



Department for
Energy Security
& Net Zero

Hy4Heat Evaluation

Annex D: Process Tracing Results

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& Net Zero

OGL

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Annex D: Process Tracing Results

Introduction

Annex A: Methods provides discussion of the rationale for using Process Tracing (PT) as a method for testing contribution claims within an overall Contribution Analysis approach. This Annex provides a breakdown and discussion of findings for each PT test. Annex A also provides a ToC diagram to illustrate how the scheme's inputs and activities are expected to translate through to intended outcomes impacts. The Process Tracing tests were applied to assess the extent to which intended impacts have been achieved and the contribution of the programme, alongside external influencing factors, to causing these impacts.

In summary, the core elements of the ToC tested through PT were:

If Hy4Heat achieves its intended outcomes:

- Establish if it is technically possible, safe and convenient to replace natural gas (methane) with hydrogen in residential and commercial buildings and gas appliances.

Then this will contribute towards achieving the following three main areas of impact:

- Enable the government to determine whether to proceed to a community a trial and commission future R&D programmes developing the use of hydrogen for heat (Contribution Claim 1)
- Stimulate industry to invest in parallel programmes of R&D to develop hydrogen heating appliances or to address wider network conversion goals (Contribution Claim 2)
- Economic Benefits - assuming hydrogen is demonstrated as being a viable pathway for decarbonisation of heat, Hy4Heat will contribute to wider economic benefits. Including benefits to manufacturers participating in Hy4Heat, through follow-on contracts and commercial exploitation of new knowledge and patents gained. As well as potential longer-term economic benefits to the UK due to a first mover advantage from exporting new technologies and services (Contribution Claim 3).

There are a number of causal links implied within the bullet point summary above. Process Tracing makes causal inferences by identifying types of evidence (or tests) that would either support or reject programme hypotheses if observed. A series of nine PT tests were developed to set out more detailed hypotheses on how the programme is expected to contribute towards this range of intended outcomes and impacts. In addition, a series of eight tests were designed to test 'alternative hypotheses' e.g., types of evidence we would expect to observe if external factors, rather than Hy4Heat, had led to outcomes being achieved. For example, if GDNO's decisions to progress R&D programmes on their networks were primarily due to other influencing factors and Hy4Heat played little or no role in these.

A PT Framework, in Excel, was developed to provide a description of each test and the rationale for it being categorised as a 'Hoop test', 'Straw-in-the-Wind', 'Smoking Gun' or 'Double Decisive' test. The types of tests are briefly defined below, with more discussion provided in Annex A: Methods:

- **“Hoop tests”** – disproves or considerably weakens the hypothesis if not found, but not sufficient to confirm the hypothesis. These are pieces of evidence that we would ‘expect to see’ if the given hypothesis is true
- **“Straw-in-the-Wind”** – evidence that lends more support to a causal claim in the hypothesis but not sufficient in itself to confirm it if observed, or to disprove with certainty if not observed. For example, evidence based on interview findings alone may be considered ‘shaky’ (like a straw-in-the-wind) if there is potential for positive confirmation bias among grant funded participants who wish to portray an overly positive picture of benefits achieved
- **“Smoking gun”** – evidence that provides a convincing cause-and-effect type contribution story. It strengthens the hypothesis if observed but does not disprove the hypothesis if not observed (although may slightly weaken it). These are pieces of evidence that we would ideally ‘like to see’ if a given hypothesis is true but may in practice be difficult to uncover
- **“Double-decisive”** – strengthens or confirms the hypothesis if observed and if not observed the hypothesis is rejected or significantly weakened.

The rest of the Annex provides a breakdown of results for each PT test.

Contribution Claim 1: Hy4Heat informs policy decisions on proceeding with community trial

The first two Process Tracing (PT) tests were focused on assessing the intended impact in the ToC relating to informing policy decisions e.g., that Hy4Heat provided:

Sufficient evidence to inform policy decisions on continuation of future work concerning hydrogen gas conversion (e.g., to proceed with a community trial and commissioning follow-up R&D developing the use of hydrogen for heat).

Two tests were designed to set out evidence to be observed in support of positive confirmation of this contribution, based on different sources of evidence. A further two ‘alternative hypotheses’ were tested to explore the role of external contributing factors, as outlined in the next section.

Table 1. Positive contribution claim

Impact in ToC:	Sufficient evidence provided to inform policy decisions on continuation of future work concerning hydrogen gas conversion
Contribution Claim (Programme Hypothesis)	Hy4Heat demonstrates it is technically possible, safe and convenient to replace natural gas with hydrogen in residential and commercial buildings and gas appliances. The evidence provided helps to de-risk policy decisions to commission work to implement a community trial.

Table 2. Summary of PT Tests and Results

PT Evidence Test	Evidence expected for each test	Source of evidence	Has test passed, failed
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			or inconclusive?
Smoking Gun – evidence that is sufficient enough to prove the hypothesis	Government publications and DESNZ documentation describing the decision to move ahead with a community trial cites outcomes from Hy4Heat as key supporting evidence for the decision.	Government publications and DESNZ documentation e.g., Business Case to progress with trial	Passed
Smoking Gun – evidence that is sufficient enough to prove the hypothesis	Findings from interviews with policy leads (DESNZ officials and Gov delivery agencies) provide general consensus that Hy4Heat provided sufficient evidence to inform policy decisions on whether to proceed to community trial.	Interviews with DESNZ officials	Passed

Findings from PT Test 1: Review of Government publications and documentation

Government published “The Ten Point Plan for a Green Industrial Revolution” in November 2020. This provided confirmation of government’s commitment to progress with trials on the use of hydrogen appliances in real domestic settings. The target milestones included in the Ten Point Plan include:

- “By 2023 we will support industry to begin hydrogen heating trials in a local neighbourhood”
- By 2025 – “Will support industry to begin a large village hydrogen heating trial and set out plans for a possible pilot hydrogen town before the end of the decade”.

The UK Hydrogen Strategy (August 2021) affirmed government’s commitment to work with industry to conduct first-of-a-kind hydrogen heating trials in residential community settings, including a neighbourhood trial by 2023 and a village scale trial by 2025. The Hydrogen Strategy report makes reference to Hy4Heat in six places. In relation to the community trials, the report notes that Hy4Heat has developed ‘100 per cent hydrogen-ready’ appliances and that the new Net Zero Innovation Portfolio (NZIP) will build upon this to commission further collaborative research directed towards end-users of hydrogen heating appliances to test consumer experience “following on from Hy4Heat endpoints”.

