

GREEN HYDROGEN AND OPPORTUNITIES FOR T&T





OUR ENERGY FUTURE...

"We must now agree on a binding review mechanism under international law so that this century can credibly be called a century of decarbonisation."

— ANGELA MERKEL

Introduction

The energy transition is upon us! The decade to 2030 will be an exciting one as efforts intensify to tackle the global climate emergency. Updated Nationally Determined Contributions (NDCs) – to be presented in November 2021 at Conference of the Parties 26 (COP26) – are expected to define ambitious targets that reflect considerable political will and commitment.

For Small Island Developing States, there is much to lose should these efforts fail. Therefore, it is essential that collaborative and meaningful actions are taken to stay on the 1.5°C climate-safe pathway of the 2015 Paris Agreement. With natural gas identified as a critical transition fuel,

Trinidad and Tobago (T&T) is uniquely positioned to not only support the shift to natural gas from other fossils but also simultaneously accelerate its progress toward zero-carbon alternatives.

Carbon-cutting actions are bringing to the fore hydrogen's versatility as an energy carrier. The potential role of hydrogen technologies in a decarbonised world is well-recognised. However, the complexities and market challenges associated with hydrogen require careful understanding and management of risk. Wide-scale success in implementing suitable hydrogen technologies has been negatively impacted by cycles of high hopes followed by disappointments.

With unprecedented momentum, an alignment of techno-economic solutions, environmental urgency, and political influence may finally be taking place to break the cycle of disappointment. In 2020, hydrogen strategies emerged from Germany, Netherlands, Spain, Portugal, and the European Commission, and even China has set a 2060 net-zero goal that will feature green hydrogen. These measures can only augur well to accelerate technological innovations, lower emissions, and improve economies of scale for decarbonisation initiatives.

The prospects that lie in the hydrogen space offer NGC and its subsidiaries an opportunity to seek new markets and products aligned towards a nascent growth area – decarbonised petrochemicals – which can be a powerful platform upon which we build a sustainable future.

The Trinidad & Tobago Energy Context

With over 100 years of experience in the oil and gas industry, it may be hard to imagine a decarbonised future in T&T, but the transition is happening. Almost every international oil and gas major has announced strategies to decarbonise operations, and the same holds even for the downstream





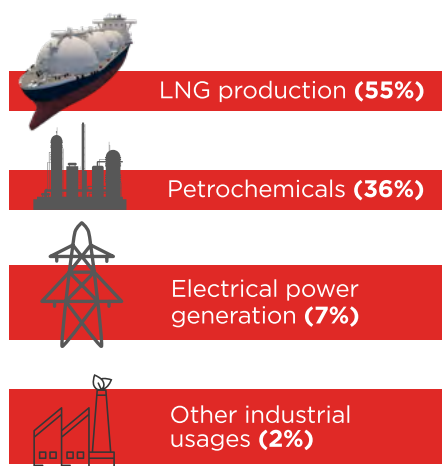
Today, solar and wind are among the cheapest sources to produce power in areas with high solar irradiation or wind speeds, with unsubsidised production costs for solar and wind being US 2 to 4 cents per kWh worldwide.

According to the International Energy Agency (IEA) (2019), hydrogen is gaining considerable momentum worldwide and could finally be on a path to fulfill its longstanding potential as a clean energy solution.

petrochemical players operating in Trinidad and Tobago.

Since the 1950s, T&T has been among the first countries to utilise natural gas for power generation. The proliferation of gas finds in the 1970s paved the way for a natural gas economy, and by the mid to late 1990s, T&T's economy shifted from an oil-based economy to one based on natural gas. Natural gas is also processed to recover Natural Gas Liquids (NGLs), a Liquefied Petroleum Gas (LPG) source - with both natural gas and NGLs being end-user fuels.

Based on the 2019 figures, usage of natural gas produced in T&T is apportioned as follows:



In the past, the local energy sector accounted for as much as 40% of the country's GDP, with the petrochemicals sector contributing over 20% of total export earnings. Further, approximately 99% of the power generated is fueled by natural

gas, making the country highly dependent on its hydrocarbon resources.

For T&T, there is an obvious opportunity to produce hydrogen and utilise it as feedstock in the country's well-established petrochemical sector, displacing hydrogen produced from natural gas. Beyond the industrial sector, hydrogen could also provide a possible avenue to transition towards clean mobility as the transportation sector shifts from gasoline and CNG towards electric driving, both with batteries and fuel cells powered by hydrogen.

