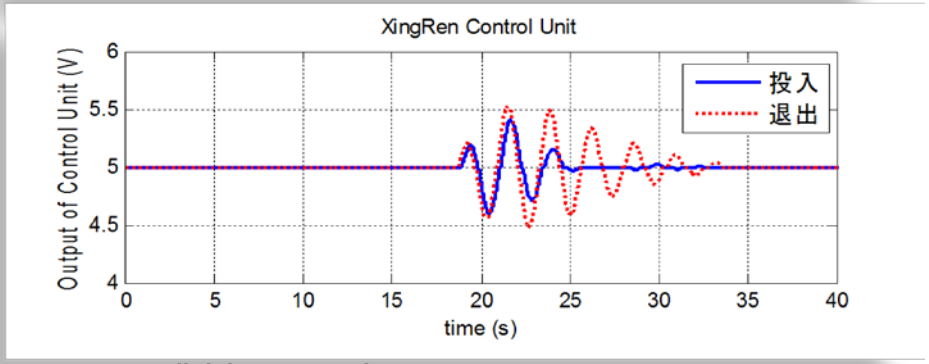
From CSG’s point of view, wide area protection can only play a role of complementary of traditional protection.

For line ground fault and circuit breaker failure case, by conventional Zone 2 relays, the delay for fault clearance is usually 0.5～1.0s.For above same fault, WAP quickly detects the breaker failure, and after 0.2s confirmation delay, trips neighbor breakers.

Wide area damping control based on PMU

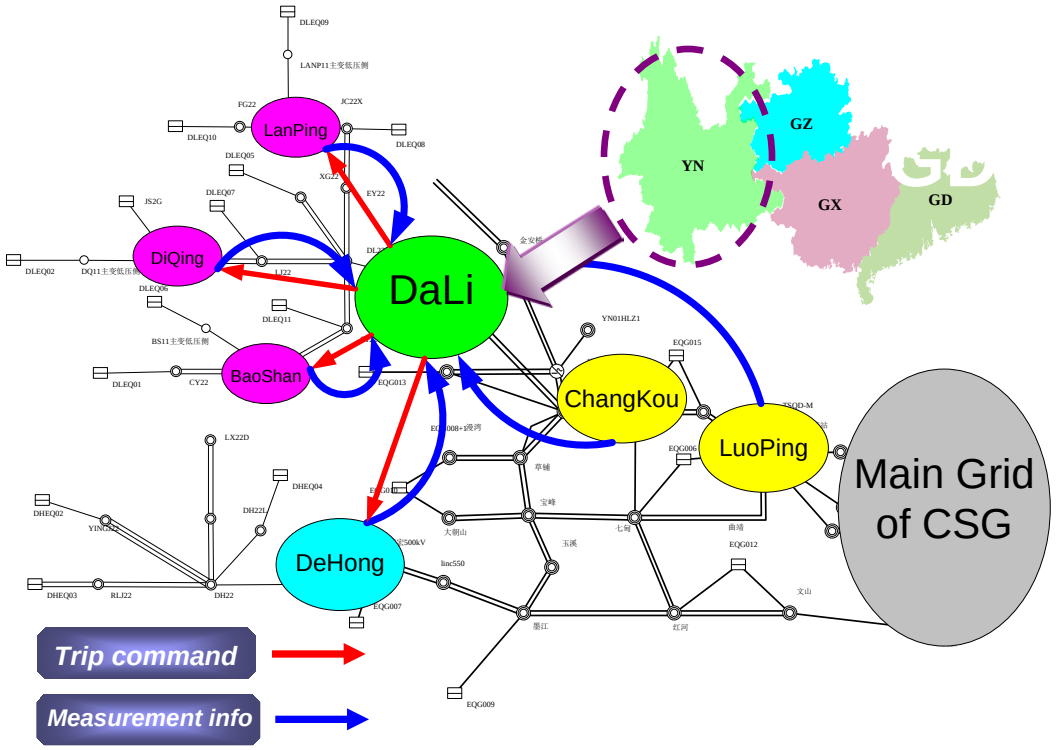
- CSG commissioned the first wide area damping control system in the world in 2008.
- The system collects global dynamic from seven PMU and send commands to three HVDC links.
- Increase damping ratio 8%-15% and transmission capability accordingly.





