

# Pumped Storage Hydropower Experience of CTG

China Three Gorges (Brazil) Co., Ltd.  
March, 2025



# I. CTG's Achievements in Pumped Storage Hydropower



China Three Gorges Corporation, originated from Three Gorges Project and founded in 1993, is the world's largest hydropower development and operation enterprise and China's leading clean energy group.

**Our Mission:**  
Harmonizing development with conservation for greater public wellbeing

**Our Vision:**  
Striving for clean energy and Yangtze River conservation and building a world-class enterprise

**Our Values:**  
Innovation-driven development for a carbon-neutral and win-win future

Total Capacity **158** GW  
Annual Generation **414** TWh

Assets **214** Billion USD  
Annual Revenue **21.7** Billion USD

World's biggest clean energy corridor of **6**  
giant HPPs with total capacity of **~72** GW  
and **110** generators

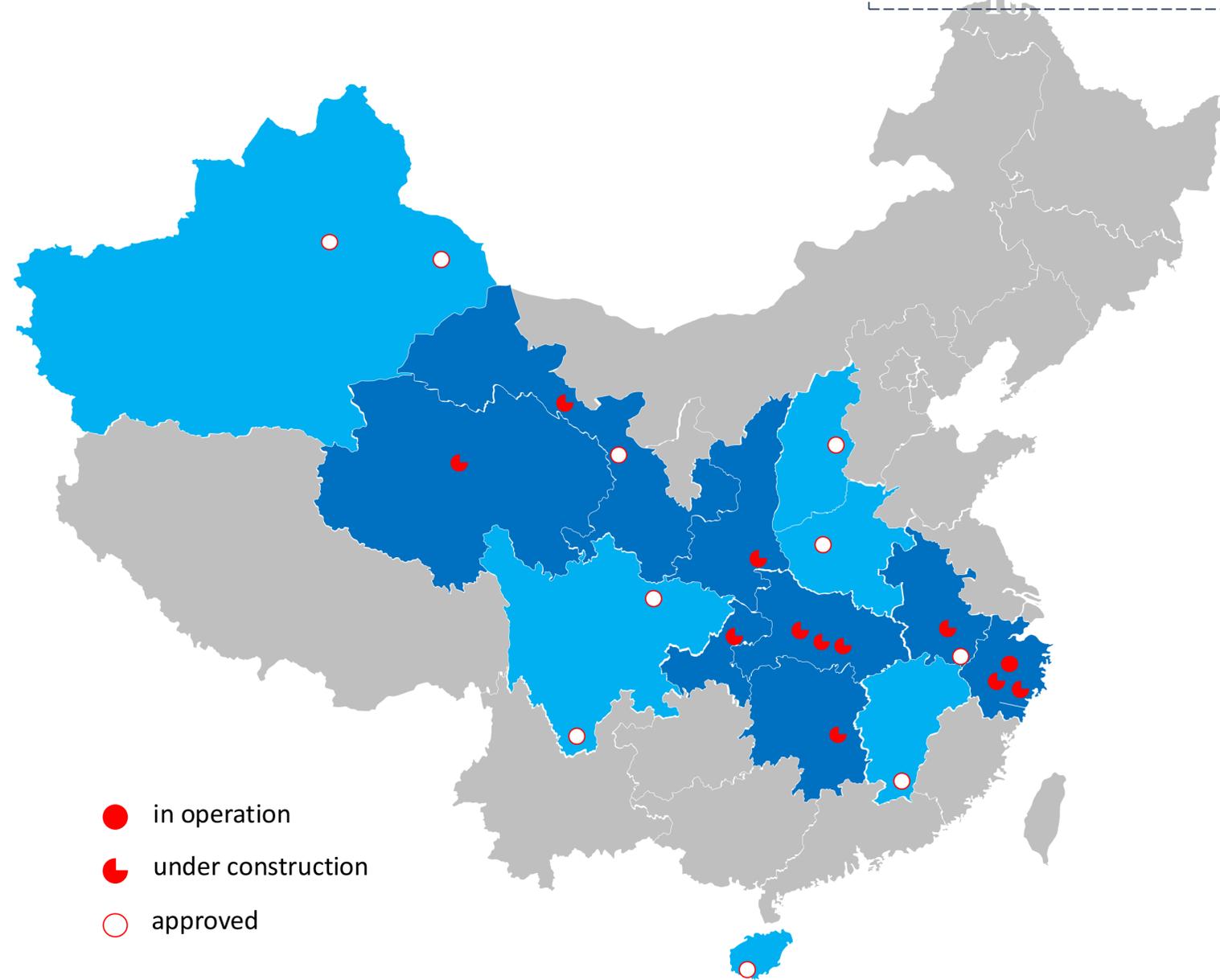
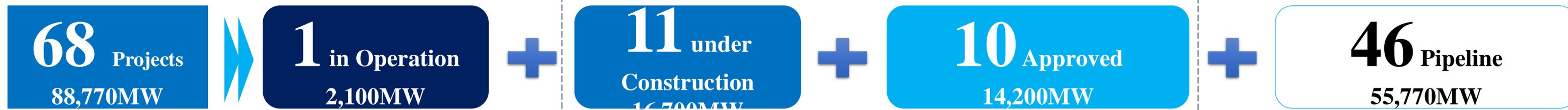
Business covers **20** countries/regions  
Overseas Capacity **20** GW

Overseas Assets **27** Billion USD  
Overseas Annual Revenue **3.3** Billion USD

**18.8** GW for Pumped Storage Hydropower  
under operation and construction  
China's Biggest Investor except StateGrid

# 1.2 CTG's Pumped Storage Hydropower Roadmap and Key Projects

Accessed in 2021 after regulatory authorities clarified rules for 'Two-part Tariffs'.



