SEMS: RESEARCH PROJECT DESCRIPTION

1. Project Background and Description

Waste to Energy: harvesting energy from wastewater and waste heat using graphene-based membranes

A large amount of untapped energy exists in the form of low-grade heat (LGH) below 100 ℃ from various industrial plants. Existing technologies are not capable enough to harvest energy from this form of LGH due to the small temperature difference and the temporal variability in heat output. Wastewater is another abundant resource, which has not been well exploited for beneficial purposes. We propose to study the feasibility of harvesting energy from LGH waste and wastewater using two membrane-based processes: thermo-osmotic energy conversion (TOEC) and closed-loop pressure retarded osmosis (CLPRO). Moreover, the bleed of the wastewater exiting the TOEC and CLPRO will be utilised to produce freshwater for drinking using reverse osmosis (RO) within the framework of regenerating draw solution for the CLPRO. The lack of suitable membranes is known to be another major hurdle to harvesting energy from these processes up to the level of commercial viability. As such, the study also aims to develop high-performance, high-pressure tolerant, low-fouling, and slow aging TOEC and CLPRO membranes with surface modification of currently available membranes using 2D materials including graphene. Our in-house developed mechanisms like Pressing & Folding as well as state-of-the-art highly efficient techniques such as solid-state drawing and targeted chemistry will be studied for membranes' surface modification. The processes will be assessed to verify their efficiency in terms of energy harvesting, water production, and waste management. Finally, a techno-economic analysis will be carried out to investigate the commercial feasibility of a TOEC/CLPRO large-scale power plant.

2. Project Scope

Three research project objectives

To develop models and carry out a numerical study to identify the lower power density bound that TOEC and CLPRO should achieve to be competitive with available renewable energy sources.

To develop high-performance, high-pressure tolerant, low-fouling, and slow aging TOEC and CLPRO membranes with surface modification of currently available membranes using 2D materials including graphene.

To build lab-scale prototypes for the processes and test their performance in power generation. The experimental results will be compared to that of the developed models.

3. Desired Skills from the Student

Key skills needed for the PhD project

A good degree in Chemical/Mechanical Engineering with knowledge and skills in separation technology, membranes, system modelling, experimentation.

4. Supervisory Team

Primary: (Name (inc title). Dr M Hasan Shaheed, SEMS, QMUL.

Secondary: (Name (inc title)/ department. Dr Emiliano Bilotti, SEMS, QMUL