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Regret-ready: A briefing on United Kingdom proposals for the mandating of 'hydrogen-ready' gas boilers

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Executive summary

The United Kingdom government is currently consulting on whether it should mandate that all new gas boilers sold from 2025 are 'hydrogen-ready'; that is, they can potentially be converted to run on pure hydrogen if the gas network is ever converted, in that particular area.

The UK is the only country currently proposing such a change. Close European neighbours with similar levels of gas use for heating, including the Netherlands and Germany,[2] are targeting near-term end dates for the sale of boiler-only heating systems and focusing their efforts on heat pumps and heat networks. Much UK government policy for heating is also focused on heat pumps, including the boiler upgrade grant scheme, the development of a new market-based mechanism to obligate boiler manufacturers to sell heat pumps and an expected ban on high-carbon fuels in off-gas-grid areas.

The vast majority of independent analysis suggests there is only a niche role for hydrogen in heating and there is a global focus on heat pump development and deployment. With even the UK government uncertain if hydrogen for heating will have any role at all, a policy to mandate hydrogen-ready boilers could be likened to using a sledgehammer to crack open a pine nutshell, only to find the shell is empty.

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[2] The Netherlands has a higher proportion of gas heating than the UK and in Germany it is lower.

The proposal may actually create significant risks for heat decarbonisation, as well as long-term downsides for consumers.

Such risks include:

- A risk of greenwashing, resulting in consumer confusion and delay when clarity from government is needed.
- The possibility that boiler prices will go up, despite industry communications, and there being no way for the government to regulate this issue.
- Increased boiler sales and the diversion of household capital away from heat pumps which can provide near-term carbon and energy security value.
- That hydrogen-ready boilers become ubiquitous and they burn fossil gas for their entire lives.
- That hydrogen-ready boilers create a 'too big to fail' commitment leading to a significant liability for government. Governments run the risk of being blamed by industry, which has 'done its part', for not deploying hydrogen.
- That hydrogen-ready boilers become obsolete for use with hydrogen due to a lack of parts availability.
- Competition in the boiler market could be reduced.

Overall, a lower-risk strategy would be to push back the decision to mandate or not mandate hydrogen-ready boilers to after the government's decision on the use of hydrogen heating, expected in 2026. If this decision is favourable on hydrogen heating, hydrogen-ready boilers should then only be mandated in areas which are chosen for conversion – which may be nowhere. In any case, if 'hydrogen-ready' boilers are ever mandated, such a change would need to come with strict requirements around marketing and communications, in order to limit the potential for greenwashing and confusion for consumers.

A national heat mapping process and local area energy planning could support decisions on heat transformations in local areas, helping with decisions not just on hydrogen/gas grid decommissioning but also on the deployment of heat networks and electricity system upgrades.

Introduction

Governments around the world are planning to remove fossil fuels from their energy mixes for the purposes of decarbonisation, energy security and cost reductions. For cleaning up heating for the buildings sector, despite the expected importance of energy efficiency and electrification primarily via heat pumps and heat networks, the UK government is investigating the potential of repurposing the fossil gas distribution system to provide hydrogen for combustion at a building level.

The Government of the United Kingdom has invested particularly heavily in research and development around heating using hydrogen and is currently consulting on whether fossil gas boilers sold from 2026 should be 'hydrogen-ready', meaning they could, subject to some modifications, use hydrogen. The UK is the only country currently proposing such a measure, and suggests that this policy change could constitute "a low-regrets action in terms of impacts to consumers". In Germany, a

country with a similar climate and a large heating appliance industry, the vice-chancellor has stated that "The use of hydrogen as a gas substitute will be far too expensive in the long term."[3]

Exploring some of the issues around the concept of hydrogen-ready boilers, this briefing suggests that the mandating of such appliances will not be a low-regret approach, that it could create some significant downsides and that any upsides would be negligible.

There are obvious concerns over the impact on boilers' costs and safety. We also have a particular concern over the confusion hydrogen-ready boilers may cause for consumers; their adoption may normalise the idea of hydrogen use for heating, despite its known limits and the expectation of it playing an extremely niche and geographically specific role in a clean energy system. This could lead to further confusion and delay and continue to strengthen expectations among the public around the role of hydrogen for heating; consumers could put off work to install fabric efficiency measures and heat pumps if they expect hydrogen to just appear one day.