- in operation
- ◐ under construction
- approved

No.	Operation	Province	Capacity (MW)	Construction Period
1	Changlongshan	Zhejiang	2,100	2015-2022
No.	Construction	Province	Capacity (MW)	Planned Construction
1	Tiantai	Zhejiang	1,700	2022-2026
2	Songyang	Zhejiang	1,400	2023-2028
3	Shitai	Anhui	1,200	2023-2028
4	Zhangye	Gansu	1,400	2023-2029
5	Caiziba	Chongqing	1,200	2026-2031
6	Nanshankou	Qinghai	2,400	2024-2030
7	Luotianpingtanyuan	Hubei	1,400	2023-2028
8	Nanzhangzhangjiaping	Hubei	1,800	2024-2030
9	Changyangqingjiang	Hubei	1,200	2024-2030
10	Youxianguanghanping	Hunan	1,800	2025-2030
11	Shanyang	Shaanxi	1,200	2025-2030

# 1.3 Changlongshan Pumped Storage Hydropower Plant

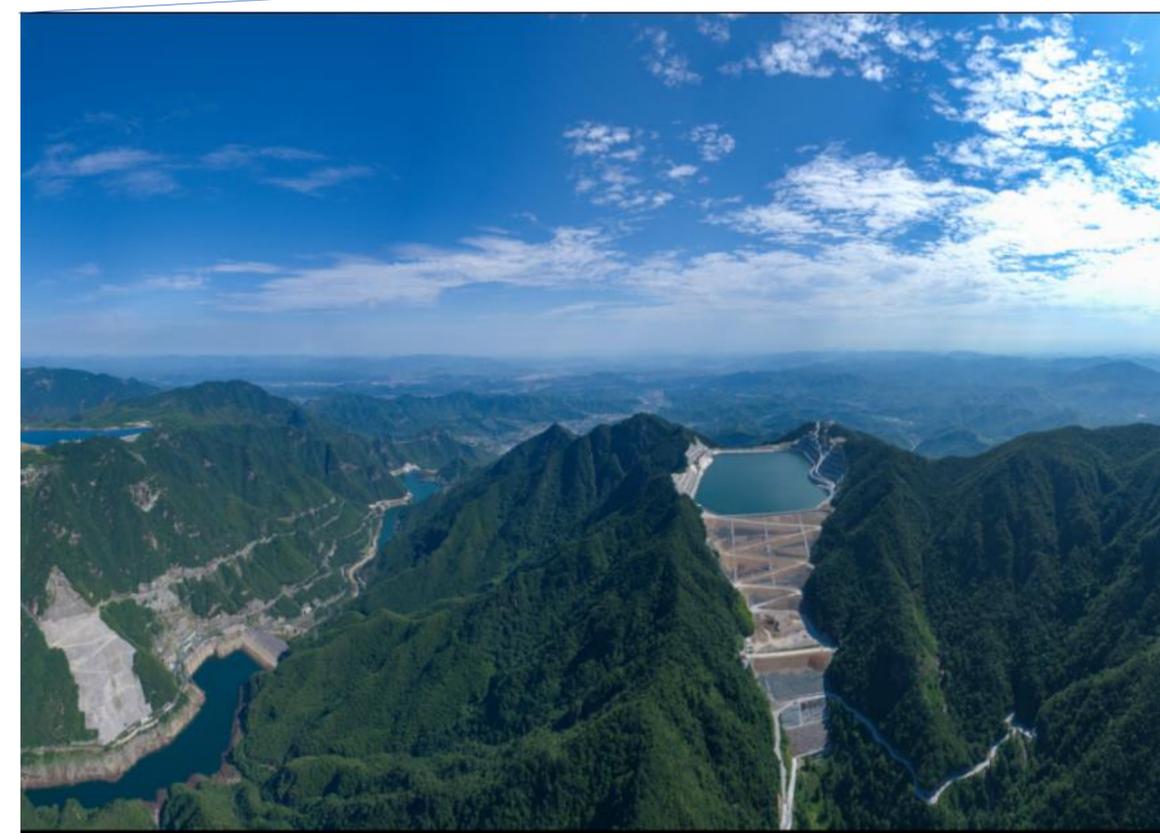


World No.1  
-Head of 755.9  
meters

World No.1  
-Reversible unit with  
350MW at high  
rated speed

World No.1  
-High-pressure steel  
bifurcated pipe HD  
of 4800m.m

- **Main Parameters:** Total capacity 2.1GW (6 units of 350MW, head height of 756 meters, upper and lower reservoir over 10 million m<sup>3</sup>, 2.53 billion kWh of generation in 2023.
- **Construction Period:** Around 7 years.
- **Construction Cost:** Total investment of 1.5 billion USD, unit investment of 710 USD/kW.
- **Benefits:** Located in the load centre of East China Power Grid, safeguard power supply, promote renewable consumption, and reduce carbon emissions by 2 million ton/year.



