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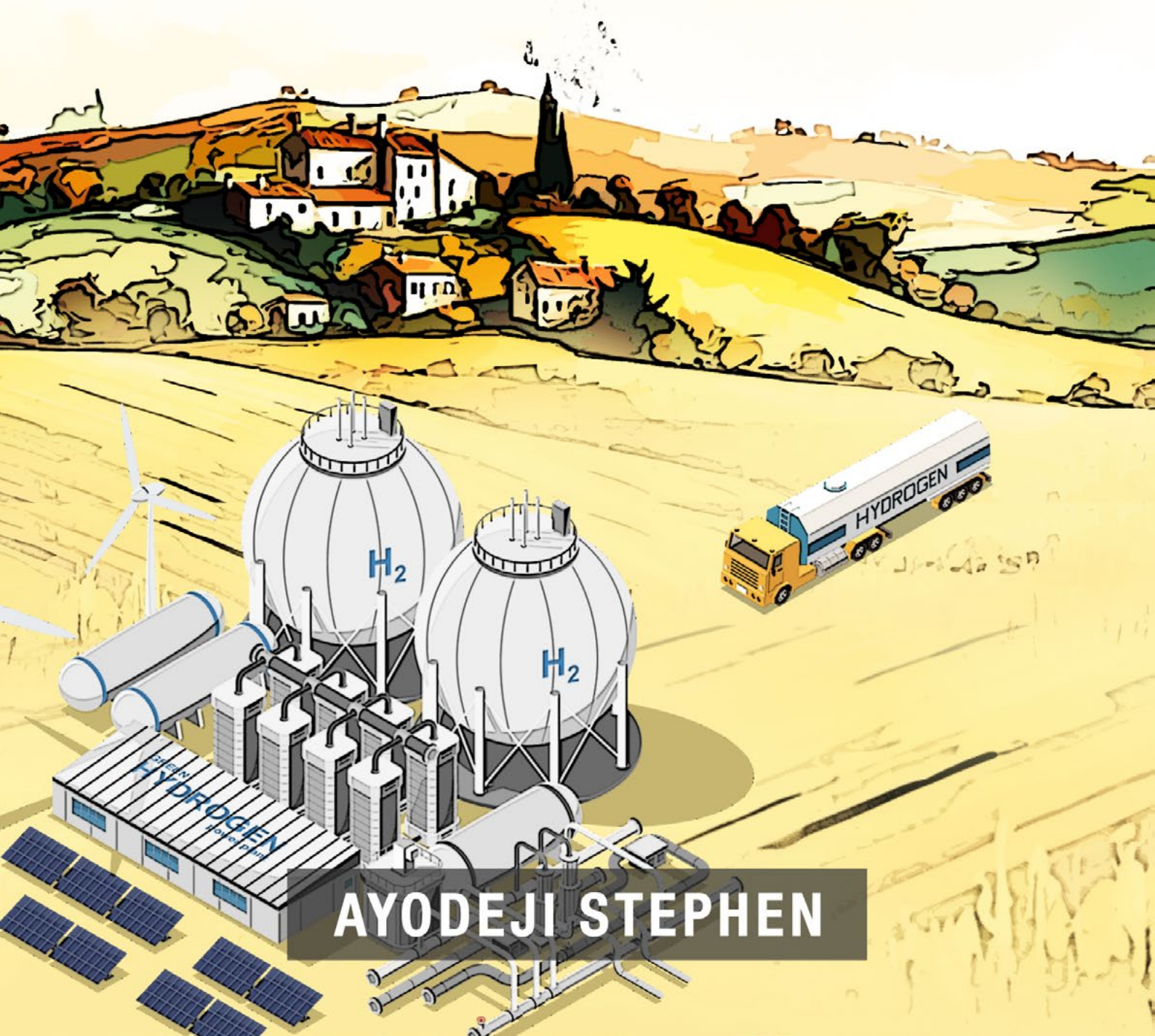
HYDROGEN VALLEYS:

Hot Cakes *for the* Global Hydrogen Economy



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Introduction

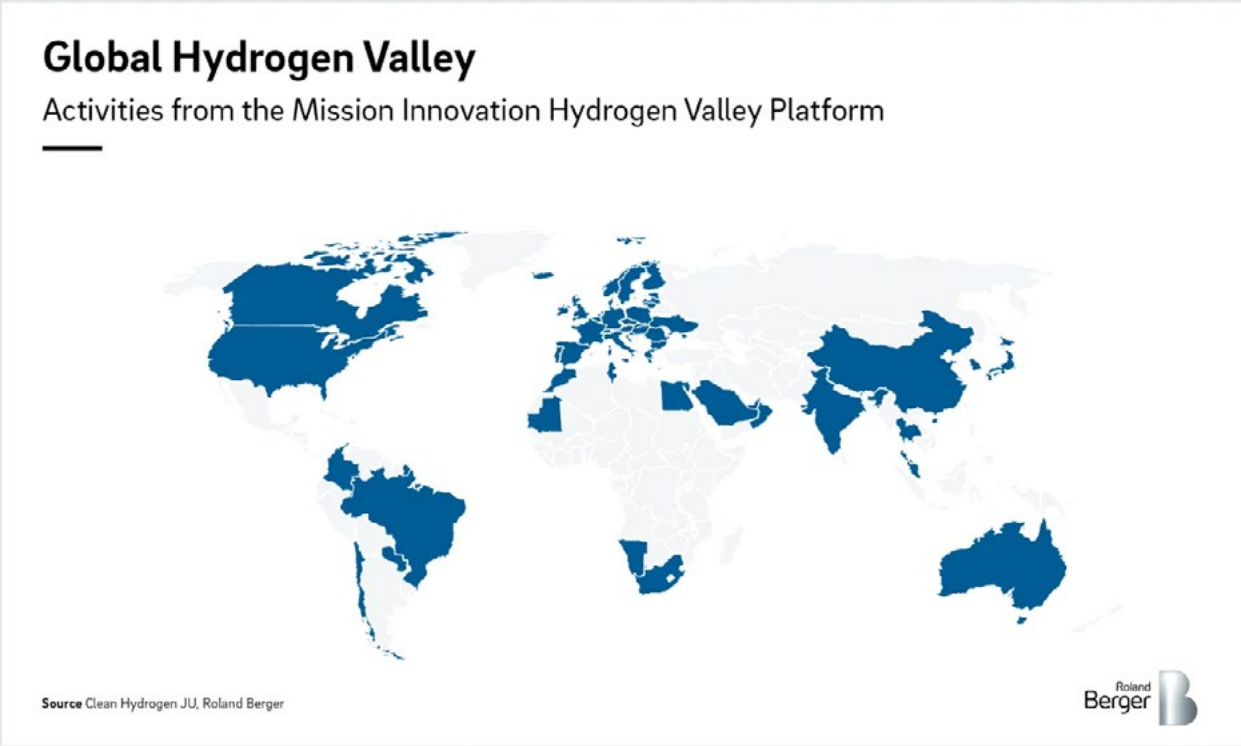
The hydrogen economy is currently experiencing tremendous growth owing to a rather unprecedented level of attention from researchers, politicians, policymakers and the entire community of enthusiasts in the energy transition. More organised activities are now being directed towards the development of hydrogen, and one such is the concept of 'hydrogen valleys'.

In 2018, the European Commission released a report titled "Towards a Hydrogen Valley in the Netherlands: Analysis of the Dutch Context and Implications for European Union Regions", in which the term hydrogen valley was first used . Since then, hydrogen valleys have become increasingly famous in their use and establishment. Rolan Berger defines hydrogen valleys as 'locally integrated "mini hydrogen economies" that combine hydrogen supply and demand to increase scale, maximise asset utilisation and reduce costs.' The term has been further used to represent a more pragmatic approach to the development of the hydrogen economy all over the world.

Given that some regions are now more suited than others for the production of hydrogen and a cluster of places can be more favourable for the application and adoption of hydrogen, hydrogen valleys can be explained as regions where hydrogen is produced, stored, and used as a fuel source for transportation, power generation, and other applications. These regions aim to establish a self-sustaining hydrogen economy, with hydrogen produced from renewable energy sources and used to power vehicles, buildings, and industrial processes . An important feature of a hydrogen valley is the availability of necessary clean energy resources (wind, solar or hydro), distribution networks and production equipment such as electrolysers.