Moreover, establishing a hydrogen production complex in T&T can kickstart a regional industrial cluster that will complement regional decarbonisation efforts.

The Case for Hydrogen in T&T

Trinidad and Tobago has a high per capita consumption of electricity and ranks among the world's most energy-intensive countries due to its extensive industrial sector and small population. Within the power generation sector, simple cycle gas turbines result in inefficient natural gas usage. Opportunities for improvement across the industry therefore abound.

In the 2019/2020 National Budget Presentation, the Minister of Finance indicated that the State was desirous of exploring different hydrogen applications within the local economy and encouraging collaborations with the private sector, academia, and international organisations. The private sector heeded the call and began work to study low carbon hydrogen applications in the first instance, using waste heat from the industrial processes to generate power to make hydrogen. The resulting economic disruption from the coronavirus has dramatically accelerated the need to advance efforts to help scale-up technologies such as hydrogen, setting the country on a post-COVID-19 path toward a sustainable energy sector.

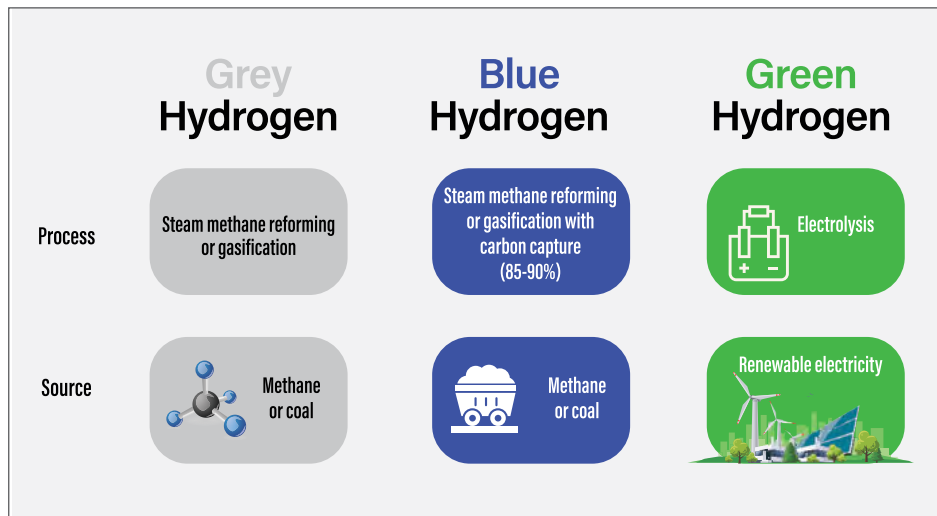


FIGURE 1: TYPES OF HYDROGEN AND SOURCES



FIGURE 3: PILOT GREEN HYDROGEN DEVELOPMENT HIGHLIGHTS

Figure 1 summarises the various types of hydrogen and sources.

Green hydrogen is another hydrogen technology that can decarbonise the sector and add significant economic sustainability to the local energy sector. With the country's first utility-scale solar farm under development and a revised target of 30% renewables by 2030, production of green hydrogen can become a reality in the medium to long term as electrolyser costs decline. Figure 2 captures the vision for T&T incorporating hydrogen into the energy landscape (See page 11).

In support of the Government of the Republic of Trinidad and Tobago's stated policy position, National Energy has initiated work to identify opportunities for applying renewables-based hydrogen locally. These efforts will be the basis for the decarbonisation of the existing petrochemical industry and hard to decarbonise sectors, like the cement and metals industries.

The overall benefits to the economy would include:

- An improved reserve to production ratio
- Storage of excess renewables as hydrogen for use as a secondary fuel;
- improved resilience;
- Job creation/ skills transfer;
- Reduced CO₂ emissions;
- Increased foreign exchange levels; and
- Energy diversification in T&T.

A Way Forward: Piloting for a Hydrogen Economy

A modular, purely green hydrogen facility can be a precursor to establishing a green hydrogen economy. A pilot would serve to advance a hydrogen economy along the most effective path and confirm proof of concept concerning the application of RE technology for hydrogen production in the local context. The pilot project would also:

- allow for the identification of the best RE technology for power generation to produce hydrogen
- lower the risks for entrepreneurial investments through the provision of relevant baseline data, specific to the T&T context
- encourage further technology development and private sector participation through access to data from a local pilot plant.