A review of a DESNZ internal Business Case to fund the trials of hydrogen appliances (as outlined in the Hydrogen Strategy) was also carried out to assess whether Hy4Heat informed direction of this future work. As this Business Case is an internal document that is not publicly available, it’s details cannot be quoted here. However, analysis of the document shows that nine paragraphs reference the work of Hy4Heat. Similar to the Hydrogen Strategy report, it outlines how Hy4Heat has supported successful development of prototype appliances and that a future programme will aim to work with industry to test their implementation and usage in a community setting. Aside from the technological development of prototype appliances, the Business Case outlines a range of other Hy4Heat outputs which future programmes will

directly build upon, including development of user standards, competency frameworks for gas heating engineers and safety assessments.

To conclude, the first PT test (based on reviewing programme documentation and government publications) has been passed in support of the contribution claim. This test was classed as a 'Smoking Gun' - it provides the type of evidence we would expect to see if government had decided to progress to a community trial, including references outlining how future trials will directly build upon successful completion of Hy4Heat outputs. It is also the type of evidence that is highly unlikely to be observed if the claim was not true e.g., government would not publicly commit to progressing with a community trial if a) there was no intention of doing so or b) Hy4Heat had been unsuccessful in developing prototype appliances or shown they were unsafe.

Findings from PT Test 2: Interviews with government officials

Whilst the announcements in reports discussed in PT test 1 provided positive confirmation of government's decision to progress with community level trials, further evidence was needed to assess the extent to which Hy4Heat contributed towards this decision over and above external factors. Interviews with DESNZ officials and public sector delivery agencies (Ofgem, UKRI) were used to further explore whether Hy4Heat provided sufficient evidence to inform decisions to progress with a community trial (as announced in the Ten Point Plan) or whether these decisions were primarily driven by other factors, such as political will to progress with a trial (even in the absence of Hy4Heat evidence) or evidence gathered from sources external to Hy4Heat.

This assessment was based on interviews with five respondents. These respondents included senior officials involved in informing government decisions on whether to progress with a community trial and in decision making on commissioning further hydrogen for heating R&D programmes which may build upon it. Four out of five respondents expressed views in support of the contribution claim e.g., that Hy4Heat did provide sufficient evidence to inform decisions on the trial. Examples of responses coded as providing evidence in support of the claim include:

Interviewer: "I was wondering the extent to which Hy4heat contributed to that policy decision in the 10 Point Plan or was it more due to other factors..."

Respondent: "Definitely, definitely Hy4heat... It was Hy4heat that showed politicians that this was doable"

Respondents explained that the first stage of the trials outlined in the Ten Point Plan (a 'neighbourhood' trial, by 2023) is expected to be delivered through the H100 programme¹, led by network operator SGN, with funding contributions from Ofgem and the Scottish Government. H100 aims to convert up to 300 homes in Levenmouth, Fife to hydrogen by 2023. The final decision to progress with implementation of H100, relies on successful completion of Hy4Heat outputs, including the production of functional appliances and approval by HSE on their safety case. As illustrated in the quote from a respondent below:

"H100 had a good proposal which they've been developing over a number of years, but they did not have a safety case and they weren't allowed to develop a safety case because the GDNOs are not allowed to do anything below the meter."

¹ <https://www.sgn.co.uk/H100Fife>

They had no appliances, and they didn't know what adjustments they'd have to make to the houses converted to hydrogen. So Hy4Heat was absolutely key to that. And we were kept really close to H100 to make sure that that first trial happened.

The first trial is funded by Ofgem, and the Scottish Government, which is made possible by Hy4Heat, so you can see all this is a bit of a domino effect. Hy4heat working meant the H100 proposal was plausible, which brought in initially the Scottish Government funding and then Ofgem, and so we can then move with confidence that the trials will happen. That then gave the Prime Minister the confidence to know, 'yes, I would be able to do.. a village by 2025 and a town by 2030.'

Similar views were expressed by officials working in government delivery bodies involved in commissioning follow-up R&D related to hydrogen heating trials. They also noted that the safety case approval from Hy4Heat was important for progressing strands of programmes such as H100 and H21 and that certain appliances developed by Hy4Heat are expected to be directly adopted within their programmes.

Although there was a general consensus that Hy4Heat had informed the decisions to progress with a trial, this view was not unanimous, as one respondent felt it was more due to political will to progress rather than primarily based on results of Hy4Heat. The respondent noted that at the time of publication of the Ten Point Plan (Nov 2020), HSE's approval of the safety case was still pending.

I think it was, frankly, more of a political will decision. They want to be seen to want to do something on hydrogen. Ministers are very keen on hydrogen, and they had the knowledge that Hy4Heat was doing this work, but at the time when the Ten Point Plan was published, the work was not finished... We weren't sure whether HSE were going to accept the safety case or not. However, knowledge that we're doing the work, gave strength to make the political decision but we can't really claim that it was actually a decision based on the outcomes of the work, because the work hadn't progressed that far. It was preliminary results.

However, Hy4Heat had developed prototype boilers by that point and we knew that they worked, functionally.

A further two tests of an 'Alternative Hypothesis' were developed to explore the role of external contributing factors, as outlined in the table below. These explored the pre-fieldwork alternative theory that Hy4Heat may end with considerable evidence gaps if work packages are not successfully completed and lead to insufficient evidence to inform decisions on progression with a trial. Therefore, any decisions to progress would be based primarily on external factors instead.

Table 3. Alternative Hypothesis for Contribution Claim 1

Impact in ToC:	Sufficient evidence provided to inform policy decisions on continuation of future work concerning hydrogen gas conversion
Alternative Hypothesis	Hy4Heat may end with considerable evidence gaps if work packages are not successfully completed and lead to insufficient evidence to inform decisions on progression with a trial. Therefore, any decisions to progress would be based primarily on external factors instead.

