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H2-MICROGRID AS A BOTTOM-UP SOLUTION FOR ENTERING INTO THE GREEN ECONOMY

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Abstract. The shift to a green economy is essential for sustainable development, with reliable and efficient renewable energy sources forming the bedrock of this transition. Projections from IRENA suggest that the global share of renewable energy will surge from 16% in 2020 to 77% by 2050. In alignment with this trajectory, Germany has committed to net-zero emissions by 2045, mandating that 80% of its electricity supply comes from renewable sources by 2030 and 100% by 2035. Addressing the variable nature of renewables like wind and solar necessitates energy carriers like hydrogen, which offers high volumetric energy density and utility in hard-to-electrify sectors such as industry and transportation. Notably, green hydrogen, although currently under 1% of total production, is anticipated to become more cost-effective than blue hydrogen within the next 5 to 15 years. This transition emphasizes the development of efficient hydrogen logistics to facilitate broader adoption. This article underscores the importance of hydrogen infrastructure in Germany and explores how decentralized H2 microgrids can effectively bridge gaps to achieve sustainability goals. It highlights initiatives such as the H2-Microgrids@LSA project by Anhalt University of Applied Sciences and other global efforts, showcasing how localized, self-sufficient energy systems can store and manage green hydrogen efficiently. The findings indicate that although the project is in early stages, preliminary steps such as site mapping and stakeholder identification have set a solid foundation for future research and practical applications. The article also discusses the economic prospects, logistical requirements and implementation strategies crucial for the successful integration of green hydrogen microgrids, ultimately contributing to the green economy and sustainable development.

Keywords: *Green economy, renewable energy, hydrogen infrastructure, decentralized microgrids, sustainability, energy transition.*

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1. Introduction

The transition to a green economy is a critical step towards sustainable development and a key aspect of this transition is the establishment of reliable and efficient renewable energy sources. According to IRENA's 1.5°C scenario, the global share of renewable energy in the energy mix is projected to increase from 16% in 2020 to 77% by 2050 (Renewable capacity statistics, 2023). Germany is proactively advancing in this direction, with its Climate Law setting the framework for achieving net zero emissions by 2045 and emphasised the crucial need for Germany to make a proportional contribution to the global CO_2 budget (https://www.oxfordenergy.org/publications/achieving-net-zero-plus-

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reliable-energy-supply-in-germany-by-2045-the-essential-role-of-co2-sequestration/; Köhnke *et al.*, 2023). To reach the ambitious goals of the Energy transition policy by 2030, 80% of all electricity supply must come from renewable sources, rising to 100% by 2035, alongside a complete phase-out of coal (https://www.iea.org/).

Due to the stochastic nature of renewable energy sources like wind and solar, an energy carrier is needed to balance supply and demand. Hydrogen because of pretty high volumetric energy density and specific energy (Zheng *et al*., 2021) offers a particularly promising solution for hard-to-electrify sectors such as industry and transportation, with the potential to reduce CO_2 emissions by approximately 12% and 26%, respectively (Falfushynska *et al*., 2024; Urs *et al*., 2023). Nonetheless, currently, less than 1% of hydrogen produced is green hydrogen, resulting in substantial yearly carbon emissions of around 843 metric tons (International Renewable Energy Agency, 2021).

Looking ahead, over the next 5 to 15 years, green hydrogen - produced exclusively from renewable-energy-powered electrolysers - is expected to become more cost-effective than blue hydrogen in many regions (Renewable capacity statistics, 2023). Green hydrogen not only drastically reduces carbon emissions but also provides versatility; it can be used in fuel cell electric vehicles and stored in hydrogen vessels for future use. The high costs associated with transporting hydrogen emphasize the critical importance of developing efficient hydrogen logistics. Improved logistics are expected to lead to a substantial reduction in overall costs, facilitating broader adoption and implementation of hydrogen-based technologies. In this context, hydrogen microgrids representing localized, self-sufficient energy systems that can generate, store and manage hydrogen independently reflect a promising bottom-up solution to address the challenges associated with transitioning to a green economy.

The present article aims to explore the importance of hydrogen infrastructure, with a specific focus on Germany and discuss how decentralized H_2 microgrids can bridge the gap to achieve sustainability goals.

