Deliverable 6.9

H2 summer School

(Summary of scientific HTPEM workshop)

Author: University of Porto

Deliverable due date: 30.9.2021

Deliverable submission date: 1.11.2021

Dissemination Level		
PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	
CON	Confidential, only for members of the Consortium	

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under Grant Agreement No 875081. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

Table of Contents

1. Summary

This document reports the deliverable D6.9 – Summary of scientific HTPEM workshop and industrial event. In this respect, this document describes the event organized by UPorto, entitled “H2 summer School”, which occurred on 20th - 24th of September of 2021.

2. H_2 Summer School

The event was online, completely free and open to public as well as students from different universities. The participant registration was simple, requiring only filling a form with basic information, such as name, affiliation, email, and position, receiving afterwards a link to participate in the conference. To those who could assist “in person”, the summer school also included a two-day experimental demonstration of PEM Electrolysis and PEMFC.

The event counted with 94 registered participants from 40 different organizations and 14 countries. Most of the participants, 70 %, were related to the academy, but ca. 30 % were from the industry sector. All the participants were based in Europe.

2.1. Content and subjects

The focus of the summer school was put on hydrogen production, transport, storage and alternative means of transporting hydrogen as synthetic fuels, such as ammonia or methanol. The hydrogen utilization in fuel cells of different types was also touched on as well as laboratory demonstrations. The theoretical lectures were blended with invited speakers from companies and research organizations. The detailed topics of the summer school are presented below.

1 - Framing the hydrogen economy (2 h)

- Energy from renewable sources – the history of a winning societal advancement;
- Sustainability
- The history of the hydrogen economy
- Hydrogen as energy vector

#2 - Hydrogen production (6 h)

- Electrolysis – PEM electrolysis, AEM electrolysis and SOEC;
- Thermochemical water hydrolysis;
- Photoelectrochemical water splitting;
- Reforming of biofuels/synthetic fuels – biomethane, biomethanol and bioethanol;
- Biomass gasification;
- Hydrogen purification.

#3 - Hydrogen storage and transport (3 h)
- Hydrogen compression to 350 and 700 bar and storing
- Hydrogen liquefaction and storing and other forms of storage
- Hydrogen pipelines
- Road and sea hydrogen transportation
- Storage in caves
- Conversion to synthetic fuels

#4 - Synthetic fuels from hydrogen (3 h)
- Ammonia
- Methanol
- DME
- Syngas
- Methane

#5 - e-Hydrogen plant (3 h)
- Design considerations
- Operation considerations
- Economics
- Round trip efficiency considerations
- Carbon footprint
- Analysis of the hydrogen lifecycle and critical comparison with other energy vectors

#6 - Hydrogen utilization (3 h)
- PEMFC
- SOFC
- Combustion

#7 - Lab work (4 h)
- PEM Electrolysis
- PEMFC

2.2. Organization

The event was organized by staff and doctoral students from University of Porto. The people behind the organization and the expertise they brought to the summer school are briefly presented here below.

Professor Adélio Mendes (born 1964) received his PhD degree from the University of Porto in 1993. Currently, he is full professor at the Chemical Engineering Department of the Faculty of Engineering –University of Porto. He coordinates a large research team with research interests mainly in electrolyzers and fuel cells, photovoltaic cells, photoelectrochemical cells, redox flow batteries, membrane and adsorption-based separation processes. He was the main responsible for the establishment of the largest Portuguese consortium on green hydrogen production, the H2Driven.

Dr. Paulo Ribeirinha (born 1982) is graduated in Chemistry since 2004 from the Faculty of Sciences of the University of Porto (FCUP) and obtained a Master's Degree in Energy and Environment in 2011 from the Polytechnic Institute of Leiria. From 2005 to 2011, Dr. Ribeirinha served in the Portuguese Air Force, Monte Real Air Base, as F16 Aircraft Maintenance Officer. Dr. Ribeirinha received his PhD degree from the University of Porto in 2018. His research is focused on the development of hydrogen fuel cells and hydrogen purification systems. He is author and/or co-author of 20 scientific articles in international journals.

