SMART ENERGY PROSUMER: WHAT DOES IT MEAN AND HOW IT IMPACTS HUZHOU - THE CITY OF SILK, TEA AND BRUSH PEN?

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Project Overview

Standing 150km away west of Shanghai, Huzhou is famous for its time-honored history of 2300 years in Zhejiang Province south of the Yangtze River. Huzhou is the origin of silk worldwide. 700 years ago, Marco Polo, an Italian merchant, traveled to Huzhou and other parts of China and his travel notes inspired the yearning of the Western world for the oriental civilization over the following centuries. Also, Huzhou is known as the land of tea in China. The world's very first monograph on tea, the *Classic of Tea* is born in Huzhou. Besides, Huzhou is a hub of Chinese calligraphy brush pens, remaining the roots of long-standing Chinese culture.

Fig. 1 Misty Rain in Huzhou

Fig. 2 Tea Garden in Huzhou

As time goes on, Huzhou today is the birthplace of the green development concept "lucid waters and lush mountains are invaluable assets", and also the first ecological demonstration city. Huzhou focuses on large-scale tea and bamboo planting, textile, new energy, machinery manufacturing,

bio-pharmaceutical, and furniture production. With concentrated efforts toward economic development, the city with 3.37 million population contributes to 0.29% of the country's GDP and ranks top in economic growth throughout Zhejiang Province.

A prosperous region has more electricity demand. Zhejiang Province boasts the most flourishing economy, while it encounters the worst shortage of electricity supply. In 2022, Huzhou registered electricity consumption totaling 35.412TWh, with the electricity gap hitting 1.3GW. The future of Huzhou heavily depends on an efficient and stable supply of low-carbon and clean energy.

Electricity lights the night for humans. In 1882, Thomas Edison built the first power plant at Pearl Street, New York. In the same year, SPIC had the first electric light working in China powered by Yangshupu (Shanghai) Power Station. Up to now, SPIC posts an installed electricity capacity of 239GW, of which clean energy accounts for over 70%. It is considered a clean energy supplier with the largest installed capacity in the world.

Fig. 3 Yangshupu Power Station

Considering the policy orientation indicated by the state and the local government, and the characteristics of the historic culture and economic development of Huzhou, SPIC presented a proposal for Huzhou to establish a Smart Energy Prosumer (SEP) in 2022. Specifically, the city may construct user-side energy storage stations featuring massive capacity, and make full use of distributed new energy such as home-stored energy and photovoltaic energy, and user-side flexible resources, including resources from office buildings and factories, to form a load-adjustable resource pool. Furthermore, with the help of Dubhe One Integrated Smart Energy Management and Service Platform, it can forecast load accurately, allocate new energy resources effectively, and regulate supply and demand-side resources dynamically, thus contributing to the stable, flexible, and efficient operation of grids. Dubhe One, a platform developed by SPIC, has worked for nearly 34.8GW installed capacity in source, storage, and load links so far, and was granted the patent for invention by China National Intellectual Property Administration in 2023.

Nowadays, China witnesses the presence of 350 million electric motorcycles. In 2012, Huzhou, a pilot city encouraging the application of new energy vehicles, initiated Tianneng Circular Economy Industrial Park in Changxing County whose GDP makes up 22% of Huzhou's GDP to manufacture environment-friendly batteries for motorcycles.

In September 2022, SPIC and Changxing Tahoe Electric Technology Co., Ltd. jointly invested USD 13 million to launch the world's largest lead-carbon energy storage station adjacent to the Industrial Park by using lead-carbon batteries produced by Tianneng Group in the Park and adopting standard-based design and modular installation. With the designed capacity of 100MW/1061MWh, the station works to charge in the valley period, and stores 1000MWh after each full charge, which can meet the electricity needs of 80000 local households one day. Phase I of this project is designed with a capacity of 45MW/477MWh, and has an annual peak load regulation capacity of 140GWh since it was put into service in June 2023. It will help cut electricity expenses by over USD 1 million for the Park per year. Phase II has a planned capacity of 55MW/584MWh and is expected to start work by the end of 2025. After Phase I and II put into operation, the annual peak load regulation capacity will reach more than 300GWh.

Fig. 4 Lead-carbon Energy Storage Station Project

Fig. 5 Station Project and the Industrial Park Nearby

Dingjiawan Village close to the SEP in Huzhou is inhabited

by 42 households. As an extending project of the lead-carbon energy storage station, the Prosumer equips Heping Village households with home energy storage devices practically, making Heping the first demonstration village that enabled whole village usage of household energy storage in China. Furthermore, photovoltaic power facilities and charging piles are erected according to the actual conditions of house roofs locally, allowing all households to serve as energy prosumers, and bringing energy self-balance in the village. These efforts help meet emergency electricity needs in case of grid outages, balance energy supply and demand, reduce electricity costs, and enable low-carbon and affordable electricity supply. In the coming future, when home energy storage comes with a scale effect, and is incorporated into electricity market trading, residents in the village will also gain incremental income.

Fig. 6 Changxing County

Fig. 7 Home Energy Storage

Neighboring Changxing County, Anji County in Huzhou, is the first county to win the UN-Habitat Scroll of Honour award in China. Director Ang Lee said, “It is Anji that makes the

Crouching Tiger, Hidden Dragon a big hit."

Fig. 8 Anji Bamboo Forest

Fig. 9 Crouching Tiger, Hidden Dragon

Anji is naturally endowed with rich light resources and fresh air, thus being an ideal place for photovoltaic power projects. And Huzhou pioneered freshwater aquaculture in China, with extensive experience in this field. Therefore, SPIC sponsored a 50MW project integrating freshwater aquaculture and photovoltaic power generation at an 83-ha pond near Caodang Village, Anji County in 2017, and constructed a 110kV booster station to connect photovoltaic power generated into the grid. As photovoltaic panels make for relatively constant water temperatures in hot summers and cold winters, villagers culture better quality fish at reduced costs, with an annual yield of up to 310t.

In December 2022, the SEP in Huzhou included this 50MW project in the Dubhe One smart system.

SPIC boasts nearly 70GW and 50GW PV and wind power units respectively that are dotted on the vast expanse of land. In this case, smart approaches play an increasingly critical role in

managing large-scale stations with diverse new energy sources.

In 2023, SPIC rolled out its “smart plant” blueprint. We have integrated new energy power stations sharing similar geographical, economic, and cultural features into provincial-level station clusters, and adopted smart solutions to efficiently manage equipment operation and maintenance. SPIC 100 demonstration smart plants in service have scored a preliminary success. They provide safer and more efficient operations and additionally facilitate power trading. SPIC always takes its employees’ physical and mental safety and health into serious consideration. With the help of smart plants, employees are liberated from isolation in remote areas and they can engage in more important and productive tasks since smart plant requires less or no field workforce. Huzhou SEP is proudly selected as a demonstration smart plant out of the 100 stations.

