PolyU ECO INNOVATIONS

EMPOWER A GREENER TOMORROW

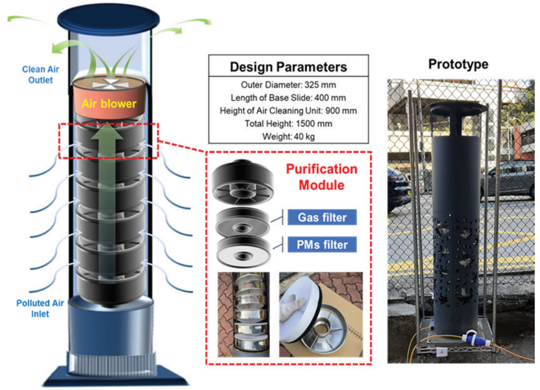
The Hong Kong Polytechnic University
香港理工大學

Research and Innovation Office
研 究 及 創 新 事 務 處

PolyU researchers, leveraging their multidisciplinary expertise, have engaged in path-breaking research projects geared towards achieving carbon neutrality.

The research projects, among other impacts, can lead to powerful applications in moving towards a sustainable future.

INDEX



The design diagram, parameters and prototype of roadside air purifier.

Roadside Air Purifier

Principal Investigator:

Prof. Shuncheng LEE

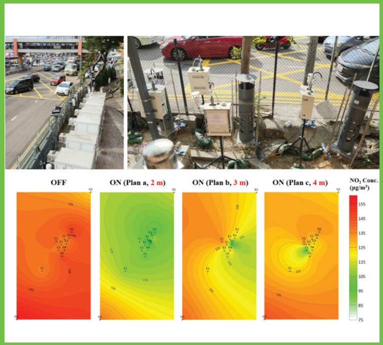
Department of Civil and Environmental Engineering

The roadside air purifier operates based on the integrated mechanisms of physical, as well as chemical adsorption/ absorption and catalytic oxidation for simultaneously removal of ambient NO2, PM2.5, VOCs, etc.

An air blower positioned at the top serves as the driving force, actively facilitating the contaminated airflow entering at the bottom and then passing upward through the air purifier. As a result, clean air is expelled from the top. Total height of the purifier measures 1.5 meters, which is strategically designed to accommodate the range of human respiration.

"Effective elimination of traffic-related emissions of NOx, PM2.5, VOC, and ozone."

F E A T U R E S



On-site field trial of the air purifiers at urban street canyons.

- Simultaneous air cleaning effects on NO2, PM2.5, VOCs, etc
- High mobility for emerging severe air pollution events
- Applicable in the urban micro-environmental sensitive areas like passenger transport interchange, tunnel and airports.

The Use of Dredged Sediments for Economical and Sustainable Reclamation Solutions in Hong Kong

SUSTAINABLE ENVIRONMENT

Considering the limited supply and high costs of importing sand fills for marine reclamations, the use of dredged local marine deposits as fill materials can potentially lead to more economical and faster construction for future large-scale reclamations. The project proposes a combined ground improvement method for dredged Hong Kong Marine Deposit (HKMD) slurry and existing HKMD.

Principal Investigator:

Prof Jian-hua YIN
Department of Civil and Environmental Engineering
Research Institute for Land and Space

"A combined ground improvement method for economical and sustainable reclamation."

To explore the viability of this approach, a prototype field trial was successfully conducted at the Tung Chung New Town Extension project site with concerted efforts of CEDD-PolyU-AECOM-the site team. After using the combined ground improvement method, the HKMD gained enough shear strength with much reduction in water content and formation of a strong crust layer on the top surface of the HKMD. Also, a study on the use of wastes for reclamation has been conducted, especially on two types of industrial wastes: ground granulated blast-furnace slag (GGBS) and incinerated sewage sludge ash (ISSA).

IMPACTS TO THE COMMUNITY

- PolyU's marine reclamation approach is capable of decreasing water content and increasing HKMD strength effectively and quickly.
- Technological advances to super-fast large area economical marine reclamations in the Greater Bay Area and other regions.
- Significantly generate positive social, economic and human impacts.

