ISSN 3030-783X

Green Hydrogen Economy in Sri Lanka: Opportunities and Challenges

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1 Introduction

The transition to a green hydrogen economy has emerged as a key strategy in the global effort to tackle climate change, enhance energy security and achieve sustainable development. Countries around the world are now seeking ways to reduce their carbon emissions to address the risks posed by climate change while implementing national level strategies to meet Paris agreement goals [1]. The Paris agreement is a legally binding international treaty on climate change, adopted by 195 countries at the United Nations Climate Change Conference (UNFCC) in Paris in 2015 [2]. Hydrogen has gained a growing interest in these decarbonization strategies due to its potential use as an energy career, as a form of energy storage and as a feedstock for several key manufacturing sectors such as fertilizer and steel [3]. Even though the carbon emissions at the point of use of hydrogen are zero, the production stage can contribute to carbon emissions depending on the method used. Therefore, the progress towards decarbonization targets mainly depends on the hydrogen production method [4]. Hydrogen produced from renewable electricity or green hydrogen is expected to play an important role in achieving long-term decarbonization goals and improving energy security. Although less than 1% of global hydrogen production was from renewable sources by 2022, renewable hydrogen is receiving increasing policy attention in many countries [5]. More than 60 countries had announced or were developing hydrogen strategies by 2024 [3].

As a signatory to the Paris agreement, Sri Lanka has also submitted amended version of Nationally Determined Contributions (NDCs) to the UNFCC in 2021. Through these NDCs, the country commits to achieve 70% renewable energy in electricity generation by 2030, carbon neutrality by 2050 in electricity generation and no capacity addition of coal power plants in future [6]. To achieve these targets, deployment of excess renewable energy potential of the country is essential. The National Hydrogen Roadmap of Sri Lanka views green hydrogen as the critical enabler of renewable integration and sustainable energy storage in the country.

According to IEA [7], 53.3 % of the Sri Lanka's energy needs were fulfilled by imported fossil fuels in 2023. Furthermore, fossil fuels (coal and thermal oil) accounted for nearly 45 % of the country's electricity generation process in 2024 [8]. These statistics show the high dependence on imported fossil fuels, and that the country is far beyond its renewable energy targets. Due to its geographical location near the equator in Indian Ocean, Sri Lanka is blessed with a substantial base of renewable energy resources such as solar and wind [9]. A study conducted in 2024 [10] revealed that a total of 25.38 GW of potential rooftop solar PV installing capacity was available in Sabaragamuwa, Northern, North Central and Western provinces. Compared to installed solar capacity by the end of 2024, which is only 1.579 GW, this potential is a massive amount. Moreover, The National Renewable Energy Laboratory (NREL) of the USA identified a theoretical onshore wind potential of 24 GW [11], while the World Bank Group [12] has estimated the offshore wind potential as 56 GW, which has not been even utilized yet. Similar to the solar energy, the total of onshore and offshore wind energy potential is far greater than the existing wind installed capacity of 267 MW [8]. Thus, green hydrogen production can be identified as a great opportunity to utilize this excess renewable energy potential while meeting the national energy targets.

Although numerous studies have analysed opportunities and challenges in introducing green hydrogen economies in many countries, very limited such studies are available for Sri Lanka in the published literature. Most of those studies are also about renewable energy development, rather than directly focusing on identifying opportunities and challenges in green hydrogen economy development. Moreover, current green hydrogen policy landscape and roadmap repeatedly frame green hydrogen as a pathway to monetize excess renewable energy, supply hard-to-abate industries and become a regional exporter. In contrast, references to households, community-level uses, or clear people-centred mechanisms are limited to brief mentions or high-level guiding principles without operational measures. Therefore, this study aims to identify opportunities and challenges in establishing a green hydrogen economy in Sri Lanka, with a special focus to decentralized green hydrogen energy solutions.

To achieve this objective, research was conducted to explore the following questions.

1. What are the most significant opportunities for developing a green hydrogen economy in Sri Lanka?
2. What challenges must be addressed to facilitate green hydrogen adoption?
3. How can green hydrogen be integrated into Sri Lanka's energy sector to provide decentralized, community-focused, and people-centric energy solutions?

The findings are intended to contribute to academic knowledge, inform policy formulation, and guide private sector investments, paving the way for a greener and more sustainable energy future for the country.