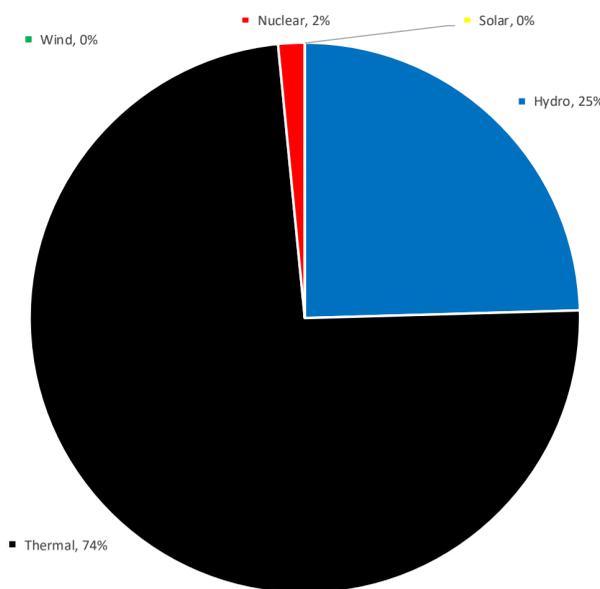
Upper Reservoir

## **II. Advantages and Necessity of Pumped Storage Hydropower Development**

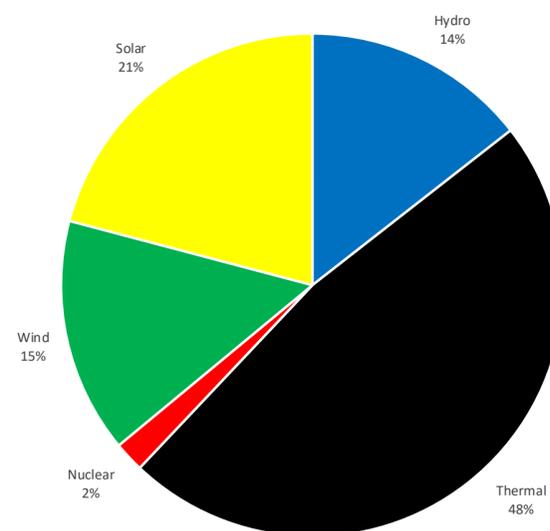
## 2.1 Era Background of High-Quality Development of China's Pumped Storage Hydropower

- Due to geographical and climatic characteristics, a large number of high-quality wind and solar projects in China are located in the "Three Norths" region, far from the main load centers (eastern coastal areas).
- China's wind and solar power installed capacity has grown rapidly since 2005, with the total installed capacity now exceeding 100GW, accounting for 36% of the national total amounts.

2005 Total Capacity  
440GW



2024 Total Capacity  
2,900GW



- The relative lag in transmission construction, the lack of flexible power sources, and the mismatch between supply and demand growth led to both "regional power shortages" and "large-scale wind and solar curtailment" occurring simultaneously in China in 2022.
- In order to achieve China's goal of 'carbon peak and carbon neutral' proposed in 2020, it is necessary to build a new power system led by renewable sources, and energy storage projects are an important factor in guaranteeing its safe, stable and efficient operation.

## 2.2 Pumped Storage Hydropower vs. Other Energy Storage Technologies

Type	Capacity (MW)	Lifespan (Year)	Construction Cost (USD/kW)	LCOE (USD/kWh)
Pumped storage Hydropower	100-3,600	>40	650-1,000	0.03-0.04
Electrochemical storage	0.1-100	8	300-400	0.06-0.08
Compressed air storage	10-350	30-40	850-1,400	0.03-0.06
Flywheel storage	0.1-20	20	300-1,000	1.00-1.10
Thermal storage	1-300	20-30	2,100-3,500	0.11-0.13
Hydrogen storage	1-200	10-15	2,000-3,500	0.60-0.70

Despite the long construction period, high initial investment, site constraints and environmental impacts, pumped storage hydropower has significant technical, safety and economic advantages over new energy storage projects, and has become a key type of energy storage for development in China.

- **Technical Advantage:** Large capacity, long service life, stable performance, high energy conversion efficiency, and fast response. It can provide longer regulation durations, inertia, and phase modulation, significantly supporting the power system.
- **Safety Advantage:** In a new power system with strong randomness of renewable energy output, pumped storage hydropower is mature and able to fully adapt to frequent system demands without affecting its lifecycle.
- **Economic Advantage:** Compared to electrochemical storage with relatively mature application and lower technological risks, the LCOE of pumped storage hydropower is only 37% of that for electrochemical storage.