The pilot provides an avenue for NGC and group member companies to pivot T&T to lead industrial renewable energy applications.

As shown in Figure 3, establishing a pilot green hydrogen facility provides an avenue to link various stakeholders such as the State and private sector. Valuable data would then be available for reference to complement other sustainable energy programmes and inform policy development that facilitates the growth of a hydrogen economy in Trinidad and Tobago.

Green Hydrogen and Opportunities for T&T | CONTINUED

HYDROGEN APPLICATIONS

● TRANSPORTATION ● INDUSTRIAL

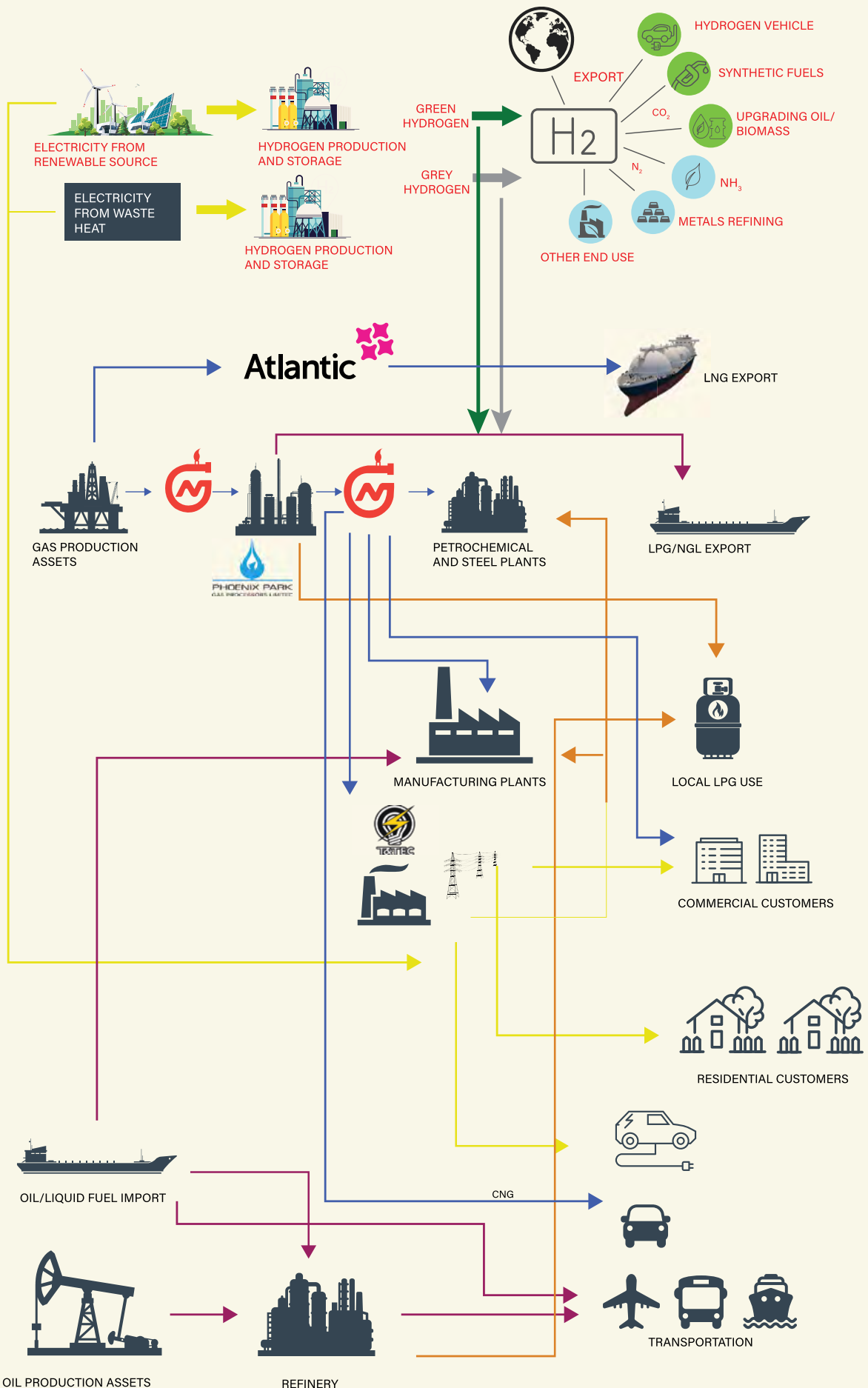


FIGURE 2: INCORPORATING HYDROGEN IN T&T'S CURRENT ENERGY VALUE CHAIN
 Source: The National Gas Company of Trinidad and Tobago Limited, National Energy modified

