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Support Grid Integration of Offshore Wind Power

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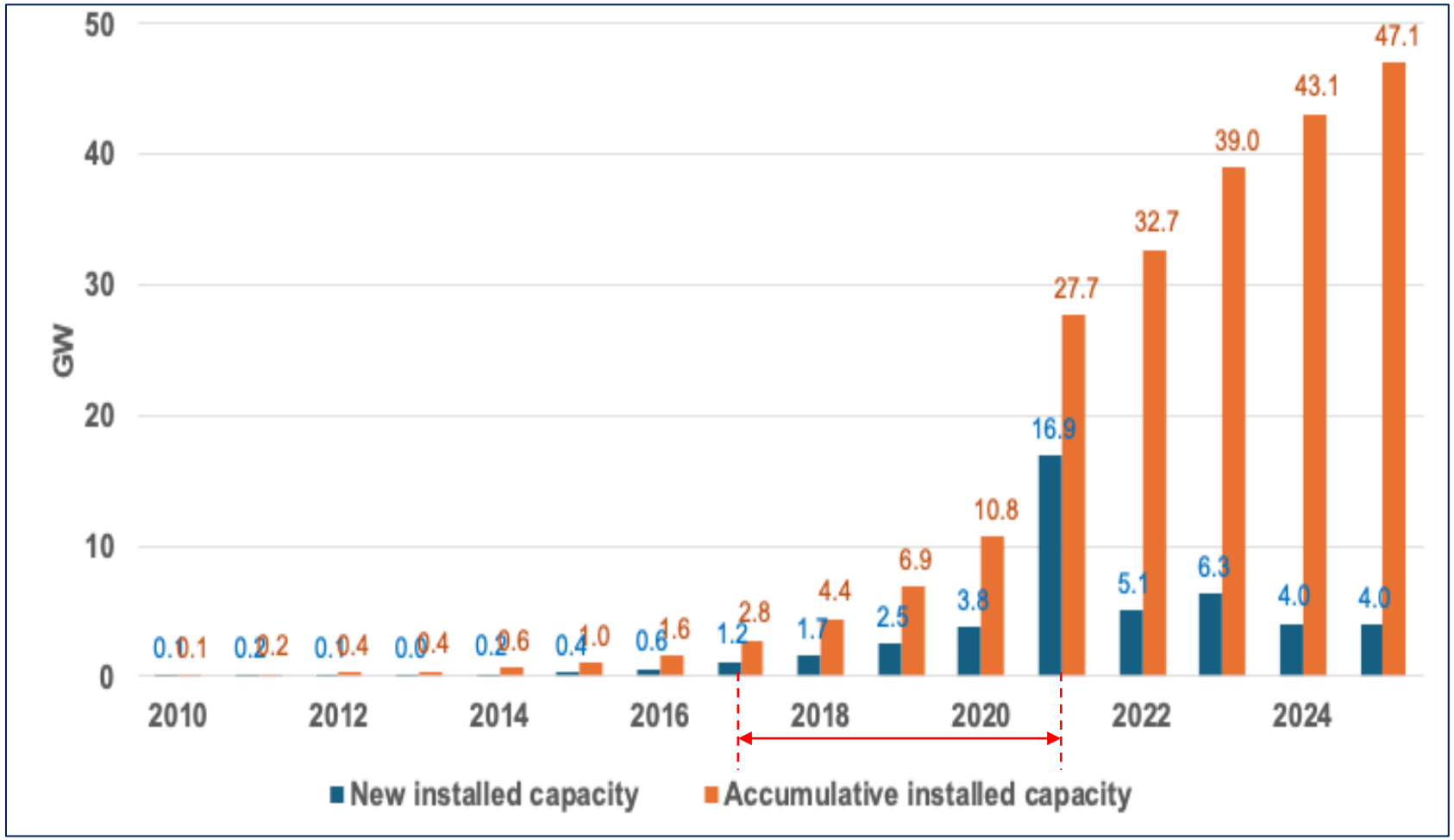
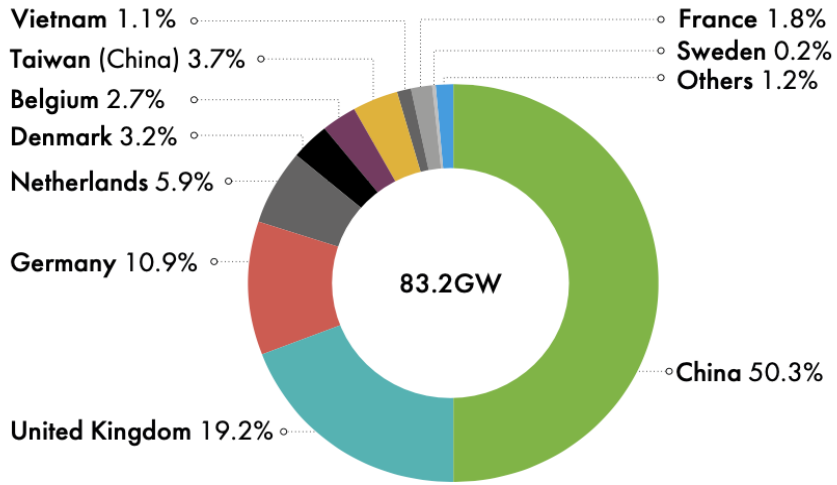
Development of Offshore Wind