Fig. 10 Huzhou Mulberry-dike Fish Pond

Fig. 11 Anji Caodang Photovoltaic and Fishing Pond

This SEP in Huzhou combines photovoltaic power, energy storage, charging piles, and big data to form a micro-grid system in which diverse energy resources complement each other. The

mini-sized low-carbon park building on the micro-grid system allows independent production for consumption, surplus energy storage, and peak shaving and valley filling. It is a new attempt by the Prosumer in the factory of Anji Chang Hong Chain Manufacturing Co., Ltd. The project covers distributed photovoltaic power equipment, photovoltaic carports, energy storage systems, and DC fast charging piles. In 2022, it was listed in the first batch of park-level generation-grid-load-storage integration demonstration projects of new power systems under the 14th five-year plan in Zhejiang Province and was granted USD 85000 government subsidy from the province.

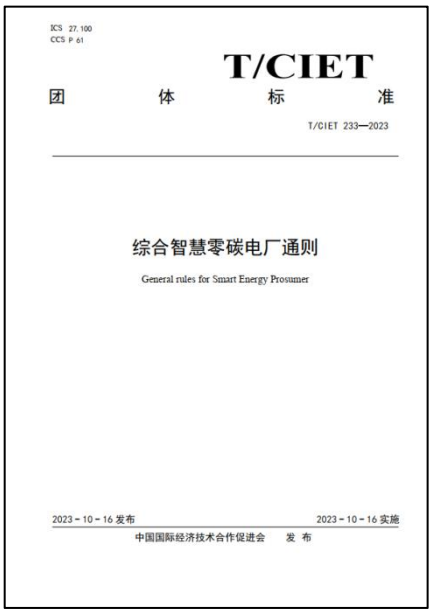
Fig. 12 Huzhou Changhong Generation-grid-load-storage Integration Demonstration Project

The favorable practice of this SEP shores up the confidence of Huzhou to engage in smart low-carbon energy projects. By 2025, Huzhou plans to roll out similar projects in 100 villages

out of 10 towns in 4 counties.

In 2023, SPIC compiled the *General Rules for Smart Energy Prosumer*, the first standard in this field at home. As inspired by the outstanding performance in Huzhou, SPIC has established an additional 9 SEPs in Zhejiang Province, rising the peak supply capacity by over 1.45GW for the province. To ease the strain of 4GW electricity gap in Zhejiang Province by 2025, SPIC intends to construct more SEPs by pooling 1.4GW new energy, 5GWh energy storage, and 0.7GW residential, commercial and industrial adjustable load resource in the province. With an investment of only RMB 10 billion, one provincial-level SEP can meet the 50% peak supply need of Zhejiang. To accomplish the same peak supply, it will need to construct 5 gigawatt-class thermal generator units, by investing over RMB 20 billion.

By the end of 2025, the figure will grow to 3GW. These prosumers can supply 12TWh of green electricity while securing an emission reduction effect equivalent to 24 Xixi wetlands (whose total area is nearly the same as 96 New York Central Parks). These SEPs are expected to offer additional 5000 jobs, increase GDP by approximately RMB 2.7 billion, and save carbon taxes by about RMB 1 billion in future export trade. Moreover, these projects will provide users with reassuring, green, and affordable power safely and constantly, freeing them from power shortage.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General rules for Smart Energy Prosumer

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Fig. 12 General Rules for Smart Energy Prosumer

Fig. 13 Hangzhou Xixi Wetland

Strides will be surely made by integrating distributed energy sources and by installing new energy equipment. SPIC takes immense pride in delivering efficient, stable, affordable, and low-carbon electricity supply to rural and urban areas. Until the end of 2023, SPIC has completed 134 SEPs in over 100 cities nationwide. By the end of 2024, it is expected that the SEP in Huzhou will expand distributed new energy by 300MW and stored energy by 100MW, and undertake works such as new heat supply pumps, and charging and battery swap stations to achieve the peak supply capacity of 500MW. The ever-growing Prosumer is powering Huzhou to carry forward the long-standing history and usher in a smart future. By the end of 2025, SPIC will sponsor SEPs in over 1000 counties out of 31 provinces in China.

China has made numerous time-honored and significant

engineering breakthroughs, such as the Grand Canal. This rigorously-planned water conservancy project was recognized as a holistic solution to confluence, diversion, water conservation, shipping, and flood control, benefiting people along the water route from Beijing to Hangzhou.

Carrying forward the wisdom, determination and courage of the 2700-year utility masterpiece, we will forge ahead with our new energy undertaking in the digital era to roll out smart new energy plants nationwide.

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I	**Strategies**			
1	**Innovation**			
1.1	Is the innovative concept come from the project itself or other existing programs?	Chapter 4 Chapter 5 Chapter 6	P8-P10 P21-P23 P24	Yes. This innovative concept holds groundbreaking significance, and has been translated into practice across multiple domestic projects. 1) SPIC is the first to propose smart energy prosumer (SEP) solutions in China. 2) The Huzhou SEP marks the pioneering venture in China. 3) In December 2022, Phase I of the project was connected to the Zhejiang power grid, supporting sufficient power supply in winter. 4) At the end of 2022, the Suzhou SEP and the Baoding SEP were integrated into power grids as well. Background: **COP21** set the goal of capping the global temperature rise at 1.5°C. In 2015, the Chinese government outlined its overall requirements, goals, and vision of ecological civilization. Innovation and smart application of clean energy are crucial pathways for response to climate change. In this context, SPIC proposed a brand new "smart energy prosumer" concept. This new model of low-carbon energy supply pools separate distributed new energy sources, energy storage, and adjustable load resources. As of the end of 2023, SPIC has completed 134 in-progress SEPs across over 100 cities in China. And it takes a steadfast commitment to expanding SEPs across over 1000 counties nationwide by the end of 2025.
1.2	How the innovative policy design encourages financial support and public-private partnership?	Chapter 5 Chapter 7	P21 P26	Yes. The Huzhou SEP was partially invested by another company and received a government subsidy from Zhejiang Province. Now, SPIC is applying for other government subsidies. 1) The Heping energy storage station project, a core project of the Huzhou SEP, is jointly invested by SPIC (the major shareholder) and Changxing Tahoe Electric Technology Co., Ltd., a lead-carbon battery solution provider in the local. 2) At the end of 2022, this project was recognized as a pilot project of new power systems by the Zhejiang Provincial Government. The applications for provincial government subsidies have been submitted for approval. The smart project of "Source-grid-load-storage" integration for Changhong Company in Anji was granted a