- Natural Gas
- Electricity
- LPG
- Liquid Fuels

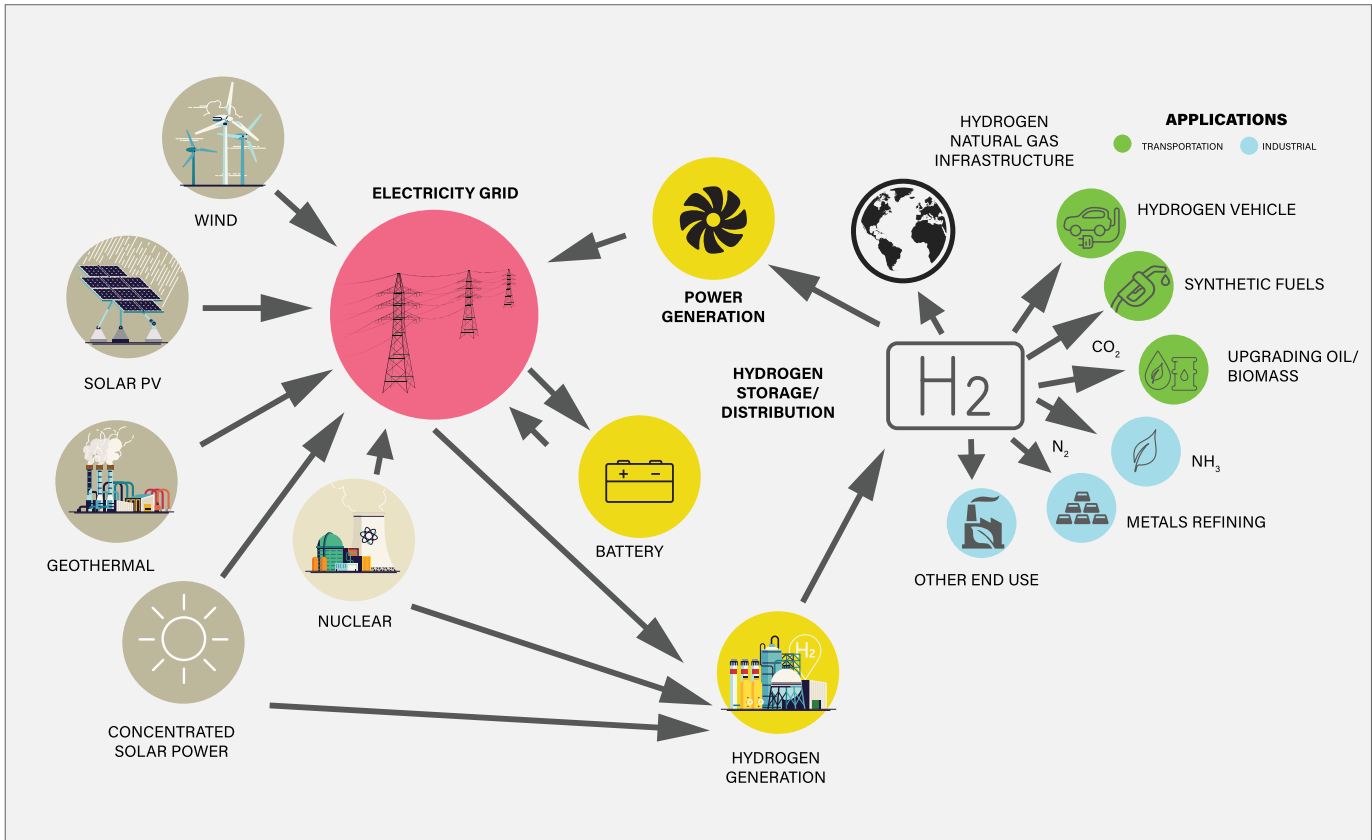


FIGURE 4: POTENTIAL SUBSECTORS FOR REGIONAL INVESTORS IN A HYDROGEN ECONOMY

Source: Sandia (2018)



The expansion of a Trinidad facility could also support regional cluster formations to showcase the advancement of hydrogen clusters among small islands or communities within large countries. Hubs and clusters are an emerging solution to overcome transport issues associated with hydrogen.