Source: GWEC

China's offshore wind power technological potential is about **2.3 TW** within 200km. (NCC)

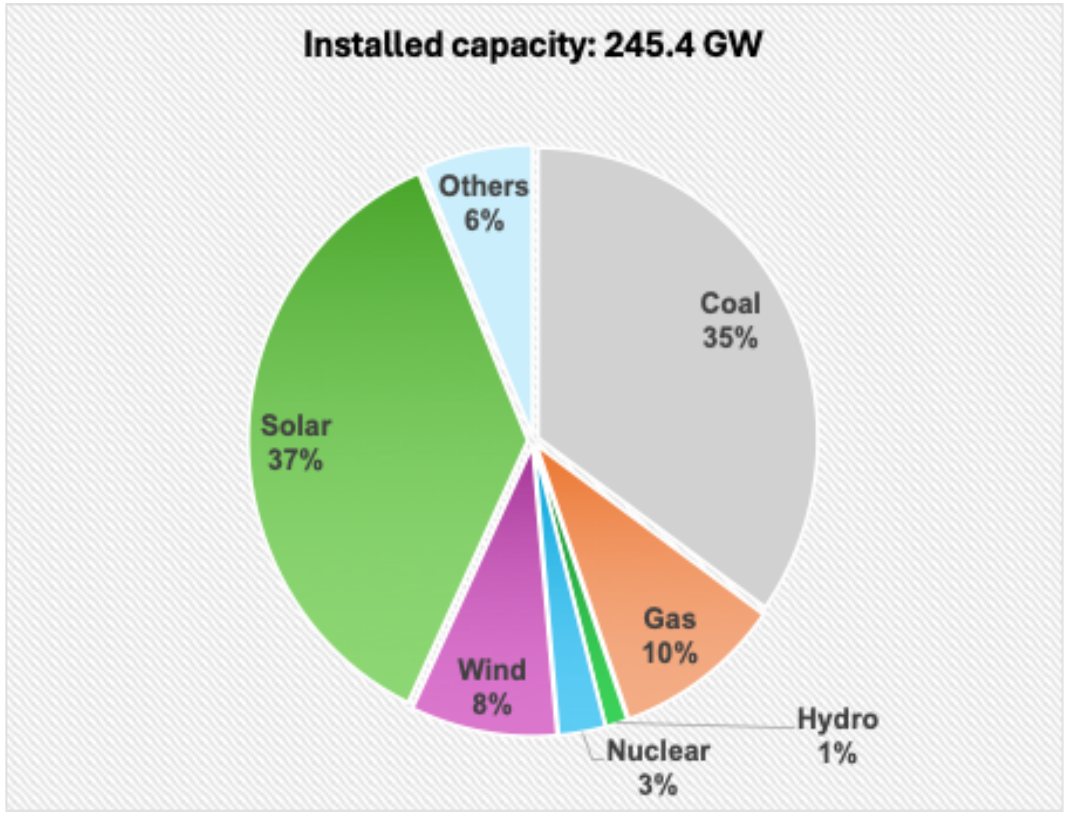
Development Plan: Completion and Outlook