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				USD 85000 government subsidy from the province.
1.3	How does the innovative concept catch the trend of future development?	Chapter 4 Chapter 5 Chapter 6	P9-P10 P22 P24-P25	In December 2022, Phase I of the Huzhou SEP was connected to the Zhejiang power grid. As of the end of 2023, SPIC has completed an additional 9 SEPs within Zhejiang Province. By the end of 2025, SPIC will roll out its SEP roadmap in industrial parks, and urban and rural areas within Zhejiang. These SEP projects will supply 3GW power flexibly to Zhejiang, grow the domestic demand by USD 5.6 billion, offer 40000 jobs, slash carbon taxes by RMB 5 billion for export-oriented enterprises, and reduce carbon dioxide emissions by 11 million tons.
2	**Inspiration**			
2.1	Whether the idea can inspire later/subsequent cases?	Chapter 4 Chapter 5	P8 P24	Yes. 1. Design Philosophy The Huzhou SEP is proudly equipped with the "Dubhe One" smart control system. This smart platform controls and dispatches geographically-dotted new energy plants, energy storage stations, and adjustable load in a smart, precise, and centralized manner, enabling source-load-storage integration. This innovative practice allows stable, flexible, and streamlined grid regulation, provides users with affordable, low-carbon, and efficient energy supply, and gains favorable return on investment under the power market operation mechanism. 2. Experience sharing The Huzhou SEP adopts the cooperation mechanism integrating **local enterprises, regional investment platforms, system integration providers, and technology companies**. With the support from a battery manufacturer in Changxing County, this project features substantial user-side energy storage capacity and has gained better-than-expected earnings.
2.2	What domain has been enlightened by this policy?	Chapter 3	P5-P7	1. National energy policies of China China remains steadfast in improving the market-oriented trading mechanism for distributed power generation, as stated in the *Guiding Opinions on Accelerating the Construction of a National Unified Electricity Market System* issued in January 2022. 2. Provincial energy policies of Zhejiang Province Zhejiang Province released the *Regulations of Zhejiang Province on Electric Power* in September 2022, encouraging energy storage.

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				This document specifies the establishment and enhancement of mechanisms dedicated to transaction settlement and operation scheduling between bulk grids and mini-grids, small grids in service, or grids under construction. These policies robustly support the development of domestic energy storage and distributed photovoltaic sectors, and drive the boom of smart energy prosumers.
3	**Clarity**			
3.1	Is there any open and transparent channel of public communication?	Chapter 8	P27	Yes. 1) The Huzhou SEP was widely reported by the Huzhou Municipal Government, Zhejiang Provincial Government, and other 11 local governments. 2) This SEP project received 11 reports from state-level official media including news.cn and cfi.cn after its Phase I was connected to the power grid. 3) Over 100 promotional articles concerning this project were published in over 50 WeChat official accounts including those of news.cn, SPIC and its power company in Zhejiang.
3.2	Is there any difference between this policy and other similar policies?	Chapter 4	P8	Yes. A SEP is a more advanced virtual power plant (VPP) than an ordinary load-side VPP, integrating source, grid, load, and storage. The SEP can harness a broader range of energy sources, including biomass and other non-electrical resources. With better characteristics of response to parameters, its "Dubhe One" smart system forecasts load accurately, allocates energy resources effectively, and regulates supply and demand-side resources dynamically, thus contributing to the stable, flexible, and efficient operation of grids.
II	**Measures**			
4	**Feasibility**			
4.1	Has any effective measure for moving ahead been made?	Chapter 4	P9-P10	Yes. All milestones of the Huzhou SEP were achieved on schedule or ahead of time. 1) In August 2022, SPIC proposed a brand new "smart energy prosumer" concept for the first time. 2) In September 2022, SPIC commenced planning, design, and construction of the Huzhou SEP. 3) In October 2022, SPIC prepared the *Technical Manual for Development of the Smart Energy Prosumer*, and the *Guide for*

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				Analysis Model of Customer Requirements, and its Application for the Smart Energy Prosumer, and passed the review of the industry expert panel. The milestones of the project were set according to these two documents. 4) In December 2022, Phase I of the Huzhou SEP was connected to the Zhejiang power grid. 5) In June 2023, the peak supply capacity increased by 0.2GW. 6) In December 2023, the peak supply capacity grew by 0.3GW. 7) In 2024, the peak supply capacity will rise to 0.5GW, and the Huzhou SEP will be finally completed.
4.2	Is there any numerical goals for reference?	Chapter 5	P19	Yes. As of December 2023, the Huzhou SEP has achieved a peak supply capacity of 0.3GW, bolstering the power grid effectively. After completion in 2024, the project will supply 200GWh green power each year. It will reduce standard coal emissions by 60000 tons, CO_2 emissions by 165000 tons, SO_2 emissions by 17 tons, and NO_x emissions by 27 tons annually.
5	**Replicability**			
5.1	Could the ideas, methods or techniques be applied internationally?	Chapter 5	P22	Yes. In November 2023, SPIC commenced a SEP for Ichihara Hospital in Tsukuba, Ibaraki-ken. After completion, this project will help the hospital reduce carbon dioxide emissions by 348 tons annually, and provide the emergency power supply in the event of natural disasters such as typhoons, and earthquakes.
6	**Cost effectiveness**			
6.1	Will it be cost-effective to implement?	Chapter 5	P19	Yes. The Huzhou SEP achieves an 80% reduction in the construction period and a 66% decrease in investment compared to a traditional thermal power plant, assuming they possess the same peak supply capacity. Under the equivalent electricity sales, the former will see significantly less strain on grid infrastructure investment.
6.2	Is there any measurable reduction of emission or energy use? Please describe the measurement method.	Chapter 5	P20	Yes. After completion by the end of 2024, the Huzhou SEP will: 1) Supply 200GWh green power annually; 2) Reduce standard coal emissions by 60000 tons annually; 3) Reduce CO_2 emissions by 165000 tons annually;

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				4) Reduce SO_2 emissions by 17 tons; 5) Reduce NO_x emissions by 27 tons annually. *The data above is measured according to the calculation methodology in the 2023 Annual Development Report of China Power Industry. In 2022, the standard coal consumption was 300.7g/kWh; the CO_2 emission 824g/kWh; the SO_2 and NO_x emissions 83mg/kWh and 133mg/kWh respectively in 6000kW thermal power plants or above nationwide.*
7	**Consistency**			
7.1	Are adopted measures consistent with energy policy and strategy?	Chapter 3	P5-P6	Yes. 1. International policy Consistent with the long-term goals of holding global temperature rise as set in the *Paris Agreement*. 2. Policies of China 1) Consistent with China's strategic direction of energy conservation, emission reduction, and combat against pollution as directed in the *14th Five-year Plan on Energy Conservation and Emission Reduction*. 2) Consistent with China's dual carbon goals of peaking carbon emissions by 2030 and reaching carbon neutrality by 2060. 3) Consistent with China's strategy for energy security that promotes a green revolution in energy consumption, supply, technology, and systems, and strengthens international cooperation in an all-round way. 3. Policies of Zhejiang Province Consistent with Zhejiang's guideline that energy storage should be promoted aligning with the regulation capacity requirements of the power system as outlined in the *Regulations of Zhejiang Province on Electric Power* issued in 2022.
7.2	Is there any long-term measure or implementing organization for this project?	Chapter 6	P24-P25	Yes. SPIC tasks its power company in Zhejiang with establishing more SEPs in Huzhou, and other cities in Zhejiang Province. SPIC devotes itself to a SEP for Ichihara Hospital in Tsukuba, Ibaraki-ken, and 134 SEPs in China.
III	**Achievements**			
8	**Tangible performance**			
8.1	Is the achievement scale measurable?	Chapter 5	P20	Yes. The achievement scale can be measured by the following data. 1) Peak supply capacity, and peak load management capacity; 2) Annual green power supply; 3) Annual reduction of standard coal emissions; 4) Annual reduction of CO_2 emissions; 5) Annual reduction of SO_2 emissions;

