DESCRIPTION OF THE PROJECT

Name of the project*: Demonstration Building with Solar Photovoltaic-Electricity-Thermal Sequential Conversion (Building No. 7 in the iHarbour campus, Xi'an Jiatong University, China)

Budget*: 100.22 Million RMB

Timeframe for completion*:

	2022-2023	Research project funded by the National Natural Science Foundation of China (ANNEXE 6.1).
	June 2023	Department of Archiecture in School of Human Settlements and Civil Engineering (HSCE), Xi'an Jiaotong University (XJTU) moved in the Building No. 7.
	April, 11th, 2023	Acceptance Certification awarded from the Shaanxi Provincial Department of Housing and Urban-Rural Development (ANNEXE 6.2).
	April, 6th, 2023	Application submitted for the Acceptance Certification of the construction completion (ANNEXE 6.2).
COVID-19 Period	February 9th, 2023	The project of Building No. 7 is listed as 'Smart photovoltaic pilot demonstration project' by China's Ministry of Industry and Information Technology (ANNEXE 5).
	November 8th, 2022	The project of Building No. 7 is selected as the Excellent case of scientific and technological innovation in Shaanixi provence by the Science and Technology Department of Shaanxi Province (ANNEXE 6.3).
	September 29th, 2022	Construction checked by the Engineering quality and safety supervision station (The Construction Project Quality and Safety Supervision Station in Fengxi New Town of Xixian New District, Shaanxi Province) (ANNEXE 6.4).
	February 23rd, 2022	Construction completed (ANNEXE 6.4).
	December 14th, 2021	Shaanxi Provincial Science and Technology Department agreed to establish the Eco-city Intelligent Green Energy Building School-Enterprise Joint Research Center, which is the "Four Subjects and a Joint" new R & D platform for supporting the collaboration between Xi'an UPM Technologies, Inc. and XJTU (ANNEXE 6.5).
	November 16th, 2020	Cooperation Agreement was signed between Xi'an UPM Technologies, Inc. and XJTU on the Establishment of Eco-city Intelligent Green Energy Building Technology Innovation Center (25 Million RMB investment from the

	Xi'an UPM Technologies, Inc.) (ANNEXE 6.6).
June 10th, 2020	Construction started (ANNEXE 6.4).
November 12th, 2019	The Ministry of Education of the People's Republic of China approved the project feasibility report from XJTU.（75.22 Million RMB investment from the National Development and Reform Commission）(ANNEXE 6.7).
October 10th, 2016	The HSCE from XJTU submitted the applicaiton for the design of the project of Building No. 7 (ANNEXE 6.8).
November 11th, 2014	The HSCE from XJTU submitted the suggestion to build the project of Building No. 7 (ANNEXE 6.9).

Demonstration Building with Solar Photovoltaic-Electricity-Thermal Sequential Conversion

Promoting the development of green buildings is an important measure for realizing the low-carbon developments in the field of urban and rural construction, and it's important to meet the growing needs of the people for a better life. In addition to the updating and exploration of technical means, the development of green building is inseparable from the construction and management of building standards.

The faculties and students from School of Human Settlements and Building Engineering (HSBC), Xi'an Jiaotong University (XJTU), China jointly and independently designed the project of Building 7 in the iHarbour campus, through the construction of the building, to realize the effective integration of technological innovation and discipline time, to promote the green energy building technology innovation and technology transformation.

Building 7 enforces the use of green building standards through the effective application of a variety of passive energy-saving building technologies through meticulous planning and design. While conserving energy, the building design strives to provide a comfortable and efficient usage environment for the occupants. In addition, the project maximizes the value of building performance through a variety of innovative designs, such as EIPV/T, solar chimneys combining active and passive, underground ventilation corridors combining active and passive design, and partially dismantleable assembled façade through the integration of systematic technologies with multi-energy complementarity to enhance the sustainability and resilience of the building, and to achieve future-oriented experimental research and talent training in the field of Zero-Net Carbon Building design.