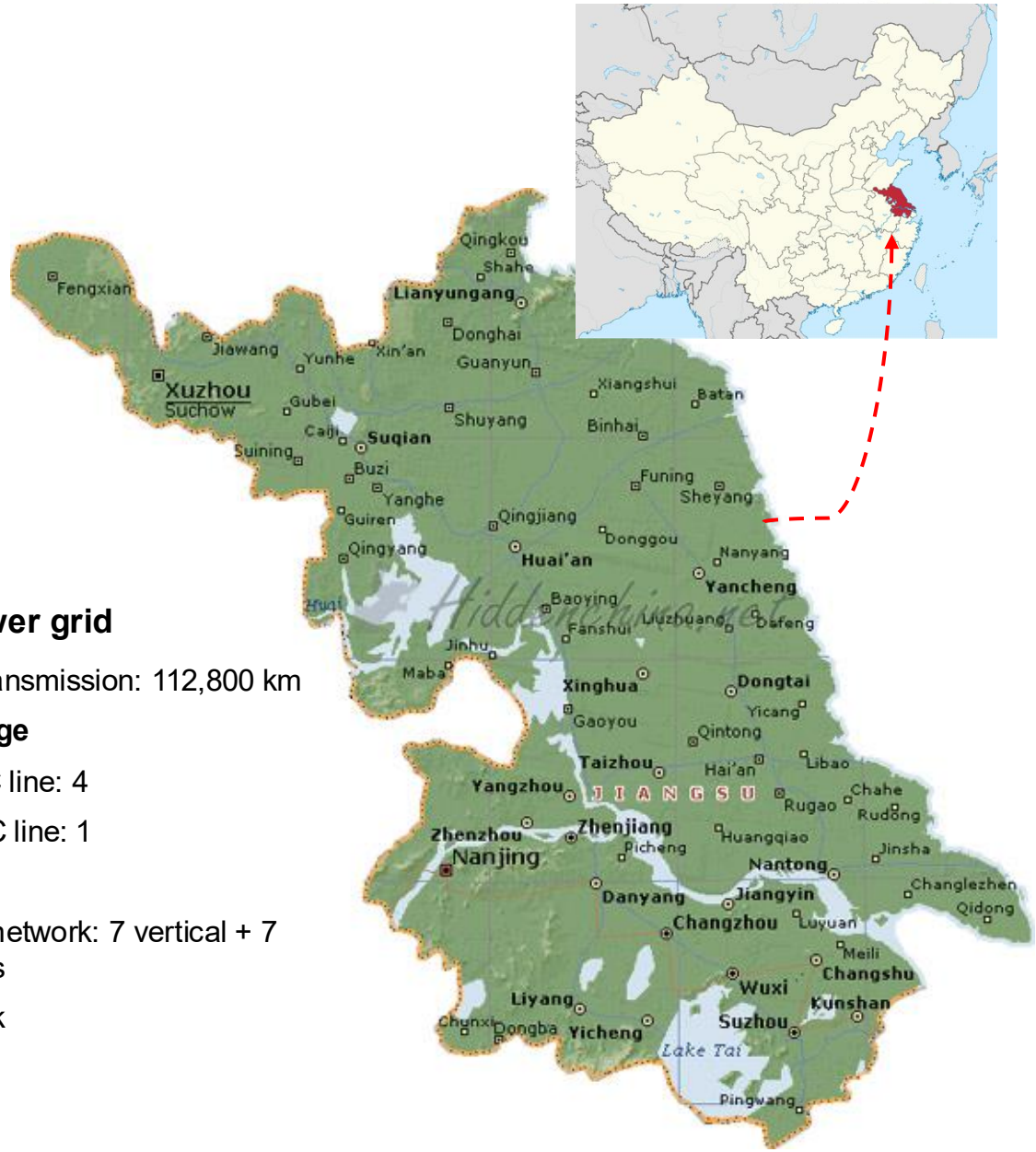
	The 14th FYP (2021-25)	The 15th FYI (2026-30)
Strategic goal	• Nearshore • Guided move from nearshore to deep-sea • Building up industrial bases	• Strategic growth: driven by carbon neutral and energy security • Deep-sea as a key priority
Capacity target	• By 2025, accumulative installed capacity **47.1GW** • Annual new capacity **7–8 GW/year**	• Doubling capacity, with the national total **>100 GW** by 2030 • **15–20 GW annual** new addition
Geographic layout	• Focus on **5 nearshore clusters** (Shandong Peninsula, Yangtze Delta, Southern Fujian, Eastern Guangdong, Beibu Gulf) • Point-based development	• Expanded to **four seas** (Bohai, Yellow, East China, South China) – covering all sea areas • **Coordinated development** across the entire coastline
Policy mechanism	• Subsidy-driven: feed-in tariffs, renewable portfolio standards • Subsides phased out in 2022 • Nearshore reached grid parity by 2025	• Special deep-sea management measures to be introduced • Goal for deep-sea: grid parity and market-based pricing
Technology	• Nearshore scale-up & deep-water demonstration • Turbine unit capacity (max. **20M**W), and development large nearshore wind farms • Pilot floating wind at small scale	• **Deep-sea projects to exceed 60% of new capacity** • Floating wind enters early commercialization • Deployment of **20+MW** turbines
Development model	• Early “offshore wind+” demonstration e.g., “wind+marine ranching”	• Offshore wind hubs • Integrated marine resources development: wind + aquaculture, wind + hydrogen/ammonia etc.

