FIRST EXPERIENCES AND LESSONS LEARNT FROM OPERATION OF POLISH SYSTEMS WITH SOLID OXIDE ELECTROLYZERS

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ABSTRACT

The last four years (2020-2023) forced a new perspective on energy security and diversification of the incoming stream of electricity as well the energy carriers. Global supply chains were exposed to tension never observed before. As that same time EU regulations focused on the reduction of carbon footprint of numerous industries, including power generation, brought hydrogen to the attention of many. Establishing hydrogen economy in countries and regions became an ultimate goal which is expected to be achieved by 2030 and beyond. At the same time existing infrastructure with production capacities which was built across Europe faces major challenges in reducing the intensity of carbon dioxide emissions as well operating in parallel with renewable energy sources.

Numerous conventional plants operated as a part of the European grid and worldwide are currently experiencing challenges related to the energy transition. Systems which belong to the group of centrally dispatched generation units (CDGU) are exposed to frequent cycling. This is mostly due to the fact that large-scale plants cannot be operated below given threshold, called the minimum load, which typically corresponds from 35% to 45% of the nominal capacity. When the plant operated at the minimum load continue to generate more electricity than the grid can accommodate it is forced to shut-down. This situation can be avoided by coupling the plant with system based on solid oxide electrolyzer which can directly use the steam and/or electricity from the process to produce hydrogen. At the same time numerous industrial processes are either decommissioned or repurposed to serve a new role. One of the most promising option is to convert these systems into sources of process heat and/or steam supply for hydrogen production in high temperature electrolyzers. This paper presents and discuss the potential of solid oxide electrolysis as technology which can be combined with existing systems such as power plants are refining processes. The potential for repurposing conventional power plants by hybridizing the cycle with modules of solid oxide electrochemical cells (see Fig. 1) which can interchangeably operate as an electrolyzer (SOE) or as fuel cells (SOFC) is presented. Such a hybrid makes it possible to trim the peaks and fill the valleys when the mismatch between the production and consumption of electricity becomes evident. In future scenarios, the concept can extended in order to help to limit the curtailment of wind and solar, and add to the resilience of electrical grids. The paper presents

unique technology which is under development at the Institute of Power Engineering – National Research Institute in Poland and was integrated with first-of-a-kind systems operated at industrial sites. The HYDROGIN and VETNI installations (see Fig. 2) which were commissioned in 2022 and 2023, respectively, provide the first lessons learned. This experience is now integrated in the development of 400 kW and 5 MW-class units in frame of MEGA-SOE project (2022-2029).

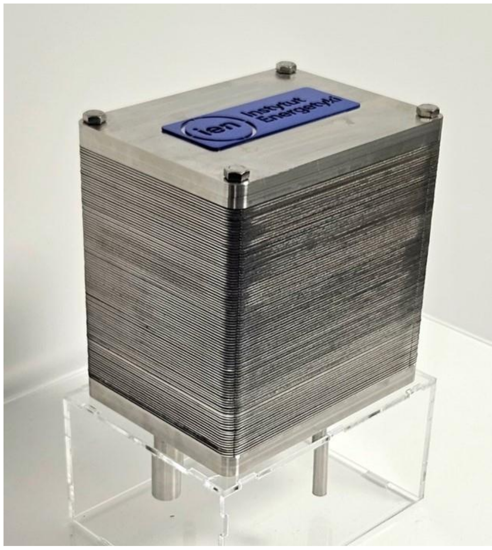

Figure 1 The 5 kW-scale solid oxide electrolyzer fabricated at the Institute of Power Engineering – National Research Institute in Poland which is a key building block of HYDROGIN (10 kW-class rSOC) and VETNI (30 kW-class) systems). The stack is based on 90 cells with fuel electrode supports fabricated using high-pressure injection molding (HPIM) and seals produced using 3D printing of glass-ceramic composite. Energy intensity of hydrogen production in the range 38-42 kWh/kg H_2 was demonstrated in both systems.

Figure 2 HYDROGIN (left) and VETNI (right) systems.

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