GAS USERS ORGANISATION

Consultation answers

Regulatory Framework overview

Q1. Do you agree with the inclusion of micro-businesses within consumer protection requirements?

As a Community Interest Company with a declared community interest to act for the benefit of domestic gas customers, and for individuals registered with Gas Safe, the Gas Users Organisation C.I.C. has no standing to advocate in the interest of micro-businesses.

However, the argument that these smaller businesses have the same lack of resources and reduced bargaining power as domestic customers is compelling.

Q2. Do you agree that consumer protection requirements should not cover non-domestic consumers (other than micro-businesses)?

As a Community Interest Company with a declared community interest to act for the benefit of domestic gas customers, and for individuals registered with Gas Safe, the Gas Users Organisation C.I.C. has no standing to advocate in the interest of non-domestic consumers.

However, we note that BEIS supports using local planning powers to force compulsory connection, through zoning, concession arrangements, and mandated connections, and such compulsory connection would affect both domestic and non-domestic customers.

1. Zoning is where a municipal authority uses local planning to identify a defined locality for a strategic heat network development. They then use planning powers to require new buildings in the zone to connect to the network; they voluntarily connect public buildings under their control in the zone, and they offer discounts to other buildings to encourage connection.

2. Concession arrangements are an extension of zoning, where the anchor load guaranteed by the local authority provides a foundation for a commercial relationship with a third party, usually from the private sector, who would, for example, provide upfront capital.

3. Mandating connections to a heat network within locally designated zones, either centrally or locally, would clearly be a mechanism for reducing connection risk. However, a centrally imposed approach would be a significant intervention into local planning and development decisions. BEIS is considering the alternative of granting local authorities the powers to take such decisions on mandating. [1]

We are generally concerned about compulsion being used to require a person, whether an individual or a company, to enter into a contractual relationship. Where compulsion is in place, then the argument that non-domestic consumers are better able to negotiate specific prices and terms of service for their connection is weakened, as they may have no option to disconnect from the contract.

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[1] "*Heat Networks Building a Market Framework*",p26, BEIS, January 2020. https://www.gov.uk/government/consultations/heat-networks-building-a-market-framework

The CMA report in 2018 observed that 88% of networks do not support the option of disconnecting because customers pay the standing charges whether or not they use the heat (i.e. they are effectively unable to disconnect and terminate their contract); and for many heat network customers, the only practical substitute to being supplied by a heat network is the use of electric heating, which is an expensive alternative. [2]

Where any person, whether an individual or a company, has had their position to negotiate contractual terms degraded through planning compulsion, then there is a case that they should have redress to a regulator, and that may include non-domestic customers.

Q3. Do you agree with our proposed approach to a definition of heat network, including that it should cover ambient temperature networks but not ground source heat pumps with a shared ground loop? Are there network arrangements you think would not be covered by this and which should, or vice versa?

We agree that ambient temperature networks should be included in the definition of a heat network. However, we also believe that ground source heat pumps with a shared ground loop should be included. Ambient loop networks are now being proposed as an alternative heating mechanism for domestic dwellings, either for new-builds not connected to the gas grid, or as retrofit to replace individual gas boilers.

We believe that where significant government subsidy is used to support a technology, then there should be regulatory scrutiny to ensure that technical standards are complied with, that customer expectations will be met, and that the proposed decarbonisation benefits are analysed and substantiated. Ambient loop networks meet this qualification, as by January 2020, a total of £141.9 million in subsidies has been paid under the Domestic Renewable Heat Initiative (RHI) scheme towards to 5812 ground source heat pumps. [3] An average subsidy of £24,415 per installation. Given this huge public subsidy, it is necessary to evaluate whether heat pumps, including ambient loop systems, achieve a cost-effective outcome. Even when the RHI is replaced, the proposed Clean Heat Grant of £4000 would still be a significant public subsidy, and would justify the same scrutiny to see whether each installation is effective. [4]

The experience of customers who use heat pumps is less satisfactory than the experience of domestic gas consumers. Many of the areas of underperformance are due to factors similar to those that contribute to the currently poor reputation of the heat network sector, and therefore there is a similar case for regulation.

