**Sustainability Dimensions in Hydrogen-Based Distributed Energy Systems**

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**Highlights**

* Distributed energy systems including hydrogen as energy carrier were studied
* The design of DES including hydrogen is focused on techno-economic issues
* There is a need of multi-dimensional approaches to evaluate this type of systems

**1. Introduction**

The constant expansion of world economy and population, as well as the concerns about climate change, represent new challenges for the energy sector [1]. In this line, the emergence of distributed energy systems (DES), and the integration of different energy networks by means of the combination of multiple energy sources, converters and carriers have represented a shift in the energy framework [2]. Among energy carriers, hydrogen has appeared as a promising alternative due to the large range of sources from it can be obtained. Additionally the possibility to use it as raw material, energy storage medium (power-to-gas) or as final energy form emitting only steam and heat in its combustion, make hydrogen a promising energy vector to be integrated in energy systems [3]. However, despite their potential capabilities, introducing hydrogen in the design of distributed energy systems (DES) is a complex problem due to the simultaneous dimensions and constraints that need to be considered, as well as to the high context dependence of this kind of projects [4]. For these reasons, in this work a literature analysis is done with the aim to identify the objectives (technical, economic, environmental and socio/political) and the specific evaluated criteria (profit, NPV, efficiency, emissions, etc) when DES including hydrogen are designed, planned or operated.

**2. Methods**

The methodology consists on a bibliographic analysis of scientific research papers, by means of a systematic literature review carried out according to the parameters noted in Table 1. Taking into account the great variety of terminology related with DES, the keyword field is composed of a set of terms (e.g. energy hub, microgrid, hybrid energy system), besides to hydrogen and power-to-gas ones.

**Table 1.** Search strategy parameters.

|  |  |
| --- | --- |
| Field | Option Introduced |
| Keywords | ("energy hub" OR microgrid OR "integrated energy systems" OR "distributed energy system" OR "decentralized energy system" OR "multi energy system" OR "hybrid energy system" OR "polygeneration") AND (hydrogen OR "power to gas") |
| Search in | Title, abstract, keywords |
| Period explored | 2000 - 2018 |
| Type of documents | Articles and conference papers |

**3. Results and discussion**

Figure 1 shows the distribution of publications according to the evaluated objective. It highlights the prevalence of economic issues, which are involved in almost 80% of studies. Additionally, it appears that around 45% of documents include multi-objective analysis and nine works address economic, technical and environmental goals simultaneously.



**Figure 1.** Performance objectives evaluated in DES. (Ec-economic, Tec-technical, Env-environmental)

**4. Conclusions**

Results indicate that the design and analysis of DES including hydrogen have been predominantly focused on techno-economic issues. Hence, there is an opportunity for future work to include another dimensions (e.g. socio/political), and thus improve the decision-making process for planning this type of energy systems.

**References**

1. International Energy Agency (IEA). World Energy Outlook 2017 2017. http://www.iea.org/weo2017/ (accessed April 8, 2018).
2. Adil AM, Ko Y. Socio-technical evolution of Decentralized Energy Systems: A critical review and implications for urban planning and policy. Renew Sustain Energy Rev 2016;57:1025–37. doi:10.1016/j.rser.2015.12.079.
3. Dincer I, Acar C. Smart energy solutions with hydrogen options. Int J Hydrogen Energy 2018:1–21. doi:10.1016/j.ijhydene.2018.03.120.
4. Eriksson ELV, Gray EMA. Optimization and integration of hybrid renewable energy hydrogen fuel cell energy systems – A critical review. Appl Energy 2017; 202: 348–64. doi:10.1016/j.apenergy.2017.03.132.