Future Prospects of Clean Energy Technologies in Energy Transport and Climate Transitions: Activities of the JRC

1. Introduction

The European Union has set ambition goals for greenhouse gas reduction by 2030 and these can only be achieved by a transition to cleaner (renewable) energy sources combined with energy efficiency actions. The JRC as the science and knowledge service to the European Commission provides scientific support to the policy formation and implementation underlying these political commitments.

2. R&D activities related to clean energy technology

The JRC has actively pursued research on green clean energy technologies since its conception, in the mid 1970's the first pilot programs on non-nuclear clean energy were launched initially studying solar thermal and solar photovoltaics where the JRC quickly established a strong reputation in quality, standards and reference measurements. Since then the diversification in to energy efficiency and focus on municipalities role in future energy transitions and management has placed the JRC in the forefront of European actions both for the support of deployment of new energy technologies, but also addressing non technological barriers to the clean energy transition.

3. Specific Research activities in hydrogen, CCUS, and related technologies

The main focus on European research on hydrogen and fuel cell technologies (H&FC) lies in the potential of these technologies to contribute to meet Paris agreement targets and the EU long term strategy on climate change. At the JRC, almost all the H&FC research activities are concentrated in the Directorate for Energy, Transport and Climate. The activities are strongly driven by mentioned EU strategy and related. JRC investigates in particular the role of hydrogen for achieving zero CO2 emissions in those economy sectors which are very difficult to make CO_2-free by means of electrification, such as industrial sectors, freight transport on road and rail, maritime sectors. Also the role of hydrogen in renewable energy storage and sector coupling is part of the JRC focus.

Since this area is very complex, various JRC projects focus on different research dimension and priorities:

The potential and the best role of the H&FC technologies for deep decarbonisation of the whole energy system and more at large for a climate neutral economy. This is done by means of modelling tools. A most visible output is the in-depth analysis performed for the mentioned European long term strategy[1]. Other, more specific studies are performed on

[1]IN-DEPTH ANALYSIS IN SUPPORT OF THE COMMISSION COMMUNICATION COM(2018) 773, A Clean Planet for all - A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy: https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf

selected applications and technologies, to assess economic potential in the next years[2].

The sustainability of the H&FC technology options, by studying environmental impacts, critical raw materials aspects and well-to-wheel studies.

JRC laboratories develop, validate and implement methods for the assessment of individual key-technologies:

fuel cells and electrolysers systems

validate technical regulations for the approval of high pressure onboard storage systems
energy and emission assessment of vehicles, including hybrids, batteries electrical vehicles and in the future fuel cells vehicles as well.

In term of Regulations and Standards, JRC dedicates particularly attention to public safety as an enabler for the deployment of hydrogen technologie. More generally, JRC performs in conjunction with European standardization bodies (CEN/CENELEC), analyses of research and standardisation gaps and priorities in H&FC technologies[3].

Some of these activities are designed and executed in collaboration with the Fuel Cells and Hydrogen Joint Undertaking, an industry-led public-private partnership co-funded by the European Commission. In this frame, JRC is leading/coordinating the following work streams:

RCS Strategy Coordination Group (industry led), aiming at developing multi-annual pre-normative research (PNR) programme and to link it to the European standardization strategy for H&FC technologies

Harmonisation of testing protocols for the performance assessment of European key-technologies such as PEMFC for transport applications and electrolysers.

At the JRC, Directorate for Energy, Transport and Climate, we address CCUS in power generation and industry primarily via the Low Carbon Energy Observatory (LCEO) project.

The LCEO is a project executed by DG-JRC for DG-RTD, to provide top-class data, analysis and intelligence on developments in low carbon energy supply technologies.

Two different reports are produced for CCUS within the project, A Technology Development Report and Technology Market Report. These reports give a neutral

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[2] Kanellopoulos, K., Blanco Reano, H. , The potential role of H2 production in a sustainable future power system - An analysis with METIS of a decarbonised system powered by renewables in 2050 http://publications.jrc.ec.europa.eu/repository/bitstream/JRC115958/kjna29695enn.pdf

[3] CEN – CENELEC Sector Forum Energy Management / Working Group Hydrogen Final Report 2016 (a new apdated version is expected in 2019).
http://publications.jrc.ec.europa.eu/repository/bitstream/JRC99525/sfem%20wg%20hydrogen_final%20report%20(online).pdf

assessment on the state of the art, identification of development trends and market barriers, as well information regarding private and public funds and policy measures.

