Clean Energy Transition in Remote Indigenous Communities: Hydrogen Energy

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***Abstract*—For remote communities in Canada, the majority of which are Indigenous communities, the transition to renewable energy sources is a need that is complementary to both the global challenge of reducing carbon emissions and limiting global warming, as well as the underlying themes of self-determination and autonomy outlined in reconciliation goals and documents. Hydrogen is an energy carrier and a renewable energy source that offers many advantages due to its versatility, its potential to be transported and stored, and its ability to contribute to other renewable energy sources' output. All these qualities are highly relevant to the transition in remote communities, allowing for conversion to more integrated, clean, flexible, and stable energy sources.**

***Index Terms*—hydrogen, clean energy, renewable energy transition, indigenous communities, remote communities, reconciliation**

I. Introduction

There are 292 remote communities spread across every province and territory in Canada, at least 170 of them indigenous. 257 of these communities heavily rely on their own microgeneration network as an energy source, primarily utilizing "greenhouse gas emission intensive diesel generators" [1]. These energy sources are often unsecure, unreliable, and costly, adding to the many disparities faced by these communities. In the context of the historical conflict in renewable energy development in Canada in relation to Indigenous community engagement [2], and with the underlying theme of self-determination in The Royal Commission on Aboriginal People, the Truth and Reconciliation Commission (TRC), and the United Nations Declaration on the Rights of Indigenous People (UNDRIP), Indigenous people's participation in renewable energy source is essential. This is particularly true for remote communities that face the disproportionate impacts of energy poverty. It can be a potential source of economic and political sovereignty and development, self-sufficiency, determination, autonomy, environmental protection, and renewable energy efforts complementary to Indigenous cultures and views [2], [3]. The crucial and imperative transition to renewable energy sources in remote indigenous communities must be done in congruence with policies that require Indigenous people's engagement, sovereignty, and leadership [4]. Clean hydrogen as a renewable energy source potentiates advantages that not only contribute to developing a cleaner and more sustainable energy future suitable for remote communities, but also an effort towards building Nation-to-Nation relationships and reconciliation as outlined by the TRC. Hydrogen, through its versatility and capacity to decarbonize different sectors, offers more flexibility in power systems including those within remote communities. The main benefits include storage systems, transportation methods, and contributions to other renewables' output.

This article is organized in five sections. Section II presents a few possible arguments against the use of hydrogen energy in remote communities. The counterarguments are dispelled in section III by presenting several strong reasons supporting the opposing view. Section IV provides a reconciliation perspective of the clean energy transition where hydrogen will undoubtedly play an important role. Section V provides a brief summary of the the main theses presented in the article and concludes by presenting the mutual benefits of reconciliation for all involved parties. The objective of this paper is to present hydrogen as a potential energy source and encourage more extensive research surrounding this possibility.

II. Why Not?

When considering the benefits of utilizing hydrogen as a renewable energy source in remote communities, the widespread challenges associated with today's hydrogen production and with this transition must be considered. These challenges and constraints may hinder or restrict the efforts of using hydrogen as an energy source at present. However, there may be more realistically tangible resources and opportunities that can be explored in the short term and utilized in the near future. Currently, global hydrogen production is responsible for massive CO2 emissions due to it being supplied primarily from natural gas and coal sources, while production from cleaner and renewable sources, as well as the development of new hydrogen infrastructure, is costly [5]. Additionally, significant energy loss occurs in its production and transportation. This may impede its broad and prospective renewable and clean use

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and its adoption in sectors such as power generation, an important factor to consider when evaluating its potential to meet the needs of remote communities. Moreover, current governmental policies regulating the utilization of hydrogen as an energy source may be hindering this imperative adaptation. Current policies and regulations must be revisited and revised with cooperation between industry and government to allow for future advancements and to remove unnecessary or outdated barriers to this development. Through further research and the continuous technological advancements, which may minimize issues with the efficiency of its production and transportation, as well as collaboration between all stakeholders, hydrogen's potential as a renewable energy source and its integration into renewable energy systems can be explored and developed in the worldwide effort of reducing global carbon emissions. Relevant data and statistics on the use of hydrogen as an energy source can be found, e.g., in a recent report [6] published by the International Energy Agency.