Table 4. Tests of Alternative Hypothesis

PT Evidence Test Alternative Hypothesis (AH)	Evidence expected for each test Alternative Hypothesis (AH)	Source of evidence	Has test passed, failed or inconclusive?
Smoking Gun – evidence that is sufficient enough to prove the hypothesis	Some WPs contracts are finished before outcomes are complete, with additional work commissioned to fill gaps before the commissioning of trials is confirmed. Business case for community trial discusses limitations with certain strands for Hy4Heat and draws upon external evidence to inform decisions instead.	Government publications and DESNZ documentation e.g., Business Case to progress with trial	failed
Smoking Gun – evidence that is sufficient enough to prove the hypothesis	Findings from Interviews suggest that whilst Hy4Heat provided some evidence to inform policy decisions on whether to proceed to community trial, there were significant gaps or uncertainties with certain strands of evidence, and decision to proceed was taken following the commissioning of additional work, or external evidence sources.	Interviews with DESNZ officials	failed

The first test of the Alternative Hypothesis (AH1) has not been met. A community trial has now been confirmed and the business case for further research relating to trial implementation does not indicate there were significant gaps in the scope of Hy4Heat which needed to be addressed. On the contrary, as outlined in discussion of PT1 above, the Business Case notes a range of ways in which the trial can build upon successful completion of Hy4Heat outputs.

There was support from interviews with government officials that other sources were also useful in informing decisions to progress with community trials. However, drawing upon multiple sources of evidence to inform a policy decision is to be expected and does not imply the evidence from Hy4Heat was limited.

The HyDeploy programme is looking at use of blending hydrogen with natural gas and testing that in the gas networks. They provided a lot of incident reports, which fed into our evidence on the safety case. That provided the HSE with some assurance because it gave more real data

As discussed in PT2, the majority of respondents supported the view that Hy4Heat played an important contribution on informing decisions to progress with a trial. We did not observe sufficient evidence for the criteria of Alternative Hypothesis to be met. Although one respondent did feel that announcements in the Ten Point Plan were primarily due to ‘political will’ and noted that approval of the safety case was still pending at that point, the same

respondent did acknowledge that the development of functional prototypes, as well as ongoing work to demonstrate safety, may have provided assurance and fed into the decision.

Conclusion on Contribution Claim: Hy4Heat informs policy decisions on proceeding with community trial

Evidence gathered strongly supports the contribution claim that Hy4Heat had an impact on informing decisions to proceed with trials. The evidence from different sources (interviews, publications, business cases for future R&D) triangulates to support this claim. In addition to informing announcements in the Ten Point Plan and Hydrogen Strategy, respondents explained how the outputs from Hy4Heat (functional appliances and an approved safety case) also provided the assurance and products needed for Ofgem, GDNOs and Scottish Government to progress with implementation of the H100 programme, which forms the first phase of the trials outlined in the Ten Point Plan.

The respondents interviewed (and business case for future programme) also acknowledge the role of wider external evidence beyond Hy4Heat to inform the decision. However, Contribution Analysis does not aim to attribute impacts solely to the policy or programme being evaluated. Rather, the aim is to demonstrate beyond reasonable doubt that the programme provided a contribution to impacts observed (progression of trials), alongside other external factors.

The Excel PT Framework sets out criteria for making an assessment of the strength of evidence in support of contribution claim. To be categorised as:

- “Strong support for programme theory that Hy4Heat played significant contribution towards observed outcomes”.

One of the criteria is:

- “All Smoking Gun or Double Decisive tests are passed in support of Programme Hypotheses (PH) AND Smoking Gun or Double Decisive tests fail for the Alternative Hypotheses (AH)”.

In this case we conclude that PT tests 1 and 2 (Smoking Gun), exploring hypotheses in support of the contribution claim have been passed, with strong support for the contribution claim, whilst the two PT tests exploring alternative hypotheses AH1 and AH2 (Smoking Gun) have not passed.

Contribution Claim 2: Stimulate industry to undertake parallel programmes of R&D

Process Tracing tests numbers 3,4,5, and 6 assessed whether the outputs of Hy4Heat contributed to intended impacts in the ToC relating to: *“Increased wider industry investment and parallel programmes of R&D in developing hydrogen heating appliances or to address wider network conversion goals”*.

One of the original aims of Hy4Heat was that it would stimulate industry, particularly GDNOs, to undertake a parallel programme of technical, performance and safety work on the distribution network. This links to work that would be required to test the use of hydrogen in the distribution network in order for a community trial and broader conversion of hydrogen for heating to progress.

In addition to work carried out by GDNOs, the evaluation also explored whether Hy4Heat had stimulated wider investment to continue R&D relating to use of hydrogen for heating among contractors of Hy4Heat and external manufacturers. For example, to continue development of domestic or commercial appliances beyond the programme or participate in further hydrogen safety testing R&D.

The description of the four tests differed slightly on the types of evidence expected to be observed, depending on the data sources used within each (see Excel Framework for full details). However, they all link to testing the claim that Hy4Heat stimulated wider industry stakeholders to undertake external programmes of R&D on hydrogen for heating. Using a range of tests in this way enabled triangulation across multiple data sources to form overall conclusions on the extent of Hy4Heat contribution to this area of impact (see conclusion of this section below). The four tests are summarised in the table below.

Table 5. Contribution Claim 2: stimulating hydrogen R&D

Impact in ToC:	Hy4Heat stimulates increased wider industry investment and parallel programmes of R&D - in developing hydrogen heating appliances or to address wider network conversion goals.
Contribution Claim (Programme Hypothesis)	Outcomes from the Hy4Heat programme de-risked industry investment in development of hydrogen appliances. This stimulated industry stakeholders to consider, prepare, and undertake parallel hydrogen R&D

Table 6. PT tests of Contribution Claim 2: Stimulating R&D

PT Evidence Test	Evidence expected for each test	Source of evidence	Has test passed, failed or inconclusive?
PT test 3, Hoop Test	<ul style="list-style-type: none"> - Pitchbook analysis of private investment shows increased investment in firms developing hydrogen for heating technologies. - PATSTAT shows new patents for hydrogen heating appliances. 	Pitchbook and PATSTAT Data.	Passed
PT test 4, Straw-in-the-wind	<p>Interviews with each of the Gas Distribution Network Operators, network trade bodies and government officials who engaged GNDOs in Hy4Heat</p> <p>Findings support claim that Hy4Heat contributed towards decisions by GDNOs to commission hydrogen R&D on their networks.</p>	Interviews with 4 Gas Network Operating companies	Passed
PT test 5, Straw-in-the-wind	<p>Interviews with manufacturers or industry representatives that have not received funding from Hy4Heat.</p> <p>Findings show that wider industry stakeholders (not funded by Hy4hHeat)</p>	Interviews	Inconclusive

have begun product development of hydrogen appliances, and that the Hy4Heat programme contributed to influencing their R&D programmes.