To reduce the risks associated with the hydrogen-ready proposal, the decision could be pushed back so that it aligns with wider government decision-making in 2026 on the future of hydrogen and the gas grid.

A niche role for hydrogen heating

A peer-reviewed meta-analysis of independent studies into future heating mixes showed that widespread use of hydrogen is not expected, across analyses based on cost, environmental impact and practicability.[4]

Expectations of hydrogen playing only a niche role are based on a combination of systemic inefficiency and high costs compared to other options, as well as expected technical difficulties concerning safety and conversions within certain geographic areas.[5] Global analyses by both McKinsey & Company and the International Energy Agency show that heat pumps are the most common heating technology in zero-carbon energy systems, with district heating (and possibly solar thermal) playing an important supporting role.[6] In the UK in 2050, hydrogen is projected to have its most sizable role in industry and shipping.[7]

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[3] PRESSEPORTAL. (2022, 7 January). *Wärmepumpengipfel in Berlin: "Gemeinsame Erklärung ist eine gute Grundlage für den Markthochlauf", sagt STIEBEL ELTRON* [Heat pump summit in Berlin: "The joint declaration is a good basis for the market ramp-up," says STIEBEL ELTRON]. https://www.presseportal.de/pm/62786/5262539

[4] Rosenow, J. (2022, 27 September). Is heating homes with hydrogen all but a pipe dream? An evidence review. Joule, 6(10), 2225-2228. https://doi.org/10.1016/j.joule.2022.08.015

[5] Lowes, R. & Cebon, D. (2022, 24 August). '*Wrong Side of History*' | *Wake up to the hype around green hydrogen for heating.* RECHARGE. https://www.rechargenews.com/energy-transition/wrong-side-of-history-wake-up-to-the-hype-around-green-hydrogen-for-heating/2-1-1282365

[6] Bouckaert, S., Fernandez Pales, A., McGlade, C., Remme, U., & Wanner, B. (2021, May) *Net Zero by 2050: A Roadmap for the Global Energy Sector.* IEA. https://www.iea.org/reports/net-zero-by-2050
and
Krishnan, M., Samandari, H., Woetzel, J., Smit, S., Pacthod, D., Pinner, D., Nauclér, T., Tai, H., Farr, A., Wu, W., & Imperato, D. (2022, January). *The net-zero transition. What it would cost, what it could bring.* McKinsey Global Institute. https://www.mckinsey.com/capabilities/sustainability/our-insights/the-net-zero-transition-what-it-would-cost-what-it-could-bring

[7] Stark, C., Thompson, M., Joffe, D., Andrew, T., Bellamy, O., Boufounou, M., Budden, P., Cole, C., Devane, E., Davies, E., Goater, A., Grant, N., Hay, R., Hemsley, M., Herring, R., Hill, J., Jassi, J., Kmietowicz, E., Lightfoot Brown, H.,…Worthington, L. (2020, December). *Sixth Carbon Budget.* Climate Change Committee. https://www.theccc.org.uk/publication/sixth-carbon-budget.

According to the UK Heat and Buildings Strategy, the UK government "will take major strategic decisions on the role of hydrogen for heat by 2026."[8] The government also has plans to rapidly scale up heat pump installations to 600,000 per annum[9], a level slightly slower than the one proposed by the UK Climate Change Committee in their balanced pathway (CCC).[10]

Within UK heat decarbonisation scenario modelling, only blue hydrogen (meaning hydrogen produced from fossil gas with carbon capture and storage) has been shown to have energy system costs comparable to the widespread adoption of heat pumps. However, that was before the gas price crisis –and in the example cited the greenhouse gas emissions associated with blue hydrogen were unsustainable.[11] With the gas price crisis and concerns over energy security, increasing the UK's exposure to global gas imports by producing blue hydrogen seems no longer to be a valid strategy – especially as the costs of renewable electricity continue to fall and UK electricity capacity, particularly offshore wind, grows rapidly. Green hydrogen (that produced by using renewable electricity to split water molecules) for heating at scale has never been seen to be cost-effective compared to electrification using heat pumps and heat networks.