III. Hydrogen for Remote Communities

A. *The versatility of Hydrogen*

Hydrogen is a free energy carrier that can be obtained through a variety of energy sources [5]. Colours, including black, blue, green, brown, and grey, have been used recently to identify and distinguish between the multiple different hydrogen production sources. Such production methods include fossil fuel-based hydrogen production (which could include black, grey, or brown depending on the source), fossil fuel-based hydrogen production combined with carbon capture, utilization and storage (referred to as blue hydrogen), and hydrogen from renewables (green hydrogen) [5] such as through the electrolysis of water or biochemical methods including biomass and photosynthetic PNS bacteria production [7]. Clean and green hydrogen, produced with renewable electricity, as a renewable energy source has acquired social, political, and business momentum in recent years. The attention has shifted from the auto industry to other sectors, including energy intensive industries such as heating, which have been considered difficult-to-decarbonize [5]. Other sources of green hydrogen also exist and can be used in various sectors and applications. Examples include blending hydrogen into public natural gas networks in low concentrations with no infrastructure changes, or its use in pure hydrogen form for heating [8]. The versatility of hydrogen allows for its production via different sources and the production of renewable electricity. This offers more flexibility and the potential of utilizing complementary sources of production from renewable resources in addition to other, non-green sources. These factors can make it advantageous for remote communities, in which hybrid or smart grids that include blended or several different energy sources can ensure more energy security and autonomy.

B. *The capacity for storage*

Hydrogen energy allows for the production, as well as the storage, of renewable electricity [8]. The long-term efficient storage of electricity is a key aspect of renewable energy transition in general, and even more so in remote communities. Hydrogen is suitable for long term storage in large quantities [8], which can consequently enable its contribution to large scale renewable integration. The production as well as the storage of hydrogen as an energy source can also provide a long term and seasonal flexibility, important components of an efficient and stable system. Furthermore, hydrogen's capacity to be stored in multiple different modes is also beneficial [5]. Hydrogen can be stored in a pure compressed structure, or liquified in pure or dedicated artificial structures. Additionally, it can also be stored as a mixture of liquid fuels or solids with other elements, as well as blended with natural gas. These different modes make it more valuable to use in the varying conditions of remote areas: different areas may benefit from one mode of storage over another, or be able to use different storage methods for different contexts such as during transportation or for long term or seasonal storage. Hydrogen's ability to be blended with natural gas can also allow for the utilization of the already established natural gas infrastructures [9], [10]. This will mitigate the cost for transitioning to the more renewable and sustainable energy source. Whilst the cost of hydrogen storage is currently relatively high [7], its potential is demonstrated by the continuous developmental and technological advances in storage with the expected fall in cost [4], by its high energy storage capacity [11], and by the numerous hydrogen energy storage projects already launched all around the world.

C. *The capability of transportation*

Physical properties, such as a higher energy density per unit mass than gasoline and natural gas, makes hydrogen attractive when looking for alternative energy sources or transport fuels [5]. Such properties of hydrogen that render it a potentially advantageous energy source for remote communities, are relevant to its transportation capability. Although today most hydrogen is produced and subsequently consumed on the same site [5] it may also be transported over long distances in gas pipes or trucks. Since most off grid and remote communities in Canada depend on non-renewable diesel fuels for their energy source which have a high cost of transportation [2], this makes hydrogen particularly interesting. Hydrogen's low volumetric density makes it lighter to transport, but it also has a low energy density per unit volume, meaning that it will need to be transported in larger quantities. Moreover, similar to the different hydrogen forms which ultimately increase the storage capacity of hydrogen, different forms of hydrogen enable different transportation methods. They will accordingly encompass different logistics, and production and overall costs. For example, compressed or liquefied form, as well as the use of energy carriers (such as methanol or ammonia) tend to have a high energy loss [5]. Notwithstanding the differences of individual transportation modes, this additional flexibility can allow for more befitting and efficient modes of transportation to be utilized to reach distinct remote regions, for example if there is a need for extensive and long truck hauls or traveling across large bodies of waters. Furthermore, the possibility of