2. Results and discussion

2.1. Germany's hydrogen balance

Germany's annual hydrogen consumption, ranging from 55-60 TWh, is predominantly supplied by fossil fuels (https://medium.com/@miteefire/germanys-green-hydrogen-ambitions-can-pipeline-imports-transform-the-energy-landscape-by-2035-2666d4c8075e; Federal Ministry for Economic Affairs and Climate Action, 2024). By 2035, it's forecasted that hydrogen could meet 11.2% of Germany's total energy demand, projected at 894 TWh (PTJ, 2024). While Germany aims to expand its electrolysis capacity to 5.6 gigawatts by 2030, the current hydrogen supply heavily relies on imports (Germany is not hydrogen-ready, 2022), particularly via pipelines from wind-rich North and Baltic Sea countries, which are viewed as the most promising sources for green hydrogen.

This heavy dependence on imported hydrogen poses notable challenges related to cost and logistics, encompassing transportation, storage and distribution. High logistic costs stem from various factors, including the transportation of hydrogen via pipelines and ships, conversion processes like liquefaction and the storage of hydrogen in different forms.

For a successful hydrogen economy ramp-up that spans the entire value chain from production to utilization, Germany requires both competitive hydrogen availability and an efficient infrastructure. According to long-term scenarios projected for the year 2035, Germany's hydrogen strategy involves importing hydrogen via pipelines from other Western European countries and managing transit flows within Germany. These flows are anticipated to move from the northern federal states to the southern states and from west to east (Spillmann *et al*., 2024). The latest report from Fraunhofer IEG reveals that transporting molecular hydrogen via pipelines is the most cost-effective option (Spillmann *et al*., 2024). Such a pipeline-based system would connect major industrial centers, storage facilities and power plants, as well as key import corridors (Federal Ministry for Economic Affairs and Climate Action, 2024). Despite this critical need, Germany's current hydrogen network is relatively underdeveloped. At present, it spans only 417 kilometers, which represents a 0.1 % of the country's extensive gas network. To address this infrastructure gap, an initial 6,800 km pipeline network is planned by 2030, connecting hydrogen valleys, with phase one planning to commence in the early 2020s. Subsequent phases will see the network expand by 2035 and further extend in all directions by 2040, eventually reaching almost 23,000 km (European Hydrogen Backbone, 2020). This substantial expansion is crucial for creating a robust hydrogen infrastructure to meet future demands.

Smaller consumers, who may not be connected to the core hydrogen pipeline network by 2035, can be effectively supplied by ship and rail (Spillmann *et al*., 2024). Rail transport is particularly advantageous, as the amount of hydrogen a full train can carry exceeds the daily demand of 95% of the locations considered in the study. From this point of view targeted expansion and new construction of railway lines are essential and their development should be expedited to enable efficient transport.

Additionally, the direct import of derivatives like ammonia and synthetic jet fuels is more cost-effective compared to domestic production combined with imported hydrogen, underscoring the importance of optimizing transport modes for specific applications (Spillmann *et al*., 2024). Furthermore, the development of a hydrogen network should include continuous review of its dimensions and topology, with significant consideration given to integrating storage systems in the planning process.

2.2. The Green Hydrogen Microgrid: A Decentralized Solution

Countries with significant renewable energy production, such as Canada, Australia and Germany, often face surplus energy exceeding domestic consumption (Holland & Knight Energy and Natural Resources Blog, 2021; Karayel & Dincer, 2024). While this surplus enables energy export, it can also result in negative energy prices where producers must pay to feed energy into the grid due to overproduction on windy or sunny days. Green hydrogen microgrids present a transformative solution in the quest for sustainable energy systems. By using renewable energy sources to produce hydrogen via electrolysis, these systems can store energy and later convert it back to electricity or utilize it in various industrial applications.