SUSTAINABLE ENERGY

Printable Organic Solar Cells: Materials and Device Investigations Towards Applications

"Achieved a breakthrough power-conversion efficiency of 19.3% with organic solar cells."

Organic solar cell (OSC) is an emerging photovoltaic (PV) technology with distinct advantages in many areas, such as flexible/portable PV, building integrated PV and transparent power applications.

With the aim of accelerating the OSC technology, this project proposed systematic materials and device structure investigation of new photoactive materials, stable transport materials, innovative ternary OSC active layer engineering, a novel approach for transparent OSC and printing technology.

The project will significantly push forward OSC technology in terms of achieving high efficiency, enhancing operation stability, ensuring compatibility with unique applications and facilitating printing capabilities. The proposed research represents a new frontier for OSC technology, which integrates chemistry, physics and material science to generate new perspectives in science and develop solutions for challenging issues in renewable energy.

Principal Investigator:

Prof Gang LI

Department of Electrical and Electronic Engineering

Otto Poon Charitable Foundation Research Institute for Smart Energy

Durable and High-performance Zinc-air Flow Batteries for Energy Storage

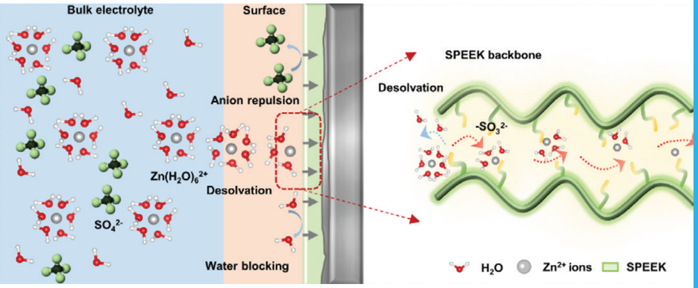
Renewable solar and wind power are intermittent and site specific. Development of high performance and durable rechargeable batteries are essential for successful application of renewable power. Compared with other types of batteries, zin-air batteries have high energy density and they are also cheap and safe.

Principal Investigator:

Prof. Meng NI

Department of Building and Real Estate

Otto Poon Charitable Foundation
Research Institute for Smart Energy



"High performance and durable Zn-air flow batteries for grid scale energy storage."

To solve problems of Zn dendrite formation and Zn electrode passivation, Zn-air flow batteries will be developed to:

- Gain fundamental understanding of how the flowing electrolyte influences on the air electrode morphology and reaction kinetics as well as Zn dendrite formation;
- Engineer the Zn electrode surface to ensure uniform Zn deposition and inhibit Zn dendrite formation for durable battery;
- Lower the charge voltage and improve the power density of the flow battery by 76% with addition of KI into electrolyte.

Practical applications:

- Surface engineering improves battery cycling performance
- KI addition significantly improves battery performance solutions for challenging issues in renewable energy.

SUSTAINABLE ENERGY

Solar Energy Performance Management System

Development of solar PV systems has become one of the major solutions towards the dual carbon targets in Hong Kong. However, the efficiency and well-being of PV panels are subject to the surrounding environment and random factors that can cause system damages or defects, resulting in significant income and equipment losses.

To prevent the losses and support system owners or relevant stakeholders in operating solar PV systems, a three-phase research programme with support from EMSD has been undertaken by the research team Led by Prof. Zhao XU with RISE and EEE Department of PolyU. The aim of this programme is to develop a Digital Twin & AI based platform dedicated for PV system monitoring and management.

"First locally developed AI platform for solar energy management."