Energy Saving Trust [5] produced a report based upon a comprehensive heat pump field trial that tested 83 heat installations in the UK: 29 air source and 54 ground source, for 12 months from 2008

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[2] "*Heat Networks Market Study*", https://www.gov.uk/cma-cases/heat-networks-market-study , pp 51-52, CMA, 2018

[3] *"Public reports and data: Domestic RHI",* https://www.ofgem.gov.uk/environmental-programmes/domestic-rhi/contacts-guidance-and-resources/public-reports-and-data-domestic-rhi , Ofgem, retrieved May 2020.

[4] "*Future support for low carbon heat",* BEIS, April 2020. https://www.gov.uk/government/consultations/future-support-for-low-carbon-heat

[5] "*The heat is on, heat pump field trials, phase 2*" Energy Savings Trust, August 2013, https://energysavingtrust.org.uk/policy-research/heat-heat-pump-field-trials-phase-2

until 2010. This field trial found that Coefficient of Performance (COP) for operational systems varied between 1.3 to 3.6 for ground source heat pumps and from 1.2 to 3.3 for air source, in most cases lower that manufacturer claims. A subsequent phase 2 field trial programme tested 44 installations, and following system design improvements, the average COP was 2.82 for ground source, and 2.45 for air sourced installations. In most cases the COP was lower in a real-life deployment than in the ideal conditions that the manufacturers assume.

One reason was poor installation, through both errors in system commissioning, but also through incorrect rating specifications. If a heat pump is too big, then it will always be operating inefficiently, but if it is too small, then the heat pump component will not be adequate, and the electric resistive heater, or gas boiler will be required to contribute more frequently than anticipated.

System commissioning errors, for Ground Source Heat Pump systems in particular, can dramatically increase operational costs, where, for example, there is insufficient ground array of pipes, or the pipes are too close together. This would be an area of concern for ambient loop networks.

A second phase of field tests were conducted by Energy Savings Trust to retest 44 sites out of the original 83 test sites. This was to remedy design failures found in the phase one testing, and retest to judge the efficiency of the improvements. Of these remedial works, 12 were major interventions requiring the input of heat pump experts and manufacturers, where, for example, the original systems had been wrongly sized and needed to be replaced. Nine systems required medium scale interventions by a qualified plumber, but these were still non-trivial, for example, installing buffer tanks, or high efficiency circulation pumps. The requirement for remedial works is attributed to greater understanding of field pumps being developed, and the first phase of installations had been undertaken before the introduction of the Microgeneration Certification Scheme (MCS), which established standards for installers. What this does show is that the skill level and capability of installers is a significant factor in system performance. It should be noted however that there has not been a comparable survey since the MCS was introduced, and the scheme’s impact on upskilling the industry has not been assessed.

Industry practitioner experts observe that it is essential that the hydronic systems are accurately designed, and will not work efficiently without very careful planning of both primary and circuitry pipework and emitters. Heat Pump installations are much less forgiving than domestic gas heating systems and require a higher skill level for design. [6] Even after the introduction of the MSC qualification, there are examples of poorly designed systems, with consequently high running costs; furthermore building controls may have become more lax, and buildings are not always performance tested to ensure compliance with regulations. [7] There is a clear need for the standard and quality of heat pump installations, including ambient loop networks, to be regulated, and the current building controls are not an appropriate mechanism.

Another reason found for unsatisfactory performance was unsuitable usage, especially where a heat pump is employed without underfloor heating, and without legacy radiators being replaced by larger units suitable for lower temperature operation, i.e., T_{low} emitters. Usage for DWH also reduces Coefficient of Performance (COP). Heat Pump systems installed into poorly insulated and draughty properties require a higher flow temperature.

[6] “*Has Gas had its day*”, Berridge R. Installer Online, May 2020. https://www.installeronline.co.uk/gas-day-rob-berridge-takes-look/?fbclid=IwAR2Po_FO8WOmO4A0Ygo5XVX-sxUpv9SaUNqL9rkn6VGKS8-QOAESG32Wl9o#

[7] Berridge, ibid.