A Brief on Jiangsu

❑ Jiangsu province

- **Population: 85 million**
- **Area:** 107,200 km^2
- **Population density:** 795 people/km^2 (one of the most densely populated province)
- **Urbanization rate:** 75.5%
- **GDP：** CNY14.2 trillion / USD1.99 trillion
- **GDP/capita:** CNY167,040 / **USD23,200**





❑ Provincial power grid

- Total length of transmission: 112,800 km
- **Ultra-high voltage**
  - ±800kV HVDC line: 4
  - 1,000kV HVAC line: 1
- **Hight volage**
  - 500kV HVAC network: 7 vertical + 7 horizontal lines
  - 220kV network

OSW Rollout in the Province

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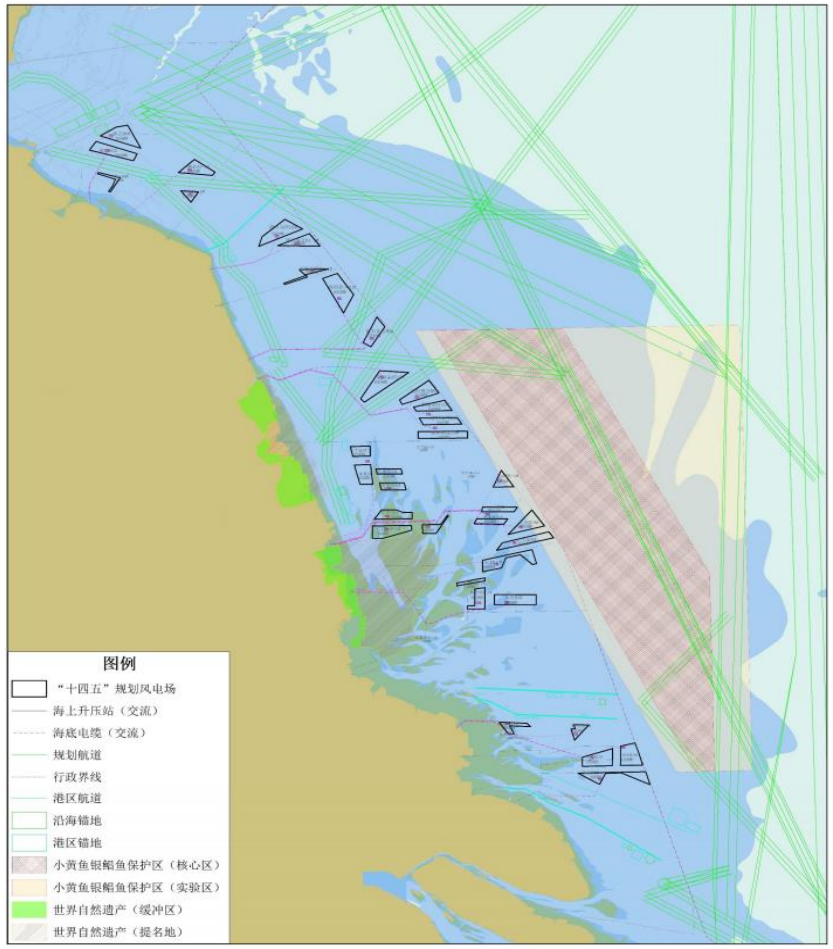
❑ Strategies (2021-25, -30)

- Project development: from nearshore to deep-sea
- Technology development: floating offshore, grid connection/transmission, smart O&M
- Integrated models for marine resource: marine ranching, green hydrogen, offshore oil and gas
- Direct green power supply to customers
- Offshore wind equipment manufacturing base and industrial chain