2 Background

Hydrogen is a versatile energy carrier, having the highest gravimetric energy density of all known substances with about 120 MJ/kg. This is 3 times the energy content of gasoline and 2.5 times more energy content than natural gas [13-15]. Based on the production process, energy source and environmental impact, hydrogen is classified into different colour codes as shown in the Table 1 [16-18].

Table 1. Hydrogen colour codes.

Hydrogen colour	Technology	Source	Cost (\$ per kgH_2)	CO_2 emissions
Grey	Reforming	Natural gas	1-2.1	Medium
Blue	Reforming + Carbon capture	Natural gas	1.5-2.9	Low
Green	Electrolysis	Water	3.6-5.8	Minimal

Currently, hydrogen production is largely dependent on unabated fossil fuels, where natural gas accounting for around two-thirds of total global production. Hydrogen production from electrolysis still contributes to very small share of the total, marking below 100 kt H_2 in 2023 [19].

Green hydrogen is produced through the process of water electrolysis, using renewable electricity to split water into hydrogen and oxygen. The device used for water electrolysis is known as water electrolyser, which are available in several types as Alkaline, Proton Exchange Membrane (PEM), Solid Oxide Electrolyser Cells (SOEC) and Anion Exchange Membrane Electrolysers (AEM) [14,17, 20-22]. A schematic diagram of a typical electrolyser cell is illustrated in Figure 1 [22].

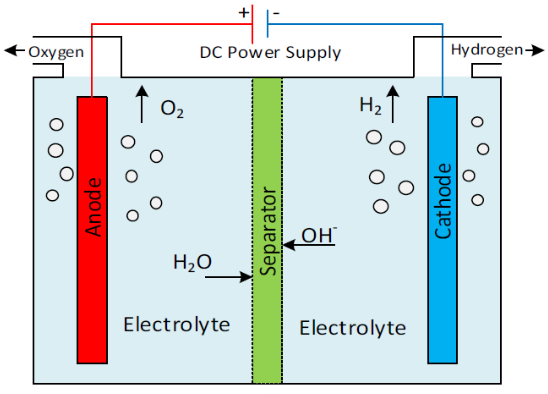

Figure 1. Schematic diagram of an electrolyser cell [22].

The uses of green hydrogen can be found in manufacturing sector as a chemical feedstock (ammonia, methanol, iron and steel), power sector for seasonal storage, buildings sector for heating and transport sector as a fuel both in internal combustion engines and fuel cells [14, 18, 21]. Since hydrogen is considered as the lightest gas and the substance with the fastest diffusion speed in air, ~20 m/s at room temperature, it can quickly disperse uniformly from a leak. [13,14,15]. Furthermore, hydrogen embrittlement is considered as another serious concern associated with hydrogen storage and transportation [23]. These factors limit material choices for hydrogen tanks, pipelines, and other infrastructure posing significant challenges. Commonly, three methods are used to store hydrogen; physical storage as compressed gas, physical storage as cryogenic liquid hydrogen and solid-state storage, whereas the first two methods are most common [24].

3 Methods

The methodology adopted in this study consists of three steps. First, a policy review was conducted to identify the existing policy frameworks for advancing a green hydrogen economy in Sri Lanka. Secondly, a separate literature review was conducted to identify the commonly applicable opportunities and challenges in developing a green hydrogen economy based on the similar types of studies available for other countries. Both academic and grey literature (reports, websites etc) were considered during the initial literature search. The academic literature was collected through Google Scholar and results were refined for the articles published after 2020 with the aim of getting more up-to-date information. Only the papers published in peer-reviewed journals are selected for the study to improve the credibility of the work. The third step involved evaluating the applicability of globally identified opportunities and challenges in Sri Lankan context. This is achieved by comparing the global level findings with the country's current energy mix, renewable resource potential, and existing policy frameworks identified during step 1.

4 Results and Discussion

4.1 Findings from the policy review

National energy policy and strategies of Sri Lanka: The national energy policy was first published in 2008 and then revised in 2019. This policy is developed based on 10 pillars to ensure the energy security of the country. Under the proposed strategies, several opportunities can be identified for the hydrogen to enter the country's economy such as renewable energy development and energy storage solutions to firm the intermittent renewable energy. However, a very limited information is available in this policy about hydrogen [25].