Engineer Tiago Lagarteira (born 1988) is a project engineer at LEPABE-FEUP. He received his MSc degree in chemical engineering (processes and products) from UPORTO, in 2016, with the thesis entitle “MEAs preparation via wet routes for PEM electrolysis”. He is currently in the final year on his PhD which is focused on electrochemical conversion and storage energy systems (PEM fuel cells, PEM electrolysis, ERCO2 and advanced redox flow batteries). He is currently Work Package Leader at 112CO2 (FET Proactive); a cutting-edge project to develop COx-free hydrogen production through low-temperature catalytic methane decomposition. His publications include 10 research articles in peer reviewed scientific journals, 1 patent and more than 12 presentations in international conferences.

Engineer Celina Fernandes (born 1995) received her master’s degree in Chemical Engineer from the University of Porto in 2018. Presently she is a PhD student of Laboratory for Process Engineering, Environment, Biotechnology and Energy (University of Porto). Celina is currently part of project, in partnership with Bondalti Chemicals, S.A and Aveiro University, focused on studies for the valorization of NOx currents, present in industrial exhaust streams from the nitric acid production process, by electrochemical processes.

Engineer Luís Alves (born 1996) received his Master’s degree from the University of Porto in 2019. Currently he is a PhD student of the Laboratory for Process Engineering, Environment, Biotechnology and Energy (University of Porto). He works in hydrogen production by catalytic methane decomposition, in the scope of the European project 112CO2: Low temperature catalytic methane decomposition for COx-free hydrogen production.

Engineer Paranjeet Lakhtaria (born 1992) received his Bachelor´s in Rubber technology from India and Master´s in Polymer Science from Germany. Currently he is a PhD student of Laboratory for Process Engineering, Environment, Biotechnology and Energy (University of Porto). Paranjeet is currently part of the European project named ´European methanol powered fuel cell CHP (EMPOWER)´. His research work focuses on the development and optimization of catalyst for methanol reforming for hydrogen production.

Engineer Luís Carlos Matos (born 1973) is a Senior Technician in the Chemical Engineering Department at the Faculty of Engineering, University of Porto, Portugal. He is graduated in Food Engineering from the Coimbra College of Agriculture (1994) and the University of Algarve (1999). He holds a Master's degree in Quality Control of Food and Water (2003) from the Faculty of Pharmacy of the University of Porto, and he is currently a PhD candidate in Biomedical Engineering at FEUP. His main activities deal with supporting and developing educational units in the Chemical Engineering Laboratories.

2.3. Invited Speakers

In addition to the lectures given on more theoretical subjects, there were invited speakers that represented companies and research organizations from the EMPOWER project and gave their view on the subjects from a company point of view. The invited speakers are presented here below and the topic of their presentations are seen in the agenda in the next section.

Dr. Johan Tallgren, Senior Scientist at VTT Technical Research Center of Finland

Dr. Jari Ihonen, Principle Scientist at VTT Technical Research Center of Finland

Dr. Fredrik Silversand, Co-founder & Executive Chairman at Catator

Thomas Leopold Berg, Project Manager and Business Development Engineer at Blue World Technologies

2.4. Program

The summer school run over five days, with approx. four hours of lectures each day. A major part of the days was divided into parts that are more theoretical and into lectures given by the invited speakers from other companies and organizations. The agenda of the summer school is presented here below.