It covers a range of technologies, one of which is CCUS.

Specifically, some of the topics the Technology Development Report addresses are:

The technology state-of-the-art
National and International projects in power generation and industry
Technology limitations
R&D overview on research focus and topics
Projects employing different CCUS aspects
Technology development outlook in terms of technology trends and needs
Technology barriers to large scale deployment

Some of the topics the Technology Market Report addresses are:

Regulatory framework and incentives
R&D investment and patenting activity in Europe
Market overview
Emerging players and markets
Industrial strategies and business models
Market outlook for future developments
Deployment under different scenarios based on modelling exercise
Key sensitivities and barriers to market expansion

Advanced Alternative Fuels

As part of the Low Carbon Energy Observatory project, the JRC has produced an assessment of the technology readiness level of a range of concepts, including:

Power to fuel (electrofuels)

H2 production using renewable electricity
Alkaline electrolysis
Solid-oxide electrolysis cell (SOEC)
PEM (Proton exchange membrane) electrolysis
Water-splitting/artificial photosynthesis
Fuels (methanol, synthetic petrol or diesel, methane)

CO2 based fuels using, recycled carbon fuels

Waste high concentration CO2 from renewable sources
Amine-based post combustion capture
Microbial fermentation
Industrial off-gases processed by bacteria into ethanol
Mixture of sewage gas and natural gas processed by bacteria into ethanol

Photovoltaic Solar Energy

PV is a key renewable energy technology for implementing the commitments of the Paris Agreement on climate change mitigation. Support is required for continued international work on standards for PV. Important areas include systems design, installation and operation, as well as reliability and performance of photovoltaics devices themselves. Standards can help reduce financing costs, but also need to accommodate product innovation. Both are key factors to exploiting PV as a key renewable energy technology.

Since 2011 JRC and AIST have worked together with the National Renewable Energy Laboratory (NREL) from the US Department of Energy, on an international project on quality assurance of PV modules and systems (PVQAT). The objective is to provide the PV community with a single set of international standards addressing quality and reliability issues. This activity involves support to three main reliability workshops held alternatingly in Europe (Sophia), Asia (Sayuri) and USA (NREL PVRW).

Furthermore activities are undertaken to assure that calibration and performance measurements made around the world are equivalent. In collaboration between the JRC's European Solar Test Installation Laboratory (ESTI) and AIST's National Institute the Research Centre for Photovoltaic Technologies the following collaborations and publications have been produced:

- Calibration of 4 Conventional PV reference cells from AIST calibrated at ESTI and AIST (report published)
- Calibration of 4 Conventional PV reference cells from ESTI calibrated at ESTI and AIST (report published)
- Primary Calibration inter-comparison of PV reference cells between ESTI and AIST (ongoing)
- 1st PV Module Round Robin ISE (FhG), NREL, ESTI, AIST (peer-reviewed paper published)
- 2nd PV Module Round Robin ISE (FhG), NREL, ESTI, AIST (peer-reviewed paper published)
- 3rd PV Module Round Robin ISE (FhG), NREL, ESTI, AIST (ongoing)
- WPVS 3rd recalibration organized by AIST, ESTI participating (under planning)

To address the future needs of PV, the IEC TR 63228 on Development of measurement procedures for emerging PV technologies (OPV, DSSC, PSC) (in print) was drafted under joint project leadership of Toshiro Matsuyama (RATO: Research Association for Technology Innovation of Organic Photovoltaics), Giorgio Bardizza (JRC) and Chris Fell (CSIRO, Australia).

Batteries

Batteries are a key enabling technology for e-mobility and electricity storage/supply. A good understanding of their performance, durability and safety is essential. Japan has an excellent position in research, innovation and production of batteries. As a consequence it is beneficial to continue collaborating with leading Japanese research institutions. This will also facilitate improved technical/scientific support for the development of future policies in the area of batteries/energy storage.