The CCC's 6th carbon budget (its most recent) included updated analysis on the buildings sector. The 'balanced pathway' in this analysis which formed the basis of the CCC's recommendations for heating suggested that hydrogen for heating would only be used in hybrid systems which combine a heat pump and a hydrogen-burning boiler.[12] In this pathway, there would be 3.9 million of these hybrid systems in 2050 and they would be installed only in geographic areas where the gas grid is converted to hydrogen (a complex process considered in the following section). The CCC's balanced pathway highlights two important issues with regard to hydrogen boilers:

1. Under the pathway, the number of homes connected to the gas grid will reduce by around 19 million by 2050, from around 23 million today[13] to 3.9 million in 2050. This reduction could be even more significant if hydrogen conversions don't happen.
2. Where the limited gas grid remains in place will be geographically specific, implying the need for mapping and then local area heat planning.

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[8] Department for Business, Energy & Industrial Strategy. (2021, 19 October). *Heat and buildings strategy (CP 388).* https://www.gov.uk/government/publications/heat-and-buildings-strategy

[9] Department for Business, Energy & Industrial Strategy. (2022, 7 April). *British energy security strategy.* https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy

[10] Lowes, R., Rosenow J., & Guertler, P. (2021, 24 March). *Getting on track to net zero: A policy package for a heat pump mass market in the UK.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/getting-track-net-zero-policy-package-heat-pump-mass-market-uk/

[11] Element Energy & E4tech. (2018, March). *Cost analysis of future heat infrastructure options*. National Infrastructure Commission. https://nic.org.uk/app/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf

[12] Element Energy. (2021, April). *Development of trajectories for residential heat decarbonization to inform the Sixth Carbon Budget.* Climate Change Committee. https://www.theccc.org.uk/publication/development-of-trajectories-for-residential-heat-decarbonisation-to-inform-the-sixth-carbon-budget-element-energy/

[13] Energy Networks Association. (2022, January 13). *Gas Goes Green. Britain's Hydrogen Blending Delivery Plan.* https://www.energynetworks.org/newsroom/britains-gas-grid-ready-to-deliver-hydrogen-across-the-country-from-2023-energy-networks-announce

The CCC has previously supported the mandating of hydrogen-ready boilers,[14] although this was over two years ago and based on an understanding that blue hydrogen would provide around half of the hydrogen.[15]

Clearly, the economics and energy security implications of blue hydrogen have become significantly worse since the gas price crisis and Russia's war on Ukraine. Supply constraints on green hydrogen –associated with the need to build extremely large amounts of renewable generation and electrolysers or rely on imports – mean that this option has natural energy security implications. The economic and energy-security headwinds against hydrogen for heating, have increased significantly.

What is a hydrogen-ready boiler and are there benefits?

The current UK consultation into gas boiler hydrogen-readiness (among some other issues) recognises that "replacing natural gas with 100% hydrogen is not yet an established option for decarbonizing heating in buildings at scale."[16] However, it suggests that mandating all boilers below 45 kilowatts capacity should be hydrogen-ready by 2026 is "low-regrets" if:

- "Hydrogen-ready boilers can satisfy regulatory requirements once converted to operate on 100% hydrogen gas which includes performance and safety.
- Price parity with natural gas boilers will be achieved when hydrogen-ready boilers tend toward natural gas only boiler sales totals.
- A single market-wide definition of hydrogen-ready boilers is agreed, which ensures that products meeting this definition can prepare homes for possible 100% hydrogen conversions."[17]

A hydrogen-ready boiler is a boiler that can run on the current gas mix (mostly methane) and be modified to run on 100% hydrogen, if the network is ever converted. Some components would need to be replaced but much of the boiler would continue to be used. As we understand it, the modifications would be the swapping of the gas burner, the swapping of a gas valve and some software updates.

Switching areas to 100% hydrogen means converting whole areas at once, likely over the course of a few days.[18] In advance of the conversion, all pipework in the area would need to be made safe and any required gas distribution equipment changes to things like valves, pressure management and capacity would need to be made; it is estimated that this would cost around £22 billion.[19]

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[14] Stark et al., 2020.