A key aspect of hydrogen valleys is their local focus. They use locally available resources to produce globally usable fuel (hydrogen) with a priority for local use. Usually, its business case model must make economic sense, pitching the production of green hydrogen as a cost-competitive fuel with the presence of off-takers willing to make the initial investments for the projects .

According to the Clean Hydrogen Partnership (CHP), over thirty hydrogen valley projects are being implemented worldwide, with Europe having the highest share.



- Towards a hydrogen valley in the Netherlands: Analysis of the Dutch context and implications for EU regions" published in 2018. The report can be accessed at https://ec.europa.eu/jrc/en/publication/towards-hydrogen-valley-netherlands-analysis-dutch-context-and-implications-eu-regions.
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One example of a hydrogen valley is the Dutch-Belgium hydrogen project called Hydrogen Delta. The project, whose main location is in the Netherlands, is a cross-border project between the Netherlands and Belgium. It is an industrial cluster project that produces and supplies blue and green hydrogen for industrial uses in chemical, refinery and steelmaking. Another example is the HEAVENN project located in the Netherlands with a focus on the production, distribution, storage and local end-use of hydrogen.

With these developments, hydrogen production, transportation, distribution and application are becoming more organised, and the lessons being learned can be quickly and pragmatically implemented.

Why are Hydrogen Valleys Important, and What Are Their Benefits?

Hydrogen valleys represent an important factor in the organised development of hydrogen in the economy. They have led to the increased practical application of hydrogen and the exploration of available resources for the best possible uses. In a report by Roland Berger, the concept was acknowledged as a critical tool for developing locally integrated hydrogen systems.

Engie Impact argues that hydrogen valleys, also known as hydrogen hubs, could redefine the pace of decarbonisation globally. Hydrogen valleys greatly reduce the investment risks of a relatively new energy fuel like hydrogen. Since it takes a 'hub approach', industrial consumers operating in the hard-to-abate sectors near the point of production can be targeted as off-takers. This helps in attaining a level of certainty for product purchase. Additionally, the cluster of hydrogen production, transport and consumption can help in establishing a shared infrastructure investment model between producers and consumers/off-takers, thereby reducing investment risk for each party.

Hydrogen valleys also prove useful and quite important in sourcing funds for the development of hydrogen projects. A solid framework for accessing project funding and grants is formed with the organised clustered format of community-based green hydrogen projects. Globally, many organisations and even national governments are rising to invest in green hydrogen projects, and hydrogen valleys provide an organised format that commits their interest and attraction of funds. An example is the European Commission's joint declaration in support of the hydrogen economy . This action by the Commission has led to several developments fostered through research, innovation and development (RI &D) in the EU hydrogen plan.

Furthermore, hydrogen valleys ensure local economic development by generating jobs while ensuring innovation in the host communities. An offshoot benefit of this is the localisation of industries in the cluster for easy access to hydrogen. Economic development through the stimulation of commercial activities is expected to skyrocket with such clustering.

What is Needed for a Hydrogen Valley?

While it is clear that hydrogen valleys bear immense benefits to the development of the hydrogen economy and the global energy and economic system, the path to establishing a hydrogen valley is not simple and easy to ply. There are several factors to consider before establishing a hydrogen valley, which is not only based on the strength of investment or the availability of technology and infrastructure.

Selecting the right location to establish a hydrogen hub is one of the major things to consider in its development. The location must have renewable energy sources (wind, solar), enough to generate the electricity to support the green hydrogen or natural gas in the case of blue hydrogen. Also, the surrounding environment should have in close proximity off-takers and other sector end-users that serve as a direct market for the product in a cost-competitive manner. Cost-competitive applications can provide short-term drivers for green hydrogen investments, while emerging users can be incubated and provide demand for future scale-up opportunities.

Another critical factor is the availability of requisite finance and infrastructure. Hydrogen production is very capital intensive, considering the various aspects that must be developed. This includes production, storage, transportation, and distribution to consumers. Therefore, for a hydrogen valley project to become successful, there is usually a need for it to have a project sponsor who is not only a coordinator and organiser (identifies potential suppliers, transporters and off-takers in the valley, and brings them to partake in the project), but is also risk-tolerant and willing to champion the project, especially through its pilot phase. The investor also paves the way in this manner, demonstrating the project's viability while gaining the interest of other potential investors towards the project. The necessary infrastructure (such as pipelines, storage tanks, and refuelling stations) is set up through these investments, and the project's viability grows.