Customer behaviour also contributed to poor performance, for example, using inefficient heating cycles. Element Energy observed that 73% of UK households use a scheduled heating cycle, for example bringing the heating on twice a day. The report concludes that this is the worst heating cycle for a heat pump, while the optimal performance is continuous heating.

Both CMA [8] and Which? [9] have reported concerns about poor information given to customers of heat networks, both before moving in and during residency, and it is not surprising that customers with heat pumps face suffer similar lack of information, and may not appreciate that heat pumps work better with a different pattern of usage. This is a good example of how the ambient loop sector and the heat network sector face similar issues; and both should benefit from the same regulatory regime.

There is also a strong evidence base that compared to domestic gas boilers, heat pumps do not provide competitive whole life costs for consumers. The Department for Business, Energy & Industrial Strategy (BEIS) commissioned Element Energy [10] to produce a detailed report on Heat Pumps. This report models different assumptions for system installation costs in three scenarios:

1. Where heat pump installation costs fall by 30% by 2030 due to increased volume,
2. where installation costs fall by 30% by 2050 due to less increased volume,
3. where installation remain static due to very modest increased volume.

They then compared the lifetime costs of a conventional gas heating system, a heat pump system and a Hybrid heat pump system (which uses an auxiliary gas supply for peak demand and DWH), based on installation today, installation in 2030, and installation in 2050.

Their report concludes that in all 9 of these scenarios, "*gas heating remains lower in cost than electrical heating using the HP over the whole time period 2017-2050 and in all scenarios considered*"

Even assuming a 30% reduction of installation costs for heat pump systems due to increased volume, then gas heating systems offer considerably cheaper installations and lifetime costs.

Comparing end user prices for an ambient loop network compared to individual gas boilers is more complex than might be expected, due to the UK's heterogenous housing stock, differing energy efficiencies of households, different usage patterns; [11] and the fact that heat pump solutions differ in their use of heat source, and whether or not they contribute to Domestic Water Heating (DWH). [12]

The consumer organisation, Which?, has pointed out that users of individual gas boilers need to include the cost of servicing and maintaining their heating systems, and that this needs to be

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[8] "*Heat Networks Market Study*", p 5, CMA, op cit.
[9] "*Turning up the heat: The experience of district heating consumers*", Which?, 2015.
[10] "*Hybrid heat pumps study*", Element Energy, for Department for Business, Energy & Industrial Strategy https://www.gov.uk/government/publications/hybrid-heat-pumps-study (April 2018)
[11] "*United Kingdom housing energy fact file*", Palmer J and Cooper I, Department of Energy and Climate Change, 2013
[12] "*Hybrid heat pumps study*", Element Energy, for Department for Business, Energy & Industrial Strategy https://www.gov.uk/government/publications/hybrid-heat-pumps-study (April 2018)

factored into any comparison. [13] It would also be true though that an ambient loop network is shared by typically only a few dwellings, and although routine maintenance and servicing costs may be lower than for a gas boiler, factoring in the replacement costs over the longer term will be a non-trivial consideration. Which's report also points out that in modern, well-insulated properties, the proportion of energy used for DWH, compared to that used for space heating, increases.

In the case of a heat pump, the thermal advantage of its Coefficient of Performance is sufficient to give heat capable of satisfying space heating, providing T_{low} emiters, such as larger radiators or underfloor heating are installed. However, heat pumps do not provide hot water at sufficient temperature for domestic use. [14] One option is to have a hybrid system that uses gas to either step up the temperature from the level provided by the heat pump, sometimes using a water tank, or to use only gas for DWH; another option is to use electric resistive heating to heat the water. [15]

Consider a two-storey house of $200m^2$ floor area built to 2010 Building Regulations standards, with a known space heating demand of 55 $kWh/m^2/yr$, then for $200m^2$ 11,000 kWh per year is required. In addition, assuming four people are living in the house, a further 4,000 kWh is required for DWH. [16] Based upon current utility prices, then for this example, the COP of a hybrid heat pump (where a gas boiler contributes to the water heating) would need to achieve COP of 4.5 to break even on fuel costs compared to an individual domestic gas boiler; the same house using a heat pump with a COP of 4.5 and electric resistive heating for DWH, would involve up to 98% higher fuel costs compared to an individual gas boiler, with a more realistic COP of 3, then fuel costs would be up to 136% higher than domestic gas.