[15] Climate Change Committee. (2020, December). *The Sixth Carbon Budget: Fuel supply.* https://www.theccc.org.uk/wp-content/uploads/2020/12/Sector-summary-Fuel-supply.pdf

[16] Department for Business, Energy & Industrial Strategy. (2023, 7 February). *Improving boiler standards and efficiency.* https://www.gov.uk/government/consultations/improving-boiler-standards-and-efficiency

[17] Department for Business, Energy & Industrial Strategy, 2023.

[18] Sadler, D., Cargill, A., Crowther, M., Rennie, A., Watt, J., Burton, S., & Haines, M. (2016, July). *H21 Leeds City Gate*. https://h21.green/projects/h21-leeds-city-gate/

[19] Element Energy. (2018, November). *Hydrogen supply chain evidence base*. Department for Business, Energy & Industrial Strategy. https://www.gov.uk/government/publications/hydrogen-supply-chain-evidence-base

Once a network area has been made ready, in the actual switchover period, all homes in the area would have their gas supply turned off, the gas network in the particular area would be purged of methane and then be refilled with hydrogen, after a hydrogen supply was connected. In the meantime, the buildings in the area would be made ready for hydrogen with gas appliances removed, changed or modified, new meters fitted and any safety issues resolved. In theory, if hydrogen-ready boilers are present, it will be quicker to modify existing boilers for hydrogen use than to fit brand new boilers and this could therefore slightly reduce the complexity of the local area conversion.

If areas are converted to hydrogen, and non-hydrogen-ready boilers are in place, all boilers would need to be changed to hydrogen boilers at the time the area is converted. Because of appliance replacement cycles, some boilers would be replaced before the end of their lives and would therefore be stranded assets with some sunk costs lost. If the boilers were hydrogen-ready, some of these sunk costs would be reduced if the area was converted to hydrogen. Any potential saving would be dependent on how many buildings eventually use hydrogen, the costs of conversions and the date that conversions take place.

If no conversions take place – which because the economics of hydrogen for heating look so poor seems likely – there would be no saving. If there is no saving and the downsides of the mandating of hydrogen-ready boilers are significant (which they appear to be), even if hydrogen-ready boilers cost the same as a current methane boiler (which they may not), costs may outweigh any assumed benefits.

The issues with mandating hydrogen-ready boilers

Analysis repeatedly suggests that large swathes of the UK will see gas distribution infrastructure decommissioned in a balanced net-zero scenario.[20,21] The current UK government consultation suggests that hydrogen-ready boilers may be "low-regrets", although regrets associated with this policy change could be significant – hence this briefing.

For households in areas which are not converted to hydrogen, likely large parts of the country, a hydrogen-ready gas boiler could cause significant consumer confusion, potentially increase costs (if costs are higher than for normal fossil gas boilers) and any potential upsides may be more limited than assumed. These issues are expanded below:

1. The risk of greenwashing and consumer confusion is substantial.

Concerns have been raised around the marketing and greenwashing of boilers with regards to their readiness for hydrogen.[22] Appliance manufacturers are already

[20] Stark et al., 2020.

[21] Rosenow, J., Lowes, R., et al. (2020 October). *The Pathway to net zero heating in the UK.* UK Energy Research Centre. https://ukerc.ac.uk/publications/net-zero-heating/

[22] Global Witness. (2022, 13 September). *Burning the public: The hydrogen heating pipe dream*. https://www.globalwitness.org/en/campaigns/fossil-gas/burning-public-hydrogen-heating-pipe-dream/

marketing boilers as 'hydrogen-blend-ready',[23] with an inference that this is a greener, net-zero-aligned technology solution. This may mislead consumers, who might think they are already switching to a clean source of heat, while in fact their new boiler continues to run on fossil heating and therefore has the same climate impact and hydrogen may never be blended into the gas grid in the consumers' area. We have also been made aware of multiple companies stating that hydrogen-ready boilers are already on the market.[24]

While existing boilers may indeed be suitable for a blend of up to 20% hydrogen, the boiler testing regime has required boilers to be tested with 23% hydrogen for decades.[25] Boilers labelled as 'hydrogen-blend-ready' are likely to already be confusing for customers who may never have considered heat decarbonisation or know very little about it,[26] even without the introduction of hydrogen-ready boilers. It seems unlikely that a typical customer would be aware of the difference between a 'hydrogen-blend-ready' boiler and a 'hydrogen-ready' boiler.

