Scoping a Hydrogen Network for the South Yorkshire Region using the Network Optimisation Model AENi

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Challenge Statement

The South Yorkshire area has a large number of energy intensive industrial sites, producing a range of products including glass, steel and ceramics. Not all of the processes behind these industries can be decarbonised using electricity, hence there is a need to swap out hydrocarbon fuels for hydrogen, or deploy small scale carbon capture plant. Unlike for electricity, there is no national network for transport of hydrogen or CO_2 that individual emitters may currently tap in to.

The UK government has already provided funding to address this issue, but only for specific larger industrial clusters, such as the Humber Industrial Cluster. As such, there is a lack of research on the feasibility of hydrogen/CO_2 networks in other areas. Additionally, the South Yorkshire area has the challenge of having several large emitters located within an urbanised environment, where routing of networks is considerably more complex than on greenfield sites, or those wholly owned by large industrial companies.

This case study represents a first step toward addressing the industrial decarbonisation challenge in South Yorkshire.

Research Response

Developing shared infrastructure is economically complex, as multiple stakeholders with differing needs and motivations must be catered for. Additionally the development of feasible network routes and modelling of their costs and timescales is complicated and data-intensive, which may prevent industry partners from initiating the research individually. The South Yorkshire Sustainability Centre (SYSC) can act as a central coordinator for multiple industries that may not otherwise share their requirements, and give them collaborative access to researchers and modelling tools.

The specific aims of this research project were to:

- Gather data on notable CO_2 emitters in the South Yorkshire region, and estimate equivalent annual hydrogen consumption.
- Research possible locations for a grid connection large enough to site a hydrogen electrolyser.
- Use the network routing tool AENi to determine a preliminary network route as the first step in assessing feasibility.

Figure 1: Graphic representation of relative CO_2 emission scale of the 21 industrial sites considered in this case study.

Figure 2: Least cost hydrogen network for 21 emitters in the South Yorkshire region, found using routing software AENi. The largest dot represents a hydrogen electrolyser plant sited at the Thurcroft Grid Supply Point (400 kV transmission). Credit Joseph Hammond of AENi.