4. International collaboration
4-1 International alliance/networking development

In the field of H&FC technologies, JRC has a long records of informal collaboration with the US DOE and its National Laboratories:

> in the past the joint work on hydrogen safety sensors with NREL has enabled industrial development and the definition of harmonised testing criteria. The most recent work focuses on the safety strategy for a correct detection of hydrogen releases in semi-confined spaces [2010-2019]
> JRC exchanges also on an informal basis descriptions of and lesson learned from safety-related events with PNNL

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In the field of batteries, a collaboration with the National Institute of Advanced Industrial Science and Technology (AIST), Japan Aerospace Exploration Agency (JAXA) and Nagaoka University of Technology addresses research on Li-ion batteries, where each partner contributes with specific expertise. Target is to contribute to the development of a deeper understanding of issues related to battery safety, performance (and degradation thereof).

4-2 International joint R&D activities

Batteries

Currently there is ongoing research between National Institute of Advanced Industrial Science and Technology (AIST), Japan Aerospace Exploration Agency (JAXA) and Nagaoka University of Technology (NUT) in the area of battery safety and performance. AIST will focus on fabrication and analysis of battery materials, JAXA on cell cycling tests, NUT on cell safety testing. JRC will contribute on complementary aspects of cell cycling tests, material analysis (e.g. XRD and computed tomography) and safety testing.

Previously, several visits to Europe and Japan have taken place under this collaboration. This included a trainee hosted by JRC Petten. The work was mainly focused on assessing the occurrence of Li plating during low temperature cycling. A common publication is in preparation.

International joint research program for innovation energy technology in your institute.

Also see attached.

5. Future perspectives

Future challenges in clean energy technologies, expected international collaborative framework in your institute.

Hydrogen

The short term activities of JRC in the field of H&FC technologies will develop along these lines:

Ranking of the best options for the development of CO2-free technologies for heavy duty transport and maritime applications. The objective is to identify which specific applications are better decarbonised by means of electrification, and which by hydrogen and fuel cells.

Identification of the expected role of energy storage in the 2050 specifically for the European power grid climate and more in general for a neutral strategy economy.

Supporting the development of a standardization frame for the key technologies enabling a massive deployment of H&FC technologies, with a special focus on public safety: bulk energy transport, a completely new maritime RCS frame and storage and distribution infrastructure. This effort is expected to take place in international forums such as the IPHE, Mission Innovation and the proposed Memorandum of Cooperation on Hydrogen to be signed between US, Japan and the EU.

CCUS

The next set of JRC reports on Technology Development and Technology Market will update the already produced series and will:

Underline R&D efforts crucial with regards to technical challenges
Present instruments that have been so far considered to incentivize the technology
Identify the expected outcomes of CCUS technology in research and development
Present the effectiveness of metrics to assess technology development
Consider a realistic role for the technology in line with the EU's Long Term Strategic Vision

PV

There are currently no standards for the measurement of the performance artificial photosynthesis devices. The EU is interested to collaborate at international level to establish best practices.

Short CV Christian Thiel

Christian Thiel works in the European Commission's Joint Research Centre (JRC) since 2009, amongst others in the Energy Systems Evaluation Unit and Sustainable Transport Unit. Since February 2018 he is Head of the Energy Efficiency and Renewables Unit in the Directorate for Energy, Transport and Climate. The unit's mission is to support the deployment of energy efficiency and renewable energy technologies, measures and policies. It provides support in the implementation of key EU Directives such as the Renewable Energy and Energy Efficiency Directives. These activities are conducted in collaboration with relevant Commission Services, national and International organisations and stakeholders. In addition, the Unit provides reference measurements and test methods for photovoltaic technologies. Previously, Christian was leader of the electro-mobility modelling and energy system modelling projects within the JRC.

Before joining the European Commission, Christian Thiel worked for more than 12 years in the automotive industry, in the Engineering Centre of Adam Opel AG/ General Motors Europe. During his tenure at Opel/ General Motors, Christian had various assignments with increasing responsibility, ranging from Technical Staff for Waste Management Systems, Project Engineer Life Cycle Assessment (LCA), Assistant General Secretary European Council for Automotive R&D (EUCAR) in Brussels to Manager Portfolio Engineering and CO2 Strategy, and European Program Engineering Manager Chevrolet Volt/ Opel Ampera.

He holds a Doctoral degree (Dr.nat.techn.) from the University of Natural Resources and Life Sciences Vienna, a Master's degree in Environmental Science (Geooekologie) from the Technical University Braunschweig, a bachelor's degree in Biology from Université Paris VI and an undergraduate degree in Economics from the Goethe University Frankfurt am Main. Christian has published 39 papers in peer-reviewed journals (with an h-factor of 17 according to Scopus).