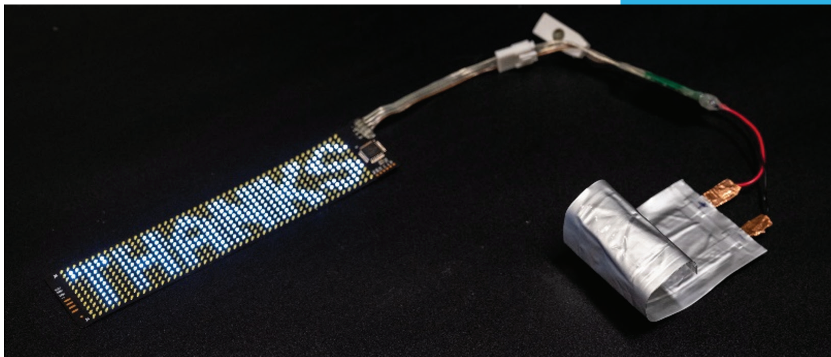
Principal Investigator:

Prof Zhao XU

Department of Electrical and Electronic Engineering

Otto Poon Charitable Foundation Research Institute for Smart Energy

The developed system is a first-of-its-kind that has been locally developed in HK. It is now undergoing field trial in the PolyU laboratory and two public schools in Hong Kong. In addition, the developed system was awarded a Gold Medal and a Bronze Medal in Geneva International Exhibition of Inventions in 2022 and 2023 respectively.



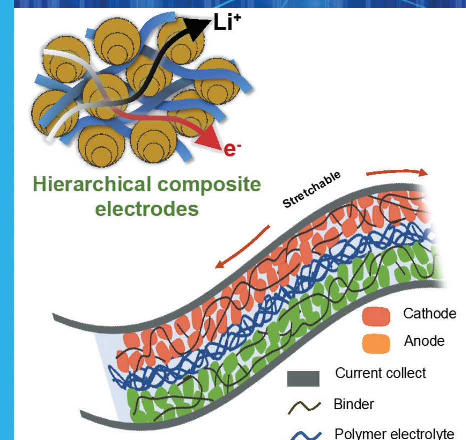
Development of Advanced Energy Materials and Devices

- Develop novel high-energy-density and stable cathode and anode active materials for achieving ultrahigh-capacity and long-cycling batteries.
- Revolutionise the electrode structures to impart high-energy-density batteries with excellent flexibility and stretchability.
- Incorporate flame-retardant components and technologies to enable durable, safe, flexible and stretchable batteries.

"Highly flexible, high-energy, lightweight lithium battery for wearable electronics."

PRACTICAL APPLICATIONS

Wearable electronics, smart textiles and clothing solutions for challenging issues in renewable energy.



Principal Investigator:

Prof Zijian ZHENG

Department of Applied Biology and Chemical Technology

Otto Poon Charitable Foundation Research Institute for Smart Energy

Umicool – An Eco-friendly Smart Sub-ambient Radiative Cooling Coating

> "An eco-friendly, long-lasting, self-cleaning, low-cost polymeric radiative cooling coating."

Principal Investigator:

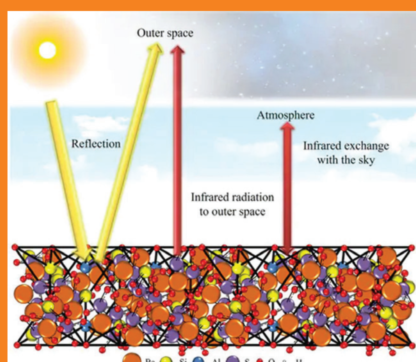
Prof Jian-guo DAI

Department of Civil and Environmental Engineering

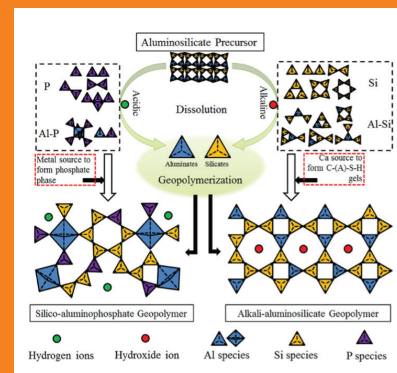
Research Institute for Land and Space

Umicool is an eco-friendly, long-lasting, self-cleaning, low-cost polymeric radiative cooling coating which can reduce the interior temperature of buildings/ infrastructure by 6°C compared to the ambient temperature under direct sunlight, without consuming electricity.