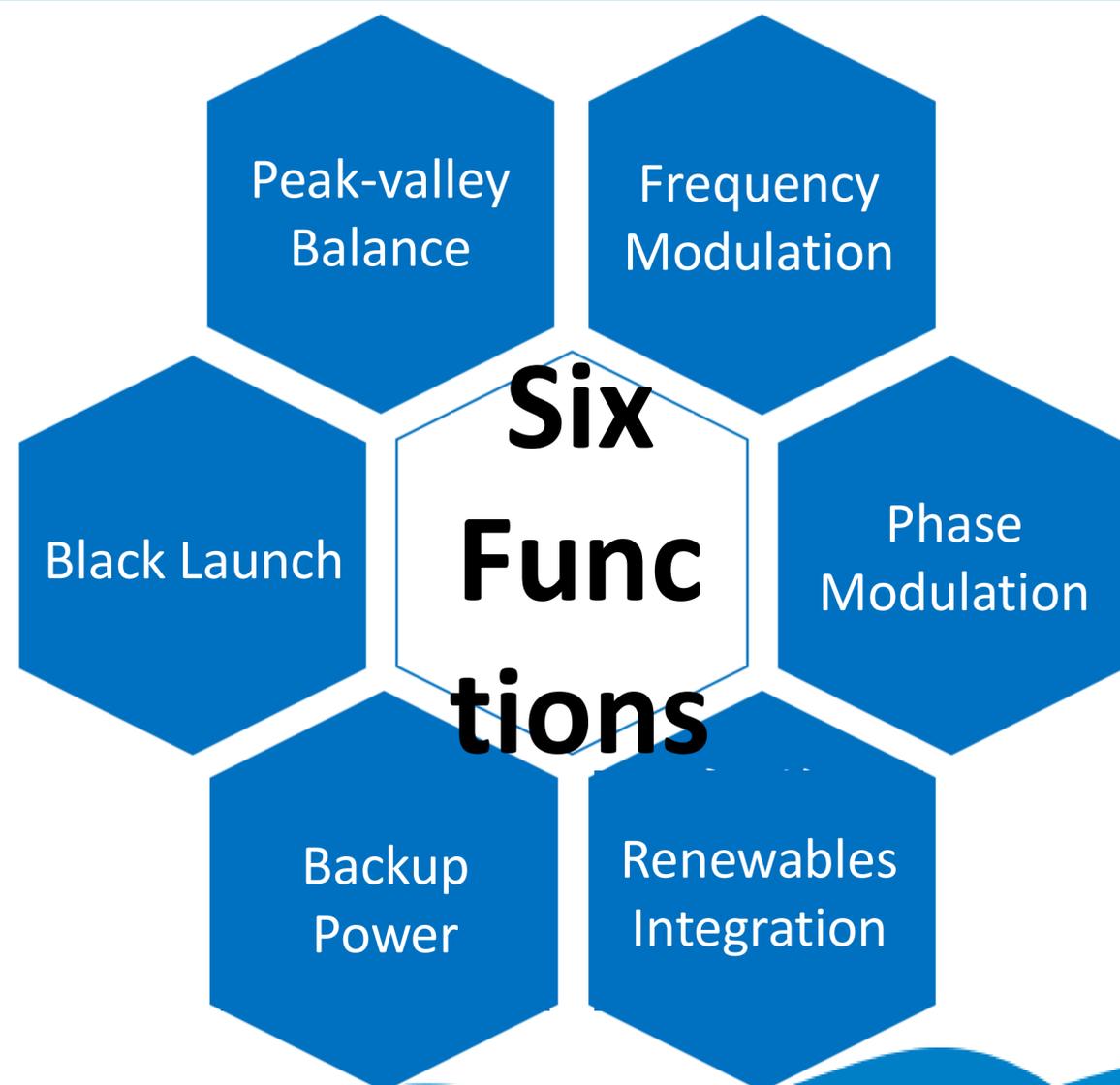
### Negative Environmental Impacts

- The construction of pumped storage power stations may have local ecological impacts, such as flooding of agricultural land, houses and forests, and affecting the habitat of aquatic organisms. At the same time, the construction of the power station and the storage of water may also affect the stability of mountains and the safety of existing buildings.
- During the construction period, there may also be pollution of the water environment, ground vegetation, noise and atmosphere. For example, the construction may affect soil and water conservation, and construction debris may affect the quality of nearby water bodies; the large number and concentration of construction machinery may generate a large amount of noise.
- Therefore, determining project site for pumped storage hydropower is crucial.

‘Intermittent operation, basic generation and pumping’  
Single peaking source



‘Long-time on grid, generation, pumping and phase prioritized’  
Multi-functional regulating source



### Resource Value

- It is constrained by factors such as elevation difference, terrain, geology, water sources, and transportation conditions. Suitable sites are limited, making it a scarce national resource as coal, oil and regular hydro resources.

### Economic Value

It converts low-value energy into high-value energy, optimizing energy resource utilization, enabling the spatial and temporal movement of electricity with different values and qualities, and creating more value than energy consumption.

