Complementarity between hydrogen supply and fuel switching: The case of HyNet

What is the HyNet North West project?

The HyNet project aims to create the UK's first regional infrastructure of its kind for the production and supply of hydrogen[1] . The North West of England and North Wales was chosen by HyNet's partners as an ideal location due to the high concentration of heat-intensive industries in the area, the opportunity to repurpose depleted oil and gas fields in Liverpool Bay, and the presence of an existing storage site for natural gas (the Cheshire Salt Basin) which could be used for the underground storage of hydrogen. The proximity to North Wales also delivers cross-border impact, for example, the decarbonisation of the Heidelberg Materials cement works at Padeswood.

The HyNet project is run by a consortium of local industry and academic partners originated by Progressive Energy and Cadent in 2016 and is now anchored on Eni's CO_2 transport and storage infrastructure. In terms of the hydrogen element of HyNet, establishing an economically viable hydrogen supply plant is critical, alongside the hydrogen transport and storage infrastructure. Under the first Low Carbon Hydrogen Supply Competition (HS) and Industrial Fuel Switching Competition (IFS), the HyNet partners undertook two funded streams of work to further this goal: the first stream (funded through the HS programme) focused on developing plans for a hydrogen supply plant in the North West. This stream aligned with the core goals of HS, which were to: "accelerate the development of low carbon bulk hydrogen supply solutions". [2]

In contrast, the second stream of HyNet work (funded through the IFS programme) focused on creating a ready-made customer base for the proposed hydrogen plant. By running feasibility studies and on-site demonstration projects, the HyNet consortium hoped to encourage large industrial sites in the North West to commit to switching to hydrogen once a local supply became available. This workstream had a fit with the goals of IFS, which were to "identif[y] and test the processes and technologies required for industries in the UK to switch to low-carbon fuels".[3]

HyNet as a test case of programme interlinkage

HyNet was one of five hydrogen supply projects which received funding under both phases of HS to develop plans for hydrogen production facilities. However, HyNet was the only case

[1] The wider project also aims to provide carbon capture and storage infrastructure
[2] https://www.gov.uk/government/publications/hydrogen-supply-competition
[3] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/838309/ietf-finalising-design-consultation.pdf

where the work carried out under HS was not a standalone project. In the case of HyNet, the HS work was just one-half of an overarching project to create a local hydrogen economy.

The HS work helped address the issue of how to create a local hydrogen supply in the North West. For example, where would the plant be located? What steps would be required to develop this plant? In contrast, the parallel work funded under IFS helped address the key demand issue: Who will use this hydrogen once it becomes available?

The fuel-switching work conducted as part of the wider HyNet project aimed to create a potential customer base for the hydrogen plant by working with local industrial partners to help make their production facilities hydrogen-ready. This work stream was funded under Phases 2 and 3 of the IFS. (see Annex Table 1).

The HyNet consortium's novelty in undertaking two separate but related sub-projects of work funded under both schemes makes it an ideal test case which allows us to examine how the IFS and HS programmes intersected and reinforced each other. Consequently, this case study explores the question, "How did the HS project and the IFS project influence one another?" [4] However, it is important to note that each project was independently assessed and funded for its own merit.

The principal source material for this case study is two interviews conducted with the respective HyNet leads for both the IFS and HS projects, and an interview with one of the industry project partners who collaborated with the HyNet consortium as part of a separate bid won under the IFS scheme. The case study also draws on the Phase 1 and final project reports submitted by HyNet partners and wider dissemination materials.

When considering the findings of this case study, it is important to consider that the wider HyNet project has received other public funding sources, which may have influenced project outcomes. For example, in 2021, the HyNet consortium secured funding for two projects under the UKRI Industrial Decarbonisation Challenge. The same year, HyNet was selected to become a "track 1" industrial cluster for developing carbon capture, utilisation and storage (CCUS).