20th September, Monday.
09:00 – 09:10 Adélio Mendes (Introduction to the summer school)
09:10 – 09:40 Johan Tallgren (Introduction to EMPOWER project)
09:45 – 11:00 Adélio Mendes (Framing the H_2 economy)
11:00 – 13:00 Tiago Lagarteira (H_2 production)

21st September, Tuesday.
09:00 – 11:00 Fredrik Silversand (H_2 production from various fuels via reforming technologies)
11:00 – 13:00 Tiago Lagarteira (H_2 production)

22nd September, Wednesday.
09:00 – 12:00 Adélio Mendes (H_2 storage and transport)
12:20 – 13:00 Jari Ihonen (H_2 supply chain for heavy duty transportation application)

23rd September, Thursday.
09:00 – 10:30 Paulo Ribeirinha (e-H_2 plant)
11:00 – 12:00 Adélio Mendes (Synthetic fuels from H_2)

24th September, Friday.
09:00 – 12:00 Paulo Ribeirinha (H_2 utilization)
12:00 – 13:00 Thomas Leopold Berg (HT-PEMFC & applications with market perspective)

2.5. Advertising

The "H_2 Summer School" advertising, considered the elaboration of a flyer/poster, as depicted in Fig. 1. The communication of this event was carried out through the official channels (in the following) and also using the individual social network of the organizing team.

- Empower Website
- UPorto Website
- Empower LinkedIn
- The website of FCH JU

Information about the summer school was also shared directly to university students, such as students at Uporto and Aalto University (Finland), which collaborates with VTT in many aspects.

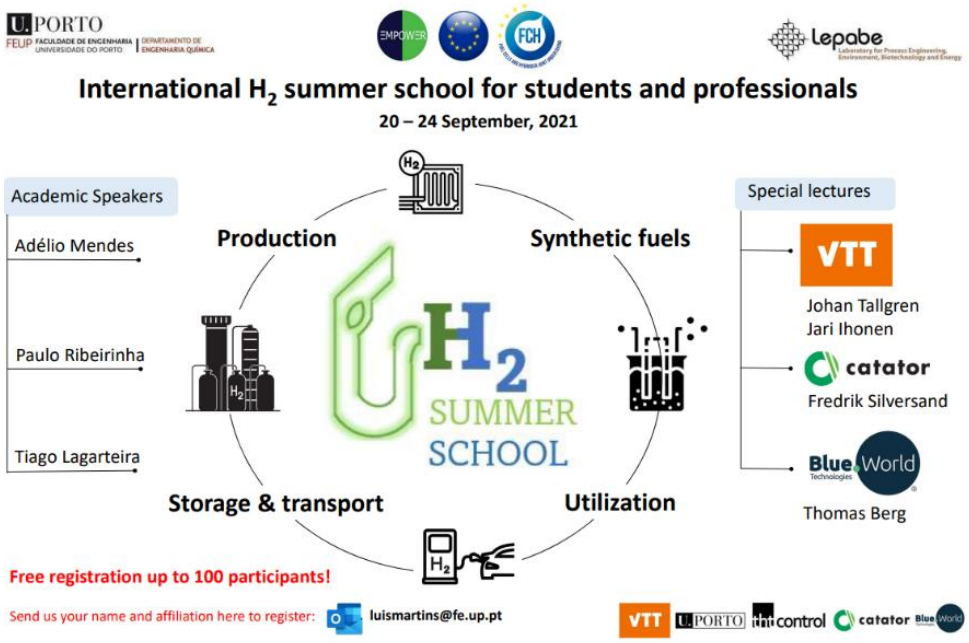

Fig. 1 - Flyer/Poster to promote H2 Summer School event.

2.6. Attendance Certificate

To the participants was provided an attendance certificate, as depicted in Fig.2.

Fig. 2 - Attendance Certificate

3. Discussion on future activites

Overall, the summer school, its feedback and the interest it sparked was regarded as very successful. As the interest for the summer school was high, there has been discussions on possibilities to continue the organization of the summer school to be arranged every year. Regarding the content, the summer school could have the same setup with lectures as in the first year with an addition of laboratory experiments that could be either attended to in person or online. The content, which now focused on hydrogen production and hydrogen economy, should also be distinguished from the Joint European Summer School on fuel cells and hydrogen technologies, arranged by University of Birmingham, Research Centre Jülich (Forschungszentrum Jülich) in cooperation with the University of Aachen (RWTH), and the Technical University of Denmark (DTU).

In addition, the possibility to award credits (ECTS) for the participation in the summer school should be investigated.