Nationally Determined Contributions (NDCs): The key highlights of these NDCs include commitments to increase the country's forest cover by 32% by 2030 and to reduce greenhouse gas emissions by 14.5%. Furthermore, the country has established targets to achieve 70% renewable energy in electricity generation by 2030, carbon neutrality by 2050 and has committed to not increase the capacity of its coal power plants [6].

National Hydrogen Roadmap (2022-2048): Sri Lanka's National Hydrogen Roadmap was developed by Greenstat Hydrogen Private Limited Sri Lanka in collaboration with the Petroleum Development Authority of Sri Lanka (PDASL) with the support of USAID. This roadmap identifies the country's offshore wind potential of more than 40 GW as a great opportunity to enable green hydrogen integration. Transport, shipping, aviation, manufacturing & agriculture and buildings & energy sectors have been identified to implement decarbonization strategies. Off-grid solutions to the rural areas in the country and the potential role of green hydrogen as a clean cooking alternative to the traditional wood and biomass burning is also highlighted. Furthermore, the roadmap mentions that the national energy policy must incorporate provisions to address cooking or other assets that encourage households to transition to cleaner energy sources, which is currently lacking in the policy [26].

Draft National Policy on Renewable Hydrogen: This policy has been developed with the goal of making the green hydrogen the third energy carrier to complete the energy transition and make Sri Lanka a leading energy exporter. Here, green hydrogen and its derivatives are identified as a potential storage medium for renewable energy other than battery energy storage and pump hydro storage to accommodate the growing power demand in future [27].

4.2 Findings from the literature review

Qatar [34], Australia [1], Brazil [29], Iceland [3], Jordan [30], India [18], Southern Africa [31], Philippines [32], Morocco [14], GCC countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE) [33] and a global level study [28] was studied to identify the country common green hydrogen opportunities and challenges. Based on this information, opportunities were identified under 3 thematic areas as energy security, de-carbonization and economic opportunities. Challenges were categorized as economic, technical, operational and social.

Opportunities

Energy Security: Green hydrogen offers a great opportunity to enhance the Sri Lanka's energy security by reducing the country's heavy reliance on imported fossil fuels. In year 2023, imported fossil fuels accounted for over 50% of energy demand of the country [7]. Furthermore, green hydrogen's potential to balance power demand and improve grid stability through energy storage when combined with renewable sources can support a more stable power system. The national energy policy's emphasis on diversification and adoption of new energy carriers such as hydrogen further reinforces its role in securing Sri Lanka's long-term energy independence [25].

De-carbonization: Although the electrification of transport sector is at an initial stage, hydrogen applications may emerge later in heavy-duty transport, maritime, and aviation sectors as outlined in National Hydrogen Roadmap [26]. Furthermore, hydrogen enables the production of low-carbon synthetic fuels such as ammonia and methanol, both identified in National Hydrogen Roadmap as future fuels. It also facilitates large scale renewable energy integration by storing excess solar and wind power contributing to decarbonize the power sector. Although Sri Lanka has a relatively small industrial base, green hydrogen will enable the decarbonisation of energy-intensive industries such as steel and cement. National hydrogen policy [27] also mentions thermal applications (kilns & furnaces) would be the first movers for hydrogen offtake in Sri Lanka. Moreover, green hydrogen introduction aligns well with the 2050 net-zero commitment and NDCs.

Economic opportunities: The development of a green hydrogen economy can significantly enhance the country's economic resilience and diversify national revenue streams. Beyond its environmental benefits, green hydrogen offers opportunities to create new revenue streams through exports, industrial development and job creation. Further, Colombo, Trincomalee and Hambantota ports have been identified as potential hydrogen export and bunkering hubs in the National Hydrogen Roadmap [26]. Additionally, the sector may attract substantial private and foreign direct investment as a country with a massive renewable energy potential. As outlined in the National Hydrogen Roadmap, green hydrogen sector could generate around 4,000 jobs by 2030. Moreover, these initiatives will strengthen international partnerships, contributing to regional and global cooperation. Currently, hydrogen diplomacy is developing through several initiatives such as the agreement signed by Greenstat Hydrogen India and PDASL [35].

