SENERGY PROJECT

SENERGY DEMONSTRATOR PROJECT

PROJECT DETAILS

Cluster: Energy Systems
Knowledge provider: Ulster University - Centre for Sustainable Technologies (PI Dr Aggelos Zacharopoulos)
Industrial Partners: Senergy Innovations Ltd, Semple & McKillop Consulting Engineers, Lawell Asphalt Company Ltd
Total project costs: £248,133 over 22 months from November 2016 to August 2018.

PROJECT BACKGROUND

Space heating and domestic hot water in buildings accounts for about half of all energy use in Europe and generates significant CO_2 emissions. Solar thermal systems have a significant role to play in reducing fossil fuel consumption as they can be installed on the building and supply heat directly to meet a proportion of its thermal energy demands. Low cost uncovered solar water heaters made from black plastic materials (~£20/m2) are popular for swimming pool heating but are unable to achieve sufficiently high temperatures for producing domestic hot water when located in cold and windy climates. Conventional solar water heaters typically cost ~£200/m2 and are constructed from selectively coated metal absorbers with glass covers (eg flat plate or evacuated tube collectors). These often compete with photovoltaic installations (PV) for roof space and are commonly perceived as being more complicated to install. Ongoing PV price reductions (£150/m2) and an increasing trend of utilizing excess electrical output for domestic hot water production has placed immense pressure on the market for solar thermal systems in Europe and North America.

Polymeric collectors (absorber, cover and frame all made of plastic) have been heralded as offering significant cost reduction opportunities for solar domestic hot water systems but prices of current market offerings are not significantly lower than conventional metal-glass collectors. It is however clear that polymer materials more readily facilitate mass production of a wider variety of collector sizes, shapes and forms which enable more harmonious architectural integration within the building fabric. Collectors which are designed to replace roof coverings, façade cladding, or other exterior building elements such as shading devices, bring improved economic benefits by offsetting material costs and environmental impacts of traditional construction components. One of the biggest challenges for covered polymeric collectors is the achievement of sufficient robustness and longevity when subjected to fluctuating temperature and pressure stresses as well as UV light exposure. Absorber temperatures can vary from around -20°C during winter up to as much as 200°C under stagnation conditions in summer. Low cost commodity plastics generally have inferior mechanical and thermal properties to more expensive engineering plastics. Optimal choices of base polymers, additive compounds, and composites, offer potential for cost reduction.

SENERGY PROJECT

COLESENERGY DEMONSTRATOR PROJECT

PROJECT BACKGROUND CONT.

Senergy Innovations have developed a technology concept which utilizes carbon nanotubes to modify the optical, thermal and structural properties of polymers used in a low cost extrusion process to produce solar absorbers. Senergy have embodied their polymer nanocomposite absorber concept into a new design of all-plastic covered solar water heater which features a minimal number of components to maximise robustness and minimize manufacturing costs. The present project aims to demonstrate the Senergy collector design and the nanocomposite absorber technology and advance it towards commercialisation.

PROJECT OUTPUTS

The initial phase of the project involved reviewing the Senergy design in conjunction with Northern Irish plastics industry experts to examine manufacturing feasibility. Performance results from previous prototypes (fabricated and tested during a progenitor project) were analysed to inform design development. Ulster University worked closely with Semple & McKillop consulting engineers to develop a computer simulation model of a Senergy collector array coupled to a domestic hot water system. Initial modelling results (Figure 1) indicated that a 9 m2 Senergy collector array located on a south-facing sloped roof would provide ~25% of annual thermal energy demands for domestic hot water in a typical 3 bedroom house in Belfast, reducing annual gas demand by around 1.2 MWh.