With support from the Ministry of Energy and Energy Industries (MEEI) and the Ministry of Planning and Development (MPD), National Energy secured funding from the Inter-American Development Bank (IDB) under an IDB-executed non-reimbursable Technical Cooperation Promotion of the Green Hydrogen Market in Latin America and Caribbean (LAC) Countries. This cooperation will facilitate feasibility studies in 2021 that contribute to understanding the economical parameters of producing green hydrogen locally. The results will add to the work of National Energy and the MEEI to provide insight into hydrogen growth for the country.

Beyond the Pilot: Caribbean Clusters

The expansion of a Trinidad facility could also support regional cluster formations to showcase the advancement of hydrogen clusters

among small islands or communities within large countries. Hubs and clusters are an emerging solution to overcome transport issues associated with hydrogen. They can link production, industrial demand, consumer demand storage, usage, and trading workforce in a small, centralised, focused area. In the future, Caribbean islands can serve as research centres to exemplify various renewable energy technologies and integration approaches. Such centres will foster evidence-based solutions, tailored to the region.

The Caribbean is predominantly dependent on relatively expensive and environmentally damaging fossil fuels for power generation and transportation. Thus, a major feature of Caribbean energy economies is the high and volatile energy prices, which have contributed significantly to the build-up of unsustainable debt and fragile economies.

TABLE 1: SUMMARY OF DOWNSTREAM SUBSECTORS HYDROGEN CAN SUCCESSFULLY DECARBONISE

DOWNSTREAM SUBSECTOR	COUNTRY
AMMONIA PRODUCTION	TRINIDAD AND TOBAGO
METHANOL PRODUCTION	TRINIDAD AND TOBAGO
METALS & REFINING	TRINIDAD, JAMAICA, DOM REPUBLIC
CEMENT AND OTHER MANUFACTURERS	TRINIDAD, JAMAICA, DOM REPUBLIC
SYNTHETIC FUELS FOR POWER PLANTS	REGION-WIDE
VEHICULAR TRANSPORT FUEL	REGION-WIDE
SHIPPING FUELS	VARIOUS
COOLING & HEATING FOR BUILDINGS	REGION-WIDE
ENERGY STORAGE	VARIOUS
HYDROGEN INTER-REGIONAL EXPORTS	TRINIDAD AND TOBAGO



Rethinking the use of energy in all sectors of the economy can boost economic growth, create jobs, enhance prosperity, support social development and advance environmental sustainability.

A decarbonised world does not equate to desolation, instead it brings benefits of healthy environments and strong economies when adequately managed.

According to the World Bank, despite the region's ideal conditions for leveraging green energy, the current renewable capacity in the Caribbean still leaves the area with a 90% dependency on fossil fuels for power generation. Sun and wind are abundant and geothermal energy and hydropower could theoretically free the islands almost entirely from dependence on fossil fuels.

There is, therefore, substantial room for expansion across the renewables supply chain to contribute to a transitioned Caribbean economy. Like the African Hydrogen Partnership, which aims to promote green hydrogen to stimulate sustainable economic development across the African continent, a Caribbean hydrogen cluster can contribute to an energy ecosystem to strengthen economic growth, improve regional transportation, and boost economic integration. Figure 4 illustrates the broad scope of opportunities that can be the catalyst for creating a resilient, integrated Caribbean energy system.

Three investment segments can be examined - upstream, midstream, and downstream as follows below:

Upstream Investments

As new power generation capacity is needed, investors will seek to develop wind, solar, geothermal, biomass, and

other forms of renewable and clean energy sources to satisfy demands.

Midstream Investments

Transportation of power from the power generation sites to the hydrogen production facilities throughout the islands will require infrastructural investments.

