#### Low-Carbon Power Planning and Operation Decision-Making Platform:

#### Depicting the Transformation Path of Green Power System

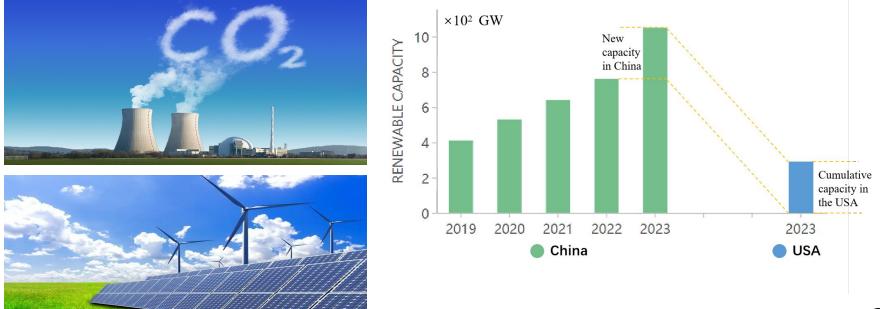
#### Organization:



State Grid Energy Research Institute Co.,

# Background

- Under the pressure of climate change and environment pollution, promoting energy transformation to reduce carbon emissions has been an international consensus.
- Currently, the scale of renewable energy is rapidly growing worldwide, especially in China. China added 300 GW new installed capacity of wind and solar power in 2023, which is equivalent to the cumulative installed capacity of renewable energy in the United State.



# **Questions and Challenges**

The output of renewable energy exhibit randomness and volatility, making it difficult to provide stable and reliable power supply like traditional generators such as coal-fired power. This may lead to imbalances in power supply and demand.Generally speaking, the green transformation of power system must **address 4 questions and overcome 5 challenges.** 

1 Target	4 Questions (4 How)	5 Challenges
Low-Carbon Transformation of Power System	HOW to accurately monitor carbon emissions in power production, transmission, storage, and utilization?	Unclear in coupling mechanism between power flow and carbon emission flow in power system, making it difficult to accurately identify the distribution of carbon emissions.
	HOW to take into account the uncertainty of renewable energy in power system planning and operation?	Lack of modeling methods for renewable energy uncertainty and assessing methods of renewable energy confidence capacity.
	<b>HOW</b> to plan the power system with a high proportion of renewable energy considering carbon constraint and strong uncertainty?	Lack of planning methods suitable for different scenarios and insufficient consideration of carbon emissions, renewable energy uncertainty, and new technologies.
	<b>HOW</b> to comprehensively analyze the operating status of the power system and assess the economic feasibility of planning schemes?	<ul> <li>Lack of algorithm to solve the "curse of dimensionality" of</li> <li>refined operation simulation model, and it is difficult to</li> <li>balance the precision and efficiency of model solutions.</li> </ul>
	L	

Low-Carbon Power Planning and Operation Decision-Making Platform was developed for carbon emission monitoring, renewable energy uncertainty simulation, low-carbon power systems planning and refined operation simulation to address the 4 questions and overcome 4 challenges

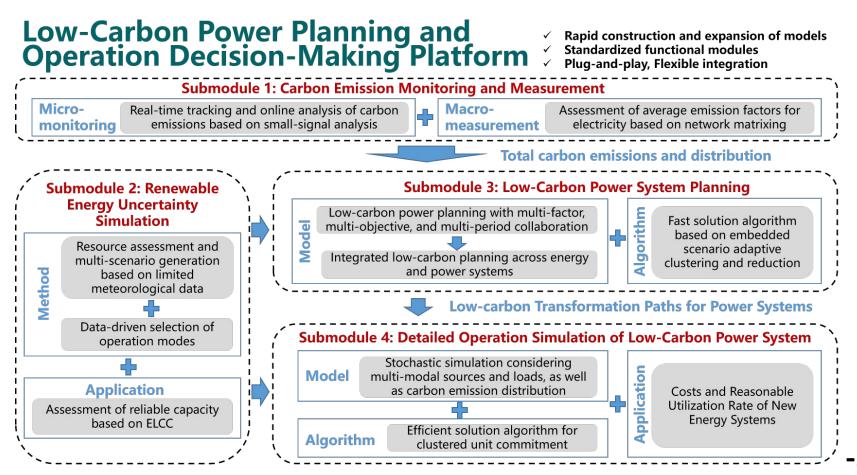
# **Solution**

In order to meet these challenges, **State Grid Energy Research Institute** developed the **Low-Carbon Power Planning and Operation Decision-Making Platform** over a 8-year period, which integrates four functions: **carbon emission monitoring**, **renewable energy uncertainty simulation**, **low-carbon power system planning**, **and refined operation simulation**.