The decentralization of energy through microgrids enhances energy security and resilience. Localizing energy production and supply diminishes the impact of large-scale grid failures, especially vital in urban areas and regions with high energy demands. The economic potential of green hydrogen microgrids in Germany is significant. As an example, The Smart Quart Kaisersesch project exemplifies the innovative use of green hydrogen in local public transport systems, showcasing the potential of hydrogen microgrids (Smart Quart, 2022). In Kaisersesch, the hydrogen is produced through electrolysis using renewable energy sources, predominantly solar and wind. This green hydrogen is then stored and dispatched to fuel cell buses, ensuring a continuous supply for the local transportation network. By implementing this microgrid, the project not only enhances energy independence but also demonstrates the viability of hydrogen as a clean energy carrier in urban settings. The Smart Quart Kaisersesch project implemented in West Germany serves as a model for future sustainable transport solutions, aligning with environmental goals and regulatory standards in Germany.

Furthermore, Anhalt University of Applied Sciences recently received financial support to develop the H2-Microgrids@LSA project, aimed at gaining a comprehensive understanding of how local microgrids can efficiently store and utilize regenerative energy through the central hydrogen infrastructure in Saxony-Anhalt. By developing small, scalable electrolysis installations, these microgrids will convert and store excess renewable electricity as green hydrogen, ensuring consistent energy availability throughout the year. This approach will empower decentralized energy producers with a versatile primary energy carrier for reuse when needed. Additionally, the project aims to minimize grid-related shutdowns of renewable energy sources, such as wind turbines, thereby maximizing their full potential.

Although the project is still in its initial stages, we have already completed several important steps. These include the initial mapping of potential microgrid sites and the identification of key stakeholders involved in the hydrogen infrastructure. Initial contact has also been made with several simulation software providers to assess their capability to model our specific requirements. These initial but critical steps set the stage for more detailed and comprehensive research moving forward. It is expected that the H2-Microgrids@LSA project will make a valuable contribution to Saxony-Anhalt's energy transition, green economy and sustainable development.

German research institutions are also working to implement successful practices globally to support sustainable economic development. In particularly the Fraunhofer IWU is spearheading two pioneering hydrogen projects in Africa, aimed at establishing sustainable and emission-free power supplies through microgrids. These projects, known as Hydrogen Tryout Areal (Hytra) and Hydrogen-based Microgrids Development (Hygo), involve the integration of electrolyzers for green hydrogen production and fuel cells for re-electrification (Smart Quart, 2022). In Cape Town, the Hytra project ensures a stable power supply for aluminium vehicle body manufacturer Alu-Cab, using excess energy from photovoltaic systems to produce and store hydrogen. This green hydrogen is subsequently converted back to electricity during periods of grid unavailability. In Namibia's Walvis Bay, the Hygo project additionally utilizes oxygen by-products from electrolysis to treat wastewater for agricultural irrigation. Initially stationed at the Namibia University of Science and Technology, Hygo will later bring reliable power and water treatment to a remote school in the Erongo District, enhancing educational facilities and supporting a sustainable garden.

The European Union's hydrogen strategy, aiming to install 40 GW of electrolysers by 2030, supports the integration of green hydrogen. Germany's National Hydrogen Strategy further reinforces this effort with investments and regulatory frameworks, anticipated to stimulate job creation, technological advancements and the development of a hydrogen economy. However, notable challenges persist. The cost of producing green hydrogen remains high compared to fossil fuel alternatives. Scaling up production and achieving cost parity through research, development and economies of scale is essential. Moreover, substantial development is needed for infrastructure supporting hydrogen transport and storage.

To sum up hydrogen microgrids, which use renewable energy to produce hydrogen via electrolysis, offer a promising solution for balancing energy supply and demand due to the intermittent nature of renewable sources like wind and solar. These microgrids enhance energy security and resilience by localizing energy production, thus minimizing the impact of large-scale grid failures, especially in high-demand urban areas. Germany is notably advancing in this direction with ambitious plans to achieve net-zero carbon emissions by 2045 and meet significant renewable energy targets by 2030 and 2035. Global efforts also reflect this paradigm shift. However, challenges such as the high cost of green hydrogen production and the development of infrastructure for hydrogen transport and storage remain.

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References

European Hydrogen Backbone. (2020). https://ehb.eu/files/downloads/2020_European-Hydrogen-Backbone_Report.pdf Accessed on 30.07.2024.

Falfushynska, H., Zhadan, V. & Holz, M. (2024, March). Advancement and assessment of power-to-x strategies as a significant contribution for the de-fossilization of economies. In *Proceedings of the 12th International Conference on Applied Innovations in IT (ICAIIT), 12*(1), 233-242.