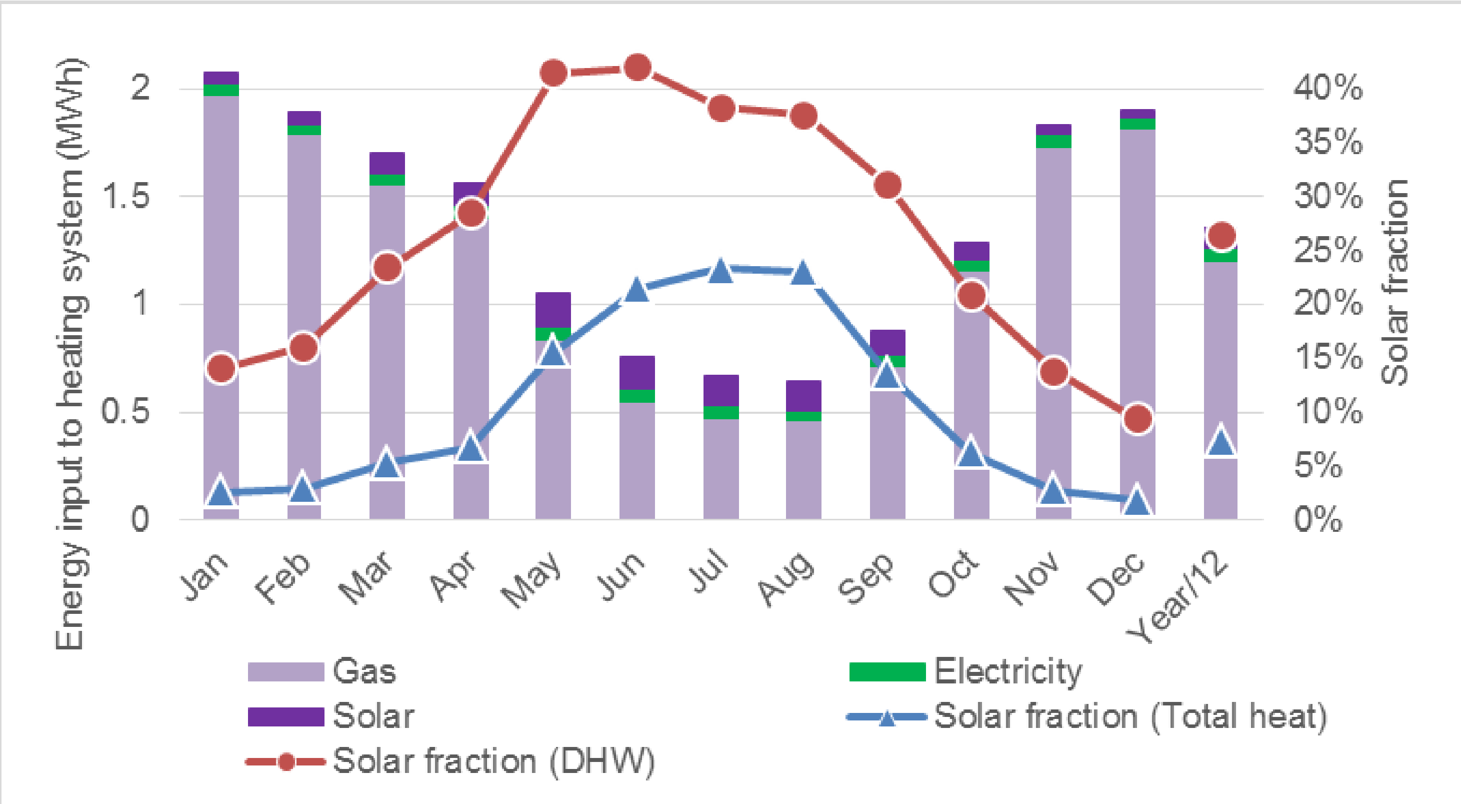

Figure 1. Simulation results for Senergy collector array coupled to a domestic hot water heating system

SENERGY PROJECT

SENERGY DEMONSTRATOR PROJECT

PROJECT OUTPUTS CONT.

Ulster University have procured materials including carbon nanotubes, plastic sheet and tube, and polymer resins, and have fabricated second-generation Senergy collector prototypes (Figures 2 & 3). These have been extensively characterised in the solar simulator laboratory and results indicate that problems (water leaks, trapped air, fragility) experience with first-generation prototypes have been largely overcome by the current design. The team will fabricate and test more prototype variants before assembling an array which will be integrated with a building envelope and coupled to a domestic hot water system. The array will serve as an outdoor demonstrator and provide data to validate the simulation model.

