Stirling Infrastructure Partners Ltd

Hydrogen

Heating

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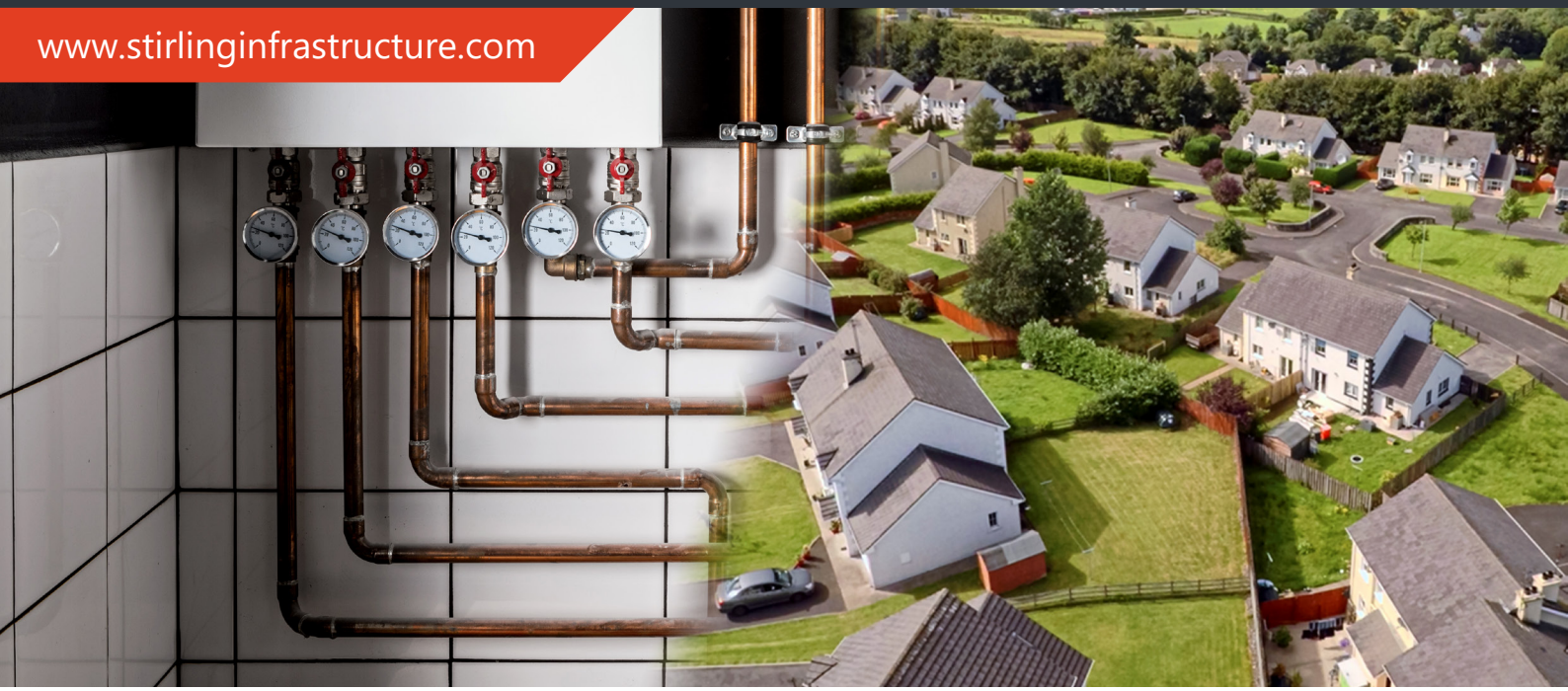

SUMMARY

WHY IS HEATING BEING CONSIDERED AS A USE OF HYDROGEN?

Domestic and commercial heating constitutes a significant portion of global carbon dioxide emissions. In fact, ~18% of global CO_2e emissions were produced by space and water heating in 2018.[1] Hydrogen can be used to help decarbonise this sector because its combustion only produces water and oxygen. This means, if the process used to produce the hydrogen is less emitting than combusting natural gas, hydrogen would be superior to gas heating.

Heating infrastructure varies globally, depending on the resources available and the policies in place. For example, in Iceland, 90% of energy for heating comes from geothermal sources.[2] Here, there would be no use for hydrogen heating because geothermal energy is more efficient and less polluting than most forms of hydrogen production. However, in the USA, over 40% of households are supplied by natural gas for heating. This constitutes a market that will be driven to be decarbonised, and therefore where hydrogen can be used.[3]

There are two main methods for using hydrogen for heating. Firstly, hydrogen can be blended with natural gas. This will only reduce the amount of natural gas used, not eliminate it, but allows existing natural gas infrastructure to be used. Secondly, hydrogen can be used on its own. This requires specialised hydrogen infrastructure but could allow heating to be fully decarbonised.

1 IEA
2 ThinkGeoEnergy
3 U.S. Energy Information Administration

OVERVIEW OF USE CASES

HYDROGEN BLENDED HEATING

Science behind blended hydrogen heating

Hydrogen blended heating works in the same way as gas heating works currently. The hydrogen-natural gas blend is combusted within a boiler or gas cooker to produce heat. This means that the consumer does not have to make any behavioral changes.

When hydrogen is blended with natural gas, existing natural gas infrastructure can be used. A blend of up to 20% hydrogen means that gas boilers and cookers will function the same way as they do currently. Furthermore, natural gas pipelines can be used to deliver hydrogen without significant change. A trial project at Keele University, HyDeploy, has provided evidence that consumers do not need to change their behavior when using a 20% hydrogen blend and many do not even notice the difference.[4] However, hydrogen blending can only be used to reduce natural gas use for heating, not to eliminate it. A 20% volume hydrogen blend will only reduce natural gas consumption by ~7% due to the different calorific values of natural gas and hydrogen. Therefore, hydrogen blending can only be used as a transition technology for economies looking to reach net zero.