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Another key criterion in developing a hydrogen valley is the implementation of favourable policies that incentivise hydrogen production. Research shows that many of the challenges currently faced by the green hydrogen economy can be addressed through appropriate policies and regulations. Specifically, policies can help level the playing field for green and blue hydrogen against traditional grey hydrogen in the financial sector, which can enhance the competitiveness of green hydrogen applications and reduce the overall cost of hydrogen. Additionally, policies can support the creation and implementation of pro-hydrogen roadmaps, strategies, and targets, which increase transparency around demand and enhance investor confidence in hydrogen projects. Ultimately, these policies can help scale hydrogen projects and accelerate the learning curve for hydrogen technologies while lowering costs. Lastly, hydrogen application, transport, and safety standards can and should be reinforced through policy and regulations.

While the above is not exhaustive, it gives a basic understanding of the necessary instruments that must be combined in the development of a hydrogen valley, whether green or blue. These factors are important if the development of hydrogen will be sporadic and would meet the necessary standards required to combat climate change and global warming, especially in the decarbonising hard-to-abate sector.

Implications of a Hydrogen Valley

Hydrogen development has attendant environmental and socio-economic benefits, such as industrial development and enhanced economic activities. With this reality, developing a hydrogen economy brings more economic advantages to its host community and even the national and international community. With each hydrogen valley, more funds are added to clean energy projects creating a ripple effect that extends to many regions and sectors of many countries. The following explains the economic role a hydrogen economy could play locally, nationally, and globally.

1. **Creation of Jobs:** A hydrogen valley necessarily means that more hands will be needed to develop the new project, and since it is such a project that requires several moving parts in a mini-village format, it leads to several roles being created in fields such as research and development, production, and maintenance. The supply chain aspect of the hydrogen valley would also create jobs in production, distribution, transportation, construction and maintenance. Other service aspects of job creation are finance, policy and trade.

2. **Energy Transition and Security:** Hydrogen valleys offer an inclusive pathway to achieving more in the energy transition, especially for the hard-to-abate emissions from the transport and chemicals sectors. They also could be a way for host communities and their host countries to achieve clean energy security, with less reliance on fossils and even imported ones. While it is true that hydrogen production is expensive, the concept of hydrogen valleys presents a good opportunity to reduce that cost . A report by Bloomberg alludes to this, stating, “By promoting innovation and technological advancements in the hydrogen industry, the efficiency of hydrogen production can be improved, which can also lead to cost reductions” . This gives credence to the tangible role that hydrogen valleys play in the global economy.

3. **Decarbonisation:** Hydrogen valleys, going by their role in the development of the global hydrogen economy, have come to play an important role in global decarbonisation. Hydrogen produced will help decarbonise local industries, attract international industries and reduce participating companies’ carbon footprint.

Case Study: Hydrogen Hub Spots in Nigeria

Nigeria has magnificent potential to be a key player in the African hydrogen economy. The country, according to H2Atlas-Africa, has the potential of producing 15,510.08 TWh/yr of green hydrogen, assuming that there are no limitations economically and all the available renewable energy resources are maximised. More potential lies in the country for the production of blue hydrogen. Another report by H2Atlas-Africa reveals that up to 110 million tons of blue hydrogen can be produced using the abundant gas resources in the country every year. The report states that this number implies that 275 million tons of CO2 emissions per year can be avoided with carbon capture and storage.