PT test 6, Straw-in-the-wind	Interviews with contractors that have received funding from Hy4Heat. Findings suggest that appliance manufacturers participating in Hy4Heat have begun to prepare and undertake product development of appliances beyond the prototype appliances produced for the purpose of Hy4Heat. Or have plans in place to undertake related follow-up work such as hydrogen safety testing as part of external programmes.	Interviews	Passed
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Four corresponding Alternative Hypotheses (AH) were also developed to explore alternative theories for each of the four PT tests outlined in the table above. These tested the alternative theories that either: a) GDNOs and wider industry stakeholders have not undertaken parallel programmes of R&D on hydrogen heating, or b) if they have undertaken hydrogen R&D, findings suggest this was primarily driven by external factors rather than being influenced by Hy4Heat.

The four corresponding AH tests used the same evidence sources outlined in the table above:

- Pitchbook data on investment trends
- PATSTAT data on new patents emerging
- Interviews with each of the Gas Distribution Network Operators, network trade bodies and government officials who engaged GNDOs in Hy4Heat
- Interviews with manufacturers or industry representatives that have not received funding from Hy4Heat.
- Interviews with contractors that have received funding from Hy4Heat.

Results of PT Test 3 – Analysis of secondary sources on investment trends and patents

This test explored whether:

- Analysis of Pitchbook data on equity investment deals shows increased investment in firms developing hydrogen for heating technologies.
- Analysis of PATSTAT data shows an increase in the prevalence of new patents for hydrogen heating appliances.

For both data sources, trends in increases (or decreases) in investment and patents were analysed from a baseline of 2010 (for the UK and globally). This provides a background overview of how the landscape for investment and patents filed for new hydrogen heating technologies have changed over time, both pre and post-launch of Hy4Heat.

PT3 was categorised as a 'Hoop test'. If there has been a recent increase in industry investment for hydrogen heating technology development, we would expect to see some observable record of this. However, this does not provide evidence that Hy4Heat contributed to these investment decisions, as wider industry may have decided to invest in hydrogen heating technology development for wider factors that are not related to Hy4Heat. Nevertheless, this type of evidence is a 'hoop' the claim needs to jump through to be true.

The methods used for this analysis and discussion of results are presented in full in Annex C.

In summary, analysis of investment deals data shows there has been a significant increase in the number and value of deals for firms developing hydrogen heating technologies (both in the UK, and globally). In the UK the highest number of deals per year occurred in 2021.

Patent analysis shows a similar global trend of increasing number of patents filed for hydrogen heating technologies since the baseline year in 2010. However, there is little evidence to link these patents directly to Hy4Heat appliance development firms. This may be due to the long timeframes until patent applications are processed for publication. For example, the UK IPO states that "*The IPO will publish your patent application shortly after 18 months from your filing date (or priority date if there is one).*" Given Hy4Heat projects are only completing this year, any patents filed may not yet be observable. Subsequent to the initial stage of fieldwork, email correspondence with Hy4Heat WP contractors shows that some have recently filed patents directly relating to their work in the programme. These patents are currently pending and are expected to be published in due course.

Evidence in support of the PT hypothesis is mixed but does provide sufficient indication of the trends we would expect to see (particularly increased private investment in recent years). It is therefore concluded that PT8 has passed in support of the contribution claim (with moderate evidence in support).

Results of PT Test 4 – Hy4Heat influenced GDNOs to undertake parallel programmes of R&D

Analysis of interview data for this test was based on a sub-set of respondents who were in a position to provide an informed view on whether Hy4Heat had an impact on influencing GDNOs to undertake parallel programmes of R&D to test use of hydrogen on their networks. This covered 7 respondents in total, including:

- Three out of the four UK GDNO companies (all were invited to participate but representatives of one GDNO declined)
- A trade body representative for energy networks
- A representative of National Grid (Gas Transmission)
- A contractor working for a GDNO to design a future trial to convert a residential area to hydrogen gas
- A senior government official who has worked to engage GDNOs in Hy4Heat.

Six out of seven respondents provided responses indicating that Hy4Heat has had some level of impact on influencing the R&D programmes of GDNOs.

Most respondents commented on the collaborative working arrangements that were in place as part of the governance arrangements for Hy4Heat. This enabled GDNOs to feed in views to

Hy4Heat programme management on which areas the programme should prioritise and, vice versa, for senior managers of Hy4Heat to identify any gaps in the development of technologies or components which may be within scope for GDNOs to cover in the R&D programmes they manage. This enabled government, GDNOs and trade body representatives to take a holistic view of the hydrogen supply chain from transmission through the networks to end usage of appliances within homes, identify gaps and agree 'who does what' to address them. As illustrated by one respondent:

They've [name of GDNO] been doing work on the safety case upstream of the emergency control valve. So basically, safety of usage on the grid, and we're working closely with them. And they were actually putting a lot of pressure on us to get our safety case done [in Hy4Heat]. We've now done that and now they're trying to merge the two. So for me, that's been absolutely fantastic that the two groups have really been pushing each other.

There are some things where we said we'll do this and, and you do that. So a good example is the gas meter. We realised that the emergency control valves can be upstream and downstream of the meter. Initially, we naively assumed that meant we weren't doing the meters and the GDNOs were doing the meters. And the GDNOs kind of went, we're actually not doing the meters and we said, OK, we'll step in and we'll do the meters, which we've done.

But we have had a poor response on hydrogen alarms so [name of GDNO], picked that up and then they've run a competition on hydrogen alarms. So I think that gives a good example of how these bodies have started to collaborate and use their Ofgem funding [discretionary R&D funds, regulated by Ofgem]. They've started to use them to move things forward and then the combination of that was for us to be able to pronounce that we're ready for a trial.

A clear example of how the results of Hy4Heat have had an impact on enabling GDNOs to progress is through HSE's approval of the safety case. As one GDNO explained:

So where this all comes together is to have a risk of quantitative risk assessment for all that work upstream of the house. We've got the safety evidence in the home [from Hy4Heat] and obviously the full picture is you put those two together and assess whether it is safe overall. So that interface between the bit our programme is now addressing.

As summarised by another respondent:

The fact that HSE has validated the safety case from Hy4Heat, it means that infrastructure and deployment trials can be taken to the next level.