	Development Target	Accumulated Installed Capacity
13th FYP (1996-2020)	3 GW integrated, 4.5 GW under construction	5.73 GW by 2020 (top in China)
14th FYP (2021-25)	Promote deep-sea demonstration projects; capacity addition: 15 GW	**13.5 GW** by 2025 (top in China, about 30% of the national total)
15th FYP (2025-30)	Deep-sea, floating Development of large offshore wind base: **10-GW scale farms**	

❑ Challenges faced for grid integration

- Intermtency of renewables, size of the farms
- Allocations of resources and load centers
- Transmission capacity
- Cost of grid integration
- Flexibility and strength of existing power system

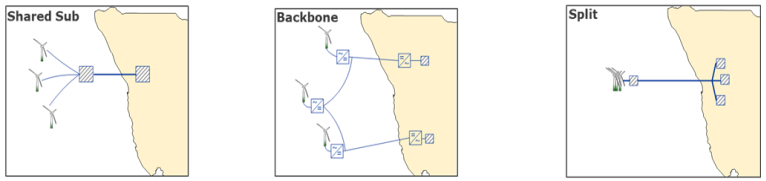


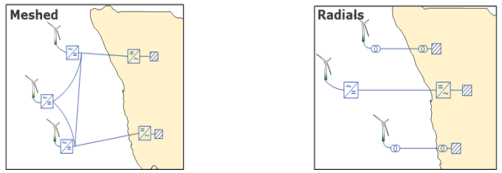
Source: The 14th FYP of RE Development of Jiangsu

OSW Grid Connection

❑ Power collection

- Power from groups of turbines in a wind farm to offshore substation by a network of inter-array cables
- Collection system: topology, AC (35kV, 66kV), DC
- Deliver collected medium-voltage power to offshore substation





❑ Grid connection

Advances in Transmission Tech

Transmission Technology	Application	Main advantage	Challenge
High-voltage AC (HVAC)	Short distance (< 70 km)	Mature, low cost for short distances	Distance and capacity limited by reactive power
Voltage-sourced converter HVDC (VSC-HVDC)	Long distance, high capacity	Efficient over long distances, active control	High cost of converter stations, system complexity
Low-frequency AC (LFAC)	Medium distance (50-200 km)	Extends AC range, no reactive power compensation requirement, small footprint, potential cost savings	Frequency converter, and larger sized transformers and reactors required
Diode-based HVDC (DRU-HVDC)	Long distance	Cheaper & more reliable offshore station	Requires grid-forming turbines, complexity of protection, no reversal power follow, pilot phase

- **HVAC** : 220kV/180-350MW; 500kV/1000MW.
- **VSC-HVDC:** efficient and cost-effective for long-distance projects with GW- scale capacity, while technologies like LFAC and DRU-HVDC are under development.

  VSC-HVDC project:

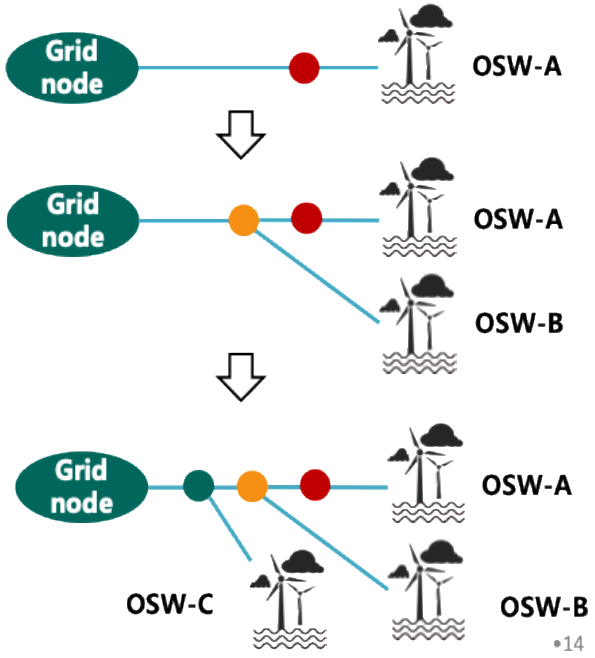
  - **Jiangsu Rudong Project:** ±400kV/1100 MW, 99km offshore cable, commissioned in Sep 2021.
  - **Guangdong Yangjiang SanShan Island Project**: ±500kV/2000MW, 115km offshore cable, under construction, April 2025 - Oct 2026.

