Project Objective

The aim of the PHASECORE project is to develop a new class of high-performance Phase Change Materials (PCMs) that will enable effective thermal balancing in Molten Carbonate e-Fuel Cells (MCeFCs). These fuel cells operate at high temperatures, around 600–650°C, and are primarily powered by renewable synthetic fuels (e-fuels), particularly in liquid form, as well as biofuels such as bioethanol. Their high energy efficiency makes them a technology of the future, but they require very stable thermal conditions, even during brief interruptions in fuel supply.

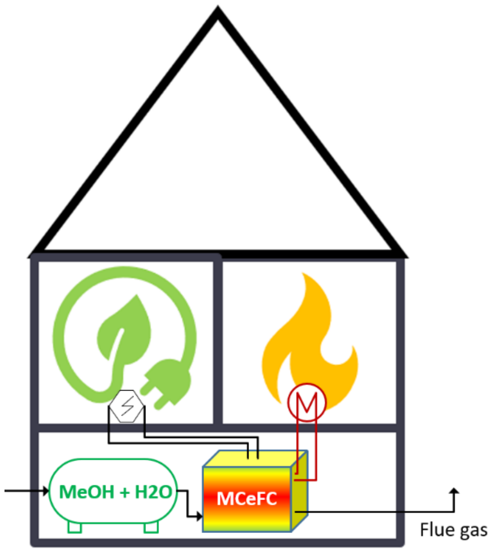

Figure 1 Concept of using a thermally balanced MCeFC device for stable electricity and heat production

Research Description

Phase Change Materials are substances that store large amounts of thermal energy during melting and release it during solidification. This allows them to act as a "thermal buffer," stabilizing the surrounding temperature. Their use is well known in heating and cooling systems, but applying PCMs at extremely high temperatures is a major challenge. In the PHASECORE project, we will search for mixtures of inorganic salts – mainly carbonates and chlorides – that melt within a range close to the operating temperature of the fuel cell. A key task will be to develop compositions that retain chemical and mechanical stability over multiple heating and cooling cycles, while also remaining cost-effective and easy to produce.

Among the salts considered are lithium carbonate (Li_2CO_3), sodium carbonate (Na_2CO_3), potassium carbonate (K_2CO_3), magnesium chloride ($MgCl_2$), and sodium chloride (NaCl). While many of these have melting points that are too high for direct use, it is possible to combine them in precise proportions to create eutectic mixtures—combinations that melt at a lower temperature than any of the individual components. This physical phenomenon, known from metallurgy and materials chemistry, occurs because the crystalline structures of the different components interfere with each other, lowering the overall melting point of the system.

In practice, by mixing lithium, sodium, and potassium carbonates in the right ratios, one can achieve a mixture that begins to melt at 500°C—already the basis for MCFC fuel cell technology. Similarly, it is possible to design mixtures that melt precisely in the desired 600–650°C range. To do this, carefully weighed quantities of salt powders are mixed and tested in the laboratory for their thermal properties, including heat capacity, conductivity, and resistance to multiple thermal cycles.

Motivation for the Research Topic

The innovation of the PHASECORE project lies in the integration of PCMs directly into the structure of the MCeFC. MCFC fuel cells already use molten carbonate mixtures as electrolytes. PHASECORE builds on this knowledge and experience to develop similar, but slightly higher-melting PCM materials that can be embedded directly into the fuel cell stack. The PCM will act as a thermal "casing," protecting the device from heat loss. As a result, when fuel supply is cut off, the cell will retain heat longer and be able to restart easily—without time-consuming start-up procedures or energy losses.

Expected Results

This approach will enable the design of more flexible energy devices—capable of short-term downtime or operating in systems integrated with renewable fuel storage. The increased operational flexibility will translate into higher energy efficiency and reduced fuel consumption.

The PHASECORE project will be carried out at Warsaw University of Technology. The research team includes specialists in electrochemistry, energy efficiency, fuel cells, and PCM materials used in both construction and energy materials processing. The results will be widely published and may contribute to the development of future generations of fuel cells and energy technologies based on renewable synthetic fuels.