However, one GDNO representative felt that, rather than Hy4Heat influencing the work of GDNOs, it was originally prior work of GDNOs which influenced government to commission Hy4Heat. The respondent explained the main reason they were not able to undertake R&D covering the end-to-end supply themselves was because components and appliances downstream of the emergency control valve are outside the remit of their licensing obligations.

Before Hy4Heat I think the networks were already doing major research programmes. Officially our licence obligations finish at the tap. Downstream of the tap, or the emergency valve just before the metre, is not really our responsibility under our licence. And so there was a gap in the market to say, well, who's

actually going to co-ordinate all the downstream work? So the government decided that they were going to do it themselves. And that is how Hy4Heat got setup”.

Nevertheless, this respondent did also acknowledge that the findings of Hy4Heat will enable networks to progress with a community trial. They also commented on the collaborative working arrangements between GDNOs and DESNZ as being a positive aspect of programme design. WP8 to develop the ‘Hydrogen Homes’ demonstration homes was cited as an example, given it is a three-party agreement between DESNZ, Northern Gas Networks and Cadent, with all three partners contributing funding.

To conclude, the vast majority of respondents provided views in support of the contribution claim, meeting the criteria to pass PT 5 (based on interviews with this sub-set of stakeholders). This test was categorised as a *Straw-in-the-Wind* test. This type of interview evidence lends support to the contribution claim but is not in itself sufficient evidence to definitively prove it. There is some scope for positive confirmation bias among firms who have received government funding via Hy4Heat.

Results of PT Test 5 - interviews with appliance manufacturers that have not received Hy4Heat funding.

PT5 focused on assessing the extent of contribution towards a similar area of impact – whether Hy4Heat contributed towards stimulating increased investment and parallel programmes of R&D in developing hydrogen heating, among wider industry. The intention for PT5 was analyse responses from interviews with wider appliance manufacturers who were not directly involved in Hy4Heat e.g., they were not part of any contracted consortium to deliver Hy4Heat’s Work Packages. These interviews were used to assess whether external manufacturers had also begun product development of hydrogen appliances and, if so, whether the Hy4Heat programme contributed towards decisions to do progress their R&D.

The approach to recruiting wider manufacturers, who may in principle have an interest in hydrogen for heating R&D, was to contact organisations which had either submitted tenders to apply for Hy4Heat work packages and been unsuccessful or had attended Hy4Heat pre-tender supplier engagement events and then not submitted a bid. However, response rates to recruitment from this stakeholder group were lower than expected, as outlined below:

- For the interim phase in summer 2020, 19 organisations were invited to participate in interviews. Interviews with 13 organisations were achieved.
- For the follow-up phase in summer 2021, all 19 organisations were re-contacted with requests to participate in short follow-up interviews or to complete an online survey to provide an overview of any work their organisation had carried out on hydrogen for heating related R&D. No organisations agreed to participate, with some noting that as they are not participating in the Hy4Heat programme, they have little interest in further participation in its evaluation.

Findings from the 13 organisations interviewed in 2020, suggest that most had a general intention to progress work in the hydrogen sector, should similar funding opportunities arise in future. However, there were no verifiable examples gathered of similar hydrogen appliance development work being carried out.

Given the non-response to participate in follow-up interviews in 2021 to check on progress, we conclude that insufficient evidence has been gathered to judge whether PT5 has passed or failed (based on interviews with this sub-group).

However, a brief review of grey literature in sector trade press suggests that some boiler manufacturers that were not funded by Hy4Heat are developing hydrogen ready boilers. Four major manufacturers (including Vaillant and Ideal, who did not participate in Hy4Heat) have published a commitment² to sell 'hydrogen-ready' boilers at the same cost as their equivalent technologies that currently run-on natural gas. A review of the websites³ of these external manufacturers suggests they are progressing R&D to develop their own hydrogen ready boilers.

Interviews with Hy4Heat contractors suggest that Hy4Heat has contributed to influencing their decisions to undertake further hydrogen R&D, beyond what was funded through the programme. This is explored in the test PT6 below.

Results of PT Test 6 - Interviews with contractors that have received funding from Hy4Heat.

PT6 assessed similar areas of impact to PT4 and PT5 – whether Hy4Heat contributed towards stimulating increased investment and parallel programmes of R&D in developing hydrogen heating. For PT6, findings are based on interviews with contractors that have received funding from Hy4Heat. This contribution claim assessed was that Hy4Heat stimulates contractors participating in the programme to continue further R&D in the sector over and above what they were funded to develop directly from Hy4Heat. For example, to continue to develop additional hydrogen appliances, or carry out further R&D on safety testing.

Analysis for PT6 was based on the 21 interviews carried out with Hy4Heat contractors. Of these, 18 gave responses in support of the contribution claim. Responses were coded as supporting if they showed a) the company had firm plans in place to continue R&D work in the hydrogen heating sector and b) they felt Hy4Heat had contributed towards this. Examples of responses include:

“We are now building our own hydrogen lab [an internal R&D lab for product development]. The lab will be very similar as the one we have for natural gas but the aim will be to test technology using hydrogen. The creation of this hydrogen lab is one of the positive results and a direct consequence of our involvement in Hy4Heat.

We are part of a bigger international group [name of company] and one of the other areas of the group is specialised in heating systems. That department is now also working and experimenting with hydrogen. Hy4Heat has created a bridge between those two divisions. Because before hydrogen was put on the table, we were not dealing between each other at all”. [Appliance manufacturer Ref no. 1]

“Very likely [they will continue developing hydrogen appliances]. Having been involved in the programme and talked to so many different businesses and customers since we started it, we have a lot more confidence that a percentage of households will be running on hydrogen. And right now, we are working on

² <https://www.hvnplus.co.uk/news/four-manufacturers-make-hydrogen-ready-boilers-cost-pact-29-07-2021/>

³ <https://www.vaillant.co.uk/for-installers/business-support/industry-drivers-and-legislation/hydrogen/>

conducting research and testing of [name of appliance product]. We know that if hydrogen does get rolled out, we want to be part of it". [Appliance manufacturer, Ref no.2]

"We operate R&D as a global function. So we've got R&D centres in a number of European markets. Hy4Heat for us has being really good from a political point of view. It shows UK government commitment to developing hydrogen as a future option and that's given us confidence to start to look at wider development. We're developing commercial boilers to be hydrogen ready, and also looking at hydrogen for things like combined heat and power. Hy4Heat has allowed us look at the real physical, practical stuff happening on the ground, which has given us that bond to really kick start those other programmes" [Appliance manufacturer, Ref no.3]

Among the three contractors interviewed whose responses did not support the contribution claim tested in PT6, the reasons were:

- One respondent felt it was too early say whether they would continue work on hydrogen. This contractor noted the outcomes from their work packages had yet to be published (at the time of interview). They felt that once published, this may lead to further engagement with wider interested stakeholders and support follow-on work.
- Another respondent stated that, in principle, they would be interested in continuing work hydrogen for heating but felt that first a clearer signal is needed on whether residential properties will be expected to convert to hydrogen. They felt the direction of this market is still too uncertain for them to invest further at this stage.
- A third respondent explained that their organisation had been involved in hydrogen R&D for years before Hy4Heat was announced. They have plans in place to continue work in the sector and that Hy4Heat was 'part of the journey' but explained they would be likely to be working on this R&D anyway, in the absence of Hy4Heat.