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				6) Annual reduction of NO_X emissions; 7) Annual reduction of energy costs for enterprise users; 8) Annual output value.
8.2	Will it make a considerable success in project goals?	Chapter 5	P20	Yes. As of June 2023, the Huzhou SEP has achieved a peak supply capacity of 0.2GW, bolstering the power grid effectively. As of December 2023, the project has achieved a peak supply capacity of 0.3GW, meeting the set goal.
9	**Verifiability**			
9.1	Is there any data presented to support the project?	Chapter 5	P19-P20	Yes. Data supporting the project is detailed as follows. 1. Quantifiable data of targets 1) In September 2022, the targets for the Huzhou SEP were set: peak supply capacity of 0.2GW by June 2023; peak supply capacity of 0.3GW by December 2023; total peak supply capacity of 0.5GW, and final completion by the end of 2024. 2. Data of milestones 1) In September 2022, SPIC commenced planning, design, and construction of the Huzhou SEP. 2) In December 2022, Phase I of the Huzhou SEP was connected to the Zhejiang power grid. 3) In June 2023, the peak supply capacity increased by 0.2GW. 4) In December 2023, the peak supply capacity grew by 0.3GW. 3. Effect data After completion, the project will supply 200GWh green power each year. It will reduce standard coal emissions by 60000 tons, CO_2 emissions by 165000 tons, SO_2 emissions by 17 tons, and NO^x emissions by 27 tons annually.
9.2	Is there any supportive measurement or reference for the provided data?	Chapter 4 Chapter 9	P9 P30	Yes. 1) In October 2022, SPIC prepared the *Technical Manual for Development of the Smart Energy Prosumer*, and the *Guide for Analysis Model of Customer Requirements, and its Application for the Smart Energy Prosumer*. 2) In November 2023, the *General Rules for Smart Energy Prosumers* drafted by SPIC was published on the national group standard platform (https://www.ttbz.org.cn/). 3) In November 2023, the *Specification of Adjustable Load Monitoring and Interface for Virtual Power Plant Electric Boiler System*, the *Specification of Adjustable Load*

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				Monitoring and Interface for Virtual Power Plant Air Compressor System, the *Specification of Adjustable Load Monitoring and Interface for Virtual Power Plant Ice Storage Air Conditioning System*, and the *Specification of Adjustable Load Monitoring and Interface for Virtual Power Plant Split Air Conditioning System* were published successively and constituted China's first standards related to edge computing in IoT for virtual power plants/smart energy prosumers. 4) The effect data of the Huzhou SEP is subject to the calculation methodology in the *2023 Annual Development Report of China Power Industry*.
10	**Influence**			
10.1	Will it make a significant change in the field of energy efficiency and energy saving?	Chapter 5	P19	Yes. With the help of the "Dubhe One" smart energy system, the Huzhou SEP will consume more supply-side new energy, and enhance the user-side energy efficiency. By leveraging mass historical data of electrical load, and the AI-based mathematic model, the "Dubhe One" can forecast load accurately, and allocate distributed new energy resources effectively and dynamically, thus contributing to the safe and stable operation of grids. After completion, the project will supply 200GWh green power each year. And it will reduce standard coal emissions by 60000 tons, and CO_2 emissions by 165000 tons. Additionally, it will help enterprises cut power costs by 15%, and create value equivalent to 200000 green power certificates.
10.2	Will it impact multiple operational areas or just single specific area?	Chapter 5	P21-P22	The Huzhou SEP will impact multiple operational areas. 1. Impacts on Zhejiang The Huzhou SEP has become an empirical practice preliminarily and is available for promotion throughout Zhejiang Province. By now, SPIC has expanded its SEP model in 90 districts/counties out of 11 prefecture-level cities in Zhejiang, supporting power supply robustly within the province. 2. Impacts on other parts of China As of October 2023, SPIC has 134 in-progress SEPs, and 368 completed projects in a number of cities including Baoding, Hebei Province, Suzhou, Jiangsu Province, and Shenzhen, Guangdong Province. The in-service installed capacity has reached 3.35GW, and the peak supply capacity 3.18GW. These SEPs have backed power supply vigorously in the localities.

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				3. Impacts on other economies In November 2023, SPIC commenced a SEP for Ichihara Hospital in Tsukuba, Ibaraki-ken. After completion, this project will help the hospital reduce carbon dioxide emissions by 348 tons annually, and provide the emergency power supply in the event of natural disasters such as typhoons, and earthquakes. 4. Impacts on power grids Power grids and SEPs rely on and reinforce each other, akin to the interdependency between aortas and the blood capillaries in the human body. Focusing on user-side and grid-side needs, SEPs can allocate the best resources effectively, and mitigate load fluctuations, thereby ensuring the safe, stable, and cost-effective operation of power grids.
11	**Inclusiveness**			
11.1	Whether it is gender inclusive?	Chapter 5	P23	Yes. 1. Complected projects SPIC organizes skill training sessions for local female residents and helps them engage in cleaning and maintenance in photovoltaic power stations, and energy storage stations, increasing their income. In turn, these trained female residents communicate the low-carbon development concept to their families and communities, encouraging all residents in the local to protect the natural environment. 2. New projects There is a cultural tourism project, Yuzhuang Resort, in Digang Village featuring mulberry-dike fish ponds that has been recognized as the “Globally Important Agricultural Heritage” by the UN’s Food and Agriculture Organization. The Huzhou SEP will present female business leaders with access to mini-grids with diverse and complementary energy sources, contributing to the boom of the green economy.
12	**Energy justice and equity**			

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12.1	Will the project deliver domestically defined equitable benefits, and pursue positive environmental, social, and economic outcomes?	Chapter 5	P19	Yes. The Huzhou SEP was designated as a pilot project for 2023 new power systems in Zhejiang Province to ensure a safe and stable power supply. This project achieves an 80% reduction in the construction period and a 66% decrease in investment compared to a traditional thermal power plant, assuming they possess the same peak supply capacity. Under the equivalent electricity sales, the former will see significantly less strain on grid infrastructure investment. Therefore, the project has been widely recognized by the government and the power grid. The Huzhou SEP has become an empirical practice in Zhejiang, and other parts of China. Now, SPIC is making intensive efforts to promote this innovative development model.
12.2	Will the project create resilient firms, institutions, and communities, and provide support for decent work and workforce development?	Chapter 4 Chapter 5	P11 P23	Yes. The Huzhou SEP is jointly invested by SPIC (the major shareholder) and Changxing Tahoe Electric Technology Co., Ltd., a lead-carbon battery solution provider in the local. A joint venture has been established to boost this project. In the Huzhou SEP, SPIC establishes an innovative development model for the local new energy industry and offers approximately 5000 jobs of station operation and maintenance for residents, especially rural females. This project boosts the rapid growth of the new energy industry in Huzhou and the far-reaching spread of the low-carbon development concept.
13	**Notes**			
13.1	Awards.	Chapter 7	P26-P27	1. Huzhou SEP 1) In December 2022, the Huzhou SEP was recognized as a pilot project of new power systems by the Zhejiang Provincial Development and Reform Commission. 2) In 2022, the Changhong project in the Huzhou SEP was listed in the first batch of park-level source-grid-load-storage integration demonstration projects of new power systems under the 14th five-year plan in Zhejiang Province and was granted USD 85000 government subsidy from the province. 3) In February 2023, the Heping energy storage station, the core project of the Huzhou SEP, was acknowledged as the user-side energy storage demonstration project in Zhejiang Province. 2. SPIC 1) In 2023, SPIC was listed in the Top 10 ESG model enterprises in China. 2) SPIC was honored as one of the Top 30 in the "Corporate Green and Low Carbon

