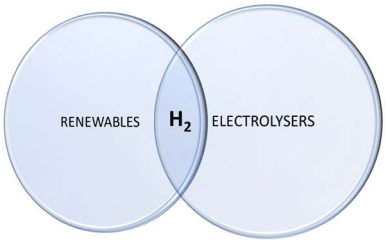

Azerbaijan: Competing in a Renewable Hydrogen Economy

Abstract:

A renewable hydrogen economy is where renewable hydrogen (created from wind and solar energy) has displaced fossil fuels as the primary energy vector. It is stored and consumed domestically to abate Green-House Gas emissions and the surplus is exported.

***In June 2020**, **Germany** stated that it will be a net importer of hydrogen owing to its lack of renewable energy resources. **In July 2020, Saudi Arabia's** ACWA Power announced plans to meet projected export demand for renewable hydrogen by building a $5 billion ammonia plant. Utilising renewable hydrogen from electrolysers powered by Saudi Arabia's wind & solar resources. **In July 2020, the European Commission** decreed priority support for a massive increase in renewable hydrogen manufacturing capability, starting with a minimum 6 gigawatts of electrolysers producing 1 million tonnes of renewable hydrogen by 2024.*

Until recently, many saw a renewable hydrogen economy as a fantasy or a nightmare. However, European governments, western oil & gas producers and the global finance industry now regard the transition to renewable hydrogen as irreversible. As evidenced by the radical changes being made to corporate and government policies and by the investment decisions of the international finance community. The renewable hydrogen industry is creating opportunities for both existing oil & gas majors and for countries with no fossil fuel resources but who, thanks to significant renewable energy resources, now have a golden ticket to becoming hydrogen exporters.

Azerbaijan has been successful in extracting value from its (below-ground) fossil fuel assets. It now has an opportunity to become a producer, user and exporter of its (above-ground) resources e.g. wind & solar as renewable hydrogen.

Azerbaijan has significant untapped renewable energy resources – representing one half of the resources and equipment needed to operate a fully functioning renewable hydrogen economy. The other half is the water electrolysis equipment Azerbaijan must have to maximise its deployed renewable energy assets and to achieve the goal of becoming a renewable hydrogen energy player.

In order to become a major hydrogen player (user & exporter) Azerbaijan must rapidly embark upon a programme of renewable hydrogen demonstration projects. The goals of such a programme would be:

1. *To maintain the country's role as a major energy supplier, as the world transitions away from a fossil fuel-based economy, and;*
2. *To become a significant exporter of both renewable hydrogen and the equipment required by the global renewable hydrogen industry.*

***Authors:** Simon Robeson & Phil Doran.*

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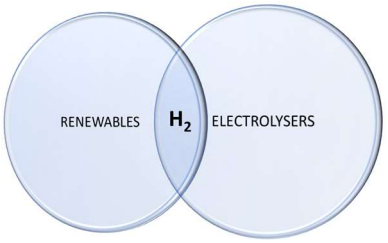


Introduction:

According to an article published in the Financial Times on June 15th 2020:

"Big Oil faces a future where it may not be so big and may have less to do with oil. The industry has faced an increasingly uncertain future as climate change has moved to the forefront of the public's consciousness. Investors, too, have stepped up their calls for action. Now the coronavirus pandemic, by radically cutting demand for oil and gas and giving governments the whip hand in directing the revival of their economies, looks likely to accelerate the long-term shift away from fossil fuels in many nations."

European governments, western oil & gas producers and increasingly the finance sector regard "Beyond Oil" as a mega trend, which is informing both corporate and government policies and increasingly being taken into account by the investment community globally.

For less diversified economies, particularly those whose welfare is predominantly reliant on fossil fuels, the success of this energy transition could have severe negative consequences. Hence, exploring the options open to Azerbaijan with respect to a global transition to a hydrogen economy may well be timely.

What is meant by the term 'Hydrogen Economy'?

A renewable hydrogen economy is one where renewable hydrogen (e.g. from wind and solar) has displaced fossil fuels as the primary energy vector.

As can be seen in Figure 1, intermittent energy sources (e.g. wind and solar) represent one half of a hydrogen economy. The generation and storage of hydrogen via water electrolysis is the other half.

