Kingsbridge 1 Green Hydrogen and Storage Assessment

Capital Power Corporation

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1. Executive Summary

Capital Power engaged with CEM Engineering and RESPEC Company to assess technical viability of the following:

- Produce green hydrogen using curtailed/excess generation at Kingsbridge 1 wind facility via electrolysis.
- Store the produced hydrogen in a nearby depleted gas reservoir, owned by Northern Cross Energy, the project partner.
- The combustion of the stored hydrogen for power generation.

The feasibility study determined that:

- There is insufficient curtailed/excess generation to produce enough hydrogen for utilization. The study scope was modified to assess using the total power generated at Kingsbridge 1 for hydrogen production.
- A modular electrolyser system could be sufficiently sized to produce hydrogen for storage/utilization.
- A nearby depleted gas reservoir is suitable for the storage and injection of hydrogen.
- Hydrogen extracted from the reservoir would need to be blended with methane for combustion in current commercially available generators.

If the implementation of a hydrogen facility were to be pursued by Capital Power, additional engineering, investigations, and studies will be required to further understand the technical, commercial, environmental, regulatory, and interconnection requirements of the project.

2. Introduction and Goal

In recent years, a lot of attention has been given to hydrogen as a potential solution towards decarbonization of the power industry. Traditionally, hydrogen was used exclusively in the oil and gas refinement. Large quantities of hydrogen are produced via steam methane reforming of natural gas. However, there is a carbon intensity associated with steam-methane reforming, both in the power required, but also in the carbon bi-product that is either emitted or sequestered. Due to this, there has been a growing interest in producing carbon-free hydrogen via electrolysis using renewable energy.

The Ontario Independent Electricity System Operator (IESO) selected Capital Power Corporation ("Capital Power") to participate in the Hydrogen Innovation Fund (HIF). The goal of this feasibility study was to assess the potential for Kingsbridge 1 wind facility to produce hydrogen via electrolysis using curtailed power, store in a depleted gas reservoir, extract the stored hydrogen to generate power, and provide grid services.

Kingsbridge 1 wind facility is a distribution connected, 40 MW wind farm located near Goderich, Ontario. The facility is comprised of twenty-two (22), 1.8 MW Vestas wind turbines, split between two separate substations.

Capital Power engaged with CEM Engineering ("CEM") and RESPEC Company, LLC ("RESPEC") for this study. A local depleted gas reservoir owned by Northern Cross Energy, the project partner, was assessed for its ability to store hydrogen.

3. Jurisdictional Scan

Climate

Kingsbridge 1 is located in Southern Ontario, near Lake Huron. As such, the facility experiences large seasonal changes in temperature and precipitation. These conditions require a flexible approach to ensure smooth operations throughout the year.

Hydrogen equipment, especially if located outside of a building, must be able to operate in both hot and cold temperatures. Typical design requires equipment to be rated for temperatures between -40°C to 35°C.

Local Generation

There are several wind facilities north and south of Kingsbridge 1, thus the area has lots of variable generation. The facility is not located near any major population centers. The closest thermal generation facility is a nuclear plant north of the wind facility.

