CIGRE Study Committee C1

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG C1.48	**Name of Convenor:** Alexandre Oudalov (CH)
Strategic Directions #[2]: 1, 2, 3, 4	**Sustainable Development Goal #[3]: 7, 9, 11, 13**
The WG applies to distribution networks: ☒ **Yes** / ☐ **No**	
Potential Benefit of WG work #[4] : 1, 2, 3, 4, 6	
Title of the Group: Role of green hydrogen in energy transition: opportunities and challenges from technical and economic perspectives	

Scope, deliverables and proposed time schedule of the WG:

Background:

Deep decarbonization is the foundation to a carbon-free economy. Electrification sourced from renewable energy is the main solution, however due to the intermittent behavior and intrinsic requirement of fuels for certain sectors, e.g. aviation and chemical industry, it is not sufficient.

Out of all clean fuel alternatives, green hydrogen is one of the strongest contestants because of the following key properties:

- Can be produced from renewable electricity and water
- Zero emissions when converted into usable energy
- Energy dense and versatile fuel.

As such, hydrogen demand is expected to ramp up steeply in the coming decade from ~80 Mt in 2020 up to 160 Mt in 2030 (according to qualified consultants' studies). The wide range in demand can be explained by significant deviations in cost reductions throughout the hydrogen supply chain, as well different outlooks on the adoption speed of hydrogen technologies. Up to 2030 hydrogen demand will remain centered on industrial feedstock, however there will be some minor demand for heavy long-distance transportation, high-grade industrial heating and some seasonal storage applications for wind and solar over-supply. However, by 2050 hydrogen applications could become more diversified, with a strong demand for long distance freight transportation, turning into a standard fuel for industrial and residential heating, in addition to its role in bulk-long duration storage of variable renewable generation V-RES, as cost parity between electrolysis and steam methane reforming (SMR) is expected to be achieve before 2050.

Today the main energy carriers across the energy sector are natural gas, oil and electricity. However, a new paradigm can be formed with hydrogen as an energy carrier replacing oil and natural gas, as well as, for long submarine links, electric cables. Coupling electric and hydrogen supply & demand sectors can help to optimize both sectors and provide a valuable flexibility resources to balance much faster dynamics in electric networks.

Modern electrolyzer technology supports fast reaction time and ramping making it as a viable alternative to fast frequency control while simultaneously working on a seasonal cycle. Scaling up electrolyzer plants from few MWs to hundreds of MWs may require (depending on their location along the supply chain) a dedicated connection to high voltage transmission grid. Grid code compliance at plant level will be one of the key aspects to address. Provision of new flexible system services, such as congestion management or frequency response, is another aspect that needs to be examined as potential source of revenue stream for the plant owners while deferring or substituting investment in grid expansion.

Scope:

The main objectives of the working group are (a) collect and analyze numerous studies related to technical and economic aspects of hydrogen supply chain and use, as well as supporting national policies and implementation strategies; (b) present different use cases in industry, transport, heating sectors and as energy storage and other system services including renewable electric energy supply needs, land and water requirements, and (c) recommend technology solutions for grid code compliance and to enable market-based provision of various local and system wide flexibility services by large scale electrolyzer plants.

The following topics will be explored and elaborated within the working group:

1. Overview of hydrogen supply chain which includes production, conversion, transport and storage. Special attention to pipeline/ship transport feasibility and comparison to power line transmission in terms of efficiency.
2. Forecasting hydrogen demand and a corresponding amount of renewable electric energy supply and installed capacity which can be translated in land requirements. Regions/countries can be classified as potentially self-sufficient or having deficit or surplus in terms of hydrogen production by means of wind and solar generation to achieve full decarbonization of all sectors.
3. Identification and analysis of specific use cases in terms of economic value of green hydrogen (drivers, break-even compared to alternatives, load factor depending on operating modality).
4. Review of technologies for scaling up electrolyzer plant capacity, including interface to transmission or distribution grid, power quality management, cost efficient and reliable on-site connection to the grid.
5. Evaluate a future role of green hydrogen and its derivatives (synthetic gases and liquids, e.g. ammonia) as:
    a. Clean feedstock and fuel to replace conventional, fossil fuel based “grey” hydrogen production such as SMR or combustion/chemical reactions of hydrocarbons by “green” hydrogen in petrochemical, iron/steel, heating and long haul freight transport segments which are hard to decarbonize by a direct use of electricity.
    b. Long-term energy storage (weeks, months) for a seasonal balancing of variable RE sources. Low cost storage is only achievable if using underground reservoirs – salt caverns, depleted gas fields, etc. which do not have an even geographic distribution. Identifying optimal sites, their connection via gas or transmission networks as well as operating principles. Analyzing a complementarity between various energy storage technologies such as batteries, pumped hydro and hydrogen.
    c. Alternative energy carrier for transporting renewable energy converted to hydrogen over long distances solving temporal and spatial mismatch of VRES and demand. The transport options may include liquid hydrogen tankers, trunk pipelines, etc. Special focus on off-shore wind conversion to hydrogen offshore (electrolyzers installed directly on off-shore platforms) or on-shore (electricity first transmitted to shore).
6. Identify region/scenario dependent optimal mix of interconnectors, storage including hydrogen and demand response in collaboration/follow-up with WG C1.44.
7. Overview of governmental policies and implementation strategies in different regions (inputs will be provided by regional WG representatives), Guarantees of Origin (GoO) and green gases taxonomy, allocated budgets and support schemes, technology development focus areas and applications of highest priority.