Federal Ministry for Economic Affairs and Climate Action. (2024). Wasserstoffnetz für die Energiewende – wichtige Weichen für koordinierten und privatwirtschaftlichen Aufbau sind gestellt. https://www.bmwk.de/Redaktion/DE/Schlaglichter-der-Wirtschaftspolitik/2024/02/07-wasserstoffnetze-energiewende.html Accessed on 30.07.2024.

Germany is not hydrogen-ready (2022). https://www.eon.com/de/ueber-uns/presse/pressemitteilungen/2022/deutschland-ist-nicht-wasserstoff-ready.html Accessed on 30.07.2024.

Germany's green hydrogen ambitions: Can pipeline imports transform the energy landscape by 2035? https://medium.com/@miteefire/germanys-green-hydrogen-ambitions-can-pipeline-imports-transform-the-energy-landscape-by-2035-2666d4c8075e Accessed on 30.07.2024.

Holland & Knight Energy and Natural Resources Blog (2021). Hydrogen production from excess renewables. https://www.hklaw.com/en/insights/publications/2021/03/hydrogen-production-from-excess-renewables Accessed on 30.07.2024.

International Energy Agency. https://www.iea.org/ Accessed on 30.07.2024.

International Renewable Energy Agency. (2021). World Energy Transitions Outlook: 1.5°C Pathway. Abu Dhabi: International Renewable Energy Agency.

IWR (2023). Fraunhofer IWU baut Microgrids für Produktion und Nutzung von Wasserstoff in Südafrika und Namibia. https://www.iwr.de/news/fraunhofer-iwu-baut-microgrids-fuer-produktion-und-nutzung-von-wasserstoff-in-suedafrika-und-namibia-news38369 Accessed on 30.07.2024.

Karayel, G.K., Dincer, I. (2024). Green hydrogen production potential of Canada with solar energy. *Renewable Energy*, 221, 119766.

Köhnke, F., Steuri, B., El Zohbi, J., Görl, K., Borchers, M., Förster, J., ... & Jacob, D. (2023). On the path to net-zero: Establishing a multi-level system to support the complex endeavor of reaching national carbon neutrality. *Frontiers in Climate*, 5, 1056023.

PTJ (2024). Germany eyes large-scale green hydrogen imports via pipelines by mid-2030s. https://www.pipeline-journal.net/news/germany-eyes-large-scale-green-hydrogen-imports-pipelines-mid-2030s Accessed on 30.07.2024.

Renewable capacity statistics (2023). IRENA installed renewable electricity capacity (mw) by region/country/area, technology and year. https://www.irena.org/Publications/2023/Mar/Renewable-capacity-statistics-2023 Accessed on 30.07.2024.

Smart Quart (2022). Einsatz von grünem Wasserstoff in lokalen Nahverkehrsprojekten am Beispiel Smart Quart Kaisersesch. https://www.tsb-energie.de/fileadmin/Redakteure/Veranstaltungen/Wasserstofftagung/2022/2022-11-17_TSB_Worms_Diederichs-Seidel.pdf Accessed on 30.07.2024.

Spillmann, T., Nolden, C., Ragwitz, M., Pieton, N., Sander, P. & Rublack, L. (2024). Wasserstoff-Verteiloptionen 2035. https://doi.org/10.24406/publica-2438

The Oxford Institute for energy studies. Achieving net zero plus reliable energy supply in Germany by 2045: The essential role of CO_2 sequestration by Ralf Dickel. https://www.oxfordenergy.org/publications/achieving-net-zero-plus-reliable-energy-supply-in-germany-by-2045-the-essential-role-of-co2-sequestration/ Accessed on 30.07.2024.

Urs, R.R., Chadly, A., Al Sumaiti, A. & Mayyas, A. (2023). Techno-economic analysis of green hydrogen as an energy-storage medium for commercial buildings. *Clean Energy*, *7*(1), 84-98.

Zheng, J., Zhou, H., Wang, C.G., Ye, E., Xu, J.W., Loh, X.J. & Li, Z. (2021). Current research progress and perspectives on liquid hydrogen rich molecules in sustainable hydrogen storage. *Energy Storage Materials*, 35, 695-722.