MaREI Supervisor	Institution	ERBE Co-Supervisor	Institution
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PhD Proposal Title:		Optimal demand side management of domestic water heating using highly efficient solar heat energy collection and storage	

ERBE Theme Alignment:

ERBE CDT Theme.	Proposed project
1.Flexibility and resilience	• Develops new generation and storage technology with smart controls • Resilience via local generation of energy.
2. Technology and system performance	• Via DSM, outcomes of this project may obviate requirements for new generation and distribution. • Directly decarbonising water heating.
3. Comfort, health and well-being	• Cost effective production of hot contributes to eliminating fuel poverty and to clean healthy homes.

PhD Proposal Abstract: (400 words max)

Introduction

Solar water heating (SWH) at present can meet 40% of a typical domestic hot water requirement in the UK and Ireland. This project will develop new types of SWH integrated with demand side management (DSM). The research will examine how 80% of typical domestic hot

water requirements can be satisfied by economically-viable SWH. This project will investigate if this goal can be achieved by (i) maximising the area available for collecting lower-solar-intensity winter sun, (ii) minimising thermal losses to retain heat in cold ambient temperatures and (iii) optimised control integrated with DSM/ heat pump.

Background

As new and refurbished dwellings have increased building insulation with lower unwanted air infiltration, energy required for space heating is lower. Proportionally energy for water heating has thus become larger. Using renewable energy generated electricity combined with a heat pump can decarbonise hot water production. Air-source heat pumps can also replace existing fossil fuel boilers without modification of the heat distribution system. However widespread deployment of this approach may lead to an accentuation of variations in grid electricity demand leading to investments in generation and transmission to solely meet peak demands. This may be obviated with DSM strategies that includes local SWH production and storage.

Scope

The research will investigate new types of EFPC with energy storage systems to collect and store solar heat to provide hot water on a greater number of cold winter days.

The key innovations to be researched are a new type of evacuated flat plate solar collector (EFPC) combined with highly-insulated highly-stratified heat storage operating in an overall DSM control context. In a new approach to including SWH in optimal dynamic DSM, this work will consider control strategies that draw supplementary energy from a grid/heat pump only in off-peak periods.

Most evacuated solar collectors are tubular to withstand atmospheric pressure. However, tubes have both non-collecting gaps (between each enclosed absorber) and optical losses. EFPC have a fuller collecting-area and lower optical loses. However in EFPCs, to-date, the internal spacers required to withstand atmospheric pressure introduce heat loss that lowers collection efficiency. The new concept to be investigated is maintaining EFPC aperture rigidity (required to withstand atmospheric pressure) by glass structural ''rib'' elements, obviating need for internal spacers. The larger area collects less-intense winter solar radiation and the very-low-heat loss maintains good efficiency in colder winter ambient temperatures.

A hot water store will thermally stratify with appropriate flow rates of water withdrawal/replenishment and low thermal conductivity of the store walls. Thermal stratification maintains a high withdrawn water temperature reducing the need for auxiliary heating. New heat stores with low-thermal-conductivity thermally-insulating walls will be investigated.

Research questions to be addressed

- What are the design requirements for a rib-structured-aperture highly-efficient EFPC? What are the materials, structural forms and adhesives that optimally meet operational requirements?
- What are the design requirements, flow rates, aspect ratio, to achieve a highly stratified heat store? What materials and components are required to minimise axial thermal conduction.
- How can solar heat collection and storage for domestic hot water be best used to contribute to optimal DSM?