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ZERO-CARBON ENERGY PROSUMERAGE SYSTEM (ZEPS) AS THE SOLUTION TO TO A CARBON FREE WORLD INNOVATION

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I. Background

The Paris Agreement sets a goal of limiting global warming to well below 2 degrees Celsius above pre-industrial levels and striving to keep it below 1.5 degrees Celsius. In May 2023, the G7 leaders' declaration stated their commitment to achieving net-zero emissions no later than 2050 and called on countries to peak their greenhouse gas emissions immediately or no later than 2025. China has announced its goal to reduce the proportion of fossil fuel consumption to less than 20% by 2060. In 2022, fossil fuels accounted for 82.7% of China's energy consumption, with coal alone accounting for 56.3%. China leads the world in terms of capacity and competitiveness in zero-carbon wind and solar power equipment, with wind and solar installed capacity and generation accounting for one-third of the global total. However, the development of wind and solar power is severely constrained by the capacity of the power grid to accommodate intermittent electricity generation. In 2022, wind and solar power accounted for only 13.8% of the energy mix. To ensure the stability of the power system, new wind and solar power installations are often supplemented with up to 50% coal power. While coal power may ensure power system stability, its high carbon emissions and lock-in effect are in contradiction to the net-zero carbon goals. Currently, the cost of photovoltaic (PV) and onshore wind power in China has dropped to around 0.15 Yuan (2.5$cents) per kilowatt-hour, and offshore wind power is approaching 0.30 Yuan (5$cents) per kilowatt-hour. Long-duration, high-capacity storage technologies such as hydroelectric power, biomass power, pumped storage, concentrated solar power, and compressed air energy storage can provide space for the grid to accommodate intermittent renewable energy sources like wind and solar power.

With a large number of distributed PV installations, each with a small capacity but aggregating to a significant volume, there is great potential for power generation. In China, there are roughly 400 million rooftops in rural areas, schools, hospitals, factories, and administrative institutions, which could generate a total of 4.8 trillion kilowatt-hours of zero-carbon electricity annually, while the country's total electricity generation in

2022 was only 8.75 trillion kilowatt-hours. Based on end-use calculations, the average annual electricity consumption per household for air conditioning and heating appliances is 4,000 kilowatt-hours, and the annual electricity consumption for electric vehicles is 2,500 kilowatt-hours (based on 20,000 kilometers driven and 12 kWh per hundred kilometers). This results in a surplus of 5,500 kilowatt-hours of zero-carbon electricity per household, which can be used for grid supply in addition to self-sufficiency. Research indicates that not only electric vehicle batteries have potential for energy storage and discharge, but also lead-carbon batteries, which have lower energy density than lithium iron phosphate batteries but are relatively inexpensive, stable, and recyclable, also have potential for household energy storage.

II. Overall Concept

Based on the background and overall calculations mentioned above, a research team led by Professor Jiahua Pan, Deputy Director of the National Expert Committee on Climate Change and a member of the Chinese Academy of Social Sciences, envisions the abundant electricity production from rooftop PV installations in rural and urban single-family homes, schools, hospitals, etc., which, however, exhibit uneven power generation. By combining the currently economically viable lead-carbon, lion and sodium batteries and electric vehicle batteries, energy storage can be utilized to meet the demand for several days or longer. In cases where self-supply is not feasible, high-priced electricity can be purchased from the grid, while the surplus zero-carbon electricity can be sold to the grid at a lower or equal price to meet the centralized power needs of cities and industries.

The idea of zero carbon energy prosuermage system (ZEPS) is envisaged as the solution for a carbon free world. The conditions are ready with zero carbon renewable highly competitive in the power market and power storage technologies are increasingly viable in the market. And the competitiveness of electric vehicles is a good example for large and longer time span storage of power. There are numerous independents units with sufficient space to install renewables (e.g. solar PV) can generate sufficient electricity for self-sufficiency of power supply. The intermittency problem can be resolved through power storage. Under such cases, the unit can be off grid for a self-generation and self-consumption with storage of power, or linked to the grid with power generation, self-consumption using power storage, with surplus selling to the grid and buying power from the grid when there is a shortage. This Zero carbon Energy Prosumerage System has been emerging and there is a huge potential to be deployed as the solution to a carbon free household, village, community, school, hospital, and town, and in aggregate at county or even large scale.

This is particularly of relevance and potential in other developing countries where access to electricity is limited as power grid is largely not in existence and investment in power grid can be highly expensive. Under the Paris Agreement, China and other developed countries such as the EU, US and the UK can join forces to cooperate with developing countries in Africa, Asia and small island countries to create a new type of

partnership as South-North-South trilateral cooperation, with the most competitive solar PV products and the highly advanced optimization systems from the west promoting zero carbon development in less developed regions.

This comprehensive solution for ZEPS, which integrates "PV generation - energy storage - electricity consumption," has already taken shape in certain areas. However, the systematic integration of technological systems and the socioeconomic implications have not been fully developed, tested, and evaluated. Establishing an integrated zero-carbon energy prosumerage system for 'photovoltaic-energy storage-electricity usage,' numerous aggregations of ZEPS (zero-carbon energy prosumerage system) form zero-carbon energy microgrids and local networks. These are relatively independent and interconnected with the regional energy grid, not only forming a 'zero-carbon energy production and consumption with power battery storage complex' but also reducing the installed capacity and load of the regional power grid, promoting the net-zero carbon process at the regional and even national levels.

Establishing pilot studies of ZEPS in selected regions, exploring the pathways for constructing comprehensive solutions, clarifying the economic, technological, policy, and institutional factors and barriers behind the utilization of clean energy distributed generation, and analyzing and summarizing the comprehensive technical integration solutions for ZEPS can promote national power grid reforms and achieve carbon neutrality goals. It can also integrate carbon neutrality with rural revitalization, common prosperity, and other national strategies, realizing synergistic win-win effects. Furthermore, the further refinement and improvement of replicable, scalable, and universally applicable comprehensive solutions can lead to the emergence of integrated systems rather than individual products, with vast market prospects and significant implications for socioeconomic system transformation.

III. Organizational Structure

Professor Jiahua Pan and his research team conducted preliminary research in Huzhou and Jiaxing, Zhejiang Province. They have extensively communicated and exchanged ideas regarding the concept of ZEPS, receiving positive responses. Considering the interdisciplinary nature, wide scope, and significant impact of this transformative research and innovation, the preliminary plan proposes the establishment of the "China ZEPS Innovation Consortium" under the support of the Sustainable Development Research Center of the Chinese Academy of Social Sciences, in collaboration with research institutions, local governments, enterprises, and international organizations. This consortium aims to facilitate the comprehensive analysis of the economic and socioeconomic transformative impacts of ZEPS from an academic perspective. It will provide a platform for administrative coordination, technical support, concept promotion, and case collection.

The innovation consortium aims to foster scientific and technological innovation through collaboration. It will serve as an open platform for sharing and exchanging

ideas, but it must have a core team. To ensure the active, orderly, and effective progress of the work, the innovation consortium will seek guidance and support from relevant departments, including research institutions, government authorities, relevant enterprises, associations, and international organizations. The Secretariat of the Innovation Consortium is located at the Institute of Ecological Civilization at Beijing University of Technology. It is responsible for facilitating cooperation between the platform, government, businesses, and other organizations. Additionally, the Secretariat provides secretarial support for platform promotion, dissemination, research, and communication. It also offers support for activities initiated by the platform.