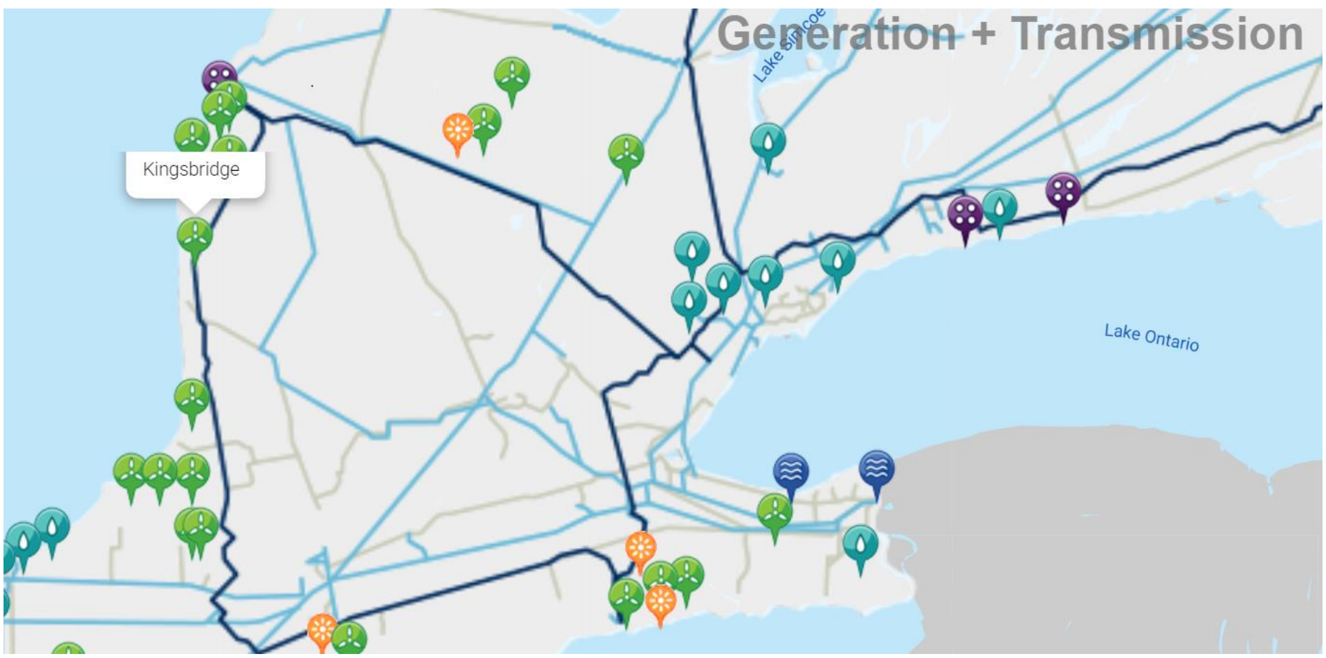

Figure 1 | Kingsbridge 1 in Relation to Other Generation Sources in the IESO (Source: IESO Ontario Energy Map)

4. Approach/Methodology and Assumptions

Assumptions

The following assumptions were utilized for this feasibility study:

- Sufficient water is available onsite.
- Natural gas infrastructure is already available for injection into the reservoir, and final blending for combustion.

Hydrogen Production from Electricity

The feasibility study evaluated the provided generation data, sized an electrolyser configuration, and determined the amount of hydrogen that could be produced.

Hydrogen Storage

RESPEC analyzed information provided by the Project Partner to develop a 3D model of the reservoir. This reservoir was then simulated against the historical data to verify the model. The pressure, amount, and rate of hydrogen produced was used as an input for RESPEC, to determine the storage potential of the nearby reservoir. RESPEC modelled the effects of injecting a blend of hydrogen and methane into the reservoir.

Electricity Generation from Hydrogen

CEM used RESPEC's reservoir data to size a combustion generator. CEM then determined the suitability to provide ancillary services to the local grid.

5. Discussion

Originally, the goal of the feasibility study was to determine the amount of hydrogen that could be produced using only curtailed generation. However, after analyzing the data, it was found that there was insufficient curtailed power to produce hydrogen cost-effectively.

Direction was provided to CEM to investigate using all available power for hydrogen production. Based on the generation capacity of Kingsbridge 1 and feasibility assessment, a modular electrolyser system was sized for the most cost-effective hydrogen production. With this, the utility requirements, waste products and amount of hydrogen production were preliminary determined.

The feasibility analysis identified a technical fatal flaw with using curtailed/excess power to produce hydrogen. There were no immediate technical fatal flaws in using the full generation capability of the site for hydrogen production.

RESPEC's preliminary model of the reservoir showed that by injecting the produced hydrogen with methane, the reservoir was able to achieve sufficient pressure within several months and was suitable for hydrogen storage. Further analysis will be required to understand the geology of the reservoir and how the specific minerals interact with the injected hydrogen/methane mix.

Based upon preliminary analysis, the extracted fuel from the reservoir will need to be blended with methane to achieve a 20% hydrogen by volume blend, prior to utilization for power generation, to match current commercially available technologies.

The feasibility study identified several potential risks including water availability and disposal; interconnection capacity available; land availability; air/emission permitting; noise studies, mitigation, and permitting; drilling and operation licenses; and water use license.

The total cycle efficiency from an electrical perspective, from hydrogen production, storage, to combustion, is approximately 25%. Thus, the economic value of power produced from hydrogen combustion must be at least four times greater than the value of the power generated by the wind facility, not including return on any capital costs.

Additional engineering and further study would be required to fully understand the technical, commercial, environmental, and regulatory requirements.

6. Conclusion and Recommendations

There is not enough curtailed power available at Kingsbridge 1 to produce significant amounts of hydrogen to support a storage and blending system. However, if utilizing the full capability of the wind facility, with current technologies, there are no immediate technical fatal flaws with producing hydrogen via electrolysis, storing in a depleted gas reservoir, and utilizing the stored hydrogen for ancillary services. Additional engineering and further study would be required to fully understand the technical, commercial, environmental, and regulatory factors if this type of facility was considered in the future.

7. Lessons Learned

From the feasibility study, there are two main lessons learned:

1) It was assumed that due to the amount of wind generation in the area, there would have been enough curtailed generation to economically support an electrolyser. However, the feasibility study concluded this to be a fatal flaw and not economically nor technically feasible.
2) When it comes to the reservoir, it was learned that natural gas infrastructure is required for the pressurization of the reservoir. Using natural gas to pressurize the reservoir not only means that natural gas needs to be procured, but also that 100% hydrogen would not be possible in the future as methane would be produced along with Hydrogen.