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Research Article

HYDROGEN FUEL: A GLOBAL CONCERN, POLICIES, FUTURE & ITS OVERALL IMPACT ON PROSPEROUS NEPAL

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Abstract

There is an urgent need to find viable ways to achieve zero-emission energy feasibility due to the significant increase in environmental pollution and global warming caused by uncontrolled fossil fuel consumption over the last decade. The recent advancements in renewable energy and electric vehicles highlight the potential of policy and technology to develop global clean energy industries. Hydrogen could be a leading solution for storing energy from renewables. It has the potential to transport energy over long distances from regions with abundant energy resources to energy crisis areas. Hence, it is a good time to explore the potential of green hydrogen in a sustainable energy platform.

1. Hydrogen Fuel: A Global Concern

Hydrogen fuel has gained global attention as a potential solution for addressing high carbon emissions, reducing dependence on fossil fuels, and transitioning to a more sustainable energy system [1]. It is seen as a versatile energy carrier that can be produced from various sources, including renewables, and can be used as an alternative to fossil fuels in various sectors, such as transportation, electricity generation, and industrial processes [2]. One of the main advantages of hydrogen is its ability to produce energy without releasing carbon dioxide when used in fuel cells, making it a promising option for decarbonizing sectors that are challenging to electrify directly, such as heavy-duty transportation or industrial processes [3]. However, there are also several challenges and concerns associated with hydrogen fuel. Firstly, hydrogen production currently relies heavily on fossil fuels, such as natural gas, which can lead to carbon emissions unless carbon capture and storage technology is implemented. Additionally, the production, storage, and transportation of hydrogen can require significant investment and infrastructure development [4].

The safety concerns regarding hydrogen are also there due to its highly flammable nature and its potential for leakages. This requires stringent safety measures to be put in place throughout the hydrogen supply chain. Moreover, the concerns regarding the overall efficiency and cost-effectiveness of hydrogen technologies compared to other renewable energy sources are

major hurdles [5]. The production and storage of hydrogen can be energy-intensive and relatively expensive compared to existing alternatives. Nevertheless, global interest in hydrogen fuel as a potential solution for sustainable energy is growing, and countries, research institutions, and private entities are investing in research, development, and demonstration projects to overcome the challenges and maximize the benefits of hydrogen as a clean energy carrier [6].

2. International Policies and Practice

International policies regarding hydrogen fuel and sustainable energy vary across countries and regions. However, several key initiatives and agreements exist to promote the use of hydrogen as a clean and sustainable energy source.

The United Nations Framework Convention on Climate Change (UNFCCC) promotes the reduction of greenhouse gas emissions and the transition to low-carbon economies. The Paris Agreement, signed by nearly every country, calls for the global temperature increase to be kept well below 2 degrees Celsius above pre-industrial levels and emphasizes the need for sustainable energy solutions. The International Energy Agency (IEA) works to promote energy security, economic growth, and environmental sustainability. In recent years, the IEA has recognized the potential of hydrogen as a clean energy carrier and has been actively involved in research and policy development to support its use. In Europe, the European Commission has set a goal to become carbon-neutral by 2050. The European Clean Hydrogen Alliance was launched to accelerate the deployment of hydrogen technologies, foster cooperation, and support investment in the sector [7].

Several countries, including Japan, Germany, South Korea, and Australia, have developed national hydrogen strategies to drive the development and use of hydrogen as a renewable energy source. These strategies involve policy measures such as financial incentives, research and development programs, infrastructure development, and regulatory frameworks to support the growth of hydrogen fuel. Overall, international efforts are increasingly focused on promoting sustainable energy solutions, with hydrogen being recognized as a crucial component of the clean energy transition. However, the specific policies and approaches vary depending on each country or region's priorities, resources, and energy mix.

3. Alternative Energy Concerns of Nepal and National Policies

Nepal has taken several initiatives and developed national policies to promote alternative sources of energy and sustainable energy. Here are a few key initiatives:

1. **Renewable Energy Subsidy Policy:** The Government of Nepal has implemented a Renewable Energy Subsidy Policy to promote the adoption of renewable energy technologies, such as solar, wind, and hydropower. This policy provides financial

support and subsidies to individuals, communities, and businesses for the installation of renewable energy systems.