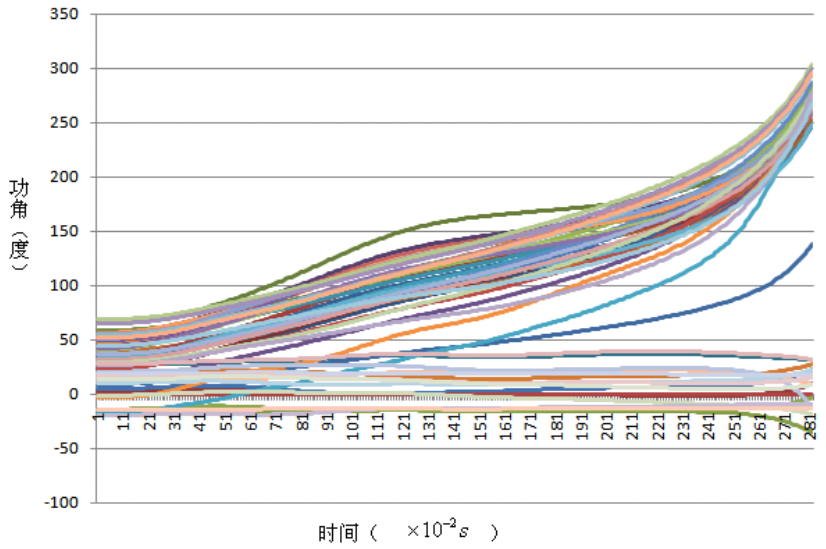
Oscillation Splitting and Tracing system based on PMU

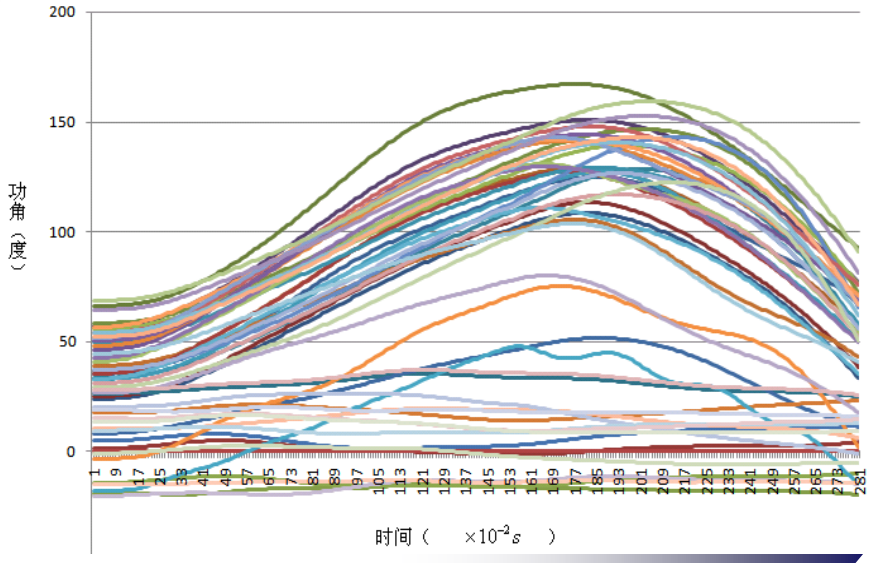
- Small hydro generator in Yunnan may be a troublemaker in oscillation, since they far away from plant and tend to lose stability.
- Locating and splitting small hydro generators that are source of oscillation was tough task for operator.
- CSG developed Oscillation Splitting and Tracing system, to detect oscillation and locate oscillation source automatically, which commissioned in 2010.



Transient stability control based on PMU

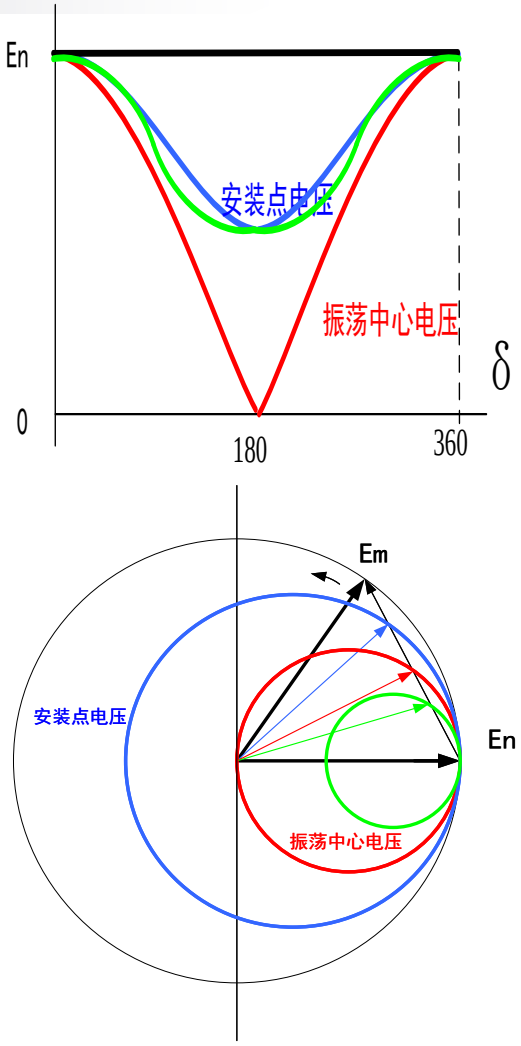
- Transient stability control based on PMU is a complementary to current SPS.
- It monitor the trajectory during transient and forecast the system is stable or not, to trig corresponding remedial action.
- The project is under preliminary study.





