cng services ltd Fingleton White

Leveraging The GNI Gas Grid to Stabilise Renewable Electricity Using Liquid Hydrogen & Wind

Report Summary

May 2023

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Introduction

Gas Networks Ireland (GNI) commissioned CNG Services Ltd (CSL) and Fingleton White (FW) to undertake a feasibility study on how the GNI gas grid can be leveraged with hydrogen generated from nearby curtailed wind to stabilise renewable electricity generation.

A comprehensive model was built detailing the outputs in an accompanying report. The report analysed how at low electricity demand; curtailed wind energy can be used to generate green hydrogen, stored to be used at a later point in time, and then combusted in a spark ignition (SI) engine to support the electrical grid when the electricity demand starts to peak.

The scope covered by the feasibility study is listed as below:

1. Hydrogen generation and storage
2. Electricity generation using engines
3. Site selection and regulatory review
4. Financial (CAPEX & OPEX) analysis

This report is a summary of the feasibility study and where required, redactions concerning commercially sensitive information.

Hydrogen Generation - Electrolysis

Hydrogen can be generated in an electrolyser from the electrolysis process by breaking down water using electricity to produce hydrogen and oxygen.

- As a simple approximation, 1MW of electricity translates to 200m^3 or 20kg of hydrogen on average (at normal temperature and pressure). This can be more or less depending on the manufacturer and type of electrolyser.
- The output pressure is typically 30 barg in gaseous form.
- Mains water can be used, and most electrolysers have built in water purifiers.
- CAPEX starts at €1.9M to €3.5M euros per MW and scales at €630/kW to €1615/kW
- After approximately 70,000 hours of operation the electrolyser stack will need to be replaced. This OPEX is about €290 to €520 /kWh over about 20 years and is highly dependent on the electrolyser make and supplier.

Hydrogen Storage

Hydrogen can be stored as a gas or as a liquid. As a gas hydrogen is stored similarly to natural gas, where a small buffer volume is installed between the electrolyser and compressor which injects compressed hydrogen into a pressure vessel.

For the liquification process, the electrolyser supplies hydrogen to a liquefier which fills a cryo-storage vessel. When required, a cryopump will pump the hydrogen to a vaporiser to regasify the hydrogen.

Some key points are as follows:

- Hydrogen compressors can typically be twice as expensive for equivalent natural gas compressors. Provided high purity is not a requirement, the approximate CAPEX is €400k to €600k. For small volumes 30 barg storage is optimal as compression is not needed. For high storage quantities, large spherical vessels are nominally at 10barg.
- For the liquification process the liquefier is the majority of the CAPEX costing €35M for a 5 tonne per day liquefier and €70M for a 25 tonnes per day liquefier.
- For large hydrogen storage requirements an assessment is required between the cost due to liquification, available space for gaseous storage, and safety assessment for highly compressed storage at large capacities.

Electricity Generation

The commercial availability and technology of hydrogen feed engines has developed since the study was taken, with blend options rising up to 60/70%. Currently, manufacturers are following different development curves following their market appetite and fuel availability with general development targets of around 2025 – 2030.

At the time of study, the commercial limit was approximately 25% blend for a ‘hydrogen ready’ engine system that can be suitably scaled to 50MW. Due to the inherent derating effect of H2 on engine technology, the focus of study was on low percentage blends or full a 100% H2 engine set.

Alternatively, other than engines fuel cells can be used to scale. Whilst feasible, the current costs of using fuel cells are significantly more expensive than using an engine. Fuel Cells are an option for particular cases where there is no other alternatives such as natural gas availability or if significant amounts of hydrogen can be made available to scale to 50MW.

CAPEX quotations from a number of fuel cell manufacturers range from €2500 to €4000/kW which equals €125M to €200M for a 50MW system. Comparatively a 50MW engine can cost €30M to €50M.

Liquified Hydrogen Analysis for a 50MW Peaking Plant

A feasibility was undertaken on a live windfarm with 2 hydrogen options for both gaseous and liquified models as summarised in the tables below.

The liquified storage model requires 1 cylindrical vessel with a 45-tonne capacity, 5 tonnes less the higher tier COMAH (allowing for other hydrogen in the system). The engines are capable of operating up to a 25% blend. With such capacity, blending operation and with a 10MW electrolyser, the facility is capable to peak continuously for an average of 4 hours per day i.e., during winter mornings. The annual operation is 1500 hours, and the refill rate is sufficient to support the prolonged period. If required, the electrolyser can be upgraded to 20MW to allow a continuous peaking operation of 8 hours a day. Financially there are key setbacks that affect the payback period, and these are the high CAPEX costs of the engine and liquefier for a project total CAPEX of €141M as well as the OPEX incurred from the price of natural gas.

Liquified Options	Option A - 25%	Option B - 15%
Hydrogen Blend %	25 %	15 %
Electrolyser	10MW	
Peaking Operation	1500 hr/annum	
Storage Capacity	45 tonnes – Lower Tier COMAH	
Storage Vessels	Liquified Cylindrical Vessel	
Consecutive Operation	Unlimited – 4-hour peaking 41 days – 6-hour peaking 14 days – 8-hour peaking	Unlimited – 4-hour peaking Unlimited – 6-hour peaking 81 days – 8-hour peaking
Operation at 100% H2	5 days – 4-hour peaking 2 days – 6-hour peaking 2 days – 8-hour peaking	
Payback Period	24 Years	34 Years

Gaseous Hydrogen Analysis for a 50MW Peaking Plant

The gaseous options have a smaller storage capacity due to the limitations of gaseous storage and are modelled with 1 spherical vessel with a 25-tonne capacity at 10 barg, 25 tonnes less the higher tier COMAH. Similarly, to the liquified options, the engines are capable of operating up to a 25% blend. With such capacity, blending operation, and with a 10MW electrolyser the facility is capable to peak continuously for 4 hours per day i.e., during winter mornings. The annual operation is 1500 hours, and the refill rate is sufficient to support the prolonged period. If required, the electrolyser can be upgraded to 20MW to allow a continuous peaking operation of 8 hours a day. The gaseous options are cheaper and have a better return than the liquified scenarios due to the removal of the liquification cost. Ultimately, there is a project-by-project trade-off between the availability of and the cost of site space compared to the cost of liquification.

Gaseous Options	Option C - 25%	Option D - 15%
Hydrogen Blend %	25 %	15 %
Electrolyser	10MW	
Peaking Operation	1500 hr/annum	
Storage Capacity	25 tonnes – Lower Tier COMAH	
Storage Vessels	Gaseous Spherical Vessel – 10 Barg	
Consecutive Operation	Unlimited – 4-hour peaking 22 days – 6-hour peaking 8 days – 8-hour peaking	Unlimited – 4-hour peaking Unlimited – 6-hour peaking 45 days – 8-hour peaking
Operation at 100% H2	2 days – 4-hour peaking 1 days – 6-hour peaking 1 days – 8-hour peaking	
Payback Period	14 Years	17 Years

Conclusion

To conclude, the model and feasibility study provided analysis to support a peaking plant at an existing windfarm with options proposed as above. The options were based on the site scope, the market, engine availability and surplus electricity.

The full project documentation is approximately 100 pages consisting of a feasibility study, excel model, and engineering drawings. For further information CNG Services and Fingleton White are available for contact, CNG Services at info@cngservices.co.uk and Fingleton White at info@fingleton.ie.