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				Leadership Index" at the 2023 China Brand Forum organized by People's Daily (one of the world's top ten newspapers recognized by UNESCO). 3. Others In 2023, SPIC was awarded the "Energy Transition Changemaker" by **COP28**.
13.2	Patents and standards.	Chapter 9	P28-P29	1) In July 2023, SPIC was granted a patent titled "photovoltaic generating capacity model training method and system based on successive model fusion" for its "Dubhe One" platform by China National Intellectual Property Administration. Furthermore, 15 patent applications were under review, including the application named "multicast real-time control method based on synchronous timestamp in oversized network". 2) In 2023, SPIC's "Dubhe One" won the second prize in the First Energy Electronics Industry Innovation Competition. 3) In November 2023, the *General Rules for Smart Energy Prosumers* drafted by SPIC was published on the national group standard platform (https://www.ttbz.org.cn/). 4) In November 2023, the *Specification of Adjustable Load Monitoring and Interface for Virtual Power Plant Electric Boiler System*, the *Specification of Adjustable Load Monitoring and Interface for Virtual Power Plant Air Compressor System*, the *Specification of Adjustable Load Monitoring and Interface for Virtual Power Plant Ice Storage Air Conditioning System*, and the *Specification of Adjustable Load Monitoring and Interface for Virtual Power Plant Split Air Conditioning System* were published by Jiangsu Province Renewable Energy Industry Association successively and constituted China's first standards related to edge computing in IoT for virtual power plants/smart energy prosumers.

Contents

1. Huzhou Overview

Standing 150km away west of Shanghai, Huzhou is famous for its time-honored history of 2300 years, and rich cultural heritage in Zhejiang Province. Its abundant resources including silk, fish, and rice highlight its strong presence in the regions south of the Yangtze River (Jiangnan regions), just as testified by a great compliment of the poet Dai Biaoyuan (1244-1310), “Huzhou is the best option among these lovely and livable places in Jiangnan regions.”

Today, Huzhou is the birthplace of the green development concept “lucid waters and lush mountains are invaluable assets”, a model of practicing the “Chinese Beautiful Villages” initiative, and a pioneer of advancing green development. In 2014, Huzhou became China's first municipal demonstration zone for ecological civilization. In 2015, Huzhou led the formulation of the *Guidelines for the Construction of Beautiful Villages*, and was listed among the first national ecological civilization demonstration cities. In December 2022, Huzhou was conferred the title of International Cooperation Demonstration Zone of Ecological Civilization, the only city in the world to win this honor, by the United Nations Convention on Biological Diversity.

Huzhou has been a place of abundance since antiquity. The

production and sales volumes of children's clothing in Wuxing, wood flooring in Nanxun, plates in Deqing, storage batteries in Changxing, and chairs in Anji account for 65%, 66%, 70%, 80%, and 33% nationwide respectively. The booming high-end equipment, modern textile, leisure tourism, new metal materials, and green household sectors as well as core sectors of the digital economy constitute the promising industrial clusters, ranking Huzhou the 27th place among the Top 100 Advanced Manufacturing Cities in China. In 2022, the city, with a population of 3.37 million, posted a GDP of USD 54.2 billion and ranked top in economic growth throughout Zhejiang Province for the third consecutive year.

2. Huzhou Energy Consumption, and Current Development Situation

The high-quality development of Huzhou requires substantial energy consumption and heavily depends on robust energy support.

Energy consumption in Zhejiang Province is characterized by significant shares of new energy and purchased power, along with a substantial peak-to-valley difference. 2021 and 2022 witnessed that the maximum power load broke 100GW barriers, with electricity shortfall lasting for 9 months each year. By 2025,

this gap is expected to widen to 13GW. During the summer of 2022, Zhejiang experienced an electricity shortage of up to 12GW to meet the peak demand, and the peak-to-valley difference hit 38GW.

Confronted with the imbalance between supply and demand, Zhejiang is compelled to purchase power from other provinces at excessively high prices. Responding to the call of the National Energy Administration to improve the market-oriented trading mechanism for distributed power generation, Zhejiang Province released the *Regulations of Zhejiang Province on Electric Power* in 2022, encouraging energy storage. This document specifies the establishment and enhancement of mechanisms dedicated to transaction settlement and operation scheduling between bulk grids and mini-grids, small grids in service, or grids under construction.

While facing power consumption characteristics and a supply-demand landscape similar to those of Zhejiang, Huzhou has redoubled its efforts to construct power facilities.

As of December 2022, the installed capacity of new energy generation amounted to 2.3043GW in Huzhou, including 2.0668GW of photovoltaic generation capacity, marking the new energy generation installed capacity taking 52.86% of the total

installed capacity of power generation.

Besides, Huzhou tapped into clean power from Baihetan Hydropower Station, a mega power project in southwest China, via UHV DC transmission lines.

In 2022, Huzhou registered a total electricity consumption of 35.412TWh. To be specific, the primary industry consumed 379GWh; the secondary industry 26.007TWh; the tertiary industry 4.995TWh; households 3.929TWh.

At present, the power supply capacity in Huzhou is struggling to keep pace with its rapid development. In 2022, Huzhou faced a pronounced strain on power supply, with the electricity shortage reaching up to 1.3GW. Ranking the 50th place in the national top 100 counties, Changxing County in Huzhou requires extensive power demands for its industrial sectors, air-conditioning units in industrial and commercial buildings, and energy storage and other facilities, resulting in an electricity gap of 0.35GW.

3. Policies

The international community, including China, has been pursuing a common goal of adopting safe, green, and low-carbon energy solutions reliably and effectively in both production and daily life. To achieve this goal, policies have

been introduced to promote the innovative development of energy sectors.

1) *Paris Agreement* of the United Nations

The *Paris Agreement* concluded in December 2015 sets the goals to hold global temperature increase to well below 2°C above pre-industrial levels and pursue efforts to limit it to 1.5°C above pre-industrial levels.

2) Energy policies of China

(1) China is committed to enhancing energy efficiency, reducing carbon emission intensity, and advancing the green transition of economic and social development, according to its 14th five-year plan on energy conservation and emission reduction.

(2) In 2014, China defined its strategy for energy security that promotes a green revolution in energy consumption, supply, technology, and systems, and strengthens international cooperation in an all-round way.

(3) In 2020, China announced its dual carbon goals of peaking carbon emissions by 2030 and reaching carbon neutrality by 2060.

(4) In 2021, China proposed the development of a new electric power systems based on new energy sources.

(5) China remains steadfast in improving the market-oriented trading mechanism for distributed power generation, as stated in the *Guiding Opinions on Accelerating the Construction of a National Unified Electricity Market System* issued by the National Development and Reform Commission and the National Energy Administration in January 2022.