2. **Alternative Energy Promotion Centre (AEPC):** The AEPC was established in Nepal to promote and facilitate the development and use of alternative energy technologies. It works to create an enabling environment through policy advocacy, capacity building, and financial support for renewable energy projects. It has been working since 1996 to provide various alternative energy solutions to the rural and urban populations, such as solar home systems, micro-hydro power plants, biogas plants, improved cookstoves, solar water heaters, wind turbines, etc.
3. **National Renewable Energy Program (NREP):** The NREP aims to increase the share of renewable energy in Nepal's energy mix by developing a comprehensive renewable energy policy framework. It focuses on promoting renewable energy technologies, energy efficiency, and energy conservation measures.
4. **Renewable Energy Standard and Grid Code:** The Nepal Electricity Authority has set up a Renewable Energy Standard and Grid Code to ensure the integration and smooth operation of renewable energy sources into the national grid. It provides guidelines for interconnection, technical specifications, and grid reliability for renewable energy systems.
5. **Mini and Micro-Hydro Power Development:** Nepal has prioritized the development of mini and micro-hydro power projects, particularly in rural areas. These projects aim to provide clean and reliable electricity to remote communities, reduce reliance on traditional energy sources, and promote local economic development.
6. **National Biodiversity Strategy and Action Plan:** Nepal has also developed a National Biodiversity Strategy and Action Plan, which includes strategies for promoting sustainable energy development while protecting the environment and biodiversity.

These policies and initiatives reflect Nepal's commitment to promoting alternative sources of energy and sustainable energy development, with a focus on renewable energy technologies and the inclusion of marginalized communities. The government's efforts aim to enhance energy access, reduce dependency on fossil fuels, and mitigate climate change impacts.

3.1. Policy Lack for Hydrogen Fuel

Though Nepal's government is concerned about alternative energy, as of now, Nepal does not have specific national policies or initiatives that focus explicitly on hydrogen fuel for sustainable energy. The country's current energy priorities and strategies primarily focusing on hydropower,

solar energy, and other renewable sources. However, it's worth noting that Nepal's renewable energy policies and initiatives can indirectly contribute to the development and adoption of hydrogen fuel technology in the future. As hydrogen is considered a clean and sustainable energy carrier, its integration into Nepal's energy system could align with the country's broader goals of transitioning towards a low-carbon economy. With the Nepal's abundance of water resources, there is potential for electrolysis-based hydrogen production, utilizing excess electricity from hydropower plants especially during the wet season when there is surplus electricity and the clean water resources [8]. This could be further explored as part of Nepal's long-term energy planning process and policies. While there may not be specific national policies targeting hydrogen fuel currently, it is possible that Nepal could consider including hydrogen in its future energy plans and policies as the technology evolves and global trends shift towards broader adoption of hydrogen as a clean energy source.

4. Imminent of Hydrogen Fuel in Nepal

The future of hydrogen fuel in Nepal is uncertain at this time. While there is currently no specific national policy or initiative in place to promote hydrogen fuel, Nepal's focus has primarily been on developing and utilizing its abundant hydropower and other renewable energy resources. Though, as global interest in hydrogen fuel grows and technology advances, it is possible that Nepal may consider exploring hydrogen as a sustainable energy option in the future. Nepal's ample water resources make it a latent intrant for electrolysis-based hydrogen production, which could be conjunct with hydropower electricity. The potential integration of hydrogen fuel into Nepal's energy system would depend on various factors, including technological advancements, cost-effectiveness, infrastructure development, and alignment with the country's long-term energy goals. It would also require policy support, investment, and collaboration with international organizations, research institutions, and industry stakeholders. Considering these factors, while the future of hydrogen fuel in Nepal is uncertain, it remains a possibility that the country could explore hydrogen technologies and potentially integrate them into its energy mix as part of its efforts to achieve sustainable energy goals [9].

There are no specific efforts or practices in Nepal for using hydrogen fuel as a future energy source at the moment, it's important to recognize that the adoption of hydrogen fuel requires careful planning, significant investments, infrastructure development, and policy support. These factors impact the feasibility and effectiveness of integrating hydrogen technologies into Nepal's energy system. With this regard, Nepal should emphasize and choose to explore hydrogen fuel as a future energy source with the several steps conferred here.