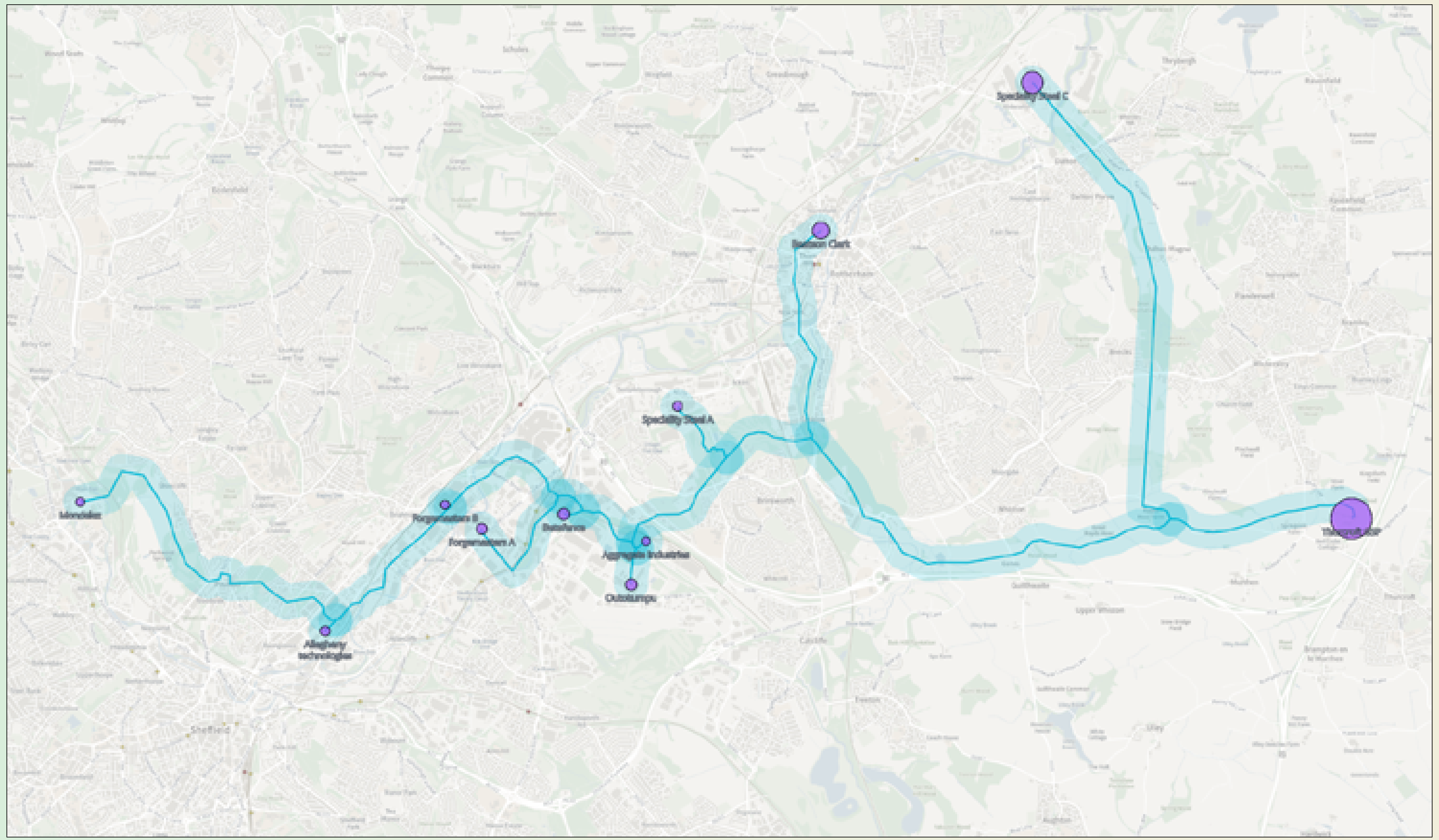

Figure 3: Least cost hydrogen network for 10 emitters in and around the Lower Don Valley area, found using routing software AENi. The largest dot represents a hydrogen electrolyser plant sited at the Thurcroft Grid Supply Point (400 kV transmission). Credit Joseph Hammond of AENi.

Evidence and Outputs

The case study considered 21 large emitters located in South Yorkshire. These ranged greatly in size as shown in Figure 1.

The pipeline routing/sizing software AENi[1] developed as a spin-out from the Brown group at University of Sheffield was used to find a cost optimal network linking these sites to the grid supply point at Thurcroft. The network found is shown in Figure 2. The network shows several notable features, including a tendency to follow existing roads and to take longer detours around built-up areas. The latter is clear to see around Doncaster, at the top right of the image.

A smaller network was then found for a set of 10 emitters in and around the Lower Don Valley (LDV) area[2], as shown in Figure 3.

For the LDV network, the average electricity consumption of the electrolyser was modelled as 70 MW. This is significant, as it is considerably lower than the current headroom of ~200 MW at the Thurcroft grid supply point. The larger South Yorkshire network has an average electrolyser power consumption of 202 MW, which likely cannot be met at Thurcroft. However, the greater challenge for the larger network is the long pipeline distances to parts of the network, particularly to the West.

The representation of the industries in the modelling was crude; it was assumed that all recorded CO_2 emissions were due to burning natural gas, that all of this gas would be replaced by hydrogen, and that hydrogen would be consumed at the same rate throughout the year. These assumptions must be improved upon by further collaboration.

What does this mean for the region?

The findings of the case study are significant in that they provide preliminary evidence that a hydrogen network for industrial sites is likely feasible using existing electrical grid connections. The next step is for policy makers to support more in depth research where partners collaborate more deeply with the researchers to develop network designs that are feasible from an economic and timeline perspective.

The modelling tool used in this case study could easily be applied to other regions with notable industrial activity, such as South Wales.

Next Steps

- Carry out further partner engagement to understand which decarbonisation option they prefer (hydrogen will not be best for all).
- Develop a methodology for analysing the economics of sub-sections of the network to predict the most favourable roadmap for rollout.
- Collaborate with partners in areas where the network cost is lowest in order to develop a more accurate model, and gauge willingness to pay.

1 https://www.runpilot.io/
2 Sheffield City Council (n.d.) Lower Don Valley Master Plan. Part 6 - LDV Districts.