3) Policies of Huzhou City, and Zhejiang Province

(1) Energy storage should be directed towards a path of safe, orderly, and market-oriented development. For this purpose, pumped storage power stations and new energy storage projects should be allocated reasonably, aligning with the regulation capacity requirements of the power system, and considering regional resource advantages. This is delineated in Article 16 of the *Regulations of Zhejiang Province on Electric Power* released by the Standing Committee of Zhejiang Provincial People's Congress on September 29, 2022. Efforts should be made to develop and define the market-oriented power pricing mechanism, the medium/long-term, and spot trading mechanism, and the mechanisms dedicated to transaction settlement and operation scheduling between bulk grids and mini-grids,

small grids in service or grids under construction, according to Article 31.

(2) The power pricing structure for large-scale industrial facilities, and general industrial and commercial users keeps consistent with daily power demands featuring two peaks and two valleys. This lays a conducive basis for Huzhou to establish a smart energy prosumer (SEP).

(3) Huzhou stays committed to charting a course towards green and low-carbon energy development, guided by the principle of "lucid waters and lush mountains being invaluable assets".

4. Features and Particulars of the Huzhou SEP

State Power Investment Corporation Limited (SPIC) stands as one of China's five major power generation groups, extending its presence across 47 countries/regions. In 2023, SPIC ranked the 262nd place among the Fortune Global 500. Its clean energy measures 167GW, representing over 70% of its total installed capacity. As the world's largest PV generation giant, SPIC holds the top spot globally in terms of its installed capacity of new and clean energy.

Embracing a great vision of "growing into a world-class

clean energy enterprise", SPIC keeps moving ahead in the realm of clean energy. As a notable milestone, SPIC became the first at home to present the "smart energy prosumer" concept in August 2022 and then embarked on SEP pilot projects in Huzhou and other parts across China.

The Huzhou SEP is proudly equipped with the "Dubhe One" smart control system, which is different from the traditional power station. The smart platform controls and dispatches geographically-dotted new energy plants, energy storage stations, and adjustable load in a smart, precise, and centralized manner, enabling source-load-storage integration. This innovative practice allows stable, flexible, and streamlined grid regulation, provides users with affordable, low-carbon, and efficient energy supply, and gains favorable return on investment under the power market operation mechanism.

A SEP is a more advanced virtual power plant (VPP) than an ordinary load-side VPP, integrating source, grid, load, and storage. The SEP can harness a broader range of energy sources, including biomass and other non-electrical resources. With better characteristics of response to parameters, its "Dubhe One" smart system forecasts load accurately, allocates energy resources effectively, and regulates supply and demand-side

resources dynamically, thus contributing to the stable, flexible, and efficient operation of grids.

SPIC consolidated its top talent for the Huzhou SEP project. With concerted efforts, all milestones of the project were achieved on schedule or ahead of time.

(1) In September 2022, SPIC commenced planning, design and construction of the Huzhou SEP.

(2) In October 2022, SPIC prepared the *Technical Manual for Development of the Smart Energy Prosumer*, and the *Guide for Analysis Model of Customer Requirements, and its Application for the Smart Energy Prosumer*, and passed the review of the industry expert panel. The milestones of the project were set according to these two documents.

(3) In November 2022, the Heping lead-carbon energy storage station started construction.

(4) In December 2022, Phase I of the project integrated distributed PV generation, user-side load, lead-carbon energy storage, and user-side energy storage, and was connected to the Zhejiang power grid, supporting sufficient power supply in winter.

(5) In June 2023, the peak supply capacity increased by 0.2GW;

(6) In November 2023, the *General Rules for Smart Energy Prosumers* drafted by SPIC was published on the national group standard platform (https://www.ttbz.org.cn/).

(7) In November 2023, the *Specification of Adjustable Load Monitoring and Interface for Virtual Power Plant Electric Boiler System*, the *Specification of Adjustable Load Monitoring and Interface for Virtual Power Plant Air Compressor System*, the *Specification of Adjustable Load Monitoring and Interface for Virtual Power Plant Ice Storage Air Conditioning System*, and the *Specification of Adjustable Load Monitoring and Interface for Virtual Power Plant Split Air Conditioning System* were published successively and constituted China's first standards related to edge computing in IoT for virtual power plants/smart energy prosumers.

(8) In December 2023, the peak supply capacity grew by 0.3GW.

As the first smart energy prosumer project in China, the Huzhou SEP is established with tremendous energy storage capacity building on the "Dubhe Cloud" platform self-developed SPIC. Its storage capacity is underpinned by lead-carbon storage batteries that are produced by Tianneng

Group, a leading accumulator enterprise in Changxing. Pooling smart power plants, user-side energy storage, and adjustable load resources in Huzhou, the SEP functions to mitigate load fluctuations, fill the peak supply gap, and provide customers with green power at lower costs. This project will be a contributor to ensuring sufficient power supply locallly, and enabling the flexible operation and better regulation of the power grid.

Fig. 4-1 "Dubhe One" Smart System for the Huzhou SEP

1) Heping lead-carbon energy storage station

With the designed capacity of 100MW/1061MWh, the station works to store 1GWh after each full charge during the valley period, which can meet the power demand of 80000 local households one day.

Phase I of this project is designed with a capacity of 45MW/477MWh and has an annual peak load regulation capacity of 140GWh since its energy storage system was put into service fully. It will help users in the Industrial Park cut electricity expenses by over RMB 10 million per year. Phase II has a planned capacity of 55MW/584MWh and is expected to start construction in 2024.

This gigawatt-class energy storage station serves as a power reservoir for the regional grid for peak shaving, peak load management, and frequency regulation. It will help Huzhou satisfy the power demand and increase the proportion of new energy sources in the energy mix for power generation.

This project is characterized by long battery cycle life, short construction period, high safety, low investment, and strong resource aggregation ability, thus offering robust market competitiveness.

The project has been included in the first new energy storage demonstration projects in Zhejiang Province during the 14th Five-year Plan period.

Fig. 4-2 Lead-carbon Energy Storage Station Project

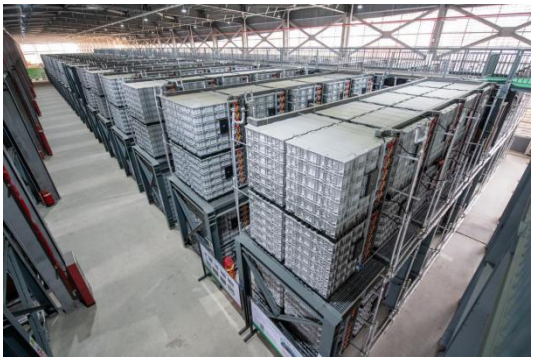

Fig. 4-3 Station Project and the Industrial Park Nearby

2) Home energy storage project

In Dingjiawan Village, Heping Township, Changxing County, Huzhou, SPIC launched the first home energy storage pilot project practically. Specifically, 42 households were equipped with home energy storage devices, including forty 11.5kWh lead-carbon storage batteries and two 10.5kWh lithium iron phosphate batteries. This pilot project enables all households to serve as energy prosumers. It will bring energy self-balance in the specific area and play a part in sufficient power supply by load regulation.

