Applied Doctorates Scheme

Project Title - Seasonal Thermal Energy Storage to Achieve Energy Equity in New Zealand

Host University - Massey University (Albany Campus)

Industrial Partners - Sustainable Engineering Ltd

Earth Building Association of New Zealand (EBANZ)

eZED Ltd

Academic Supervisor(s)

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Industrial Supervisor(s)

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Project Description

Background

More than 595,000 NZ households cannot afford to keep their homes adequately warm in winter. Since 2025, electricity cost has been rising steadily at a monthly rate of NZ$10-20 that exacerbates the energy hardship for low-income households. Harnessing renewable energy like solar for space heating is essential to achieve energy equity in New Zealand. A challenge to use solar is the seasonal mismatch between heating demand in winter and surplus solar production in summer. A promising technology to achieve a seasonal shift is thermochemical energy storage (TCES).

In summer, the hydrous salt ($SrBr_2.6H_2O$) is dehydrated by solar energy to convert into anhydrous slat to store heat. In winter, water vapour hydrates the anhydrous salt to discharge the heat. An energy efficient way to utilise this heat is low-temperature heating system embedded in earth and natural materials. As natural materials as thermal mass can store heat for a short period to reduce supply temperature fluctuation in thermal energy storage. The technology is still at an early stage and large-scale commercialisation requires understanding of use case for highefficiency and low-cost.

Excellence

Pilot research on large-scale TCES system needs numerical simulations. At the material level, hydration and dehydration are described by one-dimensional linear driving force approach. The linear model neglects the important hydration and dehydration mechanism including vapour and liquid water diffusion at the gas-solid interface and the switching between kinetics, film mass transfer and bubble rise. At the reactor scale, hydration and dehydration are modelled by computational fluid dynamics (CFD). CFD models require very small-time steps and long computation times, making it impractical for simulating annual energy performance of a large-scale TCES system. At the system-level, coupling TCES and low-temperature system embedded in natural materials is lacking in literature.

Objectives

1. develop physics-based data-driven models for TCES and low-temperature heating system embedded in natural materials;
2. integrate the data-driven models into whole building energy simulation and perform life cycle cost analysis;
3. assess the contribution of the technology to UN SDGs and the potential to achieve space heating equity in New Zealand.

Impact

The annual heating demand for NZ houses is more than 7 GWh and costs Kiwi homeowners ~NZ$350M. Preliminary simulations show that a thermochemical reactor (1mx1mx0.5m) filled with strontium bromide can potentially satisfy the heat demand of a residential house of 220 square metres at the outdoor air temperature of 10 Celsius degrees. The life cost is around NZD100k/GWh over a 20-year lifespan. The success of this project can save up to NZ$300M per year on space heating, addressing UN SDG11.1 and 7.3. The proposed technology can double the share of solar energy in NZ energy mix, addressing SDG 7.2. Preliminary research shows that a largescale implementation has a potential to reduce annual carbon emissions by 131kt CO2-e, addressing SDG13.2.2.

Student Time Split

University base for student (university, campus, department):

27 months at Albany campus of Massey University, College of Science; 1 month at Department of Physics, University of Otago

Industry base for student (company, site, address):

4 months at Sustainable Engineering Ltd Wanaka Branch, 3 months at EBANZ Dunedin, 1 month at eZed, Queenstown

Expected Time Split Between University and Industry Partner (in months):

Academic Time: 28 months, Industrial time: 8 months

Rationale for Time Split:

Year 1

Tthe PhD student works at Sustainable Engineering Ltd (SEL) for 1 month on whole building energy simulation under the supervision of Ms Winters. The student stays at University of Otago for 1 month under supervision of Dr Lowrey, to work on thermal energy storage modelling. The student stays at Massey University Auckland for 9 months under supervision of Dr Wu, to work on developing models for thermochemical energy storage. The student works at eZEd for 1 month on natural materials under supervision of Dr Jaquin.

Year 2

The student works at Massey for 9 months to develop models for low-temperature system. The student works at SEL for 3 months to integrate the models into whole building energy simulation.

Year 3

The student works at Massey for 9 months on large-scale modelling under supervision of Wu and life cost analysis under supervision of Dr Zhou. The student stays at EBANZ with Ms Bellaby for 3 months for assessing energy equity and UN SDG. Once per two months, there will be an online meeting between the student and all academic and industrial supervisors. The student will rotate between academic and industry partners to develop models, integrate simulations, and assess energy equity impacts. Online meetings with all supervisors will occur every two months.

Application

To apply for this project please first read the guidance document and then complete the application form on the Applied Doctorates Scheme website.