Energy Saving Trust [17] found in their first round of field tests that COP for operational systems varied between 1.3 to 3.6 for ground source heat pumps and from 1.2 to 3.3 for air source; the subsequent phase 2 field trial programme tested 44 installations, and following system design improvements, the average COP was 2.82 for ground source, and 2.45 for air sourced installations.

Therefore, it is reasonable to assume that ambient loop networks will tend to have higher energy prices throughout their lifetime, in addition to having considerably higher installation costs.

We are generally concerned that heat pump technology is erroneously considered to be a renewable heating technology, when this is not necessarily the case. For example, the description by BEIS of the water sourced heat pump employed by the Kingston Heights district network is misleading when it says: "*This system recovers solar energy naturally stored in river water*." [18] The category error can be observed if we note that this is equivalent to saying that water at the bottom of a hill is naturally storing gravitational energy, which can be recovered by an electrical pump moving the water to the top of the hill.

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13 "*Turning up the heat: The experience of district heating consumers*", Which?, op cit.

14 "*Hybrid heat pumps study*", Element Energy, op cit.

15 "*Hybrid heat pumps study*", Element Energy, op cit.

16 This example from "*Heat Pumps: The Real Cost*", Pullen T, Homebuilding and Renovating, May 2012, https://www.homebuilding.co.uk/heat-pumps-the-real-cost/

17 "*The heat is on, heat pump field trials, phase 2*" Energy Savings Trust, August 2013, https://energysavingtrust.org.uk/policy-research/heat-heat-pump-field-trials-phase-2

18 Heat Networks Investment Project: Case study brochure, BEIS, 2018.

This category error may be significant as presenting heat pumps not just as a relatively efficient form of electric heating, but as recovering energy that would otherwise be wasted, i.e. as a form of renewable energy. This introduces a potential bias that heat pump technology is assumed to be inherently environmentally beneficial, without a critical evaluation of each individual case. For example, a gas fuelled CHP may offer superior greenhouse gas abatement than a heat pump supplied by the electricity grid.

Heat pumps operate by transferring heat against the natural direction of energy flow, from a lower temperature source to a higher temperature destination. A heat pump is conceptually similar to a refrigerator, where a refrigerant gas is passed through an evaporator on its way to the heat source, where it expands to become a vapour accompanied by its temperature falling to below the temperature of the heat source, such that it draws heat in from the environment; the now warmer and lower-pressure working fluid is then pumped in gaseous form through a compressor, where its pressure is boosted transitioning it back to a liquid, simultaneously causing its temperature to rise, and this raised heat is then used for space heating. [19]

Heat pumps can indeed be employed to recover waste heat from a thermal store, or from an environment where the ambient temperature has been raised by anthropogenic activity, or from a geothermal source, such as a deep mineshaft, as is being proposed in Bedminster, Bristol. [20] However, outside of that particular use, they are properly thought of as a relatively efficient form of electrically powered heating technology, where the function of the ground, water or air source is to provide a lower temperature environment than the area to be heated, thus allowing the cycle of expansion and compression of the working liquid to transfer thermal energy against the temperature gradient via a circulating working liquid and heat exchangers. They are not, as such, a form of renewable heat energy.

It is overoptimistic to assume that the electricity used to power heat pump systems would come primarily from renewables. it is estimated that shifting 20% of domestic heating from individual natural gas boilers to electric powered heat pumps would also require additional electricity generating capacity, estimated at £28 billion. Both the new electricity capacity, and the write off of gas industry capital have to be factored as energy inputs into the overall Energy Return on Energy Investment (EROEI) for heating networks.

For all these reasons, we believe that both on grounds of consumer protection, and to ensure that public policy decarbonisation objectives are validated, we believe that ambient loop networks need to be regulated.

Proposed regulatory approach

Q4. Do you consider Ofgem to be the appropriate body to take on the role of regulator for heat networks? If not, what would be an alternative preference?