The transition to a hydrogen economy begins with the energy sector itself. Hydrogen is generated using renewable energy technologies via the process of water electrolysis, where H_2O is broken down into O_2 and H_2. It is widely recognised that the economy-wide use of electricity that has been generated by intermittent-renewable means requires its storage, for subsequent use downstream across the whole economy. As per the "addressable billion-dollar markets" shown in Figure 1, the stored hydrogen can also be used:

- to bridge the intermittency gap created not only by calm and cloudy days but also between summer's surfeit of renewable energy and winter's shortage ('inter-seasonal').
- to ensure the electrical grid's stability via grid balancing and frequency control.

Thus, renewable hydrogen is the agent that will serve to balance the intermittency on the electrical grid and facilitate the economy-wide use of hydrogen.

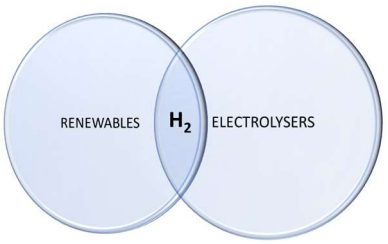
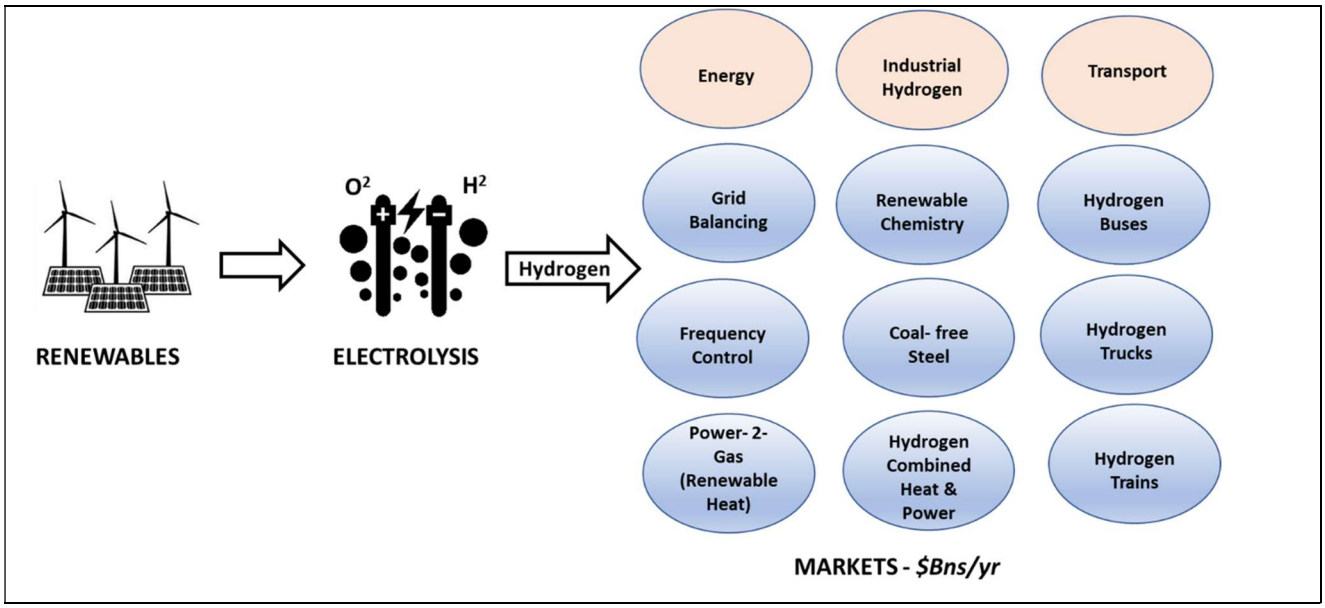


Fig 1: Carbon Free Energy Chain



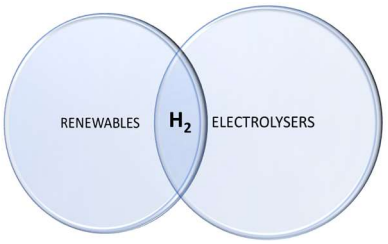
As can be seen above, there are a myriad of addressable billion-dollar markets for renewable hydrogen. The example markets shown are engaged in hydrogen demonstrations or planned demonstration projects with major corporate entities including BP, Shell, Daimler, VoestAlpine, Alstom, Linde/BOC, Air Products, Siemens, Vanhool, Amazon, RWE & Thyssen Krupp, Saudi Arabia's ACWA Power and Wallmart to name but a few.