Fig. 4-4 Home Energy Storage

Fig. 4-5 Home Energy Storage Devices

3) Smart power plants with new energy sources

The Huzhou SEP consists of five smart power plants that have been completed. The Caodang Village 50MW project integrated freshwater aquaculture and photovoltaic power generation in Anji County. A comprehensive energy project of total installed photovoltaic capacity of 30MW contains 4 projects, including a 2.1MWp photovoltaic power generation project in the abandoned Xinjiang Mine, Changxing County, a photovoltaic power generation project in Jiangnanhong Village, Changxing County, a smart project of "source-grid-load-storage" integration for Changhong company in Anji, and Yuzhuang Resort Digang Village project.

(1) A 50MWp project integrating freshwater aquaculture and photovoltaic power generation in Caodang Village, Anji County

SPIC sponsored a 50MWp project integrating freshwater aquaculture and photovoltaic power generation in Caodang Village, Meixi Township, Anji County, the first project of this kind in Anji.

In December 2023, SPIC rolled out its "smart plant" blueprint. The project in Caodang Village has been listed in 100 demonstration smart plants. Efforts have been intensified to

upgrade security facilities in the power plant, adopt smart inspection in an unattended manner for the booster station, and establish a production and operation center for centralized, digital, and smart monitoring. As a result, this smart upgrade not only enables a safe and effective run of the project, but also facilitates efficient integration and collaboration between the power plant and the smart energy prosumer.

Fig. 4-6 Project Integrating Freshwater Aquaculture and Photovoltaic Power Generation in Caodang Village, Anji County

(2) A 2.1MWp photovoltaic power generation project in the abandoned Xinjiang Mine, Changxing County

This project is located in a 100*mu* (= 6.67 hectares) abandoned mine area in Zhaxi Village, Heping Township, Changxing County. The power plant offers job opportunities while promoting ecological restoration in the subsidence area

and the abandoned mine, as the first project of this kind invested by SPIC in Zhejiang.

Fig. 4-7 Photovoltaic Power Generation Project in the Abandoned Xinjiang Mine

(3) A photovoltaic power generation project in Jiangnanhong Village, Changxing County

This green energy project involves 150kWp and 35kWp distributed photovoltaic panels on the rooftop and the shed respectively, and 1 DC quick charging pile to boost the development of the revolution base. It is the first project of this kind constructed by SPIC in Zhejiang.

Fig. 4-8 Photovoltaic Power Generation Project in Jiangnanhong Village, Changxing County

(4) A smart project of "source-grid-load-storage" integration for Changhong company in Anji

This project has been included in the first pilot projects of new power systems in Zhejiang Province during the 14th Five-year Plan period.

Fig. 4-9 Smart Project of "Source-grid-load-storage" Integration for Changhong Company in Anji

(5) A comprehensive energy project for Yuzhuang Resort, Digang Village

SPIC, in collaboration with an ecological tourism company in Digang Village, is planning a comprehensive energy project that covers rooftop distributed photovoltaic panels, charging piles for new energy vehicles, and cleaning and heating facilities for hotel guest rooms. It is expected to deliver smart and zero-carbon power services to the ancient village that has been recognized as the “Globally Important Agricultural Heritage” by the United Nations.

Fig. 4-10 Comprehensive Energy Project for Yuzhuang Resort, Digang Village

4) Resource aggregation

At present, photovoltaic generation capacity, energy storage, and adjustable load from 88 enterprise users in Huzhou have been put in place, including 134.52MW photovoltaic and

wind power capacity, 69.30MW/682.78MWh energy storage, and 254.44MW adjustable load. Through user-side energy peak shaving management, the load from air-conditioning units in the office building of Huzhou Urban Construction & Investment Group, hotels, and supermarkets, and the adjustable load from Huzhou Convention and Exhibition Center, and Changxing Economic Development Zone have been included.

5. Value of the Huzhou SEP

With the help of the "Dubhe One" smart energy system, the Huzhou SEP will consume more supply-side new energy, and enhance the user-side energy efficiency. By leveraging mass historical data of electrical load, and the AI-based mathematic model, the "Dubhe One" can forecast load accurately, and allocate distributed new energy resources effectively and dynamically, thus contributing to the safe and stable operation of grids.

The Huzhou SEP achieves an 80% reduction in the construction period and a 66% decrease in investment compared to a traditional thermal power plant, assuming it possesses the same peak supply capacity. Under the equivalent electricity sales, the former will see significantly less strain on grid infrastructure

investment.

As of December 2023, the Huzhou SEP has achieved a peak supply capacity of 0.3GW, bolstering the power grid effectively. After completion in 2024, the project will:

(1) Supply 200GWh green power annually;

(2) Have the peak supply capacity of 0.5GW, the peak load management capacity of 0.4GW, and the frequency regulation of 0.2GW;

(3) Reduce standard coal emissions by 60000 tons, CO_2 emissions by 165000 tons, SO_2 emissions by 17 tons, and NO_x emissions by 27 tons annually, according to the calculation methodology in the *2023 Annual Development Report of China Power Industry*;

(4) Free nearly 100 people from exposure to common occupational diseases in thermal power plants such as pneumoconiosis, asbestosis, and noise-induced hearing loss every year;

(5) Help enterprises cut power costs by 15%, and create value equivalent to 200000 green power certificates.

In addition, the Huzhou SEP has made profound and widespread impacts across multiple communities and sectors in various regions.

1) Impacts on Zhejiang

The Huzhou SEP has boosted the lead-carbon storage battery sector locally and attracted more investment in green energy. The lead-carbon energy storage station project, a core project of the SEP, has introduced a new development model for the new energy sectors in Huzhou, and driven the boom of these sectors. This project is jointly invested by SPIC (the major shareholder) and Changxing Tahoe Electric Technology Co., Ltd., a lead-carbon battery solution provider in the local.

To implement the carbon dioxide peaking action plan, Huzhou intends to draw on replicable experiences and models of low-carbon or even zero-carbon development learned from the Huzhou SEP as a practical case. By 2025, Huzhou aims to establish 4 low-carbon pilot districts/counties, 10 low-carbon (zero-carbon) pilot townships (sub-districts), and 100 low-carbon (zero-carbon) pilot villages (communities).

The Huzhou SEP has become an empirical practice preliminarily and is available for promotion throughout Zhejiang Province. As of the end of 2023, SPIC has expanded its SEP model in 90 districts/counties out of 11 prefecture-level cities in Zhejiang Province, and constructed 9 SEPs, supporting power supply robustly in the province.

2) Impacts on other parts in China

As of October 2023, SPIC has 166 in-progress SEPs, and 368 completed projects in a number of cities including Baoding, Hebei Province, Suzhou, Jiangsu Province, and Shenzhen, Guangdong Province. The in-service installed capacity has reached 3.35GW, and the peak supply capacity 3.18GW. These SEPs have backed power supply vigorously in the localities.

3) Impacts on other economies

In November 2023, SPIC commenced a SEP for Ichihara Hospital in Tsukuba, Ibaraki-ken. After completion, this project will help the hospital reduce carbon dioxide emissions by 348 tons annually, and provide the emergency power supply in the event of natural disasters such as typhoons, and earthquakes.