The first project in Asia that utilizes flexible HVDC for OSW connection.

Optimize Grid Connection Configuration

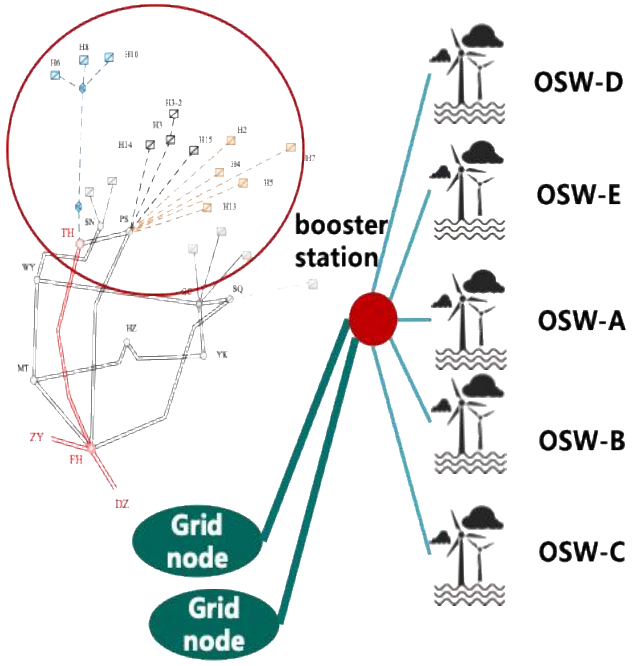
❑ Integrate to AC 220 kV station nearby

- Point to point



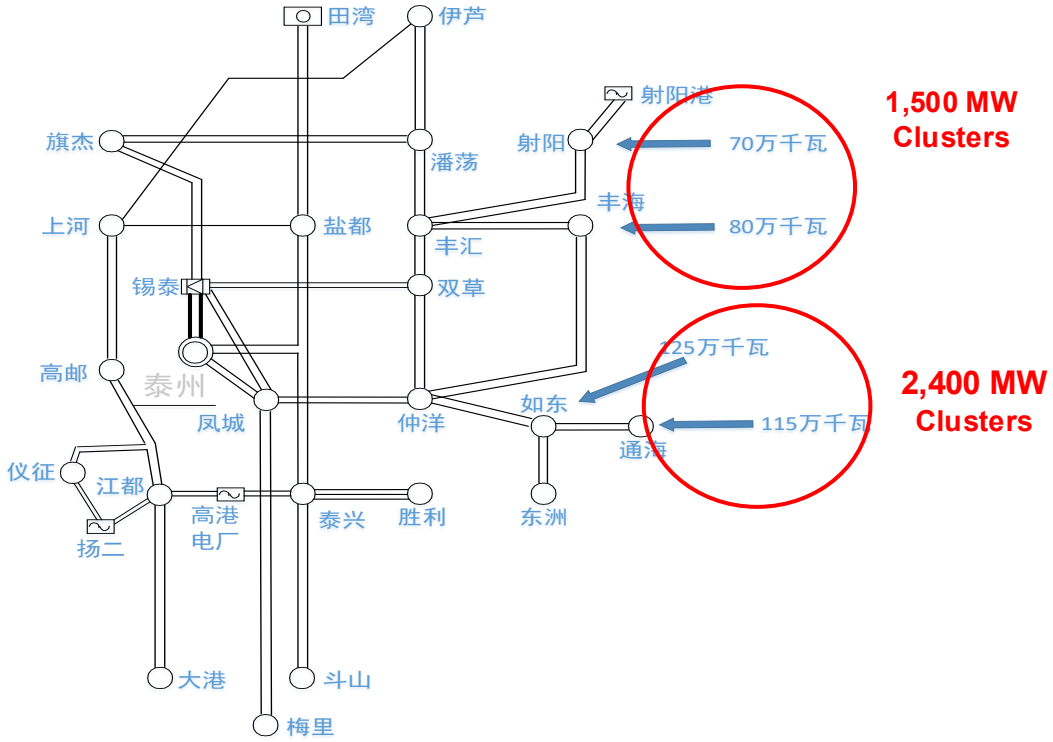
700 MW

- Group to power grid



1,400~2,000 MW

❑ Integrate to AC 500 kV station



Installation of world's first 500 kV offshore AC step-up station, Yangjiang, Guangdong, 2023.