In summary, for the vast majority of cases where this assessment was applied (18 out of 21 contractors interviewed), responses were provided that gave clear support for the contribution claim. Most had plans in place to continue work on hydrogen for heating R&D and felt their involvement in Hy4Heat had contributed towards this. The criteria to pass PT6 has been met.

Similar to PT4, this test was categorised as a *Straw-in-the-Wind* test. This type of interview evidence lends further support to the contribution claim but is not in itself sufficient evidence to definitively prove it. There is some scope for positive confirmation bias among firms who have received government funding via Hy4Heat.

Conclusions on Contribution Claim 2: Stimulate industry to undertake parallel programmes of R&D

To draw conclusions on whether Hy4Heat has met the intended impacts in the ToC of contributing towards stimulating industry to undertake parallel programmes of R&D, we triangulated evidence drawn upon interviews with a range of stakeholder groups and analysis of secondary data sources. The sources of evidence were used to form distinct PT tests based on the types of evidence we would expect to observe to support/refute the contribution claims. Table 6 above summarised whether each test was passed, failed or inconclusive.

The Excel PT Framework sets out criteria for making an assessment of the strength of evidence in support of contribution claim. To be categorised as:

- “Strong support for programme theory that Hy4Heat played significant contribution towards observed outcomes”.

One of the criteria is:

- “IF: All or vast majority of process tracing tests are passed, and the assessment of the evidence is strong in the majority of cases. No hoop tests fail.”

For Contribution Claim 2, the Hoop Test was passed and two out of three of the corresponding PT test passed, with strong evidence in support. One PT test was not passed, but the evidence gathered was inconclusive. It is therefore concluded that overall, across the evidence sources gathered, there is strong support for the claim that Hy4Heat has contributed towards stimulating industry to consider, prepare, and undertake wider programmes of hydrogen for heating R&D.

Contribution Claim 3: Economic Benefits

Generating economic benefits was not a primary aim of the Hy4Heat programme (by the time of programme closure in 2021 at least). However, one aim of the evaluation was to assess whether a range of economic benefits have started to emerge or can be expected to in future. As outlined in the programme ToC, these potential economic impacts include:

- Benefits to firms participating in the programme through new skills development and job creation or retention. The role of Hy4Heat on skills development was to develop a competency framework for the training, accreditation, and registration of gas engineers working with hydrogen
- The potential for longer-term economic benefits to the UK due to a first mover advantage from patenting new technologies developed and their export potential
- Overall, that DESNZ investment in the programme has been a cost-effective means of achieving its outputs.

The final three PT tests were designed to assess hypotheses on the extent to which each of these three types of economic benefits have emerged and whether Hy4Heat has contributed towards them. These tests are outlined in turn below.

PT7: new skills development, jobs creation or retention

The role of Hy4Heat (WP2) on skills development was to develop a competency framework for the training, accreditation, and registration of gas engineers working with hydrogen. This will support industry to train and accredit gas heating engineers for the installation and maintenance of hydrogen appliances, in the event that government decides to convert gas networks to hydrogen in future.

As gas network conversion, or community level trials, have not yet been implemented, it is too early to expect indicators to be observable that relate to a significant increase in new skills or job creation among the gas engineering sector (relating to hydrogen). The contribution claim assessed in PT test 7 was therefore designed to assess whether the aims the WP2 strand to

develop a skills and competency framework had been met. As outlined in the table below, this focused on whether intended outputs had been delivered, any initial evidence of how they have been received or accepted by sector trade bodies and whether funding from Hy4Heat was needed to achieve this output (e.g., whether other sector bodies would likely have progressed this work on skills identification in the absence of Hy4Heat).

An alternative hypothesis was developed to explore the extent to which external factors contributed towards the outcomes achieved. For example, whether boiler manufacturers had invested their internal resources in skills identification or whether other external providers of training programmes in the sector had worked towards addressing the future skills needs for hydrogen conversion.

Table 7. PT test 7 – new skills development, jobs creation or retention

Impact in ToC:	Economic benefits - new skills development
Contribution Claim (Programme Hypothesis)	The installation and maintenance of hydrogen boilers and cookers will require new skills and safety training. Relevant workstrands in Hy4Heat will identify skills gaps and requirements for training and accreditation of gas heating engineers. This new skills development in the sector will help retain jobs to support implementation of a potential future conversion of UK networks to hydrogen. May also contribute towards job creation for UK firms through contracts to service hydrogen appliances in other countries which have plans to implement them in future
Evidence expected to be observed if true	Hy4Heat outputs include a plan for training and accreditation of gas engineers to service hydrogen appliances. This is accepted by relevant trade bodies e.g., Gas Safe and Heating and Hot Industry Council (HHIC). Interviews with Hy4Heat participants suggest this plan would not have been produced by industry alone, in the absence of funding from Hy4Heat.
Source of Evidence (PT test 7, Straw-in-the wind)	- Reports of outputs from training work package. - Interviews with Hy4Heat WP leads and industry trade bodies.
Has test passed, failed or inconclusive?	Passed

On 26 July 2021, the ‘Hydrogen Competency Framework’⁴ (by Energy and Utility Skills) was published. This delivered the main expected output from this strand of WP2. The report establishes a series of sequential components designed to ensure any future work done to install and maintain new hydrogen appliances will be completed safely, to the highest standards, and will only be carried out by hydrogen competent, Gas Safe Registered engineers.