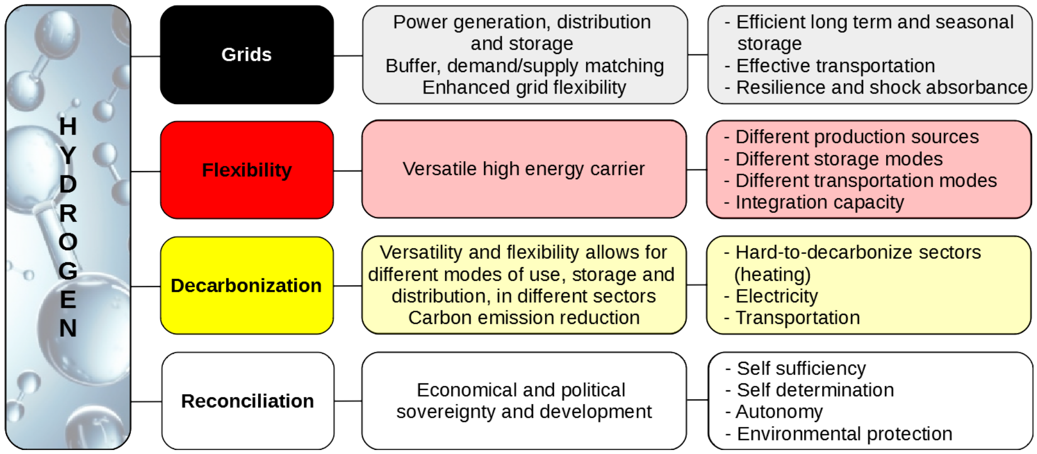

Fig. 1. A concept map showing features of hydrogen energy important for energy transition in remote Indigenous communities

using existing natural gas infrastructure, grids, and pipelines, can alleviate some of the cost of hydrogen transportation, decrease the need for new infrastructure, and consequently accelerate the transition.

Another prominent promise for the use of hydrogen is in the transportation sector and the auto industry [2, 5, 7]. Hydrogen has long been heralded as a powerful transport fuel with a very large theoretical potential usage range [5]. This further demonstrates the positive impacts such transitions could potentiate in Canada's rural communities. Hydrogen's broad prospect for usage in transportation sectors, as well as the ability and relatively high capacity for different transportation methods allows it to be a crucial element in the effort towards transitioning to renewable energy in remote areas.

D. Contribution to other renewable outputs

Perhaps the most pertinent and significant utility of hydrogen as a renewable energy source in remote communities is its contribution to other renewable energy outputs such as solar photovoltaics or wind turbines, expanding the reach of renewable solutions [5]. According to the IEA, a dramatic increase in renewable electricity shares must be undertaken to meet the world goal of limiting global warming to 2 degrees Celsius. Hydrogen can be a key enabler in challenging the complexities of transitioning to renewable energy systems [8] in remote regions. Such challenges include difficulties in matching demands with supply as well as strategic reservations and supply buffering especially when using intermittent sources, in addition to challenges associated with managing transportation across regions and sectors. Hydrogen can act as a complementary source of renewable and clean power generator, storage, distributor, and buffer and can enhance the applications of smart grids and microgrids in remote communities. One of the major issues facing this transition to renewables is the low operating cost of renewable sources, relatively low efficiency and flexibility due to this nature of and the difficulty of matching the electrical supply with the actual demand, as well as a large variation in seasonal production [5]. Hydrogen, through the advantages it offers for numerous long term and seasonal storage and its properties as an energy carrier, can thus make large scale renewable integration for variable renewables energies feasible and offer more flexibility to constrained power systems and grids. This flexibility can be enhanced through using hydrogen to produce clean dispatchable power during peak hours, and act as a strategic reserve and buffer to balance supply and demand as well as absorb shocks such as supply chain shocks, geopolitical shocks, and shocks associated with major environmental hazards [8] to which remote communities may be susceptible. Furthermore, through its powerful transportation capacity, hydrogen and hydrogen fuels offer remote communities more complementary options for meeting their electrical and power needs, especially using the economically viable power-to-gas electricity [12].