### Ecological Value

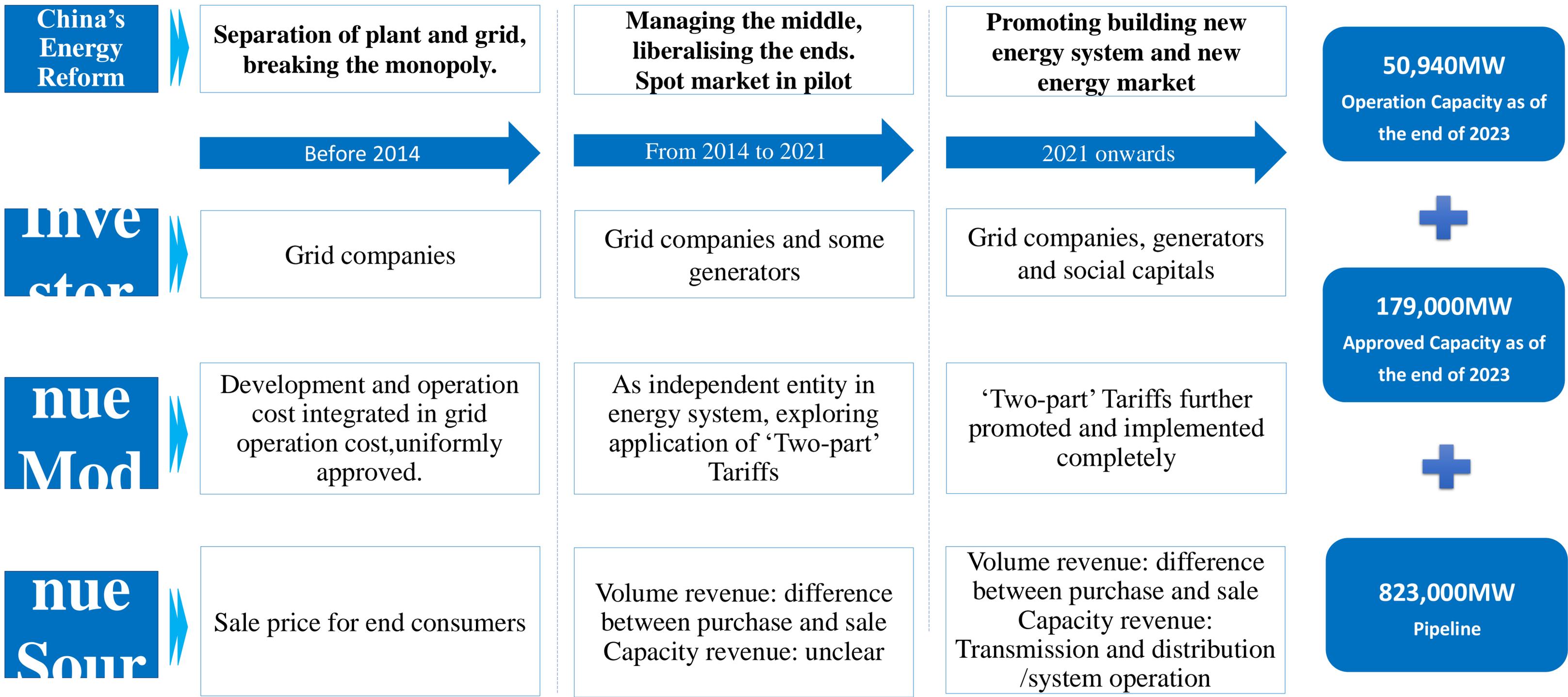
By reducing peak-shaving pressure on thermal power, it improves the efficiency of thermal power units, reduces coal consumption and carbon emissions. Synergistic development with renewables can reduce curtailment and promote consumption. It will ultimately form a beautiful natural environment after project completion.