If hydrogen-ready boilers are mandated, consumers may believe (and may have been told by appliance manufacturers) they have done their part for heat decarbonisation and it is "job-done" from their perspective. This could make the consumer challenge of heat decarbonisation even more difficult and risks delaying the transition towards meaningfully low carbon heating systems, like heat pumps, alongside fabric efficiency upgrades.

2. Boiler costs may not remain the same even if industry says they will.

There is no guarantee that a hydrogen-ready boiler will cost the same as a traditional fossil gas boiler. Indeed, with innovation, safety costs and the need for moveable parts and software changes, it seems quite plausible that the price of manufacture would not remain the same.

The requirement to also have every boiler model on the market tested independently for performance and safety with a normal gas mix as well as with 100% hydrogen will undoubtedly lead to additional costs.

A previous CCC publication had suggested an additional cost of £100 for a hydrogen boiler compared to a fossil gas boiler.[27]

Even if the gas boiler industry says that the costs will remain the same there is no guarantee that they will and there is nothing to stop the manufacturers increasing costs in the future. This should be seen as a key risk for government. The Department for Business, Energy & Industrial Strategy (BEIS) impact assessment carries out

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[23] Worcester Bosch. (n.d.). *Hydrogen-fired boiler: What does 'Hydrogen blend ready' mean?* https://www.worcester-bosch.co.uk/hydrogen

[24] Jo Alsop, the Heating Hub, personal communication, February 2023.

[25] Schaffert, J., Fischer, P., Leicher, J., Burmeister, F., Flayyih, M., Cigarida, H., Albus, R., Görner, K., Milin, P., Carpentier, S., Krishnaramanujam, K., Bohms, O., Endisch, J., Wit, K., Geerts, E., & Schweitzer, J. (2020, 11 December.) *Testing Hydrogen admixture for Gas Applications.* European Commission. https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5d6f8897a&appId=PPGMS

[26] Addario, G., Jessop, C., Mezzanzanica, M., & Wood, M. (2020, January). *Transforming heat – Public attitudes research report.* https://www.gov.uk/government/publications/transforming-heat-public-attitudes-research

[27] Climate Change Committee. (2020, December). *The Sixth Carbon Budget: Buildings.* https://www.theccc.org.uk/wp-content/uploads/2020/12/Sector-summary-Buildings.pdf

sensitivity analysis which considers a higher boiler cost but does not consider this sensitivity under a scenario of limited or no hydrogen being used for heating.[28] This could be an important piece of analysis to support the decision which may flip the positive net present value currently assumed in the impact assessment.

Furthermore, it is unclear how any regulation could manage this issue. If purchase costs remain the same but manufacturing costs are higher and are absorbed by manufacturers, the capital available to invest in alternatives like heat pump development is reduced.

3. This could create significant decarbonisation and energy security delivery risk for government.

If hydrogen-ready boilers do become the standard installation and they become widespread, consumers may naturally believe that hydrogen is their key option for heating in the future. This normalisation of the promise of hydrogen heating could affect wider debates. If as expected evidence and economics continue to suggest that hydrogen is a poor option for heating, there is a risk that government ends up being blamed for not delivering hydrogen and heat decarbonisation and is made a scapegoat by industry.

In such a situation, the gas industry could simply say that they have done their part and now it is up to government to deliver hydrogen. We have recently witnessed water utilities blaming the government for increased numbers of sewage discharges, linking this to previous policy failures.[29] While this example is not identical, it does highlight the need for clarity and decisiveness; after all, in expert circles it is known that frequent sewage discharges are part and parcel of the UK's sewage water system during times of high rainfall and the issue is complex. The issue of heat decarbonisation is also complex for non-experts yet it is widely appreciated in expert circles that hydrogen is a poor option for heating. The complexity could be misused.

Such a blame-game could make decarbonising heating even more difficult for the government, who may then need to explain that, actually, hydrogen is not a good option for heating to a public wondering why hydrogen-ready boilers have been being installed for years. This delay could prevent the government from meeting its legally binding climate targets and continue exposure to gas imports.