Umicool can also scatter sunlight, convert absorbed UV light to fluorescence emissions and re-emit infrared radiation to the cold universe.



PRACTICAL APPLICATIONS



In addition to white smart paints designed for applications on architectural structures such as roofs and walls, we also offer paints in different colours and even translucent, as well as for materials other than concrete, such as glass, to expand the application range of products. The target markets for Umicool include different types of buildings and infrastructure such as oil tanks, water tanks, roads, solar panels, and textiles such as clothing, masks and hats.

Low Carbon Architectural Products for Anti-virus (Anti-COVID19)

The project aims to develop low-carbon and antibacterial architectural products, utilising waste glass based on carbon capture technology. This is to achieve carbon sequestration in building materials, thereby reducing carbon emissions, promoting the popularity of green buildings, and fostering sustainable urban development.

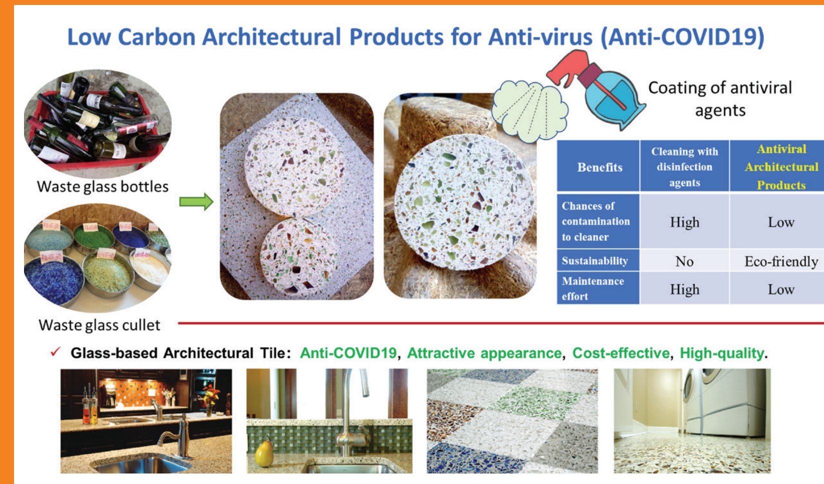
Principal Investigator:

Prof Chi Sun POON

Department of Civil and Environmental Engineering

Research Centre for Resources Engineering towards Carbon Neutrality

"A low-carbon, anti-bacterial, aesthetically pleasing architectural product made by waste glass."



Providing aesthetically pleasing and virus-resistant products will improve hygiene conditions in public areas, particularly during epidemics, which is of significant importance. By utilising waste glass, the project also encourages the reuse of glass resources while enhancing the durability and serviceability of the products. Therefore, the project plays a crucial role in environmental protection and public safety.

SUSTAINABLE CONSTRUCTION MATERIAL

Foam Glass-based Lightweight Concrete for Low Carbon MiC

This project aims to promote the multiple reuses of local waste glass in Hong Kong by producing ultra-high-performance lightweight concrete that is suitable for modular integrated construction (MiC) buildings.

Principal Investigator:

Prof Chi Sun POON

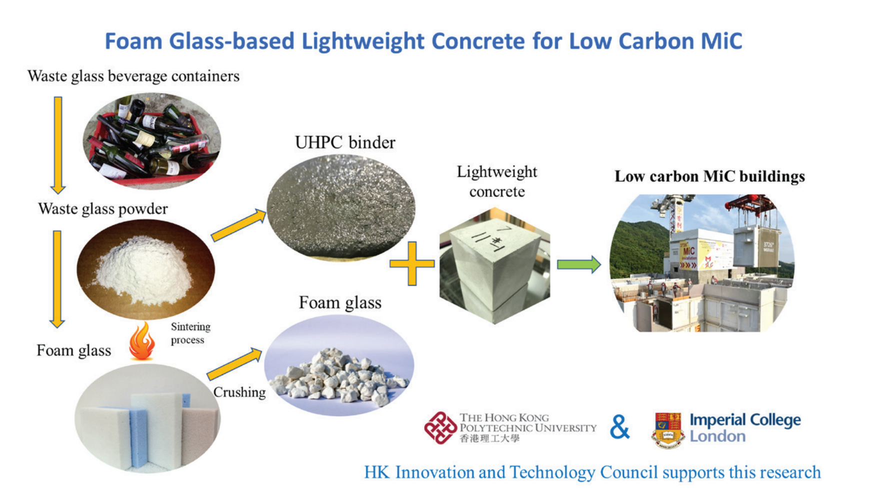
Department of Civil and Environmental Engineering

Research Centre for Resources Engineering towards Carbon Neutrality

"Ultra-high performance lightweight concrete to reduce waste and carbon emissions."

On the one hand, waste glass powder is used as a supplementary cementitious material to replace cement in preparing ultra-high-performance lightweight mortar. This method significantly reduces cement consumption, thereby achieving energy-saving and emission reduction effects in mortar preparation. On the other hand, the high-temperature processing of waste glass is used to produce foamed glass lightweight aggregates. The material composition and sintering process can be flexibly adjusted according to actual needs to prepare lightweight aggregates that are suitable for different application scenarios.

The substantial reduction in waste and carbon emissions achieved by this project can make a vital contribution to environmental solutions for promoting sustainable development in Hong Kong.



Turning Concrete Waste into Low Carbon Products by Carbonation

Due to the massive release of greenhouse gases, our whole world is facing severe environmental challenges, with CO2 being one of the main greenhouse gases. The construction industry is a major source of CO2 emissions, accountings for 8% of the global total. As a carbonisation reaction material, the cumulative annual output of concrete waste in Hong Kong is 5 million tons, and 2.36 billion tons in Mainland China.

Principal Investigator:

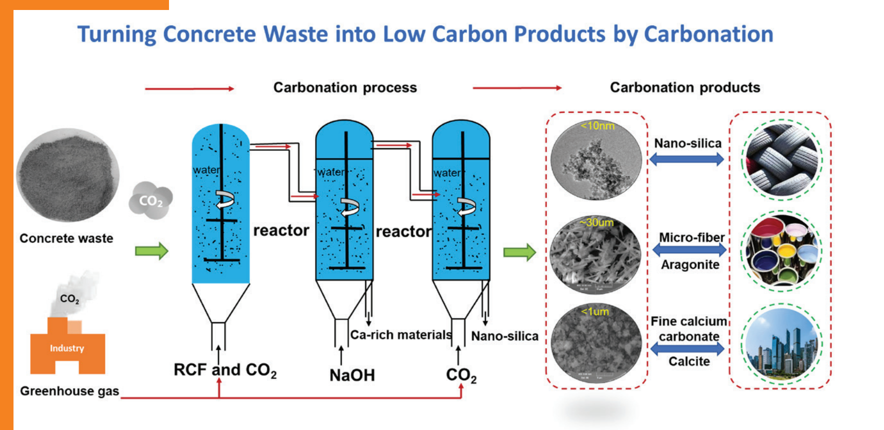
Prof Chi Sun POON

Department of Civil and Environmental Engineering

Research Centre for Resources Engineering towards Carbon Neutrality

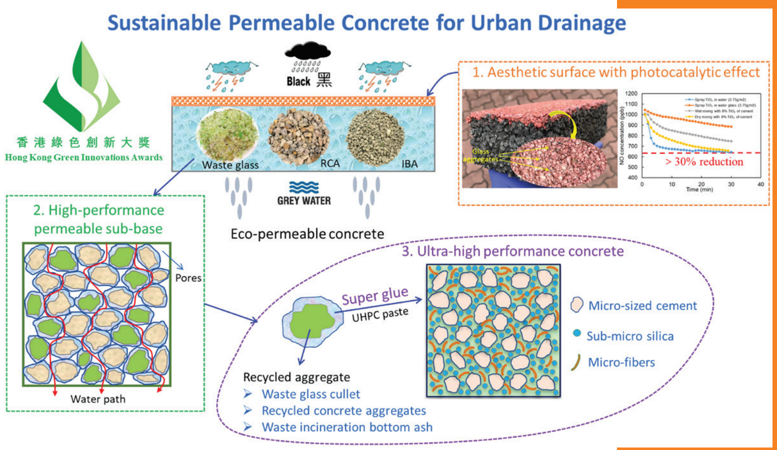
"Turning concrete waste and carbon dioxide into useful products."

In our project, we have developed advanced carbon curing techniques to convert concrete wastes into low-carbon products. Three value-added products have been produced: nano-silica, micro-Calcium Carbonate Fiber and fine calcium carbonate. Notably, this carbonation process can permanently sequestrate a large amount of CO2 (>0.1 kg CO2/kg concrete waste).



Sustainable Permeable Concrete for Urban Drainage

In Hong Kong, heavy rainfall and disposal of large quantities of solid wastes at landfills are common problems. The research team from the PolyU has thus developed a high-performance eco-permeable concrete using local waste materials.



"High performance permeable concrete made by recycled aggregate."

Principal Investigator:

Prof Chi Sun POON

Department of Civil and Environmental Engineering

Research Centre for Resources Engineering towards Carbon Neutrality

With high strength and good water permeability, the product can bring about various environmental benefits. These include reducing waterlogging due to stormy weather, reducing waste disposal at landfills, improving air and groundwater quality, recharging water in soil for plant growth, mitigating the urban heat island effect and reducing road noise.

Development of Next-generation Key Technologies for Smart Buildings

SUSTAINABLE BUILDING

Based on emerging information technology, data science and distributed real-time optimisation, this project will adopt a multidisciplinary approach to advance the next-generation of smart buildings by:

- Implementing innovative "distributed optimisation" and time-critical process control technologies to achieve "edge computing" on IoT field networks and 5G networks;
- Developing new-generation real-time optimisation methods for cross-system coordination and building-grid response by adopting AI at field network level of building automation systems;
- Establishing a big data analytics framework and implementing automated data-driven health monitoring and fault diagnosis technologies.

Principal Investigator:

Prof Shengwei WANG

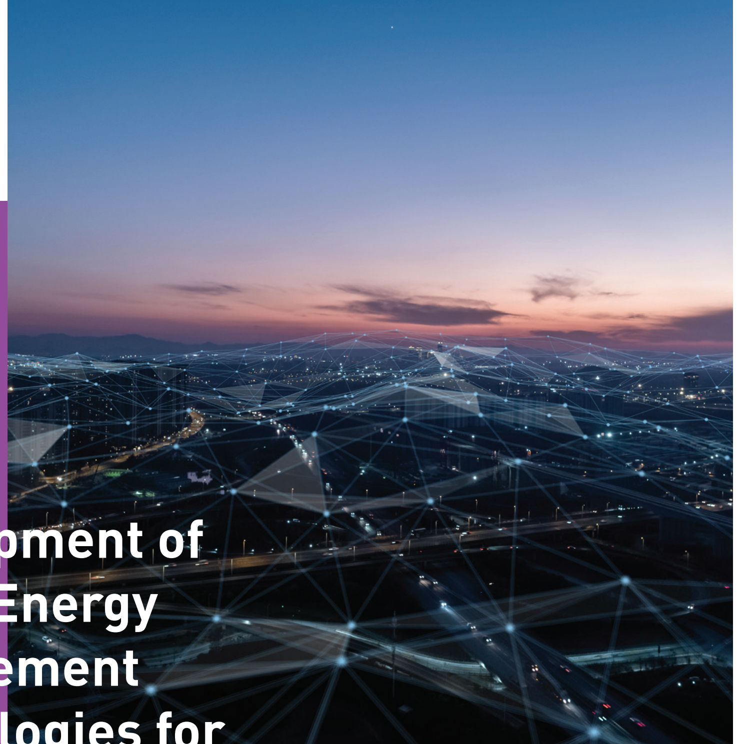
Department of Building Environment and Energy Engineering

Otto Poon Charitable Foundation
Research Institute for Smart Energy

> "Real-time optimisation and monitoring for smart buildings with information technology."