### Social Value

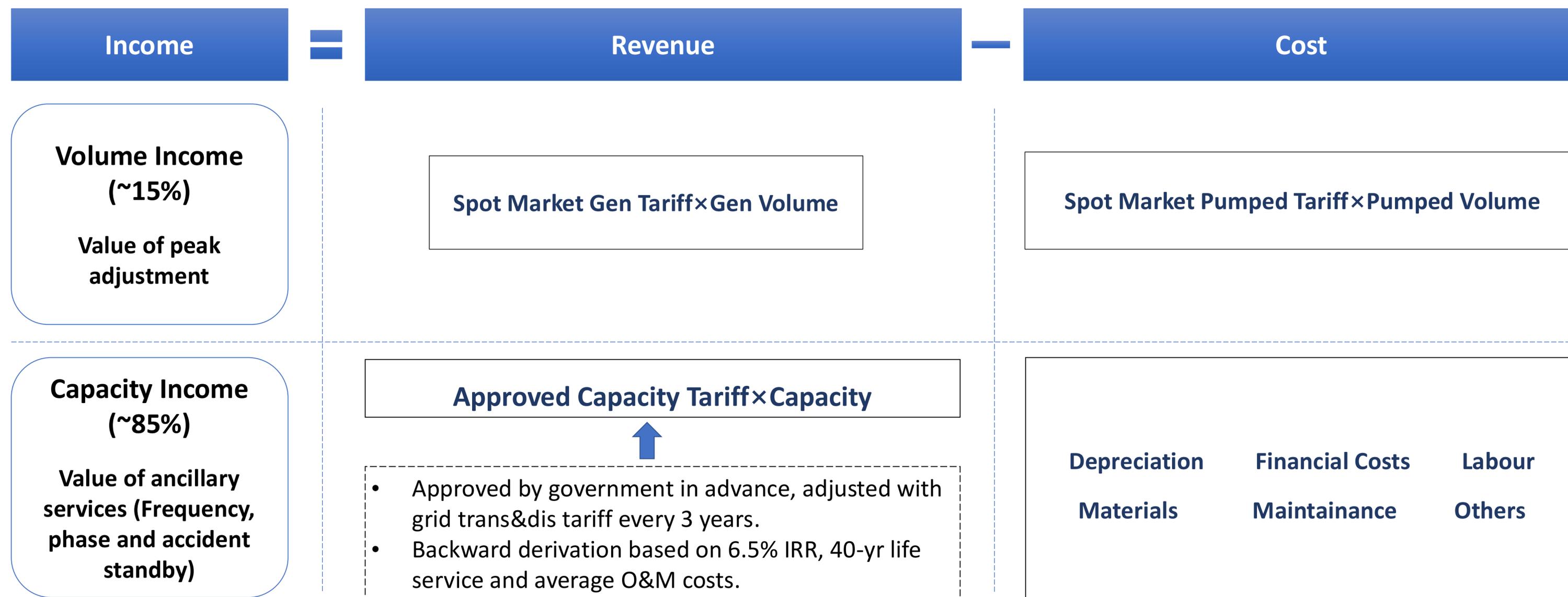
- With large investment scales and strong economic driving capabilities, it effectively promotes local economic development.