4. If hydrogen use in heating has most efficacy in certain geographies and in hybrid systems made up of a heat pump and hydrogen boiler, then hydrogen-ready boilers will offer little value unless they can be hybridised.

As indicated previously, current analysis suggests that if hydrogen is used for heating, its optimal use may be in limited geographies in hybrid systems comprised of a heat pump and a boiler running on hydrogen.[30] If this is the case, then any appliance

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[28] Department for Business, Energy & Industrial Strategy. (2022, 13 December). *Improving boiler standards and efficiency: boiler efficiency, hydrogen-ready boilers, and the role of hybrid systems.* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1123311/Improving_boiler_standards_and_efficiency_consultation-stage_impact_assessment.pdf

[29] Horton, H. (2022, 26 November). Water chiefs blame UK government for failure to stop sewage pollution. *The Guardian*. https://www.theguardian.com/environment/2022/nov/26/water-chiefs-blame-uk-government-for-failure-to-stop-sewage-pollution

[30] Element Energy, 2021.

regulations may want to consider that new boilers and their controls are suitable to form part of hybrid systems as well as being hydrogen-ready, though of course similar issues apply to hybridisation as they do for hydrogen around likely market scale and geography.

While this technological option is recognised as cost-optimal in some modelling, including that of the CCC, its novelty suggests that the same care, over issues like geography and marketing, should be taken over mandating for hybrid readiness as it should for hydrogen-readiness.

5. There is a risk of hydrogen-ready boiler obsolescence.

Current UK government proposals suggest that the conversion kits which contain the components needed to make a boiler hydrogen-ready need not be stockpiled but can be produced on demand by boiler manufacturers, if an area is to be converted. There is no guarantee that manufacturers will produce such components X years into the future, particularly as they will be able to make more from selling new boilers. It is also unclear how consumers could be protected from this risk. This could significantly reduce the potential benefits of this policy even further.

6. Competition in the boiler market could be reduced

Making a boiler hydrogen-ready will require some technical changes and all hydrogen-ready boilers on the market will need to be tested for use with 100% hydrogen – both of these elements naturally have cost and time implications.

If a company sold boilers into the UK from abroad but didn't have to face a hydrogen-ready regulatory stipulation in other larger markets, this could lead to it withdrawing from sales in the UK market. This could naturally reduce competition and further exacerbate price pressures.

Conclusions

Overall, the proposed mandating of hydrogen-ready boilers is far from a no-regrets option. Risks include increased appliance costs for consumers, a risk of appliance obsolescence, consumer confusion and government potentially being blamed for heat decarbonisation failure if/when hydrogen for heating doesn't appear.

The mandating of hydrogen-ready boilers in advance of a government decision on the role of hydrogen for heating brings significant risks for the delivery of heat decarbonisation, that do not appear to be outweighed by the possible benefits. The government's current impact assessment does not recognise some of the more subtle but socially and politically important issues recognised in this briefing. Full sensitivity analysis should also be undertaken to consider the possible scenario where boiler costs go up and where there is no hydrogen used for heat.

Government should make a decision on the future role of hydrogen for heating and, if it has a place, determine in what geographies this will be. Only if and when the role of hydrogen heating is determined should a decision on hydrogen-ready boilers be made and the decision should be geographically specific. Such an approach would be much lower risk than what is proposed.

Any potential boiler stranding cost is likely to be very limited because hydrogen is unlikely to be delivered at scale. However, if hydrogen does end up being deployed,

delaying the decision on hydrogen-ready boilers to 2026 would only increase potential and already small stranding costs by a tiny amount because of the likelihood that hydrogen will not be deployed.

In any situation, if 'hydrogen-ready' boilers are ever mandated, such a requirement would need to come with strict regulations around marketing and communications. Without tight control over 'hydrogen-ready' boiler marketing, the potential for greenwashing and confusion for consumers is significant and could lead to delays to decarbonisation of the heat sector.

A heat mapping process, led at a local level but with central government support alongside local area energy planning, would allow local governments and the network regulator to determine optimum heat mixes across the country. Such a process could indicate where heat networks should be deployed, where gas grids may be decommissioned, where electricity networks may require capacity increases and where, if anywhere, hydrogen might have value in heating.

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