Source: SASAC

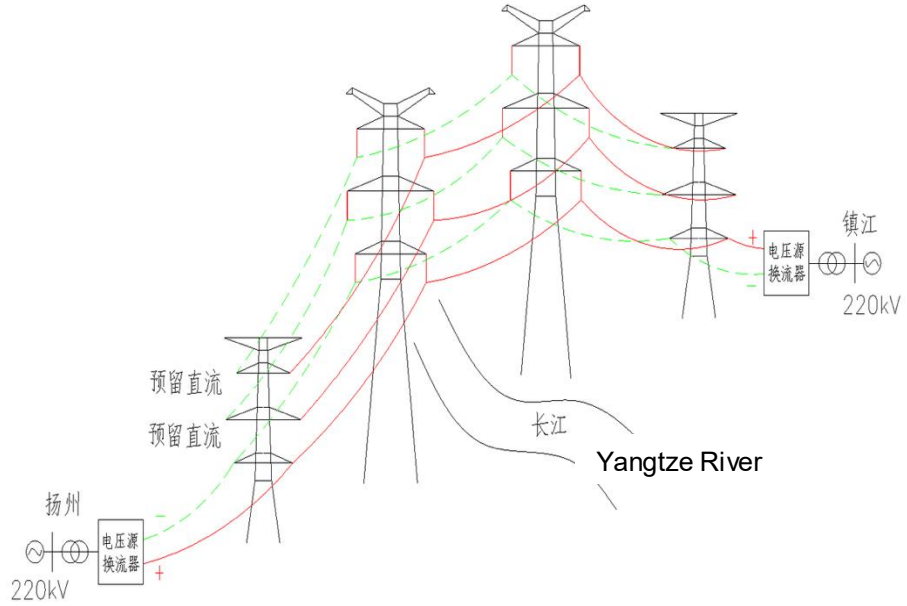
Alleviate the Network Bottleneck

❑ AC-to-DC conversion project

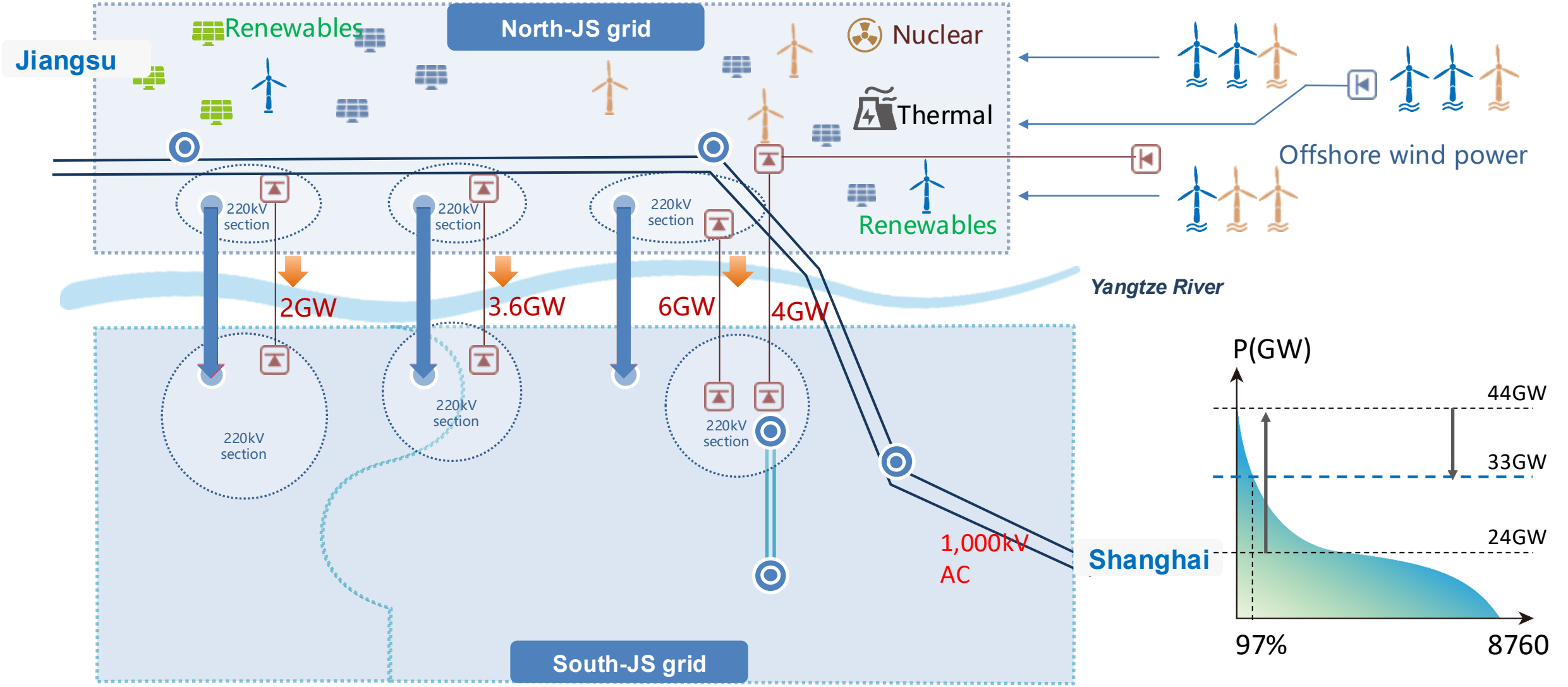
The first “AC to DC conversion” project: Yangzhou to Zhenjiang ±200 kV DC transmission project.