According to the EIA (2019), some pilot projects show that pipeline systems can be converted from natural gas to hydrogen gas with the limited investment required, but this is case-specific. A recent study for the Netherlands concluded that its transmission pipelines can be converted to facilitate hydrogen gas by replacing compressors and gaskets (DNV GL, 2017). Therefore, Trinidad's existing gas infrastructure and any new infrastructure to enable gas-fired power generation throughout the region could represent considerable infrastructure-in-place for integrating green hydrogen. Modifications and the build-out of new hydrogen/ gas-fired infrastructure will, however, be quite capital intensive.

From a storage perspective, hydrogen can go where batteries cannot facilitate long-term energy storage of clean energy. Energy storage can be attractive business cases for Caribbean grids, improving grid reliability and resilience against power shortages and outages. Additionally, as prices decline, a hybrid solution (batteries and hydrogen) coupled with solar generation can yield an attractive business case for Caribbean grid operators to integrate hydrogen into the energy mix with storage options in Trinidad and Tobago and elsewhere.

Downstream Investments

A suite of sub-sectors can potentially be built with renewable or green hydrogen as the feedstock on the downstream end. These are outlined in Table 1. The Caribbean is also a large hotel and cruise tourism region. A hydrogen cluster in the area can generate innovative solutions within the global tourism industry, with the Caribbean as the first-mover.

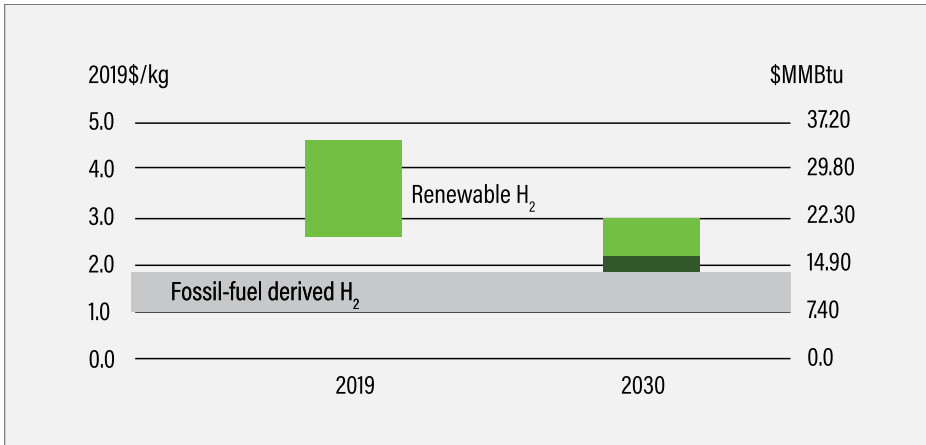


FIGURE 5: GREEN HYDROGEN CAN COMPETE WITH FOSSIL-DERIVED HYDROGEN
 Source: BNEF (2020)

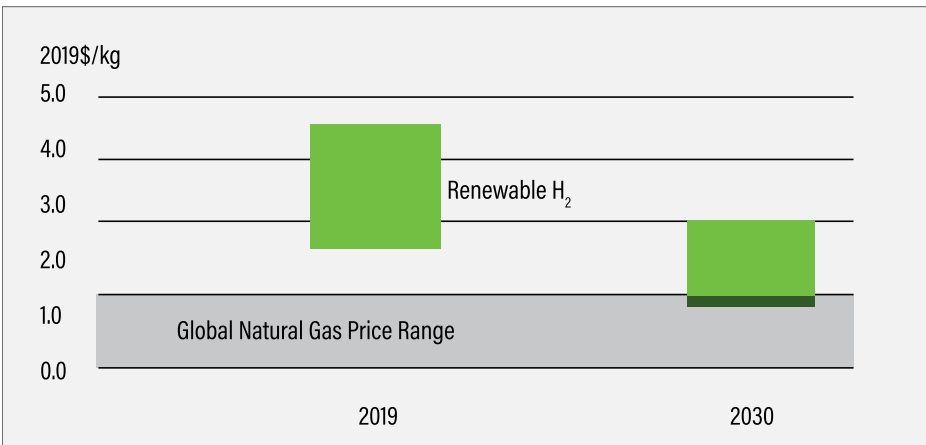


FIGURE 6: GREEN HYDROGEN CAN EVEN COMPETE WITH THE COST OF NATURAL GAS
 Source: BNEF (2020)

Today, most governments within the region have set aggressive renewable energy targets, coupled with public policies and incentives that enable solar photovoltaic systems, wind turbines, geothermal and marine energy to become competitive with fossil fuel-based generation. Another impetus for regional collaboration has arisen from the 2020 pandemic.