Effects on industry confidence in switching and supply technology

The HyNet partners' decision to bid for both IFS and HS projects was driven by an understanding that confidence in supply would be difficult to achieve without confidence in switching (and vice-versa). In their end of Phase 1 HS report[5], they described the work carried out under the IFS project as being pivotal to the wider goals of the supply competition work:

> *"To ensure deliverability, the initial industrial users have been selected to minimise the reliance on extensive hydrogen distribution and use hydrogen in a way which maximises*

[4] While the rest of this case study refers to the HyNet IFS project and the HyNet HS "projects", the term "project" in this context refers to the two sub-projects of HyNet work that were funded under IFS vs HS.
[5] HyNet Low Carbon Hydrogen Plant - Phase 1 Report for BEIS, February 2020

> *confidence in ability to adopt hydrogen. However, to roll out wider adoption across other industrial users and at higher levels of hydrogen utilisation requires technical and commercial market confidence. In that regard it is imperative that demonstration of successful industrial fuel switching is delivered in parallel with development of hydrogen supply."*

This strategy of engaging with likely hydrogen supply customers via IFS appears to have had the intended effect. Around the time IFS concluded, all manufacturers who participated in the feasibility and demonstration projects listed in Annex Table 1 had signed a memorandum of understanding to receive a future connection to the HyNet supply infrastructure. [6]

Key finding: The HyNet consortium saw creating future hydrogen demand for hydrogen, through the demonstration of switching technology to local partners, as integral to building market confidence and ensuring the success of future hydrogen deployment.

Equally, the HyNet consortium's HS work appears to have benefitted IFS by making switching more attractive to local companies. HyNet's IFS project lead felt that the HyNet consortium's concurrent involvement in the HS project at Stanlow refinery meant that demonstrations would have a higher chance of achieving the long-term aim of building confidence among potential adopters of switching technology:

> *[It] showed we were going to be able to produce and supply hydrogen. It wasn't just demonstration for demonstration's sake. There was a route map to these sites actually getting hydrogen, which I think was important. I'm trying to think of the sequencing of it. I mean, I think the hydrogen supply competition was running at the same [time]. [It] was exactly the same timing. But the fact that [it] was there was really helpful."*

Interviews with an industry partner involved in the Phase 3 demonstrations confirm that the presence of HS work to develop the plant made exploring switching possibilities appear more commercially viable. In particular, the interviewee mentioned that the HS project was critical to obtaining wider buy-in within his organisation for investigating hydrogen switching technology:

> *"..the fact it was cluster-based meant that it wasn't done in isolation. You knew that there was a potential source available. Firing hydrogen without a potential source of hydrogen would have seemed academic to us, to be honest. It would have been nice, but it's hard to justify*." (NSG Pilkington)

Key finding: For manufacturing industries, collaborating with a bid partner who was also involved in an HS project to establish a local plant stimulated interest and supported the business case to move forward.

[6] https://hynet.co.uk/wp-content/uploads/2022/04/042022-Organisations-commit-to-low-carbon-hydrogen_-002.pdf

Complementarities in project delivery

Using the same consortium of organisations to deliver the parallel HS and IFS projects has enhanced the potential decarbonisation impact of both HyNet projects, especially its IFS project. Specifically, the partnerships HyNet formed to deliver its HS work meant it was uniquely positioned to engage a company from a particularly large industry – oil – in its IFS work. Among all the projects which received funding under IFS, the HyNet consortium's project was notable as the only project which included work that would develop switching technology at the site of an oil refinery (Stanlow in Ellesmere Port) owned by Essar.[7] As the oil refining process is very energy-intensive, including the refinery meant the potential reduction in carbon emissions was far greater than if the IFS work had focused solely on manufacturers of consumer or industrial products. [8]

It is unlikely that Essar (a member of the HyNet consortium) would have participated in this switching work had it not already been heavily involved in the parallel HyNet HS project. Essar was integral to the plans for the hydrogen supply plant, as it provided a site at Stanlow, which had space for the plant's construction and was ideally located, being close to many other energy-intensive industries.[9] In addition to providing the location for the planned hydrogen plant, towards the end of Phase 3 of IFS, Essar (together with Progressive Energy) set up the 'Vertex Hydrogen' company (since rebranded as 'EET Hydrogen'[10]) to provide a legal entity which would own and operate the eventual hydrogen plant.