1. Technological Innovations

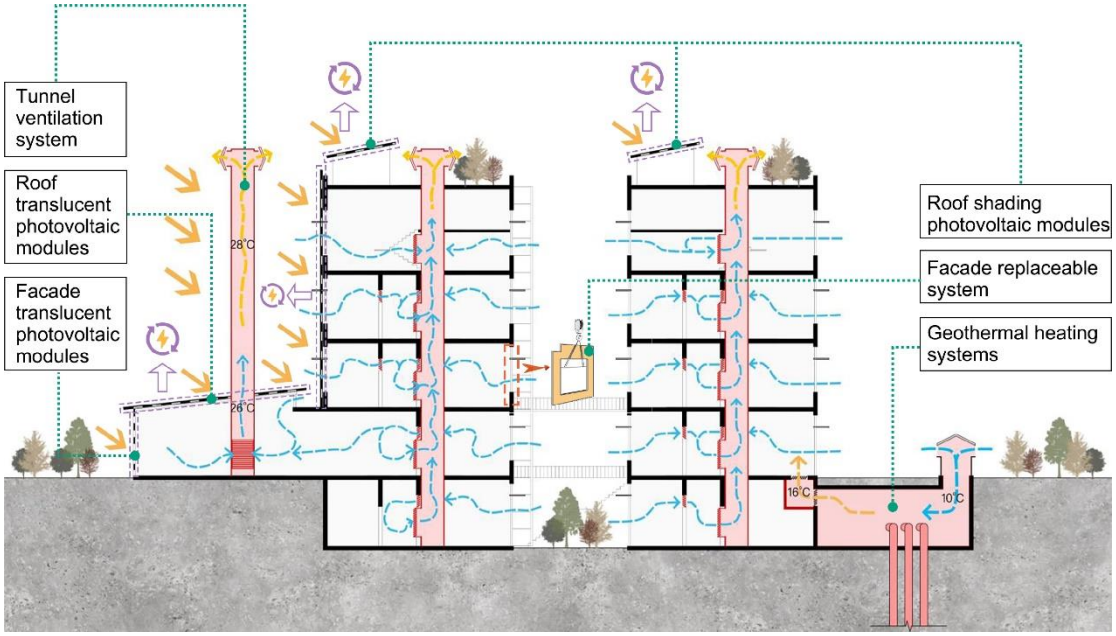

Figure 1. The concept of integrated net-zero-carbon building technologies

1.1 From BIPV to EIPV/T

The development of photovoltaic technology is attracting more and more attention in recent years. Essentially solar radiation affects the heat gain of the envelope. In order to better combine with the building envelope, in summer, through the effective airflow organization of the air sandwich of the double-layer envelope structure, the air-cooled PV/T has better photoelectricity-thermal performance, and reduces the surface temperature of the inner envelope structure. In winter, under the low-temperature environment, through the effective airflow organization of the air sandwich of the double-layer envelope structure, it raises the surface temperature of the inner envelope structure, and further recovers heat to achieve the building winter heating. Under the low temperature environment in winter, the surface temperature of the inner envelope is enhanced by the effective airflow organization of the air sandwich of the double-layer envelope, and further heat recovery can realize the building heating in winter. Therefore, this project proposed a double-layer building solar photovoltaic-electricity-heat conversion double-layer enclosure structure and its internal flow control technology, and indoor environment control integrated system from the construction of the building enclosure structure to realize the solar photovoltaic production capacity of the outer surface of the building. The enclosure structure to reduce the cooling/heating load.

1.2 Solar chimney combining active and passive design

In order to solve the problem of integration between passive building design and renewable energy for the ventilation system, a solar photovoltaic/photothermal integrated energy storage system, chimney wall heating module, solar photovoltaic-driven active ventilating fan module are constructed to finally integrate the solar energy chimney active and passive coupled ventilating experimental device. Combined with the local climatic conditions and thermal comfort requirements of students and faculty in the building to obtain the experimental effect of the system under different operation modes. The experimental effect of the system in different operation modes will be obtained, and the economic evaluation of the annual operation will be carried out according to the annual hot water and power supply demand of the solar photovoltaic/photovoltaic-thermal integration system in the future.

1.3 Ventilation tunnel combining active and passive design

This system utilizes shallow buried pipes and underground corridors to realize the dual utilization of geothermal energy, which can be applied to cooling and ventilating building rooms in summer, ventilating buildings in excessive seasons, and preheating air in winter. Underground corridors and shallow buried pipes are coupled to realize the cooling and ventilation needs of building rooms.

1.4 Assembly Building Design

The detachable assembled façade design is developed, which can be used for assembled façade replacement technology oriented to the maintenance and transformation of the whole life cycle of the building, and can realize a flexible response to the technological development of the future building façade and the ever-changing demand for the use of the façade. On the other hand, it can provide an experimental platform for the evaluation of application scenarios during the development of façade insulation materials and insulation structures.