May 2020: BP announced "a feasibility study into the development of an export-scale renewable hydrogen production facility in Australia. The extensive study will help BP and the energy sector better understand the possibilities of using hydrogen to export renewable energy at scale." (Source: BP.com)

July 2020: Saudi Arabia's integrated power company ACWA Power announced plans to build a renewable ammonia plant based on renewable hydrogen in Saudi Arabia powered by 4 gigawatts of wind and solar power. The $5 billion plant will be jointly owned by Air Products and ACWA Power. "The completed facility will produce 650 tons of renewable hydrogen daily, enough to run around 20,000 hydrogen-fuelled buses, Air Products said. Renewable ammonia production is expected to start in 2025." The fuel will be shipped as renewable ammonia to end markets globally then converted back to hydrogen. (Source: www.acwapower.com)

July 2020: the European Commission decreed a policy to prioritise the development of renewable hydrogen, produced using mainly wind and solar energy:

- *"From 2020 to 2024, we will support the installation of at least 6 gigawatts of renewable hydrogen electrolysers in the EU, and the production of up to one million tonnes of renewable hydrogen.*
- *From 2025 to 2030, hydrogen needs to become an intrinsic part of our integrated energy system, with at least 40 gigawatts of renewable hydrogen electrolysers and the production of up to ten million tonnes of renewable hydrogen in the EU.*
- *From 2030 to 2050, renewable hydrogen technologies should reach maturity and be deployed at large scale across all hard-to-decarbonise sectors."* [i]



One of the many Government and industry reports into the potential size of the renewable hydrogen market in Europe estimates that by 2030 c. 3bn tonnes of renewable hydrogen will need to be imported into Europe.

Hydrogen's deployment is increasingly having an impact on the financing of investments, particularly in the coal sector. Oil & gas is being critically evaluated by the finance sector and is being forced into fundamental long-term change, a move seemingly accelerated by the Covid 19 pandemic.

H_2 Storage & Distribution

To be sure, the economy-wide deployment of renewable energy demands the mass generation and storage of hydrogen on an inter-seasonal basis, i.e. storing summer's surplus renewable electricity production for excess winter consumption. There are a number of storage options available, e.g.:

Gas networks: Azerbaijan's pre-existing gas network will have a major role to play in the storage and transportation of renewable hydrogen.as networks will be used to export hydrogen from surplus producing countries to net consuming economies as is the case with natural gas today. As noted above, Germany has already stated that it will be a net importer of hydrogen owing to the fact that it does not preside over sufficient renewable energy resources[ii]. Indeed, according to Economy Minister Peter Altmaier, Germany has "…set aside €9 billion to expand H2 capacity at home and abroad".

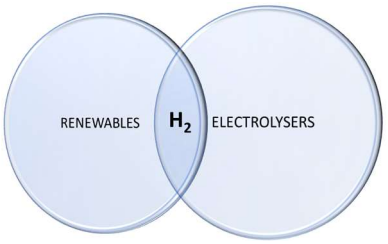
As well as using distribution and transmission networks for the storage and transportation of hydrogen, Ammonia has proven, hydrogen storage and distribution characteristics. As evidenced by Saudi Arabia's planned renewable ammonia plant, above.

Ammonia (NH_3):

- has a high hydrogen content (18% by mass) and is easily liquified. Ammonia's energy density is comparable to that of compressed natural gas (CNG) and methanol.
- is already profitably transported over large distances.
- has a long history of large-scale, cost optimised industrial production through its global use as a fertiliser, chemical raw material and refrigerant, and;
- has similar physical properties to LPG providing an opportunity for Azerbaijan to use existing LPG storage, transport & terminal equipment and export know-how.

Azerbaijan exported c. 11,000 tons of LPG and up to 400,000 tons of diesel fuel on the world market in 2019. (source: www.azernews.az).

In summary, renewable Ammonia is a unique, carbon free energy dense molecule. It has the ability to displace fossil fuel based fertilisers, to be used as a direct fuel for hydrogen fuel cells and to be used as a hydrogen energy vector.