Joint work with other SCs:
Liaison experts from SC C6, B1 and C5 will be invited.

Deliverables:

☒ Technical Brochure and Executive Summary in Electra
☒ Electra Report
☒ Future Connections
☒ CSE
☒ Tutorial
☒ Webinar

Time Schedule: start: January 2021 **Final Report**: December 2022

Approval by Technical Council Chairman:

Date: November 28th, 2020

Notes: [1] Working Group (WG) or Joint WG (JWG), [2] See attached Table 1, [3]See attached Table 2 and CIGRE reference Paper: Sustainability – at the heart of CIGRE's work. [4] See attached Table 3

Table 1: Strategic directions of the Technical Council

1	The electrical power system of the future reinforcing the End-to-End nature of CIGRE: respond to speed of changes in the industry by preparing and disseminating state-of-the-art technological advances
2	Making the best use of the existing systems
3	Focus on the environment and sustainability (in case the WG shows a direct contribution to at least one SDG)
4	Preparation of material readable for non-technical audience

Table 2: Environmental requirements and sustainable development goals

	CIGRE selected the 7 SDGs that are the most relevant to CIGRE. In case the WG work refers to other SDGs or do not address any specific SDG, it will be quoted 0.
0	Other SDGs or not applied
7	**SDG 7: Affordable and clean energy** Increase share of renewable energy; e.g. expand infrastructure for supplying sustainable energy services; ensure universal access to affordable, reliable, and modern energy services; energy efficiency; facilitate access to clean energy research and technology
9	**SDG 9: Industry, innovation and infrastructure** Facilitate sustainable infrastructure development; facilitate technological and technical support
11	**SDG 11: Sustainable cities and communities** Increase attention on sustainable and resilient buildings utilizing local (raw) materials, power for electric vehicles, strengthening long-line transmission and distribution systems to import necessary power to cities, developing micro-grids to reinforce the sustainable nature of cities; protect and safeguard the world's cultural and natural heritage; reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and waste management
12	**SDG 12: Responsible consumption and production** E.g. Promote public procurement practices that are sustainable; address reducing use of SF6 and promote alternatives, encourage companies to adopt sustainable practices and to integrate sustainability information into their reporting cycle, address inefficient fossil-fuel subsidies that encourage wasteful consumption
13	**SDG 13: Climate action** E.g. Increase share of renewable or other CO_2-free energy; energy efficiency; expand infrastructure for supplying sustainable energy; strengthen resilience and adaptive capacity to climate-related hazards and natural disasters; integrate climate change measures into national policies, strategies and planning; improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
14	**SDG 14: Life below water** E.g. Effects of offshore windfarms; effects of submarine cables on sea-life
15	**SDG 15: Life on land** E.g. Attention for vegetation management; bird collisions; integration of substations and lines into the landscape

Table 3: Potential benefit of work

1	Commercial, business, social and economic benefits for industry or the community can be identified as a direct result of this work
2	Existing or future high interest in the work from a wide range of stakeholders
3	Work is likely to contribute to new or revised industry standards or with other long term interest for the Electric Power Industry
4	State-of-the-art or innovative solutions or new technical directions
5	Guide or survey related to existing techniques; or an update on past work or previous Technical Brochures
6	Work likely to contribute to improved safety.