The Framework developed in the report covers five main components:

1. A Comparative Analysis of Hydrogen and existing hydrocarbon gases

⁴ <https://www.hy4heat.info/wp2>

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2. A Skills Matrix that translates the analysis into skills, knowledge and understanding
 3. An Interim Hydrogen Technical Standard that defines acceptable parameters and requirements for hydrogen installation work
 4. A Hydrogen Training Specification that will enable training course consistency and facilitate industry recognition
 5. An independent Hydrogen Assessment Module that will facilitate the addition of a hydrogen competence category on the Gas Safe Register.

Interview data used to assess this PT test was based on a sub-group of 5 respondents who had some involvement in delivering the Competency Framework and/or in using its outputs, including two WP2 contractors, a DESNZ official, and two sector trade bodies.

Respondents explained the rationale for this work package and its role in identification of skills needs for hydrogen appliance installation and maintenance.

Hy4Heat has set out the required skills standards that the workforce will need to be confident in. The next challenge will be delivering this skillset, especially as the skills be needed rapidly – no-one will want an insufficient skills supply chain to be barrier to hydrogen roll out. [Sector trade body]

WP contractors noted how this work package had contributed towards developing a deeper understanding of the skills barriers that need to be addressed and provided recommended solutions.

Currently in the natural gas sector we have around 130,000 engineers, which is quite a lot of the work force, but almost all of them are nearing retirement age. So this is one of the things that BEIS⁵ had not considered by 2017, they were talking about upskilling the work force from natural gas to hydrogen. But what has emerged is that we need to start looking at apprenticeships and ways to attract fresh work force to the sector. And their skills will take around 5-6 years to be developed. We need to start thinking about it now if we really want to move forward hydrogen. That is something that came out as part of the Hy4Heat programme. [WP contractor]

Respondents acknowledged that government and sector skills training providers had been working on addressing the skills requirements for a low carbon transition prior to Hy4Heat. It is feasible similar work may have been produced in the absence of the programme. However, Hy4Heat was reported to have accelerated skills analysis specifically on hydrogen. The programme was also well positioned to take this strand forward, given the remit of Hy4Heat to draw in expertise from a wider range of sector stakeholders.

Hy4Heat has accelerated our progress in this area. But we had (before Hy4Heat) written the skills strategy for 2025 and we had identified six key skills priority areas, one of them around building a safe and sustainable world. And because one of my jobs is scanning the future of new technologies around skills, hydrogen was one of the emerging technologies. So hydrogen was always there, but certainly Hy4Heat has accelerated our work in this area. [WP contractor]

⁵ BEIS changed its name to DESNZ in 2023

One of the strands of evidence this PT noted as being “expected to be observed” was that the outputs (Competency Framework) were well received, and the recommendations accepted by relevant sector trade bodies. However, the Competency Framework report had not yet been published by the time most interviews were completed as part of this evaluation. Discussion of the Framework was therefore restricted to those who had some involvement in its delivery. It is also too early to determine to what impact publication has had on wider gas sector stakeholders.

However, the report describes how the Framework was developed through a collaborative process with extensive input from a wide range of stakeholders including, appliance manufactures, GDNOs, trade bodies, regulatory bodies and trade associations. It notes that the process for review and sign-off required input from a range of stakeholders for it to be accepted⁶.

The Hydrogen Competency Framework was signed off in March 2021 through the industry governance process, which involves industry representatives, certification bodies, Gas Safe Register and the HSE” (Hydrogen Competency Report, page 7).

Contractors involved in its delivery also felt it would be well received and used by a wide range of stakeholders:

We have a huge list of stakeholders that in the future are likely to use our results. There are employers, manufactures, certification bodies, training providers, all the regulatory and policy staff including BEIS. [WP contractor]

The pre-fieldwork test for the ‘Alternative Hypothesis’ explored whether other research funding bodies may have commissioned similar work to train engineers with the skills requirements for future hydrogen conversion. For example, the EPSRC funded Centre for Doctoral Training (CDT) on Sustainable Hydrogen⁷. However, the CDTs such as this focus on training PhD students to work on addressing industry-relevant scientific or engineering challenges. For example, how to design a hydrogen electrolyser facility. Research Council funding in this area is targets different parts of the sector supply chain to the Competency Framework of WP2 – which is focused on skills needs for gas heating installers and maintenance engineers. One interview with a UKRI representative supported the view that their research funding has focused on different areas to Hy4Heat.

To conclude, on balance, there is sufficient evidence to supports passing PTT in favour of the programme contribution claim. The core expected output from WP2 has been delivered, with input and sign-off from a range of sector stakeholders. Interview findings suggest Hy4Heat played an important contributing role in accelerating work in this area and coordinating input from experts.

PT was categorised as a Straw-in-the-Wind test. The majority of evidence relies on stakeholder interviews (many of whom received funding from the programme), although their views do triangulate with reviews of supporting documentation. This type of interview evidence lends further support to the contribution claim but is not in itself sufficient evidence to definitively prove it. The strength of evidence in support of the contribution claim is categorised as ‘moderate’. Given the timing of the fieldwork (prior to publication of the

⁶ <https://www.hy4heat.info/wp2>

⁷ <https://www.sustainablehydrogen-cdt.ac.uk/about-the-centre/about-the-centre.aspx>

Competency Framework), there is limited evidence to assess the extent to which it has been well received by relevant sector trade bodies.

PT8 Economic benefits: potential longer-term benefits to UK firms from first mover advantage.

PT8 assessed contribution to potential impacts in the theory of change relating to providing UK firms with a first mover advantage. The contribution claim is that, assuming other countries proceed towards conversion of gas networks to hydrogen, the appliances developed in the UK via Hy4Heat would provide firms with a commercial advantage through patenting of new technology, or the knowledge and experience gained. This may provide a competitive advantage for the sales of hydrogen products or services internationally.

An ‘Alternative Hypothesis’ explored the possibility that whilst Hy4Heat UK contractors may support development of hydrogen for heating appliances or services internationally, this is primarily driven by their wider organisational capabilities or product development that is external to Hy4Heat.