2. Sustainability:

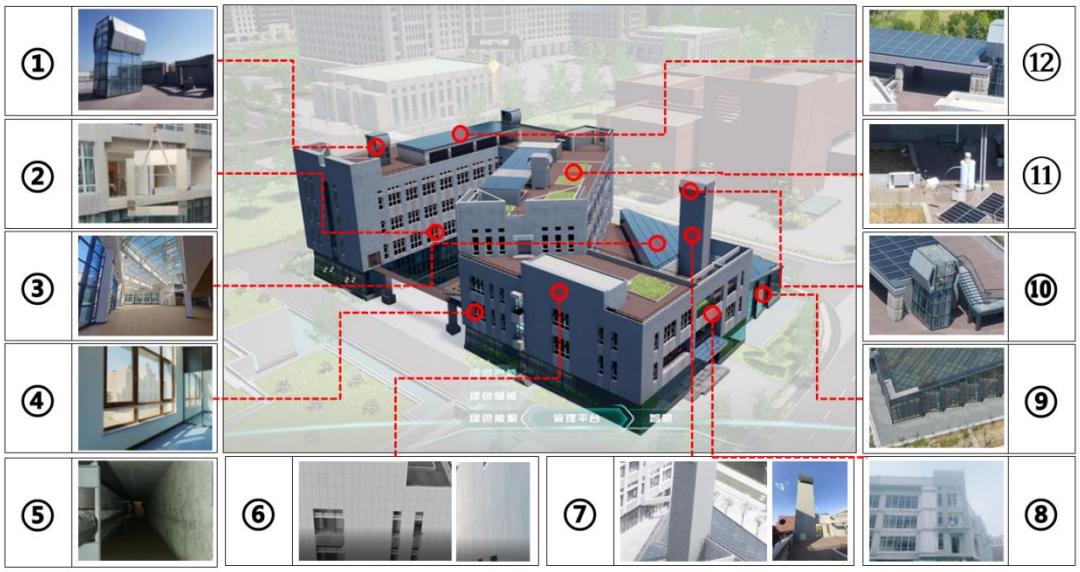

Figure 2. Innovative platform integrating research, exhibition and communication

2.1 Innovative talents Cultivation for the future

Building 7 was designed and constructed with the participation of students and faculties. In the future use phase, experimental research oriented to the development of low carbon building technology will also be conducted by students and faculties. Graduate students were involved in the whole process of research, design and construction, and developed a deep understanding of the concept and technologies of low-carbon buildings in practice. Therefore, as a platform for training innovative talents about low-carbon building, this program can continuously contribute talents to the development of related technological innovation.

2.2 Continuous support for scientific and technological innovation

With the help of the all-weather empirical test platform for the integration of PV modules with building function, structure and form, it provides optimized test services for the deep integration of PV technology and building design, and promote the continuous improvement of the technology. In addition, the demonstration platform for PV building integration application scenarios established in this project will support the application and promotion of the Zero-Net Carbon Building design concept. Comprehensively create a technology integration platform for the integration of office, experiment and demonstration.

2.3 Sustainable development model

From the stage of design, technology development, till technology promotion, the project has established a development mode with university-government-enterprise integration, which guarantees the policy demand, market demand and technical quality, explored the path of transforming the advanced scientific research concepts in the process of industrial promotion, and formed a sustainable development mechanism based on the cooperation of multiple parties. The feasibility report was recognized by the Ministry of Education of China and was approved for a construction grant of 75.22 million RMB by the Ministry of Education. Based on the cooperation with Xi'an UPM Technologies, Inc., Ltd., Ltd, the team was jointly approved as the Shaanxi Province "Four Main Bodies and One Joint" Eco-city Intelligent Green Energy Building Joint Research Center of Schools and Enterprises. In the process of construction, the related research projects have been funded by the National Natural Science Foundation of China. After the completion of this project, the integrated demonstration results were recognized by the Ministry of Industry and Information Technology of the People's Republic of China and listed as a pilot demonstration project of smart photovoltaic technologies.

3. Resiliency:

Figure 3. Comprehensive Energy Management and Control System

3.1 Low-carbon development of urban and rural construction

In order to realize sustainable low-carbon building construction and operation, it is necessary to integrate the use of multiple renewable energy sources and combine the design concepts of energy supplementation and energy saving and carbon reduction. This project realizes the complementary and integrated application of multiple renewable energy sources through the design of solar light-heat-electricity sequential conversion in building monoliths, all-weather use of geothermal energy in underground corridors, and active and passive chimney ventilation. Focusing on the effective combination of active and passive technologies, the

project comprehensively realizes energy saving and carbon reduction of the building from a systematic perspective to create a Zero-Net Carbon Building.

3.2 Urban Heat Island mitigation

Facing the high-density and high-height development of Chinese large cities, the building façade area accounts for a large proportion of the three-dimensional urban surface. The proportion of building facades in a three-dimensional city has a great impact on the absorption and release characteristics of solar radiation in a complex urban form. The traditional passive building design usually incorporates the concept of seasonal regulation, which has been maturely applied in the glass curtain wall technology of existing high-rise buildings. Based on this concept, the new envelope proposed in this study takes advantage of the seasonal characteristics of the air layer and gives full play to its role in optimizing the temperature of the building surface on the inside of the air layer under different seasonal climatic differences. The time shift of solar power generation and electrical energy utilization on the building façade reduces the immediate thermal effect of solar radiation and will change the heat island effect in the local area.

3.3 Responding to sudden-onset disasters

The façade PV implementation area of this project is 2775 m^2, and the power generation capacity is 400,000 kWh per year. Taking a 3,000 m^2 standard building in Xi'an, Shaanxi Province as an example, according to the per capita residential area of 39.72 m^2/person, each residential unit is about 80 m^2, and roughly 35 rooms in total. According to the local measured value and related analysis, the overall electricity consumption (including heating and lighting, etc.) of this standard building is about 100,000 kWh. In addition, according to the total annual solar radiation of Xi'an City, Shaanxi Province, and the formula for calculating PV power generation, the annual power generation is about 317253.6 kWh, which indicates that this new PV envelope structure meets the requirements of the Zero-Net Carbon Building and has the potential to mitigate urban sudden-onset disasters.