According to international consultancy firms, the world's risky dependence on vulnerable nodes in global supply chains has been exposed to supply chain disruptions.

As a result, production or sourcing could move closer to end-users, with companies localising or regionalising their supply chains.

Drivers

1. Sufficient Fossil-Based Capacity

The Bahamas, Barbados, Belize, Dominican Republic, Guyana, Haiti, Jamaica, Suriname, and Trinidad and Tobago represent the nine larger islands in the region. Among them, total primary energy supply (TPES) is 37,703 ktoe. Fossil fuels – oil, natural gas and coal – account for 89 percent of TPES in these countries. Natural gas accounts for 53 percent of all

energy use in the countries but this is primarily a Trinidad and Tobago story as over 90 percent of the gas used in the region is from T&T. Oil products account for 34 percent of TPES, followed by biomass as the third most important energy source, and the most important renewable resource, at 11 percent of TPES.

2. Growth Opportunities

Bloomberg New Energy Finance (BNEF) analysis concludes that by 2030 hydrogen will be competitive with fossil-derived hydrogen. Further, they conclude that green hydrogen will be competitive with the cost of natural gas. Figures 5 and 6 illustrate. According to Greentech Media, however, forecasts on when green hydrogen might be competitive with existing high-carbon production methods keep accelerating.

Given that Caribbean countries currently import natural gas at relatively high prices compared to the rest of the world, this can represent one of the first regions where green hydrogen will compete with natural gas in an unsubsidised market. Therefore, there is significant potential for both investors and the economies as each would maximise value by considering a hydrogen-based economy. A pilot facility at this time would therefore serve as preparation for fully capitalising upon this competitive cost position.

Roadblocks

The road toward a hydrogen economy will not be an easy one as future demand and the structure of the market remain uncertain. Most major projects are in the early phases of development, with few confirmed off-takers. Wood Mackenzie estimates that 80 percent of low-carbon hydrogen deployed this decade will be used to displace existing fossil-fuel-derived hydrogen (grey hydrogen). Hydrogen demand for heating, shipping and aviation are still considered longer term, and uptake by these sectors that have not previously utilised hydrogen, are crucial to further driving costs down.