- Retrofit the existing 220 kV AC corridor, total length of 110km, across the Yangtze River.
- After the conversion, the transmission capacity has been increased from **500MW to 1,200MW**.
- Compared to building a new line, it saves nearly CNY60 million in investment and shortens construction period by 5-6 months.
- Large-scale application of intelligent construction robots significantly improved work efficiency of the project.

- First phase commissioned in **April 2024.**
- After the completion of all three phases, the transmission capacity is expected to **reach 3,600 MW**.



Strengthening Grid Backbone



Innovation Enabling Grid Integration

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Grid-forming converter

- From testing to commercial
- A 6 MW GFM-equipped wind turbine tested at Sheyang Offshore Wind Farm.
  - Emulate a synchronous generator.
  - Perform self-synchronization.
  - Allow wind turbine to actively establish and maintain a stable voltage and frequency for the grid.
  - Able to provide ancillary services.
- Others: up to 24 MW.

Grid-forming motor-generator (M-G) Pair for renewable energy / RE grid-connection stabilizer

- 4.5 MW, installed at onshore booster station of the Rudong Offshore Wind Farm, commissioned in April 2024.
- A motor-generator sets on a common shaft, with a large flywheel.
  - Active inertia response
  - Short-circuit current contribution
  - Electrical isolation
- A 100 MW stabilizer to be installed on an offshore converter platform to support a wind clusters.

Smart operation and control system for offshore wind farm

- Industry-University-Research Cooperation research project.
- Functionality:
  - Multi-point combined second-level wind resource forecasting
  - Wind farm operation simulation model and control
  - Optimization of wind farm wake deflection control
  - Intelligent operation and maintenance
  - Fault diagnosis and dynamic adaptive scheduling for optimal dispatching

Recommendations

- **Integrated planning**
  - **Layout optimization:** offshore wind farm clusters and onshore grid as a single system; Coordinate internal collection grids, offshore transmission networks, and onshore grid enhancement.
  - **Innovative project development:** offshore hub (multi-purpose interconnector, energy islands, OSW+hydrogen etc.) to enhance resilience and enable power sharing.
  - **Corridors and interconnection point:** shared cable corridors and landing points to lower cost, reduce environmental impacts and improve asset utilization.
- **Overcome deep-sea transmission bottleneck**
  - Transmission technology: distance, capacity and cost.
  - Configuration.
- **Standardization and grid code compliance**
  - GB/T 19963.2-2024, IEC TS 63487:2026, T/ZJSEE 0021.7-2025, T/CEEIA 804-2024 etc.
  - Turbine performance.
- **Support innovation and application**
  - Grid-forming technology, forecasting and optimal dispatching, smart O&M and control, predictive maintenance.
- **Optimize grid structure and capacity enhancement**
  - Reinforce transmission network (backbone of main grid).
  - Enhance renewable energy absorption capacity (distribution to the load centers).
- **Utilize flexible resources**
  - Flexibility of conventional generation units (gas and coal), energy storage, demand side response.

THANK YOU !

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