An academic paper detailing experimental work on early prototypes has been submitted for publication in Elsevier's prestigious Renewable Energy Journal. Abstracts for two further papers have been submitted and accepted for presentation at forthcoming conferences in London (ICSEB 2018: 20th International Conference on Solar Energy and Buildings) and Stockholm (AEMC 2018 Advanced Energy Materials Congress). The conference papers will detail results of tests on second-generation prototypes under both solar simulated and realistic outdoor operating conditions. The project will conclude with technoeconomic analysis of Senergy system concepts based on experimental results and further simulation modelling examining different climatic and building integration scenarios.

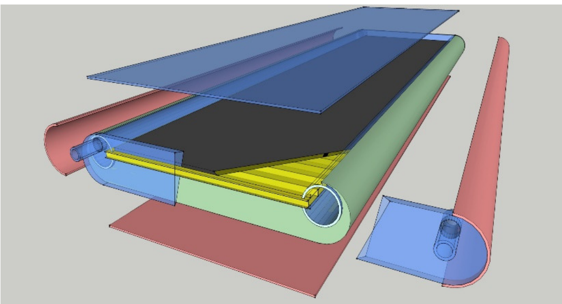


Figure 2 –Senergy collector (Left: exploded design drawing, Right: Absorber substructure assembly)

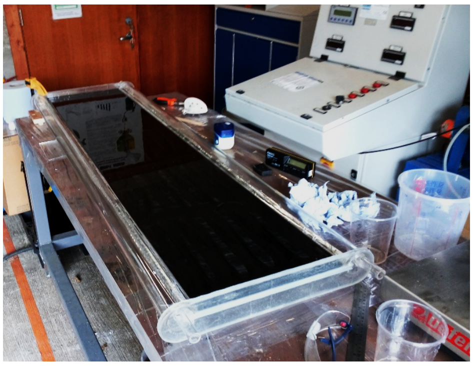
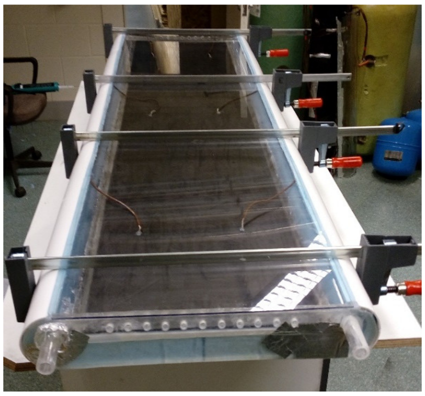

Figure 3 – Prototype fabrication (Left: Bare absorber, Right: Covered and insulated)

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IMPACT OF CASE FUNDING

CASE funding enabled Senergy to advance their technology concept from an embryonic stage by realising pre-production prototypes. The funding also facilitated an upgrade to Ulster University's outdoor solar collector testing facilities enabling these to host the Senergy array demonstrator coupled to a domestic hot water heating system.

BENEFITS FOR CASE MEMBERS

The project has enabled Senergy Innovations to access the solar energy engineering expertise and unique solar simulator test facilities available at Ulster University Centre for Sustainable Technologies. The collaborative approach to computer simulation modelling work has facilitated shared learning for both Semple & McKillop Consulting engineers and the Ulster University team, as well as giving Senergy improved understanding of potential energy yields. The outdoor demonstrator will prove the operation of the current collector design in a relevant environment and enable Senergy to showcase their technology to potential investors and commercial stakeholders.

CASE is an Invest Northern Ireland funded competence centre with grant funding of £5 million. The centre has successfully funded 18 research projects in renewable energy across biogas, marine renewables and energy systems sectors.

Centre for Advanced Sustainable Energy
David Keir Building
Stranmillis Road
Belfast
BT9 5AG
UK
Tel: 0289097 5577
Email questoratu@qub.ac.uk