4) Impacts on power grids

Power grids and SEPs rely on and reinforce each other, akin to the interdependency between aortas and the blood capillaries in the human body. Focusing on user-side and grid-side needs, SEPs can allocate the best resources effectively, and mitigate load fluctuations, thereby ensuring the safe, stable, and cost-effective operation of power grids.

5) Impacts on users

Firstly, SEPs provide green and low-carbon power for users

in a reassured and efficient manner by leveraging distributed PV facilities. Secondly, power stored by SEPs during off-peak periods is subsequently utilized to meet peak supply demands, lowering electricity costs for users. Thirdly, these SEPs effectively alleviate peak loads, ensuring uninterrupted power supply to users.

6) Impacts on female employment

During construction, operation, and maintenance, the completed projects, such as the project integrating freshwater aquaculture and photovoltaic power generation in Caodang Village, Anji County, and the home energy storage project in Changxing, bring job and income opportunities to residents, especially rural women. SPIC organizes skill training sessions for them and helps them engage in operation and maintenance in home-level or village-level photovoltaic power stations, and energy storage stations, increasing their income.

The newly implemented projects, such as the comprehensive energy project for Yuzhuang Resort and Digang Village, also present female business leaders with access to mini-grids with diverse and complementary energy sources. Besides, the project instance puts green and low-carbon energy services in place to boost the green economy, especially catering

and tourism sectors, and generates jobs for females in the local community.

The success of the Huzhou SEP is owed to the cooperation mechanism integrating **local enterprises, regional investment platforms, system integration providers, and technology companies**, and the battery manufacturer in Changxing County. With substantial user-side energy storage capacity, this project has gained better-than-expected earnings. This valuable empirical experience will lay a solid foundation for the establishment of more SEPs.

6. Future Implementation Plans

Phase II of the Heping energy storage station project is scheduled for construction in 2024, with an energy storage capacity of 55MW/584MWh, adding the total capacity of the project to 100MW/1061MWh. From 2023 to 2025, newly-built distributed photovoltaic panels and newly-developed user-side resources will be incorporated into this project. SPIC tasks its power company in Zhejiang with establishing more SEPs in Huzhou, and other cities in Zhejiang Province.

By the end of 2025, SPIC will roll out its SEP roadmap in industrial parks, and urban and rural areas within Zhejiang.

These SEP projects will supply 3GW power flexibly to Zhejiang, grow the domestic demand by USD 5.6 billion, offer 40000 jobs, slash carbon taxes by RMB 5 billion for export-oriented enterprises, and reduce carbon dioxide emissions by 11 million tons.

With the widespread promotion of SEPs from Zhejiang to other parts of China, SPIC takes a steadfast commitment to expanding SEPs across over 1000 counties nationwide by the end of 2025.

With the mature development of the electricity spot market and the introduction of more favorable new energy policies in China, SEPs will demonstrate their significant advantages in resource aggregation, precise user-side load forecast, and effective energy allocation during the engagement of new energy in the spot market. By smartly pooling diverse green power sources, these practices will supply affordable, low-carbon, and clean power to users, and facilitate effective source-storage-load allocation and coordination. This will result in a favorable return on investment under the power market operation mechanism.

7. Recognitions and Honors

1) SPIC

(1) In 2023, SPIC was listed in the Top 10 ESG model enterprises in China.

(2) SPIC was honored as one of the Top 30 in the "Corporate Green and Low Carbon Leadership Index" at the 2023 China Brand Forum organized by People's Daily (one of the world's top ten newspapers recognized by UNESCO).

2) Huzhou SEP

(1) On December 20, 2022, the Huzhou SEP was recognized as a pilot project of 2023 new power systems by Zhejiang Provincial Development and Reform Commission, and Zhejiang Energy Administration. The related reward is under approval.

(2) In 2022, the mini-grid in the factory of Anji Chang Hong Chain Manufacturing Co., Ltd. was listed in the first batch of park-level source-grid-load-storage integration demonstration projects of new power systems under the 14th five-year plan in Zhejiang Province and was granted USD 85000 government subsidy from the province. This mini-grid covered distributed photovoltaic panels, the photovoltaic shed, the energy storage system, and DC quick charging piles.

(3) On February 24, 2023, the Heping energy storage station

was acknowledged as the user-side energy storage demonstration project in Zhejiang Province.

3) Others

(1) In 2023, SPIC was awarded the “Energy Transition Changemaker” by COP28.

(2) In 2023, SPIC’s “Dubhe One” won the second prize in the First Energy Electronics Industry Innovation Competition.

8. Media Reports

The Huzhou SEP has attracted extensive media coverage in recognition of its innovation and breakthrough achievements:

(1) The Huzhou SEP was widely reported by the Huzhou Municipal Government, Zhejiang Provincial Government, and other 11 local governments.

(2) This SEP project received 11 reports from state-level official media including news.cn and cfi.cn after its Phase I was connected to the power grid.

(3) Over 100 promotional articles concerning this project were published in over 50 WeChat official accounts including those of news.cn, SPIC, and its power company in Zhejiang.

9. Patents and Standards

1) Patents

In July 2023, SPIC was granted a patent titled "photovoltaic generating capacity model training method and system based on successive model fusion" for its "Dubhe One" platform by China National Intellectual Property Administration. Furthermore, 15 patent applications were under review, including the application named "multicast real-time control method based on synchronous timestamp in oversized network".

(1) Patents awarded:

Photovoltaic generating capacity model training method and system based on successive model fusion

(2) Patents in progress:

i. Device and cloud platform communication connection method and system;

ii. Multicast real-time control method based on synchronous timestamp in oversized network;

iii. Method and system for realizing external authentication of smart home cloud equipment;

iv. Model development and deployment method and system suitable for energy internet;

v. Energy production statistical report template

configuration method and system;

vi. Energy storage self-generating device and method based on liquid cooling;

vii. Graph model construction method and device suitable for comprehensive smart energy system;

viii. Three-phase unbalanced power distribution network rapid load flow calculation method considering distributed photovoltaic;

ix. Intermittent distributed energy flow rapid tracking method;

x. User energy consumption prediction method and device and storage medium;

xi. Fault prediction method and device for energy internet equipment, and storage medium;

xii. Multi-network information fusion and retrieval system and device and storage medium;

xiii. Energy network cloud edge collaboration method and device based on deep reinforcement learning;

xiv. Regional energy consumption intelligent guiding method and device based on heuristic multi-objective optimization;

xv. Multi-energy control system and method for

photovoltaic service.

2) Standards

(1) In November 2023, the *General Rules for Smart Energy Prosumers* drafted by SPIC was published at the national group standard platform (https://www.ttbz.org.cn/).

(2) In November 2023, the *Specification of Adjustable Load Monitoring and Interface for Virtual Power Plant Electric Boiler System*, the *Specification of Adjustable Load Monitoring and Interface for Virtual Power Plant Air Compressor System*, the *Specification of Adjustable Load Monitoring and Interface for Virtual Power Plant Ice Storage Air Conditioning System*, and the *Specification of Adjustable Load Monitoring and Interface for Virtual Power Plant Split Air Conditioning System* were published by Jiangsu Province Renewable Energy Industry Association successively, and constituted China's first standards related to edge computing in IoT for virtual power plants/smart energy prosumers.