Infrastructure

Because blended hydrogen and natural gas can use existing natural gas infrastructure, most of the infrastructure required for hydrogen blending is already in place. Natural gas boilers do not need to be replaced and gas cookers will function normally. Natural gas pipelines delivering the blend from producers to consumers do not need to be retrofitted when using a blend of up to 20% volume. Therefore, the only real change to infrastructure required would be hydrogen production capacity to introduce the hydrogen. Blended natural gas and hydrogen systems could be a case for increasing production capacity.

The key milestones required for blended natural gas and hydrogen would be:

1. A large sample project proving the effects and feasibility of blending.
2. Hydrogen production infrastructure increases to meet the demand from gas companies looking to reduce their carbon footprint.

Risks

The main risks with hydrogen blending are twofold. Firstly, blending would never be a final outcome and therefore is unlikely to be a long-term solution; the blend will only slightly reduce emissions, not eliminate them. This means that investors and natural gas suppliers are unlikely to see opportunities in this technology. Combined with this, introducing hydrogen is unlikely to be economically viable in the short term when production is limited. This is could be alleviated if projects are linked inherently to production, for example if it were combined with an elctrolyser in a microgrid.

Opportunities

The introduction of blended hydrogen heating can begin the process of decarbonising heating. It could be used as a steppingstone to reach full hydrogen heating. Blended hydrogen heating would increase the demand for hydrogen which the production could then meet. This could provide the groundwork for full hydrogen heating and other hydrogen projects.

HYDROGEN HEATING

Science behind hydrogen heating and comparison with heat pumps

Hydrogen used for heating without blending could be used to reach net zero, provided the hydrogen was produced from green sources. To use hydrogen on its own, boilers and pipelines would have to be retrofitted because natural gas pipelines cannot be used without adaption.

4 HyDeploy

Competition with heat pumps

Heat pumps are the main competitor when it comes to net zero heating. They operate by transferring stored heat from the environment (usually the air or ground) to homes. By doing this, heat pumps can operate with efficiencies in excess of 300%. This means that, if only green hydrogen is used to heat homes, heat pumps would be in the order of 6 times more efficient and therefore use 6 times less energy. For this reason, this paper concludes that green hydrogen cannot compete with heat pumps.

As heat pump efficiencies are much higher than hydrogen heating, electricity demand from heat pumps is much less than hydrogen produced by electrolysis. In 2020, if UK domestic natural gas usage was replaced with hydrogen, ~7.7 million metric tonnes (MMT) of hydrogen would be required which is about 460 TWh of electricity. In 2019, if US domestic natural gas usage was replaced with hydrogen, ~41 MMT of hydrogen would be required which is about 2450 TWh of electricity.

Infrastructure

Although hydrogen has many similarities with natural gas heating, it is unable to use most of the infrastructure in place. For example, steel natural gas pipelines are unable to transport hydrogen alone because hydrogen will embrittle the metal by a process called hydrogen embrittlement. Instead, plastic pipes must be used to stop this. The added advantage of plastic pipes is the reduction in leakage of hydrogen and, if natural gas is transported in them, natural gas. The UK has already converted a portion of its old iron gas pipelines to new plastic pipes in order to reduce emissions due to leakage. Hydrogen boilers operate similarly to natural gas boilers but will not feasibly be able to be plugged in to existing ones. New hydrogen boilers would be able to function on both natural gas or hydrogen, meaning homes can be hydrogen ready before hydrogen is able to be delivered to them. As with blended hydrogen heating, hydrogen production would need to be scaled up to meet the required demand. If the USA were to convert all of their domestic natural gas usage to hydrogen, they would need to increase their hydrogen production by an order of 5 from 2019 levels.

The key milestones required for blended natural gas and hydrogen would be:

1. A large sample project proving hydrogen heating is able to function in the place of natural gas.
2. Hydrogen production infrastructure increases to meet the demand from gas companies looking to reduce their carbon footprint.

Risks

The main risk associated with hydrogen heating is its comparison with heat pumps. Heat pumps can operate at a much higher efficiency than hydrogen heating. This means, if the production of hydrogen is from electricity via electrolysis, for example green hydrogen, then the initial electricity requirement from hydrogen will be ~5-6 times higher.

Replacing domestic heating with heat pumps would increase US energy consumption by ~1/8, so replacing with electrolysed hydrogen and seeing an increase in consumption by ~5/8 is not feasible.

Opportunities

The opportunity that can be seen with hydrogen heating comes from the use of blue hydrogen. If blue hydrogen was used to supply homes (hydrogen from natural gas with CCUS), then this could remove the efficiency comparison with heat pumps. However, this use of blue hydrogen would also mean that emissions from heating are not completely eliminated as natural gas will still be extracted from the ground and CCUS only reduces emissions by ~80%-95%.

CONCLUSION

Generally, the view is that hydrogen can only compete with heat pumps if either the relevant subsidies are introduced, or if hydrogen is not produced through the process of electrolysis. If steam methane reforming is used to produce hydrogen, then it is no longer subject to the efficiency comparison. Assuming heat pumps run on the grid, as long as enough carbon dioxide is sequestered in the production process, the use of hydrogen in heating could even be comparable to heat pumps in terms of the positive environmental impact its development could produce.

FOR FURTHER INFORMATION

This paper provides insights into allocating capital into the hydrogen value chain.

The firm provides a comprehensive range of services which includes M&A transaction services and raising both debt and equity to finance hydrogen projects globally.

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