We believe that, as a question of principle, the regulatory protections afforded to customers of heat networks should not be inferior to the protections enjoyed by domestic customers of the current gas

[19] "*Cogeneration and District Energy Systems*", p90, Marc A. Rosen and Seama Koohi-Fayegh. The Institute of Engineering and Technology, 2016

[20] Bristol City Council, Cabinet Report Pack, March 2020, p 354 https://democracy.bristol.gov.uk/documents/g3693/Public%20reports%20pack%2003rd-Mar-2020%2016.00%20Cabinet.pdf?T=10

network. This is particularly important as evidence shows that customers supplied by heat networks are likely to be older people including a higher proportion of vulnerable or financially precarious people than in the general population; they are significantly more likely to be in social housing.

Given that local authorities connecting buildings under their direct or indirect control is one of the anchors of demand for heat networks, the high proportion of customers in social housing is likely to be a sustained trend, and given the residualisation of social housing towards families in more difficult circumstances, then heat network customers are likely to remain, on average, a more vulnerable cohort.

The higher incidence of vulnerability was evidenced in a survey for BEIS, which found that around two thirds of surveyed customers supplied by a heat network were renting their property from a housing association or a local authority. Only 20% of all heat network customers lived in private accommodation which they owned, compared to 65% nationally. The remaining 11% of heat network customers were renting privately-owned accommodation. Over four in ten (44%) heat network customers were retired; the equivalent figure for the wider population was only 14%. The survey also identified that among the heat network population, 40% were classified as vulnerable consumers and roughly a quarter (27%) identified themselves as financially struggling. [21]

The Office of Gas and Electricity Markets (Ofgem) is already the economic regulator of the gas and electricity markets in Great Britain, and is therefore best positioned to ensure convergence of outcomes for both domestic gas customers and heat network customers.

Regulatory model options

Q5. Do you agree that the proposed regulatory model is appropriate for the regulation of heat networks?

We believe that, as a question of principle, the regulatory protections afforded to customers of heat networks should not be inferior to the protections enjoyed by domestic customers of the current gas network. Ofgem currently operates a licencing model for water and sewerage, gas, and electricity. This arrangement is explained well in the consultation document: Suppliers must hold a licence (or be granted an exemption) before they can operate in the market and are expected to meet entry requirements to demonstrate that they are 'fit and proper' to hold a supply licence. Supply licences describe how the licensee must interact with customers, both domestic and non-domestic (as applicable) structure and market its products. They also define other obligations on the supplier, such as compliance with industry codes. [22] We believe that such a licence model should be employed for heat networks.

We note that Citizens Advice Scotland has recommended to the Scottish Government to introduce price controls and a statutory licence for heat network suppliers covering consumer protection and efficiency standards; [23] and that the Scottish government is considering a requirement for

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[21] "*BEIS Heat Networks Consumer Survey, BEIS research paper Number 27*", pp 17-18. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/665447/HNCS_Results_Report_-_FINAL.pdf

[22] "*Heat Networks Building a Market Framework*",p32, BEIS, January 2020.

[23] "*Different rules for different fuels – exploring consumer protection in the district heating market". Citizens Advice Scotland*, May 2017. https://www.cas.org.uk/publications/different-rules-different-fuels-exploring-consumer-protection-district-heating-market

developers to obtain a district heating consent, which would have conditions including the requirement to have a licence and meet licensing conditions. [24]

BEIS argues that a licencing model is unsuitable for the following reasons:

- The 'one size fits all' supply licence already used for the gas and electricity markets, is starting to hold back progress by preventing consumers from benefitting from innovation, and is slowing down decarbonisation [25]
- The essentially monopolistic nature of the service to end consumers.
- The complex and diverse stakeholder landscape with many different models and structures for the ownership and operation of schemes.
- Disproportionate cost.

We find this unconvincing.

Firstly, Ofgem, has already taken steps in moving from prescriptive rules to outcomes-based principles, and further reforms are being considered. These reforms are not inconsistent with the licencing regime.