# **III. Current Status and Experience of Pumped Storage Hydropower Development in China**

# 3.1 Development Roadmap of China's Pumped Storage Hydropower



## 3.2 Experience Summary: Two-part Tariff Mechanism

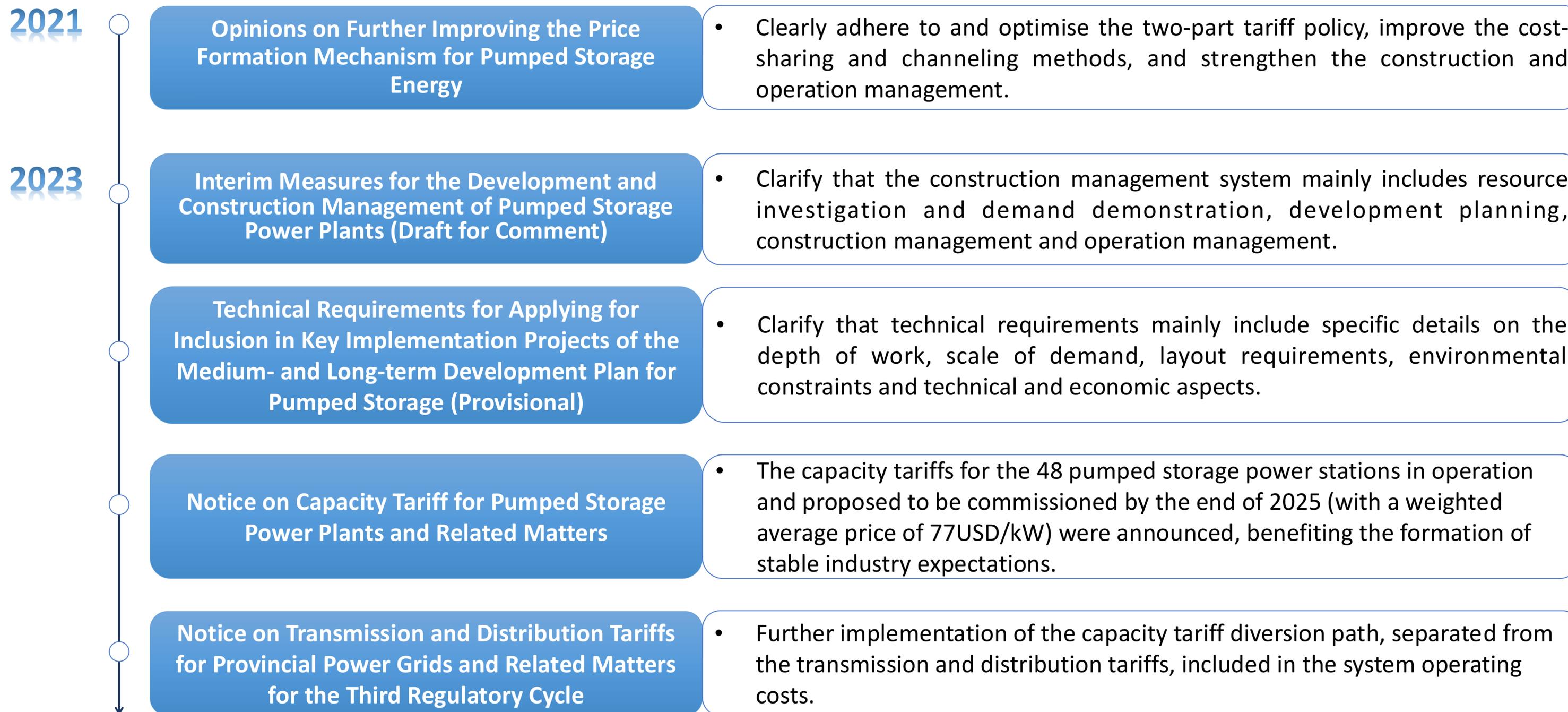


- In regions piloting spot markets, the valley tariff (during midday) is about one-third of the peak tariff (during morning and evening peak hours).
- Two-part Tariff Mechanism is well adapted to nowadays China's electricity market reform, where capacity tariffs guarantee effective recovery of investments and reasonable returns, and volume tariffs encourage market-oriented development of pumped storage hydropower, significantly increasing various investors' enthusiasm.
- With the gradual maturation and promotion of the spot market and auxiliary services market, China's power regulator may increase the market-based portion of the revenue from pumped storage projects.

## 3.2 Experience Summary: Development process



	Resource Survey	Formulate 5-Years Plan	Auction	Project Approval	Apply for Permissions	Construction
Participants	<ul style="list-style-type: none"> <li>Provincial Regulatory Authorities</li> <li>Grid Companies</li> </ul>	<ul style="list-style-type: none"> <li>National Regulatory Authorities</li> <li>Provincial Regulatory Authorities</li> <li>Research Institute</li> </ul>	<ul style="list-style-type: none"> <li>Provincial Regulatory Authorities</li> <li>Potential Investors</li> </ul>	<ul style="list-style-type: none"> <li>Provincial Regulatory Authorities</li> <li>Winning Investor</li> </ul>	<ul style="list-style-type: none"> <li>Relevant Authorities</li> <li>Winning Investor</li> </ul>	<ul style="list-style-type: none"> <li>Relevant Authorities</li> <li>Investor</li> </ul>
Main Contents	<ul style="list-style-type: none"> <li>Establish Pumped Storage Resource library based on survey results.</li> </ul>	<ul style="list-style-type: none"> <li>Determine the Projects List of each province during the next 5 years</li> </ul>	<ul style="list-style-type: none"> <li>Select investor for each Project through auction</li> </ul>	<ul style="list-style-type: none"> <li>Detailed feasibility study</li> </ul>	<ul style="list-style-type: none"> <li>Apply for all permissions to start construction</li> <li>Approve capacity income for pumped storage project</li> </ul>	<ul style="list-style-type: none"> <li>Supervision throughout</li> <li>Organize Construction</li> </ul>
Key Consideration	<ul style="list-style-type: none"> <li>Feasibility for reservoirs layout</li> <li>Anti-seepage condition</li> <li>Water Head and Height Ratio</li> <li>Geological Condition</li> <li>Distance to Load center</li> <li>Immigration Condition</li> </ul>	<ul style="list-style-type: none"> <li>System Demand</li> <li>Grid access condition</li> <li>Potential impact on End-user electricity prices</li> <li>Ecological and environmental impact</li> </ul>	<ul style="list-style-type: none"> <li>Technical and economical strength</li> </ul>	<ul style="list-style-type: none"> <li>Capex</li> <li>Technical feasibility</li> <li>Water and Soil Conservation</li> <li>Water resource usage plan</li> <li>Resettlement of Reservoir Area Immigrants</li> </ul>	<ul style="list-style-type: none"> <li>Environment</li> <li>Safety</li> <li>Immigration</li> </ul>	<ul style="list-style-type: none"> <li>Environment</li> <li>Safety</li> <li>Immigration</li> </ul>



### DESIGN

- **Planning and Design:** e.g. CEEC and POWERCHINA
- **Technical standard:** Well-developed design codes and technical standards, such as the Design Code for Pumped Storage Power Plants.

### MANUFACTURE

- **Hydroelectric Generating Units:** e.g. Harbin Electric and Dongfang Electric can independently develop large-scale units.
- **Other Key Equipments:** pump turbines, high-pressure equipment, control system have achieved localization.

### CONSTRUCTION

- **Technology:** Mature technologies under complex geological conditions, efficiency in key projects like water transfer tunnels.
- **Speed:** Short construction cycle, with an average period of 6-8 years, and some shortened to 5 years.

### MANAGEMENT

- **O&M:** e.g. State Grid and Southern Power Grid with mature operation and management system.
- **Intelligent Management:** Achieve remote monitoring, fault diagnosis and intelligent scheduling by digital and intelligent technology.