IV. Hydrogen Through the Lens of Reconciliation

The urgent need to address the continuous and ongoing damages caused by historical and contemporary exploitation of relationships between indigenous and non-indigenous nations, as well as the damages caused by the exploitation of the planet's resources, has led to viewing renewable energy development within the scope and concept of reconciliation [13]–[15]. As such, renewable energy development and reconciliation must happen concurrently, with projects such as the SHARED Future project2 [3] making this connection, as well as MacArthur et al. [4] arguing in the Pact for a Green New Deal movement in Canada that 100% of renewable energy transition requires the sovereignty and leadership of Indigenous people. Renewable energy development is thus viewed as a path to achieve energy autonomy and security, alleviating some of the health, socioeconomic, and financial strain on indigenous communities and asserting self-determination and the collective indigenous rights to the lands.

However, this perspective cannot be viewed without acknowledging the potential risks associated with the assumption that such developments are inherently advantageous for indigenous communities. Thorough research pertaining to the impacts and effects of renewable energy developments and projects is a necessary step to ensure that these developments don't perpetuate the exploitative nature and relationships of colonial structures and the disregard the rights of the Indigenous people of Canada.Cases such as Muskrat Falls in Labrador and Site C in British Columbia [16] are prominent contemporary examples of the negative impacts associated with various renewable energy developments. Thus, clean hydrogen projects as an energy source must be evaluated on a case-by-base basis. Policies to ensure equity ownership, capacity building, access to capital, and control over renewable energy projects must be put into effect. This must be done with concurrent and continuous research into such policies and effects [2]. Through this, the potential and advantages of hydrogen may be realized in remote communities, allowing us to move forward effectively in our strive for clean energy transition.

V. Conclusion

Hydrogen is an essential pillar and component in the transition towards renewable energy sources that will help achieve the goal of limiting global warming at two degrees Celsius [8]. Despite the mentioned challenges and limitations, its positive potential impacts may make it a useful scope to consider. One way Hydrogen can contribute to this transition is through its adoption and integration in remote community energy systems. Properties such as its versatility allow it to be obtained from different sources, such as from fossil fuels or water electrolysis, in addition to its capacity for storage in multiple different modes manifests its promises for its application in remote community settings. Furthermore, physical properties that allow for its transportation as well as the utilization of established infrastructures are also essential when considering these settings. Considering its versatility and it's tempting ability for decarbonizing multiple sectors with these advantageous properties, perhaps one of its characteristics that makes it an asset to remote communities is its ability to be integrated into diverse and other renewable energy systems, such as complementing current electrical systems, smart grids and microgrids. These properties make it advantageous for developing a cleaner energy future with more stable and secure renewable sources that may alleviate some of the disproportionate impacts of energy poverty in remote communities and support the pathway towards development, self-sufficiency and determination, autonomy and environmental protection, goals that are interlaced with the goals of developing Nation-to-Nation relationships and reconciliation. Additionally, the history of renewable energy development in Canada has demonstrated the need for indigenous involvement. With respect to renewable energy developments and projects, Indigenous contribution, engagement, sovereignty, and leadership is necessary for this transition with heightened importance in indigenous remote communities.

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