This involvement in developing a hydrogen plant on the site of its existing refinery opened up an opportunity for Essar to decarbonise some of the refinery's operations. To ensure the refinery itself was ready to run some of its activities via hydrogen once it became available, the HyNet partners applied for funding under IFS to carry out a FEED study[11] for switching the refinery's existing Combined Heat and Power (CHP) technology to one based on hydrogen.

Some of these changes may have occurred even without the HyNet HS and IFS projects. Essar is a member of the UK Petroleum Industry Association (UKPIA), the industry body which represents the main oil refining companies operating in the UK. In October 2017, UKPIA and BEIS published a joint Industry-Government Action Plan for decarbonisation and improving energy efficiency in the oil refining sector.[12] This document identifies investing in more efficient CHP technology as a key step that refineries can take to reduce their emissions output. Therefore, it is possible that Essar may have followed this recommendation and upgraded its CHP accordingly. However, it is likely that Essar's commitment to develop a hydrogen-powered CHP (as opposed to a more efficient gas-powered CHP) was influenced by HyNet's plans to build a hydrogen plant at the Stanlow refinery. By facilitating the development of a new

[7] https://www.gov.uk/government/publications/industrial-fuel-switching-to-low-carbon-alternatives/industrial-fuel-switching-demonstration-successful-projects-phase-3
[8] See Annex Table 1 for a full summary of HyNet's IFS work.
[9] HyNet Low Carbon Hydrogen Plant - Phase 1 Report for BEIS, February 2020.
[10] https://www.essar.com/vertex-hydrogen-to-change-brand-name-to-eet-hydrogen/
[11] The Front End Engineering Design (FEED) stage is a basic engineering phase involving creating initial drawings which can then be used as the basis for estimating the costs of constructing the new CHP.
[12] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/652109/oil-refining-decarbonisation-action-plan.pdf

CHP that will dispense with natural gas altogether, involvement in IFS has helped Essar reduce its emissions further.

In addition to maximising the potential decarbonisation impact of HyNet's IFS work, including the refinery in the portfolio of IFS work had a clear benefit for the plant that was developed under HS in that it created a customer who would require a large amount of hydrogen. The IFS work to develop plans for switching Essar's refinery CHP to hydrogen means that the refinery will be in a position to use the hydrogen from the plant once it becomes available. In September 2022, not long after the conclusion of IFS Phase 3, Essar signed an offtake agreement with Vertex Hydrogen, where it committed to purchasing a substantial amount of hydrogen to power the refinery.[13]

Key finding: Parallel delivery of a switching and supply project can reinforce the decarbonisation impact of each project, as this allows for an energy company partner such as Essar to 'wear two hats' – as a contributor to the new hydrogen supply plant and as a future customer of the plant.

Looking forward: How did joint participation in IFS and HS help advance the wider HyNet project?

The HyNet consortium is not unique in aiming to create a regionally focused hydrogen storage and distribution infrastructure. However, the consortium partners' decision to also focus on creating demand for hydrogen by working with energy-intensive industries to develop switching solutions is novel. The feasibility and demonstration projects completed under IFS were useful for directly generating a customer base for the wider HyNet project. On-site demonstrations gave the companies involved the confidence to commit to receiving a future hydrogen supply. However, the IFS projects also indirectly recruited potential customers by providing valuable information for other companies using similar industrial processes. For example, in the final report for IFS produced by the HyNet partners, Encirc – a company producing container glass near the HyNet site – was singled out as an "ideal candidate" to use the furnace technology demonstrated at NSG Pilkington's float glass production facilities[14] and in July 2021, towards the end of HyNet's IFS work, Encirc made a public commitment to receiving hydrogen from the HyNet consortium.[15]

The HyNet IFS lead explained how the industry engagement generated by the demonstration projects meant that the wider HyNet project was a step ahead of similar regional projects when it came to being ready to supply hydrogen, and this ultimately gave the HyNet project an edge in its bid to become a track 1 CCUS cluster:

[13] https://hynet.co.uk/wp-content/uploads/2022/09/20220927_Essar_Vertex-Offtake-Final.pdf
[14] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1119899/phase_3_hynet_industrial_fuel_switching.pdf
[15] https://hynet.co.uk/wp-content/uploads/2021/07/08072021-BEIS-Minister-Visit-Release-Encirc-joins-HyNet.pdf