Azerbaijan's potential role in a Hydrogen Economy:

Azerbaijan is well placed to adapt to becoming a 'Hydrogen Major':

- its long-standing technical knowledge of fossil fuel economics (e.g. LPG) is transferrable to the emerging renewables and renewable hydrogen industry, and;
- it has a significant capacity for renewable energy generation - as much as 23,000 megawatts of solar energy and 3,000 megawatts of wind (source: Azerbaijan Ministry of Energy).

The combination of Azerbaijan's transferrable energy know-how with its vast renewable energy resources offers the country a significant head-start over the new entrants to the energy markets who, thanks to the emerging renewable hydrogen market and their substantial renewables capacity have a golden ticket to becoming energy producers & exporters, e.g. sun-rich North African countries and the Ukraine[iii].

Azerbaijan has a range of options with respect to managing the risks associated with the emerging renewable hydrogen economy. Below, we outline possibilities at either end of the risk and cost spectrum.

- **Option 1: (Low-risk, low-cost strategy)**

N.B.: *We believe that Option 1 is the optimal risk management & least-cost approach***.**

In this option, Azerbaijan recognises the economic risks represented by a renewable hydrogen economy. It chooses to develop a renewable hydrogen production capability and capacity at a steady pace i.e. in line with the unfolding market. Its objective is to become a renewable hydrogen user and exporter.

To achieve this objective, Azerbaijan will embark upon a programme of renewable hydrogen demonstration projects and accelerate its domestic wind and solar installation programme.

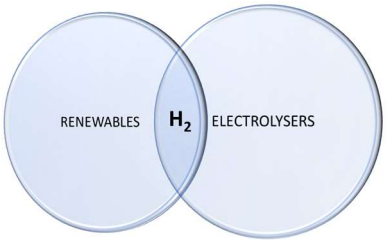
The programme's goals are to:

1. protect Azerbaijan's position as a major energy supplier, as the world transitions away from a fossil fuel-based economy, and;

2. enable Azerbaijan to become an exporter of both renewable hydrogen and the equipment required by the global renewable hydrogen industry.

In so doing, Azerbaijan will avoid falling behind countries that are already mastering the complexities of combining and operating their renewable energy systems with water electrolysis i.e. where both halves of the hydrogen economy are being integrated.

Over time, this approach may lead to investment in manufacturing in Azerbaijan by existing foreign manufacturers of renewables and electrolysers and/or be seen as an opportunity by Azerbaijan to mass manufacture its own renewables equipment (e.g. solar/wind) and electrolysers.



- Option 2 (High-risk, high cost strategy):

  Azerbaijan sees no risk from an emerging hydrogen economy and thus does not accept that a transition to a hydrogen economy is taking place and continues 'business as usual'.

  However, the probability of the hydrogen economy becoming a reality is clearly increasing. The consequence of a business as usual strategy by Azerbaijan would in all likelihood result in Azerbaijan having to become an importer rather than an exporter of renewable hydrogen and lose ground against the competition.

About the Authors:

Simon Robeson and Phil Doran formed Core Technology Ventures Services (CoreTec) in 2002 as a specialist hydrogen, fuel cell and wider clean energy industry investment advisory boutique. To date they have worked with over 25 H_2 industry participants from start-ups to later stage companies and with multiple EU, UK, Central Asian and US government agencies.

Azerbaijan: Simon formed TransTech Capital Azerbaijan in 2012. This led to an agreement with Azerbaijan's Ministry of Education for TransTech to roll-out national Centres of Excellence for the commercialisation of technologies emerging from Azerbaijan's sizeable scientific institute and university sector at ADNSU.

[i] See: https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf

[ii] "Considering the status quo, it is unlikely that the large quantities of hydrogen that will be needed for the energy transition can be produced in Germany alone, as Germany's renewable energy generation capacity is limited. This means that Germany will continue to import much of its energy from abroad. We will foster and intensify international cooperation and partnerships on hydrogen." Source Page 3 German Federal Ministry for Economic Affairs and Energy, The National Hydrogen Strategy. See link https://www.bmwi.de/Redaktion/EN/Publikationen/Energie/the-national-hydrogen-strategy.html

[iii] See Hydrogen Europe, "Green Hydrogen for a European Green Deal A 2x40 GW Initiative", Link, https://hydrogeneurope.eu/sites/default/files/Hydrogen%20Europe_2x40%20GW%20Green%20H2%20Initative%20Paper.pdf