System splitting based on PMU

- System splitting based on local information (ucosφ) traditionally.
- Information from multiple PMUs bring more flexibility and robust into splitting decision.
- CSG study novel splitting system based on PMU.



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Challenges

- **Management challenges in PMU application**
- **Technique challenges in PMU application**

Stability control in China is different from other countries

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Our defense scheme – the three defense line – is unique in the world

In China, power system stability control depends a lot on Special protection system (SPS), which is an independent system and different from other countries

Besides PMU, many systems have their own timestamp

In China, the three defense line could be taken as a more general wide area control.

In China, power system is protected by *Three Defense Lines*

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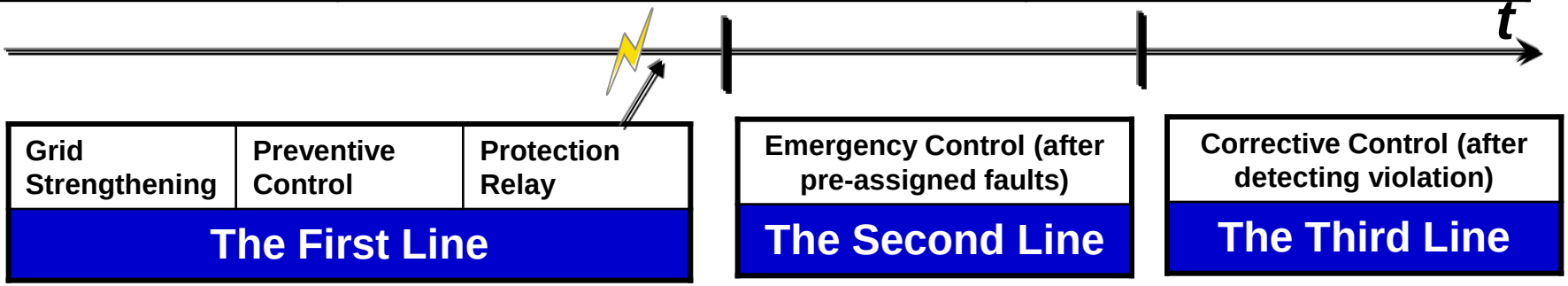
	Object	Measure
The first line	Assure load uninterrupted after a single and non-severe disturbance	◆Reasonable grid structure ◆Operation plan ◆AVC/AGC ◆Relay
The second line	Keep system stability and integrity after a severe disturbance	◆SPS/SPIS ◆WACS ◆DAS
The third line	Prevent large-scale blackout after an extremely severe disturbance	◆Out-of-step relay ◆UFLS ◆UVLS ◆OFGS



A tentative new defense line

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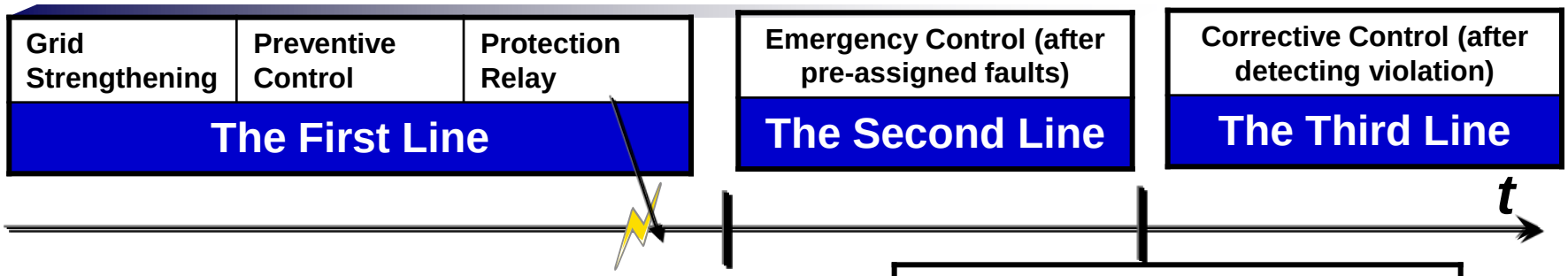

Prediction and Emergent Control for Cascading failure (Judgment based on PMU)

The 2.5 Line

1. Trajectory prediction based on measurements
2. Instability detection and judgment based on predicted curve
3. Emergent control (Remains a challenge)

Just based on measurements

Timestamp is needed

1. Triggered by measurements
2. Model identification (challenge)
3. Faster-than-real-time simulation
4. Instability detection based on simulation results
5. More accurate control based on simulation results

Based on simulation

Conclusions

- We need to take full advantage of PMU and convince people to install more
- Theoretical analysis is needed to achieve this goal.
- All parties are welcome to participate in solving the issue and improving PMU application

Thanks!

万家灯火
南网情深
A Myriad of Twinkling Lights
Great Rapport of CSG