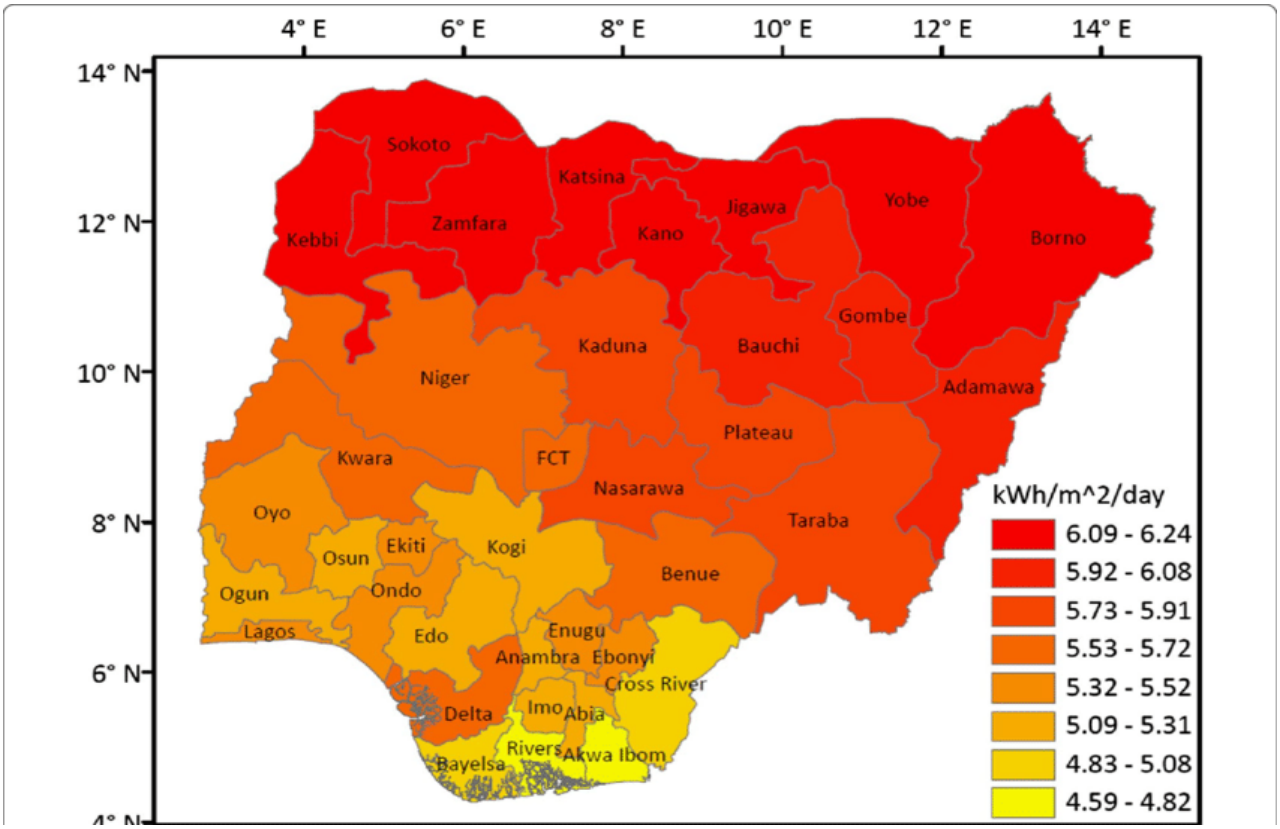
This figure already promises the potential for developing hydrogen hubs in select locations in the country based on the availability of local resources (gas and renewables), which, if well implemented, would serve the local economy. Several locations stand out as potential hydrogen hubs due to their strategic advantages, available resources and infrastructural readiness.

Nigeria is blessed with enormous wind energy resources. Wind energy, a form of clean energy, has seen significant growth over the years as a result of the push for renewable energy models, concerns over energy supply security and fuel diversity, environmental awareness, and economic incentives . Despite this, Nigeria is classified as having a poor to moderate wind regime. Wind speeds in the southern part of the country range from 2.12 to 4.13 m/s, with the exception of coastal and offshore areas. In contrast, the northern regions experience wind speeds between 4.0 to 8.60 m/s. The total exploitable wind energy reserves in the north and northeast regions

are estimated to range from 8 to 97 MWh per year. wind power development in Nigeria remains minimal, even with existing wind energy projects include a 5 kWp facility in Sayya Gidam and a 0.7 kWp system in Danjawa, both located in the north. A notable pilot project began in Katsina State in 2007, aiming to generate 10 MW of grid-connected power using wind energy.