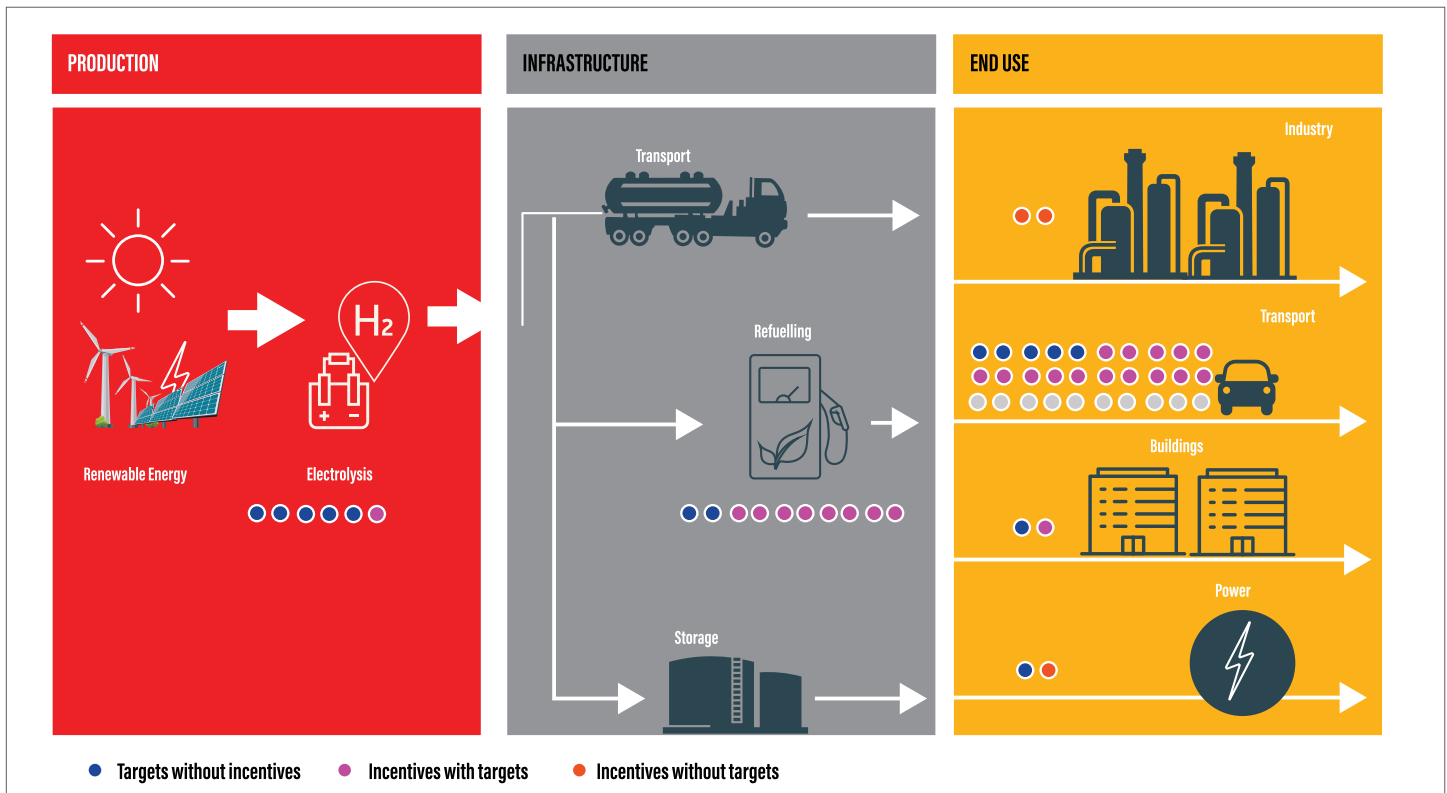


FIGURE 7: GLOBAL HYDROGEN POLICY SUPPORT SNAPSHOT

Source: IRENA analysis based on IEA (2019)

Role of Policy

To realise the true potential of hydrogen locally and to capture the benefits outlined earlier, policy support mechanisms are essential for the penetration of green hydrogen into multiple sectors and encourage sector coupling. The graphic on page 15, derived from IRENA, captures hydrogen policies at a global level by value chain segment.

Conclusion

As a state-owned enterprise, NGC and its subsidiaries are well-positioned to support the country's pursuit of a hydrogen economy, through the establishment of a pilot green hydrogen facility, with the expectation of scaling up over time, which will:

- Support long-term sustainability of the petrochemical sector by reducing exposure to non-renewable supply factors.

- Reduce fossil-based natural gas consumption and therefore decarbonise the petrochemical sector over time.
- Serve as a new source of revenue through the sale of hydrogen.
- Improve location competitiveness of Trinidad and Tobago.
- Allow the State to lead by example and mobilise private sector investments in advancing the hydrogen economy. ■

References:

Pivovar, B. (2016). "H2 at Scale: Deeply Decarbonizing our Energy System." Briefing to Deputy Under Secretary Adam Cohen. NREL chrome-extension://oemmnndcblldboiebfnladdacbdadm/https://www.nrel.gov/docs/fy16osti/66246.pdf

Gonzalez, J. (2017). "Is Hydrogen a Solution for Green Energy Resilience in The Caribbean?" Hincio chrome-extension://oemmnndcblldboiebfnladdacbdadm/https://www.hincio.com/file/2017/10/Is-Hydrogen-a-solution-for-green-energy-resilience-in-the-Caribbean.pdf

IRENA (2020), Green Hydrogen: A guide to policymaking, International Renewable Energy Agency, Abu Dhabi chrome-extension://oemmnndcblldboiebfnladdacbdadm/https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Nov/IRENA_Green_hydrogen_policy_2020.pdf

Sandia National Laboratories (2018) - Hydrogen Embrittlement Considerations for Distribution of Gaseous Hydrogen by Pipeline - Chris San Marchi and Joe Ronevich PRCI mtg, October 2018. Available at: https://www.osti.gov/servlets/purl/1593013

The full suite of documents relating to the technical co-operation can be found at https://www.iadb.org/en/project/RG-T3777.

John Parnell - GTM - https://www.greentechmedia.com/articles/read/woodmac-on-green-hydrogen-its-going-to-happen-faster-than-anyone-expects