

Summary for publication

Name of the project: R&D and application of PV direct-drive air-conditioning system

Name of the company: Gree Electric Appliances, Inc. of Zhuhai.

Essence of the project : Gree successfully developed an air conditioner system directly driven by PV direct current. The system uses PV to directly drive air-conditioning units, and returns excess PV power to the grid, creating economic benefits for customers, maximizing high-efficiency energy-saving applications and sustainable economic and social development. The core technological innovations mainly include: (1) R&D of PV direct-drive air conditioning systems with a new topology structure, reducing losses, and achieving efficient use of electrical energy; (2) Proposing a multivariate commutation control technology for the first time, overcome the technical problems of two-way energy flow, self-generation and self-utilization , realize the balanced operation of PV, energy storage, grid, and load energy; (3) Establish the IEMS system based on the PV direct-drive air conditioning system as the energy center. Propose an open high voltage and low voltage bus layered energy architecture, realize the free connection of energy and open interconnection of information.

Problem statement : The traditional PV air-conditioning system has the following problems: (1) The PV output is first connected to the grid through the grid-connected inverter and isolation transformer, and then the grid is still supplying power to the refrigeration equipment. After multilevel energy conversion, PV energy is to waste, the PV power generation cannot be maximized; (2) The PV output passes through the intermediate DC/DC voltage stabilization link to provide power for the refrigeration equipment; surplus power generation is connected to power grid through the grid-connected inverter, and it is impossible to switch the working mode flexibly. This scheme cannot realize the two-way flow of energy, and the surplus PV power still needs additional equipment to return to grid; (3) When PV- energy storage-grid-load multiple energy flows coexist, each part operates independently, lack of energy dispatch, and cannot realize the linkage of supply and demand.

Steps taken, methods used, analysis performed : The team collects customer needs by using questionnaires, and uses QFD to convert customer needs into design requirements and component characteristics. In the dynamic matching operation of PV, air-conditioning and utility power, we adopted the DOE method to find the best matching point of three aspects, and generated the optimal model. Through simulation analysis, various extreme conditions of PV air-conditioning were simulated, and the best power adjustment method was found. We use TRIZ innovative tools to develop a new type of compressor with high-efficiency oil circulation structure, bipolar oil separation technology and compressor oil storage control technology, which can accurately control the operation of the compressor. In order to make the PV direct-drive air conditioner durable, the team also used DFMEA and PFMEA, conducted a comprehensive analysis of the failure mode and failure of the PV direct-drive air conditioner, and took protective measures.

Resources used: R&D costs for project development: USD 989,600; R&D cycle: 3.5 years; R&D team: 6 doctors, 51 masters, and 10 company technology experts; Simulation and test resources: ANSYS, PADS, Air-conditioning equipment and system operation energy-saving national key Laboratory, National industrial design center.

Results achieved : The project has obtained 146 authorized invention patents in China (7 PCT items), of which "PV direct drive system and its control method" won the highest honor of China's patent in 2018-patent gold medal, "Direct-current bus voltage fluctuation suppression method and control method for dual-pwm current converter" won the China Patent Excellence Award. "PV direct drive air-conditioning system and its control technology" and "Key technologies for air-conditioning optical storage and DC conversion" were identified as "International Initiatives, Reaching the International Leading Level" by the Academician and Expert Group of the Chinese Academy of Engineering, and were selected as "National Key Energy-saving Low-Carbon Technology Promotion Catalog" (2016 low-carbon part). In February 2016, this product won the British RAC Annual International Achievement Award for its excellent technological innovation and significant economic benefits. The PV utilization rate of the air-conditioning system using the PV direct-drive mode is as high as 99.04%, saving more than 30% of the electricity consumption of the grid. At present, it is promoted and applied in 25 countries and regions in Southeast Asia, the Middle East, North America and Europe, covering many fields such as scientific research, medical and health, industrial production, restaurants, real estate, commercial offices, etc. In the past three years, cumulative product sales have reached 279 million U.S. dollars. The products in operation save 37.8 million kilowatt-hours of electricity each year, which is equivalent to saving 11907 tons of standard coal and reducing 30958.2 tons of carbon dioxide emissions.

UN Sustainable Development Goal affected : GOAL 7: Affordable and Clean Energy. The PV direct-drive air conditioner system greatly reduces the energy consumption of the public grid, and provides new solutions for building energy consumption, which is in line with the global energy saving and emission reduction demands; it also leads energy consumption habits of green environmental protection and clean economy.

Appropriate image that reflects the project and the results:

<p>Phoenix World Trade Center PV multi VRF: 228 GMV-Y120WM/C-F(U) 228 GMV-Y96WM/C-F(U) PV installed capacity: 6700kW Power generation: 10.5 million kWh/year Reduce pollutant emissions: 8761 tons/year</p>		<p>Thailand SCG high-speed service area PV multi VRF: 20 GMV-Y335WM/A-X PV installed capacity: 196.65kW Power generation: 267500 kWh/year Reduce pollutant emissions: 222.99 tons/year</p>		<p>Malaysia Yip's Precision Wood Co., Ltd PV multi VRF: 108 GMV-Y280WM/A-X PV installed capacity: 884.52kW Power generation: 1.1771 million kWh/year Reduce pollutant emissions: 982.19 tons/year</p>	
<p>Guangzhou Guoguang Electric PV centrifuge: 1 LSBLX350SVS PV installed capacity: 253kW Power generation: 245277 kWh/year Reduce pollutant emissions: 204.43 tons/year</p>		<p>Tehran University, Iran PV centrifuge: 1 LSBLX350SVS PV installed capacity: 240kW Power generation: 319400 kWh/year Reduce pollutant emissions: 266.5 tons/year</p>		<p>Houston hotels United States PV multi VRF: 50 GMV-HY48WLT/A-T(U) PV installed capacity: 220kW Power generation: 292800 kWh/year Reduce pollutant emissions: 244.29 tons/year</p>	