Table 8. PT8 Economic benefits from first mover advantage

Impact in ToC:	Economic benefits - new skills development
Contribution Claim (Programme Hypothesis)	Assuming other countries proceed towards conversion of gas networks to hydrogen, the appliances developed in the UK via Hy4Heat would provide firms with a commercial advantage through patenting of new technology, and the early production of market ready hydrogen appliances which can be scaled up for export.
Evidence expected to be observed if true	<ul style="list-style-type: none"> - Contractors interviewed provide examples of how their work on Hy4Heat has led to, or is expected to lead to, a competitive advantage for the sales of products or services internationally. - evidence of other countries developing similar hydrogen for heating products and services
Source of Evidence (PT test 8, Straw-in-the wind)	<ul style="list-style-type: none"> - Interviews with Hy4Heat contractors. - literature review of international programmes and policy documents
Has test passed, failed or inconclusive?	Inconclusive

Two related sources of evidence were used to assess the contribution claim in PT8. The first was interview findings from the 21 interviews with Hy4Heat contractors. Responses were coded as being in support of the contribution claim in instances where they stated that Hy4Heat had (or was expected to) lead to further work on hydrogen for heating AND that this provided an opportunity for international sales. The second was a review of documentary evidence that would support these claims – including a review of international R&D programmes with similar aims to Hy4Heat, where there is opportunity to build on the work of Hy4Heat.

Around three quarters of WP contractors interviewed stated they plan to continue working on developing hydrogen for heating solutions. In most cases, contractors explained that their work

on Hy4Heat has acted as catalyst to enable follow-up work in the sector. However, in most cases the clearest links were with other UK based R&D programmes, for example, to work with GDNOs in developing a community trial.

Most felt that, in principle at least, Hy4Heat will contribute towards giving the UK first mover advantage with respect to hydrogen for heating solutions (assuming other countries follow a hydrogen conversion pathway). Several respondents noted that Hy4Heat is gaining increased interest among manufacturers and gas network operators internationally.

However, there was little evidence that the UK has derived much in the way of tangible economic benefits to date from this first mover advantage. In large part, this is because use of hydrogen heating appliances is still a nascent market, with few countries actively progressing their development to a similar level as the UK. Only one contractor reported they had already been able to generate some international sales as a result of their Hy4Heat work. Providing examples of their work on Hy4Heat was used to demonstrate relevant expertise when bidding for the contract. The respondent noted they had achieved some small commissions for hydrogen heating engineering advisory services in both Australia and the United States. They were also in the process of exploring wider opportunities in Europe.

Representatives from regulatory bodies in other countries were reported to have approached Hy4Heat contractors to draw on their expertise. It was suggested that other countries are seeing the UK as leaders on developing hydrogen heating appliances and safety testing

“Hy4Heat has been an enabling project, helping put the UK in a good position in relation to hydrogen for heating solutions. Other countries are looking to see what progress the UK is making and using this to influence their own plans. For instance, standards agencies in Australia have been engaging with Hy4Heat and us to help inform their own decisions”. (WP2 Contractor)

Although contractors felt future export opportunities were feasible in principle, it should also be noted that the Hy4Heat programme has not yet fully completed and therefore some felt it is currently too soon for this to have translated through to actual sales.

“It is too early in terms of revenue and turnover, but we have potential customers certainly”. (WP 5 Contractor)

Some WP contractors are manufacturers whose companies are part of a larger international group. These larger companies explained how Hy4Heat is influencing the direction of R&D of their sister companies in other countries.

“We are part of a bigger international group [name of company] and one of the other areas of the group is specialised in heating systems. That department is now also working and experimenting with hydrogen. Hy4Heat has created a bridge between those two divisions. Because before hydrogen was put on the table, we were not dealing between each other at all”. [WP contractor]

“We operate R&D as a global function. So we’ve got R&D centres in a number of European markets. Hy4Heat for us has being really good from a political point of view. It shows UK government commitment to developing hydrogen as a future option and that’s given us confidence to start to look at wider development. We’re developing commercial boilers to be hydrogen ready, and also looking at hydrogen for things like combined heat and power. Hy4Heat has allowed us look

at the real physical, practical stuff happening on the ground, which has given us that bond to really kick start those other programmes” [WP contractor]

Whilst the above points give positive examples of Hy4Heat influencing wider programmes of R&D, these may not necessarily translate through to a competitive advantage for UK firms if a parent company, headquartered abroad, is exploiting IP gained through a subsidiary company in the UK that participated in Hy4Heat. That said, it may provide their UK suppliers with increased exports if the appliances are manufactured in the UK. However, from the evidence gathered to date this appears too early to determine.

Evidence from the international review shows that there are a range of other countries that are progressing hydrogen R&D programmes (See Annex B for examples). Whilst it is feasible that Hy4Heat may act as a catalyst for WP contractors to undertake future work in supporting these programmes, there is little documented evidence to suggest this has occurred to date.

In conclusion, the evidence gathered to date suggest that, in principle, the UK may gain a first mover advantage, given Hy4Heat has supported development of First-of-A-Kind hydrogen heating technologies and expertise on safety testing. However, to date there are limited examples of this translating into signed contracts or sales. Overall, the evidence in support of this contribution claim for PT8 is considered “inconclusive” (neither passed nor failed).

PT9: Economic benefits: BEIS investment in the programme has been cost-effective

The contribution claim explored for PT was that; overall BEIS investment in the programme has been a cost-effective means of achieving its outputs.

More specifically, the hypothesis was that - Hy4Heat advances the TRL of hydrogen heating and cooking appliances. The outputs include prototype appliances that have been demonstrated as being safe and convenient to use. The programme assumes government grants were a cost-effective use of public funds to achieve these outputs.

This test drew upon multiple evidence sources to draw overall conclusions on cost-effectiveness. These include; programme KPI data on TRL progression, the costs of TRL progression compared with other BEIS Energy Innovation Programmes, interview findings and secondary analysis of data source on investment trends in hydrogen R&D.

PT9 was categorised as a “Straw-in-the-wind” test, because evidence gathered lends support to the claim that outputs delivered by the programme represent a cost-effective use of funding, but is not sufficient to definitively prove this.

Discussion and results of the Cost Effectiveness Analysis are provided in the Value for Money Chapter of the main report. Overall, it is concluded that that the Hy4Heat programme has been delivered in a cost-effective manner. In summary, the key evidence to support this conclusion includes:

- The value of grants being made through the programme to support technical progress being broadly comparable to the wider Energy Innovation Portfolio (EIP)
- Technological progress being made at an appropriate cost - at a lower average cost per TRL increase than the wider EIP

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- The programme reducing potential duplication of activities, and timescales for completion, compared to if they had been delivered by the private sector in the absence of the programme
 - Coordination and engagement with relevant organisations meant challenges could be overcome rapidly to allow key outputs and outcomes to be achieved
 - Qualitative interview evidence suggests Hy4Heat has stimulated increase in R&D relating to Hy4Heat.



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