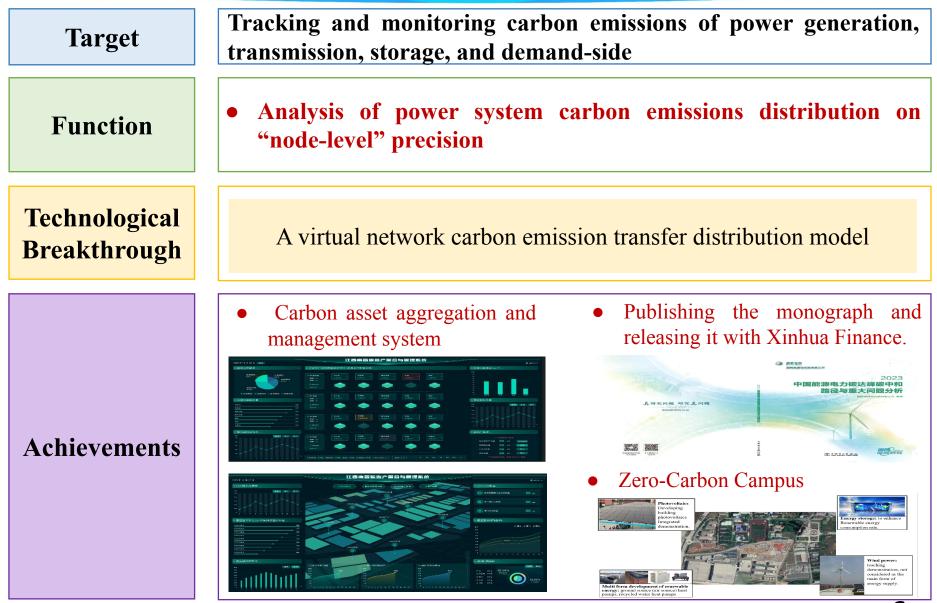


## Framework

- The four submodules can **operate independently** to realize the above four functions.
- Through the **flexible combination and interactive operation** of different submodules, higher and richer functions can be achieved.



### **Submodule 1: Carbon Emission Monitoring**



-6-

#### Submodule 2: Renewable Energy Uncertainty Simulation

Target	Modeling of renew renewable energy cor		nty and assessing of
Function	<ul> <li>Massive scenarios generation of renewable energy generation output</li> <li>Clustering and screening of massive scenarios</li> </ul>		
Technological Breakthrough	The MCMC based massive scenarios generation technology	A big data analysis framework and algorithm for massive scenarios	The evaluation model for the confidence capacity of renewable energy
	<ul> <li>Submodule 2 is applied by State Grid to determine the renewable energy dispatch and operation modes in the Beijing-Tianjin-Tangshan region every year since 2020.</li> <li>Renewable energy bases in the Beijing-Tianjin-Tangshan region</li> </ul>		
Achievements			

# System Planning

Target	Mid-Term and Long-Term Planning for Low-Carbon Power Systems			
Function	<ul> <li>Capacity Expansion</li> <li>Transmission Expansion</li> <li>Analysis of rational ratio of wind and solar power curtailment</li> </ul>			
Technological Breakthrough	a power system planning model considering carbon emissions and renewable energy uncertaintya rapid solution algorithm based on multi-parameter linear programming theory			
Achievements	<ul> <li>The research on the implementation path for achieving carbon peak and neutrality in the power industry of the Chinese Academy of Engineering was completed relying on Submodule 3;</li> <li>The power system transformation path in the "Carbon Peak and Neutrality Action Plan" and the "New Power System Action Plan of the SGCC" were calculated by Submodule3 from 2020 to 2024;</li> <li>The carbon peak and neutrality path of Chinese power system was analyzed by Submodule 3, and the relevant content was published as a part of the monograph "Carbon Peak and Neutrality Path in Energy and Power Industry", which is released publicly through Xinhua Finance with exceeded 360,000 audiences.</li> </ul>			

## **Submodule 4: Refined Operation Simulation**

Target	8760-hour refined operation simulation of low-carbon power system		
Function	<ul> <li>Analysis the operating status of power system</li> <li>Analysis of wind and solar power curtailment</li> <li>Economic analysis of power system operation</li> </ul>		
Technological Breakthrough	A transfer distribution factor algorithm to achieve adaptive clustering of embedded massive scenariosA rapid operation simulation algorithm for power systems based on 		
Achievements	<ul> <li>Calculate the ratio of wind and solar power curtailment in 26 provinces within the operational area of the SGCC for five consecutive years and puts forward effective suggestions reducing the ratio by more than 2%;</li> <li>The collaborative operation simulation of both the sending and receiving ends of the YaZhong UHVDC Transmission Project was completed.</li> </ul>		

-9-

# **Application and Potential Impacts**

The platform has been widely used by various entities, such as national ministries and commissions, local governments, the World Bank, grid companies, and power generation groups. It has provided important decision-making tools and reference solutions in supporting the formulation of the national carbon reduction strategic plan, serving the low-carbon transformation of the energy and power industry, planning and building the power system with high renewable generation penetration.

- Economic benefit
- Cumulative investment 13 million CNY and direct economic benefit 137 million CNY.
- Social benefit
- (1) Renewable Energy Development
- Evaluation of wind and solar power curtailment in 26 provinces by State Grid and give effective suggestions to reduce wind and solar power curtailment.
- (2) Low-Carbon Economy Development
- Facilitating interconnectivity among renewable energy companies, equipment manufacturers, operation and maintenance enterprises.
- Providing data services and technical support for fostering carbon reduction industries.

# **Application and Potential Impacts**

#### (Continue from the previous page)

Buliding Low Carbon Community, such as Zero-Carbon Campus at Jiangxi Vocational and Technical College of Electricity.

#### (3)Policy-Making

- supporting the energy and power transformation, renewable energy development, and carbon accounting management of national ministries and commissions as well as local governments.
- Supporting policy formulation. The platform has also supported the issuance of multiple policies in the fields of energy storage and renewable energy development.
- (4) Industry-university-research collaboration
- Providing free educational software to universities and opening paid access for partners.
- Establishing joint research institutions, such as the Jiangxi (Nanchang) Carbon Neutrality Development Institute.
- (5) Talent Training
- **4 professor-level senior engineers** have been trained, including a **female.**
- **3 researchers** have been awarded the title of **SGCC young talents**.
- 2 researchers have been awarded the title of Outstanding Young Scientific and Technological Workers by the China Energy Research Society.
- **5 researchers** have served as **expert committee members** in academic organizations such as the IEEE PES Energy Technology and Economics Committee.

# Thank you!

3.5

The platform is continuously being developed and upgraded, aiming to contribute Chinese wisdom and inject green momentum into the global energy transformation.