RESEARCH INSTITUTE FOR SUSTAINABLE URBAN DEVELOPMENT (RISUD)

News Article for RISUD Emerging Frontier Area (EFA) Scheme

		Name	Department
1.	**Principal Investigator**:	Dr. Sunliang Cao	BEEE
2.	**Name of EFA:**	Seashore Zero-Energy Community and Ocean Energy Development	
3.	**Project Title:**	Development of the frontier ocean energy technologies to utilize the renewable and storage resources of sea for supporting the seashore residential zero-energy communities	

4. **Annual Progress/Achievement (***in layman's language, no more than two A4 pages, pls attach photos***)**

Brief introduction of the project

The zero-energy buildings (ZEBs) and communities (ZECs) are internationally recognized as the ultimate goals to reduce primary energy consumptions and equivalent CO_2 emissions of the building sector. However, most of the applied ZEBs and ZECs are based on the conventional inland renewable and storage resources, whereas the sea-sourced resources were barely utilized for these zero-energy applications. Moreover, the special conditions in the densely-populated coastal regions, such as the intense urbanization and limited above-/under-ground space, further restrict the utilization of the inland resources, whereas the sea-sourced resources present a higher potential. The above conditions hereby stimulate the core research idea of this project, which focuses on the development of the frontier ocean energy technologies in order to fully utilize the renewable and storage resources of sea for supporting the seashore and coastal zero-energy communities. In the 2nd year, we have further deepened our understanding for the diversified ocean energy and storage technologies for supporting a variety types of coastal buildings and communities, while we have particularly focused on the energy flexibility investigation and enhancement for the ocean-energy supported zero-energy system with enhanced cost-efficiency and grid responsiveness.

Research teams in this project

We have a very outstanding and multi-disciplinary team in this project, as shown in Figure 1. The PI of this project is Dr. Sunliang Cao from BEEE, while the Co-Is are Dr. Xiaolin Zhu (LSGI), Dr. Yang Xu (LSGI), Prof. Vivien Lin Lu (BEEE), and Prof. Shengwei Wang (BEEE). Furthermore, there are four talented research staffs/students involved in this project with different focuses of the ocean energy system, including Mr. Haojie Luo (Offshore wind turbines and wave energy converters for coastal hotel buildings), Mr. Shijie Zhou (Floating photovoltaics and tidal stream generators for coastal high-rise buildings), Ms. Xinman Guo (Ocean energy supported zero-emission boat and hotel integration and interactions), and Mr. Ming Li (Large-scale ocean energy systems and coastal communities).

We also would like to briefly present some highlighted research progresses as listed below:

(1) We have finished the state-of-the-art review for the flexibility and feasibility of emerging offshore and coastal ocean energy technologies in the East and Southeast Asia, and a high-impact journal paper has published based on this literature review. The literature review covers a wide variety of emerging ocean energy technologies including the wave energy, tidal energy, ocean current energy, floating photovoltaics, and offshore wind turbines. The characteristics and challenges of these ocean energy technologies for the region of East and Southeast Asia have been highlighted and summarized in this study, while we have also compared the characteristics of these technologies to those in other regions of the world.

(2) Regarding the study for the hybrid wave-wind supported coastal hotel building, after investigating the advantages of the indirect seawater heat exchanger to support the thermal system and the combination of the hybrid renewable system to enhance the energy matching, we also investigated further to conduct the flexibility controls by various sources of the system

as highlighted in Figure 2(a). Towards the existing electricity tariff which concerns both energy consumption and maximum power demand during the on-peak and off-peak periods, it was utilized the battery and overtopping wave energy converter as the flexibility sources. The smart utilization of the overtopping wave energy converter was inspired by the reservoir-type power plant. Aiming at the energy shift, the imported energy from the grid was transferred from the high price period to the cheaper one. Meanwhile, with the target of peak shaving, the maximum demand was kept at the setting level that brought the least demand charge.

(3) Regarding the study for the tidal-floating PV supported coastal office building application, after verifying the techno-economic feasibility of an ocean-energy-supported zero-emission office building in Hong Kong, one optimum case with hybrid floating PV panels and tidal stream generators has been selected, the impact of energy flexibility control and viability enhancement with existing utility business models and dynamic demand response project on the economic performance has been investigated. The results indicated that with flexibility control and incentives from demand response project, the economic performance can be improved. Several modification suggestions have also been proposed for business model and demand response project to promote renewable energy system. The configuration of electricity system is shown in Figure 2(b).

