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INDUSTRIAL ELECTRIFICATION (I)

Reference

Based on the first Task Report – Mapping of Activities - from the IETS Annex XIX Electrification in Industry.

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Information about current projects can be found at the IETS website.

Background

The global commitment to keep global temperature rise well below 2°C, and preferably below 1.5°C, requires deep GHG emissions reductions throughout all sectors of the economy. For the industrial sector, whose direct CO2 emissions currently account for about 25% of global energy-related and process CO2 emissions, this commitment implies a reduction of direct GHG emissions of 80% by 2050. The industrial sector is complex, diverse and contains numerous emission sources as it encompasses all activities related to the processing of raw materials into final products. This covers everything from a large petrochemical plant to a brewery.

Electrification of the industrial sector has been identified as a key option to reduce GHG emissions in several innovation agendas at national level. These agendas indicate a high overall technical potential for industrial electrification. Literature also indicates significant potential co- benefits of industrial electrification. It is, however, recognized that although many of the essential technological elements for industrial electrification already exist, the large diversity of processes and high levels of process integration required make solutions very complex. Significant challenges exist in cost and engineering development as well as barriers in investment and infrastructure requirements, and further technological development to reduce costs.

Mapping of activities in the area of industrial electrification

The aim of this first step in the Task was to identify current key activities and hotspots in the topic of industrial electrification by:

- mapping the areas of research on industrial electrification in the last 10 years by bibliometric analysis.
- identifying stakeholders (institutes, universities, countries) that are working in industrial electrification.
- identifying aspects and/or activities that are considered important by the stakeholders, as well as areas with critical mass and current gaps.

To achieve this aim desktop research was combined with stakeholder consultation (survey, interviews and a workshop). In this Topic sheet, the first part, mapping by bibliometric analysis is briefly presented.

A bibliometric analysis is a quantitative analysis used to identify national and international networks and map the development of fields of science and society. The result is presented in a map where each node (circle) represents a keyword in the field. The size of the node reflects the number of co-occurrences of the keyword. In general, the closer two nodes are located to each other in the visualization, the stronger they are related to each other based on bibliographic coupling.

Results

Figure 1 shows the result of the bibliometric network for the search industrial electrification.

The red cluster focuses on research topics related to electric utilities and energy use. This cluster is composed of publications that explore aspects such as alternative energy sources and cost effectiveness, which are crucial system aspects that require further understanding towards an electrified industrial sector.

The green cluster focuses on research topics related to greenhouse gas emissions and its direct relation with electrification towards a zero emitting industrial sector. This cluster also highlights the potential use of carbon dioxide in power-to-x systems, as those are expected to be relevant in upcoming developments towards electrification.

The yellow cluster focuses on research topics related to energy efficiency and renewable energy systems. Noticeably, topics related to cost reduction are emerging as a key aspect of the publications and are not yet dominant.

The blue cluster emphasizes the integration of renewable energy systems with the industrial sector. The cluster is the smallest of the four suggesting that understanding of sector coupling between the power and industrial sector in peer review publications is still at early stage. Aspects such as hydrogen, electrolysis and methanation among others also appear in this cluster.

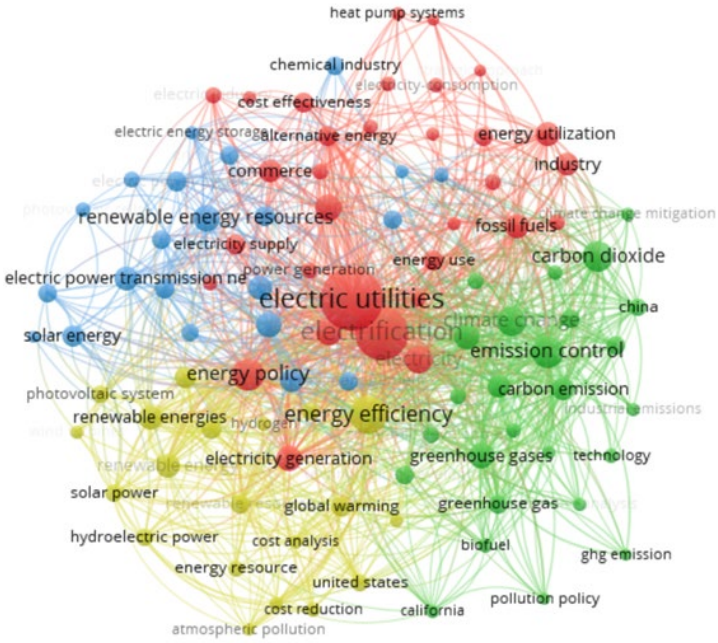

Figure 1 Bibliometric network of industrial electrification

In a detailed assessment of topics the networks for power-to-X, power-to-gas, power-to-hydrogen, and power-to- chemicals are compared, see Figure 2. The comparison between the networks highlights some interesting points. Among the four terms, the power-to-gas network appears as the densest, most mature network while power to chemicals is, in contrast, an emerging network. Interestingly, all networks share a series of keywords such as renewable energy, electric power transmission, energy storage, and electrolysis.