> *"[This was] the process whereby HyNet was selected as a track one cluster, alongside the East Coast cluster … Some of the critical evidence within our bid was, "Okay, we've got a big cohort of hydrogen customers. Here [are] your 40 MOUs." We've got people who really want to take hydrogen for us. There's real demand, etc., etc. So, coming back to that point, that may not have happened. We wouldn't have had such a strong evidence base had the fuel switching programme not been about."*

In addition, several of these new partners (Kelloggs, Novelis, Essity) have collaborated with the HyNet consortium to undertake demonstrations at their own sites as part of the follow-on IFS-2 scheme, underscoring their commitment to switch to hydrogen.[16]

Key finding: Engaging with local energy-intensive industries via switching projects can help create a critical mass of potential consumers for a hydrogen supply project. This industry support may also have a follow-on effect of helping the supply project secure further investment.

What lessons can be learned?

HyNet has shown that working with local industry to explore and demonstrate the feasibility of industrial fuel switching can accelerate the goals of a regionally focused hydrogen supply project.

Jointly pursuing supply and switching projects has created a positive feedback loop, whereby the realistic possibility of obtaining a supply supports the business case for being involved in switching feasibility studies and demonstrations. In turn, these demonstrations can generate further interest, as demonstrated by the large and increasing number of MoUs with companies wishing to make the switch as supply becomes available. This show of support from local industry partners then supports the case for additional investment in hydrogen supply.

In addition, having a host company for the site who is not only a potential supplier but also a potential customer may amplify the effect that switching work has on local industry engagement and confidence.

In the Hynet consortium's case, the interaction between its IFS and HS work has helped secure additional funding for both aspects of the wider HyNet project: The number of potential customers who signed MoUs following the original IFS demonstrations was instrumental to the HyNet consortium securing further funding to develop its hydrogen plant as a "track 1" cluster. Moreover, several of these customers have opted to host demonstrations of HyNet switching technology on their own sites under IFS-2 funding.

Attempts to replicate this formula to create other regional hydrogen clusters may note that the proposed plant's location has likely contributed to its success. Essar's Stanlow refinery is located in an existing industrial centre, making it easier to forge connections with energy-

[16] https://www.gov.uk/government/publications/industrial-fuel-switching-programme-successful-projects/industrial-fuel-switching-programme-phase-2-summaries-of-successful-projects

intensive companies nearby. The location has also allowed the plant's plans to use existing infrastructure, such as the gas network, which also makes “blending” hydrogen with natural gas a possibility for local companies exploring switching.

It is also likely that the involvement of an existing energy company, Cadent Gas, from the inception of the wider HyNet project lent the HS and IFS projects early commercial credibility and accelerated the process of recruiting industrial partners to the HyNet consortium.

Annex Table 1 – Summary of HyNet Activities under Phase 2 and Phase 3 of IFS

Site	Work package	Phase 2 - Feasibility	Phase 3 - Demonstration
NSG - Pilkington	Direct Firing	Study on the feasibility of using increasing proportions of hydrogen in a regenerative glass furnace.	On-site demonstration of hydrogen-firing in a float glass furnace at NSG's Greengate Works in St Helens
Unilever	Boiler	Trial on a boiler at a test site in Rochdale. The aim of the trial was to demonstrate that hydrogen can be used as a replacement for natural gas in the boilers at Unilever's Port Sunlight facility and to finalise the design of the burner for use at Port Sunlight.	On-site demonstration of hydrogen-firing in a boiler at Unilever's Port Sunlight plant. 100% hydrogen was used to power the manufacturing of personal care and home care products
Essar	Refinery CHP (Hydrogen Firing in a Gas Turbine)	HyNet ran a procurement process for an EPC contractor to undertake a FEED study in relation to a new plant at Stanlow. The tender process was won by Costain.	A Front-end Engineering and Design (FEED) study in relation to a new hydrogen-fired gas turbine combined heat and power (CHP) plant at Essar's Stanlow Refinery.

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