1. **Policy and Regulatory Framework:** First, the developing of comprehensive national policy and regulatory framework that supports the production, distribution, and use of hydrogen fuel is mandatory. The policy for establishing safety guidelines, technical standards, and creating incentives to attract investments would be included in the process.
2. **Research and Development:** Investing in research and development activities to advance hydrogen production, storage, and usage technologies that are suitable for Nepal's context. This would involve collaborations with research institutions, energy companies, and international organizations.
3. **Infrastructure Development:** Building the necessary infrastructure for hydrogen production, storage, and distribution. This would involve establishing hydrogen refueling stations, ensuring the availability of hydrogen-compatible vehicles or machinery, and considering the addition of new technology on existing infrastructure.
4. **Renewable Hydrogen Production:** Exploring methods for producing hydrogen from renewable energy sources, such as electrolysis powered by excess electricity generated from hydropower plants. This would contribute to reducing carbon emissions and aligning hydrogen production with Nepal's renewable energy potential.
5. **Capacity Building:** Developing the necessary human resource capacity through training programs and partnerships with academic institutions to ensure a skilled workforce capable of operating and maintaining hydrogen infrastructure.
6. **Public Awareness and Acceptance:** Launching public awareness campaigns to educate and engage citizens, businesses, and policymakers about the benefits and challenges of hydrogen fuel. This would help foster acceptance and support for hydrogen as a future energy source.

It's important to note that implementing hydrogen fuel technologies in Nepal would require a thorough assessment of its feasibility, considering factors such as cost-effectiveness, environmental impacts, and the country's energy priorities. Close collaboration with international partners and organizations experienced in hydrogen technology implementation can also provide valuable support, expertise, and funding opportunities.

5. Future Impact of Hydrogen Fuel for Prosperous Nepal

The successful integration of hydrogen fuel could have a significant impact on Nepal's energy system in the future. Some potential benefits and impacts are:

1. **Energy Security:** Energy security is a key component for fostering economic growth and development. Utilizing hydrogen fuel could enhance Nepal's energy security by diversifying the energy mix. As hydrogen can be produced from various sources, including renewable energy, it could help reduce Nepal's reliance on imported fossil fuels and enhance its self-sufficiency in energy supply.
2. **Carbon Emissions Reduction:** Hydrogen fuel, when produced from renewable sources, has the potential to significantly reduce carbon emissions to achieve the net zero emission goal. If Nepal can transit to hydrogen as a clean energy carrier, it could contribute to mitigating climate change and meeting its commitments under international agreements like the Paris Agreement.
3. **Economic Opportunities:** The development and deployment of hydrogen technologies in Nepal could create new economic opportunities. It could attract investments, stimulate innovation, and promote the growth of local industries involved in hydrogen production, storage, and infrastructure development. This could contribute to job creation and economic prosperity.
4. **Sustainable Transportation:** Hydrogen fuel cells can power various transportation modes, including cars, buses, and even long-haul trucks. Adopting hydrogen fuel for transportation in Nepal could lead to reduced air pollution, improved air quality, and better public health outcomes.
5. **Electricity Generation and Industrial Applications:** Hydrogen fuel can be used for electricity generation and industrial processes, such as chemical production and heating applications. By diversifying its energy sources and utilizing hydrogen, Nepal could enhance the reliability and resilience of its power grid, as well as meet the energy needs of various industries.
6. **Diplomatic Impact:** The adoption of hydrogen fuel could have diplomatic implications, especially in the context of international cooperation and partnerships. Collaborating with other countries that have expertise in hydrogen technologies could facilitate knowledge sharing, technical assistance, and potential investments. It could enhance Nepal's engagement in global sustainable energy initiatives and contribute to its recognition as a proactive player in climate change mitigation efforts.
7. **Overall Prosperity:** Achieving a prosperous Nepal through hydrogen fuel as sustainable and reliable energy requires careful planning, robust policies, and successful implementation. It is important to consider the long-term environmental, social, and economic impacts of adopting hydrogen technologies. Balancing the

benefits with potential challenges, such as infrastructure development, resource availability, and societal acceptance, is crucial for ensuring the sustainable and inclusive growth of the country.

The potential impact of hydrogen fuel in Nepal's future on the economy, diplomacy, and overall prosperity is uncertain and dependent on several factors. While hydrogen fuel is considered a clean and versatile energy source, its adoption and integration at a large scale will require significant investments, infrastructure development, and policy support.

6. Conclusion

It is worth noting that the impact of hydrogen fuel on the economy, diplomacy, and overall prosperity of Nepal would be influenced by Nepal's individual circumstances, priorities, and efforts in advancing hydrogen fuel technologies. Close collaboration with international partners, expertise exchange, and accessing technological advancements are likely to play a role in shaping the potential impact in these areas. Of course, the actual impact would depend on the successful implementation of hydrogen technologies, the availability of renewable resources for hydrogen production, infrastructure development, and policy support. Thorough planning, careful considerations of efficiency and cost-effectiveness, and close collaboration with stakeholders would be necessary to maximize the benefits of hydrogen fuel in Nepal's prosperous future.

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