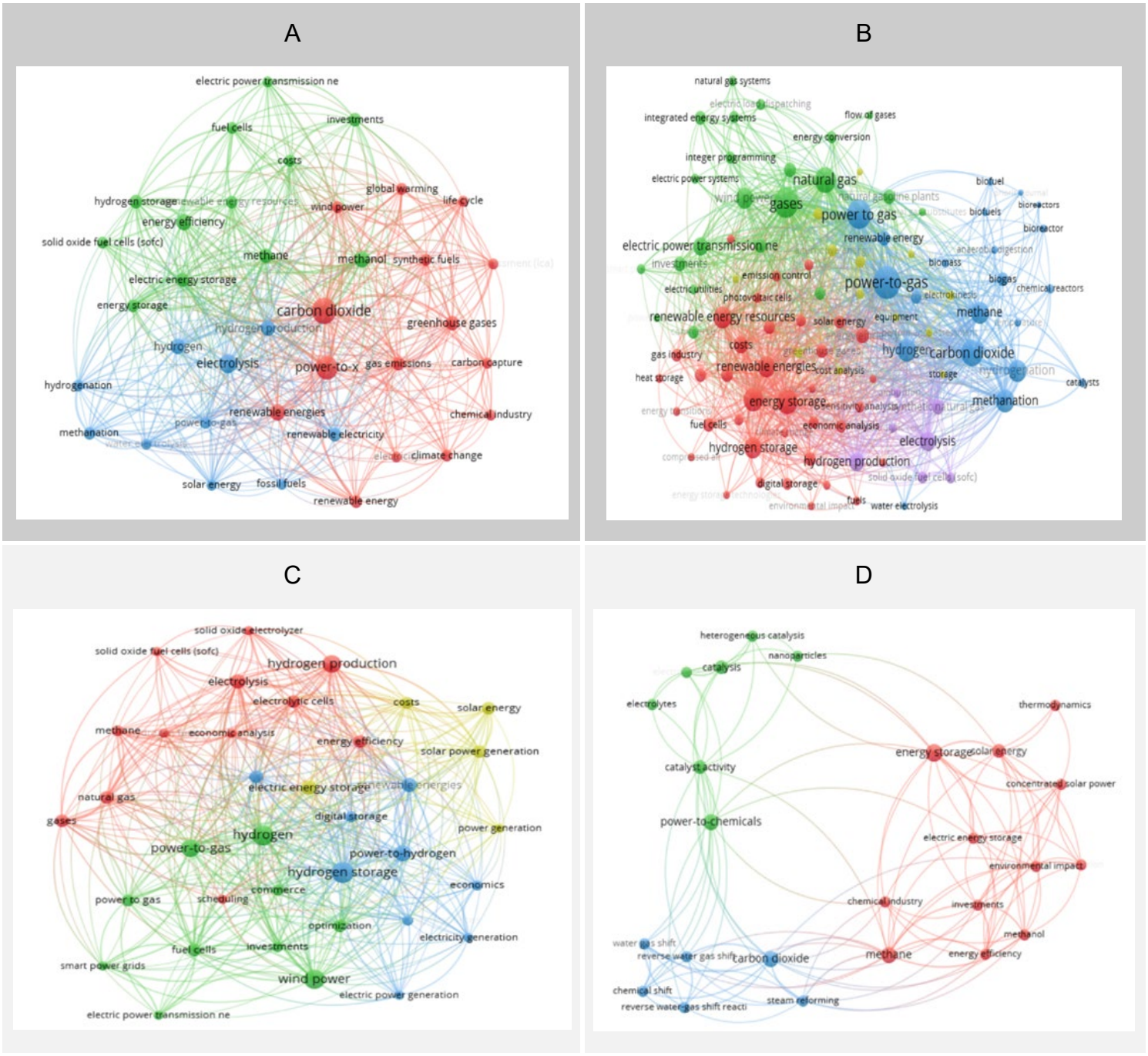

Figure 2 Bibliographic network analyses. Figure 2A: power-to-X; Figure 2B: Power-to-gas; Figure 2C: Power-to-Hydrogen and Figure D: Power-to-Chemicals

Power-to-hydrogen, however, does not require per se that the power is produced from renewable energy sources. However, given the importance of this aspect as a driver of industrial electrification, a bibliometric analysis for the topic of green industrial hydrogen was carried out. This is the term used to refer to hydrogen produced from solar and wind power (via water electrolysis). In the last ten years, a significant number of papers have included this topic as keyword and the network appears to be consolidating. Cluster formation are around the topics technology development, use of hydrogen as a storage technology, cost and investment.

Electric heating has been a major research area during the last ten years in which areas such as heat pumps, heat storage, energy efficiency and electric boilers have emerged as clear topics. This is not surprising as heat represents three-quarters of industrial energy demand worldwide, and about half of it is heat at low to medium-high temperatures. Maybe because of the topic's maturity, areas related to system analysis are clearly linked to the topic. This includes optimization at system level, sink-source matching (beyond a plant) and economic analysis.

An aspect that is currently discussed in some of the countries national agendas is flexible industrial electrification. This is related to the expected variability of electricity grids that are driven by renewable energy sources such as wind or solar. In the bibliometric analysis we only found a limited number of studies dealing with this topic during the past ten years. This is, however, not surprising as the need to understand the impact (or demand for) flexibility in the electrification of the industrial system is a consequence of the accelerated penetration of intermittent sources of electricity in the last decade, and the (inter)national targets to drastically increase the share of these renewables in the short to midterm.

In the bibliometric network for policy making and industrial electrification, the research papers are clustered around three areas: climate change, power sector and economics. Technological aspects appear throughout the three clusters but, in comparison to the other networks discussed so far, are not a driven factor. In addition, we also looked into research related to electrification roadmaps. Most roadmaps are related to the transformation of the power sector to a low carbon system, while taking into account a potential increase in demand (from but not limited to the industrial sector).

Finally, we examined the network for publication focusing on circular economy and industrial electrification. Green electricity is often named as one of the system requirements for a sustainable circular economy. Interesting this is the only case we found where the total network appears rather linear, that is, the interconnections within the clusters is strong but between clusters is rather weak.

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