Nigeria has a wealth of biomass resources, including dead trees, wood chips, tree trunks, animal and human waste, as well as household and industrial organic waste. Biomass is the main energy source in Nigeria, accounting for about 37% of total energy consumption, particularly among rural and semi-urban populations. The country produces approximately 83 million tons of crop residues and 61 million tons of animal waste annually. Additionally, around 80 million cubic meters (43.4 billion kg) of fuelwood are used each year, with individual daily consumption ranging from 0.5 to 1.0 kg of dry wood . Wood fuel is primarily utilised for cooking, heating, and other domestic needs. In 2011, Nigeria's biomass resources were estimated to exceed 816 MJ (0.02 tons of oil equivalent). Despite being predominantly used in its raw form, there are government plans to harness biomass for sustainable energy, including biodiesel production.

In Northern Nigeria, particularly states like Katsina, Kano, and Kaduna, the potential for green hydrogen production is significant. These areas receive high solar irradiance, making them suitable for solar-powered electrolysis. The high solar irradiance in northern Nigeria is ideal for solar energy projects, which can be harnessed for green hydrogen production. Northern Nigeria enjoys an average solar irradiance of about 5.5-6.5 kWh/m²/day. Also, a significant portion of northern Nigeria's land area is suitable for solar farms.



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For instance, if we assume conservatively that 10% of northern Nigeria's land area (with Nigeria approximately 923,768 square kilometers in total) can be utilised for solar energy projects. This estimation indicates that northern Nigeria alone has the potential to generate approximately 202,299 TWh of solar energy per year if 10% of its land area is utilised for solar farms. This significantly exceeds the total green hydrogen potential for the entire country, indicating the substantial renewable energy resources available in this region. Thus, northern Nigeria alone could potentially produce approximately 35,402 TWh/year of green hydrogen, assuming optimal utilisation of solar energy and a conversion efficiency of 17.5%. This significant potential exemplifies the strategic importance of developing solar energy projects in northern Nigeria for green hydrogen production, contributing substantially to the country's overall renewable energy and hydrogen economy goals.

However, Northern Nigeria faces significant infrastructural challenges, including underdeveloped electricity grids and limited industrial activity, which necessitates substantial investments in infrastructure to support hydrogen production and distribution. Additionally, water scarcity is a critical concern, as green hydrogen production through electrolysis requires substantial water resources. In arid regions, this could strain local water supplies, and further compound the socio-economic challenges faced by residents and indigen of the communities. Additionally, the spreading insecurity in the country, particularly prevalent in the north, could tremendously hamper the development of hydrogen initiative in the area.

Lagos State, Nigeria's economic hub, presents opportunities for both green and blue hydrogen production. The state has access to natural gas and is also investing in renewable energy projects. Lagos is Nigeria's largest city and economic center, with a robust industrial base and port facilities, making it a strategic location for hydrogen production and distribution. The state's relatively well-developed infrastructure, including power plants, ports, and transportation networks, can support hydrogen projects. Combining solar and wind potentials, Lagos could generate approximately 21.84 TWh/year of renewable energy. With an average conversion efficiency of 17.5% for green hydrogen production. This translates to substantial hydrogen production capacity, supporting both local consumption and export.

However, the high population density and urban congestion in Lagos could pose logistical challenges for large-scale hydrogen production facilities. High urbanisation limits the space available for large-scale renewable projects. Innovative solutions such as rooftop solar installations and vertical integration of wind turbines need to be explored. Navigating the complex regulatory environment in Lagos, which includes various local and state regulations, could delay project implementation.

Conclusion and Recommendation

Hydrogen valleys represent an important factor in the organised development of hydrogen in the economy. They could redefine the pace of global decarbonisation and reduce the huge investment risks of a relatively new energy fuel like hydrogen. Additionally, hydrogen valleys also prove useful and quite important in sourcing funds for the development of hydrogen projects. A solid framework for accessing project funding and grants is formed with the organised clustered format of community-based green hydrogen projects. Hydrogen valleys also ensure local economic development by generating jobs while ensuring innovation in the host communities.

Necessary for the development of a hydrogen valley are supportive regulatory frameworks. This includes policies that incentivise the adoption of hydrogen technologies and ensure a level playing field for all stakeholders. Also, it is important to have a solid financing plan in place that includes various funding sources, including government grants and private investments. Furthermore, it is important to involve local communities in the development of a hydrogen valley as it can help to build support for the project and ensure that it is aligned with the needs and priorities of the local community, among many other things that must be done.

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