Challenges

Economic challenges: High production and infrastructure development costs are reported as a main challenge in all the above countries considered and as a developing country, this will be applicable to Sri Lanka as well. The country's limited capital availability and dependence on imported technology significantly increase the cost of establishing hydrogen production facilities, storage systems, and distribution networks. Furthermore, limited financial support for investment and research and development (R&D) activities can hinder the development of the sector.

Technical challenges: Sri Lanka faces multiple technical barriers also that could hinder the safe and efficient deployment of hydrogen technologies. Safety concerns related to green hydrogen supply chain (production, storage, distribution, utilization etc.) is among the major barriers as national safety regulations related to hydrogen sector are not yet developed in Sri Lanka. Even though there is no hydrogen storage or transport infrastructure exist in the country, this infrastructure should be developed in a way that prioritizes safety considering the flammability of hydrogen. Additionally, there is a shortage of skilled professionals and technical expertise in hydrogen technologies as education and training programs in this field are still emerging. Relatively low energy efficiency (~30%) of water electrolysis compared to direct electrification remains a global limitation, therefore applicable to Sri Lanka as well [34]. Although Sri Lanka has strong solar and wind potential, green hydrogen production from current generation capacity is challenging as it is insufficient for large scale electrolysis. Furthermore, hydrogen integration will need advanced control and balancing systems as existing energy grids will not be compatible with hydrogen integration. As water plays a key role in green hydrogen production, water resource constraints specially in the dry region poses significant challenges. Noteworthy challenges can be arisen when it comes to distribution of hydrogen, due to distribution inefficiencies arising from low energy density, lack of dedicated pipelines, and high liquefaction costs.

Operational Challenges: Absence of comprehensive regulatory, legislative, and standardization frameworks also hinders the green hydrogen development. The draft national hydrogen policy is not yet enacted, leaving a policy vacuum. Moreover, political and financial instability of the country pose risks to sustained hydrogen policy implementation. Even though a National Hydrogen Roadmap is published, insufficient policy incentives and tax schemes creates uncertainty for potential investors and project developers.

Social Challenges: Beyond technical and economic barriers, social acceptance is another crucial challenge for hydrogen deployment in Sri Lanka. Public awareness on hydrogen technologies remains limited, and misconceptions regarding safety could further hinder the adoption.

Apart from these opportunities and challenges, a technical report published by the Ministry of education and National Science and Technology Commission (NASTEC) in 2023 identifies hydrogen storage as a promising and sustainable solution for long-term storing and converting renewable energy. This report suggests 3 hydrogen storage options for Sri Lanka as large-scale centralized storage facilities, decentralized storage systems for micro grids and mobile hydrogen storage solutions for transportation applications. They further mention economic feasibility, lack of knowledge transfer potential and safety issues as the key challenges [36].

5 Conclusions

The development of a green hydrogen economy presents Sri Lanka with significant opportunities to enhance energy security, achieve decarbonization goals, and strengthen economic resilience. With abundant renewable resources such as solar and wind, the country has strong potential to generate green hydrogen and utilize it for power generation, industrial applications and transport while reducing dependence on imported fossil fuels. The National Hydrogen Roadmap and Draft Renewable Hydrogen Policy outline clear directions for integrating hydrogen into the national energy system, supporting the 2030 renewable energy target and the 2050 carbon neutrality goal. However, Sri Lanka faces major challenges, including high production and infrastructure costs, lack of financing and policy incentives, technical barriers such as safety and efficiency concerns, and limited human resource capacity. Additionally, weak regulatory frameworks and low public awareness hinder large-scale adoption. Addressing these economic, technical, operational, and social challenges through coordinated policy actions, capacity building, and international collaboration is essential for realizing the full potential of green hydrogen. By doing so, Sri Lanka can transition toward a decentralized, people-centric, and sustainable energy future.

Declaration of Competing Interest

The authors declare no competing interests

Acknowledgements

The authors acknowledge the University of Moratuwa and other universities involved in Master's in Energy for Circular Economy degree program.

Abbreviations

IEA	International Energy Agency
NDC	Nationally Determined Contributions
NREL	National Renewable Energy Laboratory
PDASL	Petroleum Development Authority Sri Lanka
UNFCC	United Nations Climate Change Conference

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Keywords

Green hydrogen economy, Renewable energy, Sri Lanka, Opportunities, Challenges

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