P R A C T I C A L   A P P L I C A T I O N S

New buildings atop West Kowloon Station



Development of Smart Energy Management Technologies for Complex Building Energy Systems in High-density Cities

The development of high-density cities poses significant energy and environmental challenges. With urbanisation, buildings are becoming larger and more complex.

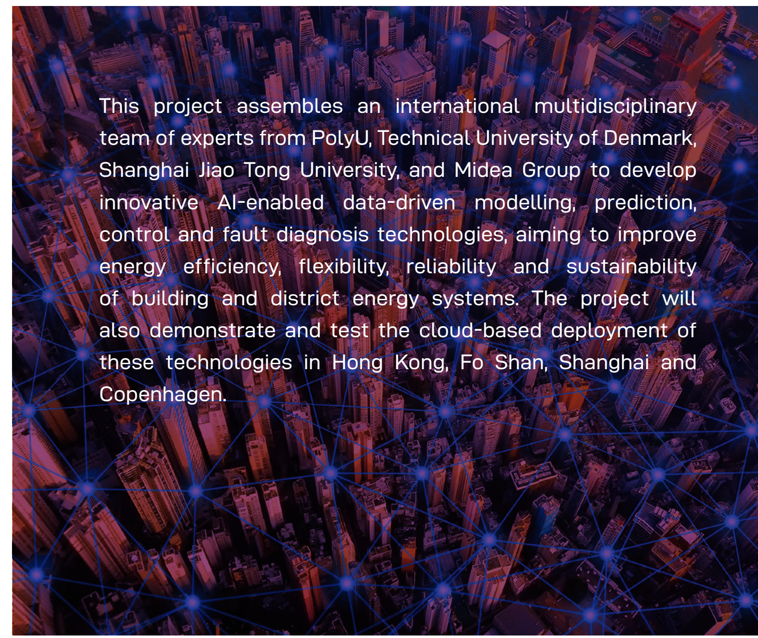
"Innovative AI-enabled data-driven modeling of complex energy systems."

Principal Investigator:

Prof Fu XIAO

Department of Building Environment and Energy Engineering

Otto Poon Charitable Foundation Research Institute for Smart Energy



This project assembles an international multidisciplinary team of experts from PolyU, Technical University of Denmark, Shanghai Jiao Tong University, and Midea Group to develop innovative AI-enabled data-driven modelling, prediction, control and fault diagnosis technologies, aiming to improve energy efficiency, flexibility, reliability and sustainability of building and district energy systems. The project will also demonstrate and test the cloud-based deployment of these technologies in Hong Kong, Fo Shan, Shanghai and Copenhagen.

Research and Innovation Office (RIO), as a forward-looking department in the University, is devoted to propelling the University's technology development and advances to benefit the society by providing all-rounded support to facilitate research endeavours within the PolyU community, and foster partnerships among universities, industries, governments, supranational bodies, and the public.

RIO is committed to synergise research capabilities and the transformation of innovation to technology advancement, thus delivering positive impacts to the community. We pursue excellence in managing Research Grants and Contracts, exploring Partnership Development, as well as providing Proactive Support to Key Research Projects of the University.

Our roles:

- Exert all-rounded support to facilitate research endeavors, including the application for funding, both internally and externally,
- Impel translational research across disciplines to provide joint responses to global challenges.
- Engage PolyU experts with industry players to spur high-impact research partnership.
- Build strategic platforms to foster university, industry, and government (UIG) collaboration.

For collaboration opportunities, please contact:

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Stay tuned with our research updates:

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