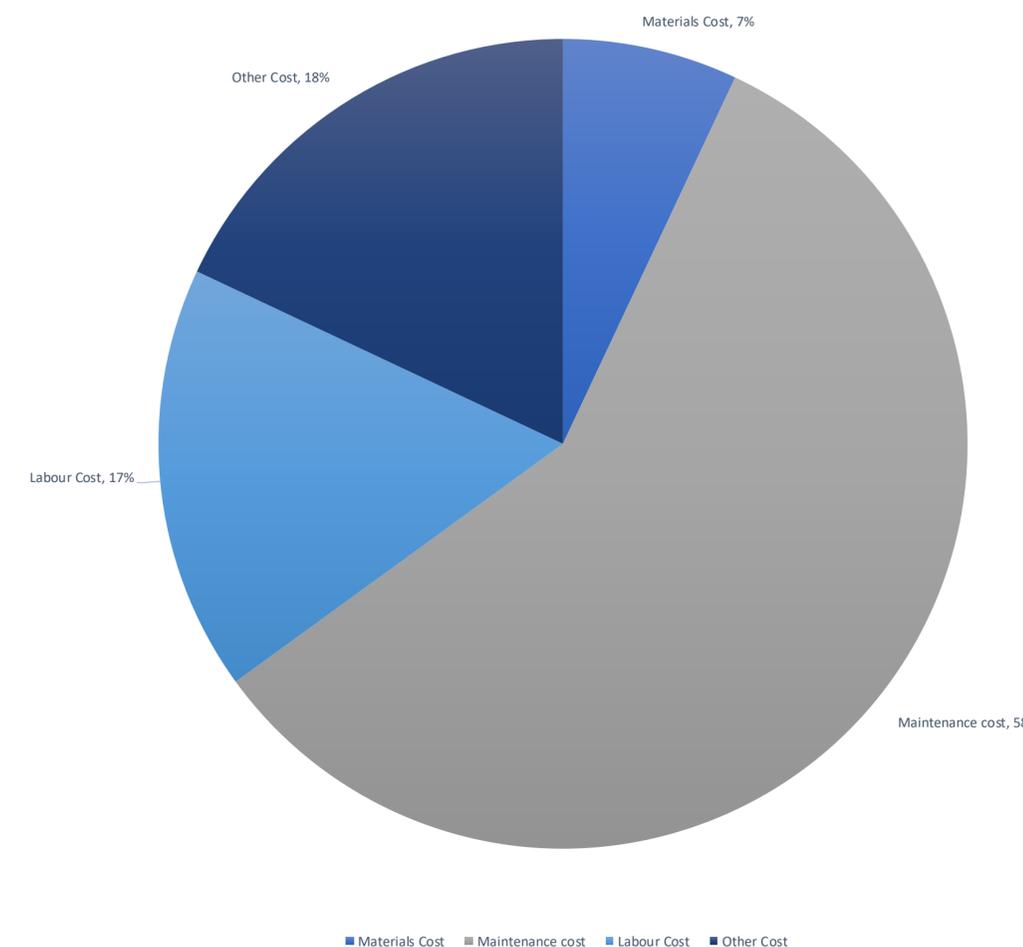
### TECHNOLOGY

- **Key Breakthroughs:** Variable-speed unit, seawater pumped storage, ultra-high-head technologies.
- **International Cooperation:** CTG's participation in IHA's Policy Framework.
- **Research Platforms:** Hydropower Technology Research Centre.

➤ The **static investment** for pumped storage hydropower projects in China is **814 USD/kW**, **annual operation cost is 12-19 USD/kW**.

No.	Project	Cost (USD/kW)	Percentage
1	Construction	303	37%
2	Electrical and Mechanical Equipment and Installation Works	184	23%
3	Independent Costs <sup>(1)</sup>	129	16%
4	Construction Auxiliary Works	61	7%
5	Basic Reserve Costs	47	6%
6	Metal Structure Equipment and Installation	40	5%
7	Compensation for Resettlement of Immigrants on Land	29	3%
8	Environmental protection works and soil and water conservation works	21	3%
<b>Total</b>	<b>Static Investment</b>	<b>814</b>	<b>100%</b>

## O&M Costs Composition of Pumped Storage Projects



(1) Independent costs refer to construction management fee, supervision fee, production preparation fee, survey and design fee, etc..

## Construction

### 1 Survey and Design

- It is fundamental to select experienced and qualified design unit to ensure reasonable working cycle and the depth requirements stipulated in the regulations.

### 2 Approval by Law

- Carry out approval and commencement procedures in strict compliance with the law, to avoid irregularities and potential risks.

### 3 Safety and Quality

- It is key to guarantee safety and quality by strengthening of safety supervision, good acceptance of project completion and dam safety record registration.

### 4 Technical Innovation

- Breakthroughs in construction and equipment.
- Digital and intelligent application.
- Mechanisation, and standardisation etc..

## Operation

### 1 Tariff Mechanism is the basis.

- The price mechanism is crucial to the development of pumped storage, guaranteeing a smooth transition of the price policy, promoting marketisation in a planned and step-by-step manner, stabilising investment expectations, and guiding the industry as a whole to reduce costs, increase efficiency and make technological progress.

### 2 Standardised dispatch is the guarantee.

- Standardising the transfer of units to commercial operation.
- Standardising dispatching and operation.
- Strengthening the regulation and monitoring of dispatching and operation.
- Strengthening the monitoring of industry development and publication of industrial reports.

Thanks!