(4) Up till now, we have also finished two studies relating to the sea-water transportation. The first study was conducted on a hybrid marine renewable energy generation system to support a coastal hotel building. The floating PV and wave energy converter power generation system was equipped to achieve the building and electric boats' zero energy goal. A fleet of zero-emission electric boats were used to help improve the on-site energy matching capability of the overall hybrid system. The second study was based on a non-dominant case from the previous study, which focused on energy flexibility enhancement and flexibility-based control. An innovative energy management control strategy was proposed to improve the techno-economic performance of the hybrid system. The schematic of the ocean energy supported hybrid zero-energy building and seawater-transportation system with enhanced energy flexibility is shown in Figure 2(c).

(5) We have also finished the investigation and analysis for the techno-economic feasibility to achieve a zero-energy coastal community by large-scale hybrid offshore wind and tidal stream energy generation system, as well as an ocean and solar thermal energy supported district cooling and heating system. Our study has obtained the market competitiveness of 21 renewable combination cases and showed the significant impact of the battery systems and the FiT policy on the techno-economic performances. This study has contributed to the academic community with a better understanding and a very timely reference for the development of coastal zero-energy communities via large-scale offshore wind and tidal stream energy in densely-populated coastal cities.

Figure 1: The research team in this project.

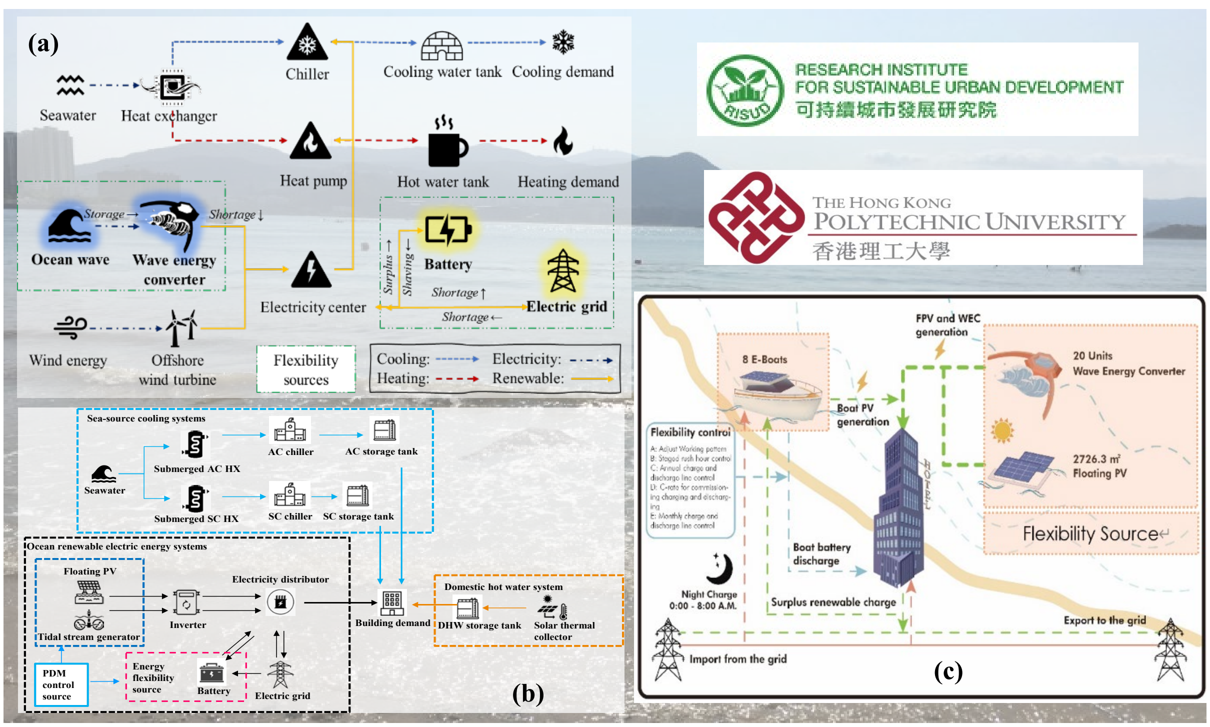

Figure 2: The brief schematic of updated design and controls of ocean energy systems with enhanced energy flexibilities.