Secondly, the monopolistic service to end customers leads to situations where, according to the CMA, heat network providers face little competitive pressure to offer reasonable prices, reliable supply and high quality of service. [26] Redressing the negative aim of monopoly should be an objective for regulation, not a reason for rejecting a licencing model.

Thirdly, the complex landscape of stakeholders is itself a structural factor contributing to the low reputation of the heat network market, and its poor reputation with customers. The aim of regulation should be to remedy these failings.

Some structural problems with the market have been identified as follows, for example:

The CMA has raised the potential concern that a property developer could have the incentive to design and build a network which has cheaper up-front costs at the expense of higher long-run operation and maintenance costs (based on the premise that if construction costs are reduced and the sale value of the property remains the same, this would increase developers' profit margins as ongoing costs will be borne by customers instead). For example, developers may choose not to install key components, in order to reduce capital expenditure, without regard to how the network as a whole will operate in the longer term. This can reduce the operational efficiency of the network and therefore the quality of the service. [27] They argue that the lack of measurable and enforceable standards for the design, build, commissioning and operation of heat networks means that

[24] "*Scotland's Energy Efficiency Programme: Second Consultation on Local Heat & Energy Efficiency Strategies, and Regulation of District and Communal Heating*", Scottish Government, 14 November 2017.
[25] "*Flexible and responsive energy retail markets consultation*", BEIS and Ofgem (2019), https://www.gov.uk/government/consultations/flexible-and-responsive-energy-retail-market s
[26] "*Heat Networks Market Study*", p33, CMA, op cit.
[27] "*Heat Networks Market Study*", p 49, CMA, op cit.

customers are afforded little guaranteed protection and means that there is a significant risk to customers from misaligned incentives between property developers, heat network operators and customers. [28]

CMA also reports that the lack of standards and expertise in this market can lead to property developers demanding inappropriate requirements when specifying the network. These requirements can increase the upfront and ongoing costs of operating networks. Design engineers may not challenge this due to concerns regarding their professional indemnity insurance. Which?'s report [29] expresses concern that many schemes in the UK have been over-sized and are therefore less efficient.

Another commercial constraint from the fractured stakeholder landscape is that potential owners or investors will often not have the specialist engineering knowledge to design, implement, operate and manage a district network. The solution is often to outsource the contract energy management (CEM) to an energy service company (ESCO). As the Competition and Markets Authority (CMA) reports:[30]

> *The ESCO enters into a long-term agreement under which it has the right to access and operate the network and to charge customers for heat, normally under specified terms and conditions, such as by reference to a gas benchmark price. These agreements can vary in duration, but will tend to last a minimum of 20 years, and pass responsibility for the replacement of assets to the ESCO, which bills customers and collects revenues directly from them.*

Up to 60 % of heat networks in the UK have some recourse to CEM from an ESCO [31] As the CMA observes, an ESCO will have its own institutional and commercial interests, that may affect the design considerations, so that property developers and heat network operators may not take the interests of end customers into account when taking decisions on the design and build of networks. [32] and ESCOs typically set consumer price based on the cost of an alternative reference model and therefore any potential benefits or savings won't necessarily be passed on to customers. [33]

Finally, BEIS expresses concern over the balance between potential costs of funding the regulator's activities – which may affect consumer bills – against the level of oversight and anticipated compliance activity required for this market. They wish to ensure regulation is proportionate and that any resulting costs to consumers remains appropriate to benefits delivered. [34] This seems to accept that the regulatory framework for heat networks will inevitably place customers at a disadvantage compared to customers in the existing domestic gas market: heat network customers will be faced with either weaker regulation, or higher prices.

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[28] "*Heat Networks Market Study*", p 50, CMA, op cit.
[29] "*Turning up the heat: The experience of district heating consumers*", Which?, 2015.
[30] "*Heat Networks Market Study*", https://www.gov.uk/cma-cases/heat-networks-market-study , p8, CMA, 2018
[31] "*Cogeneration, a Users' Guide*", David Flin. The Institute of Engineering and Technology, 2010, p46.
[32] "*Heat Networks Market Study*", p7, CMA, ibid.
[33] "*Heat Networks Market Study*", p50, CMA, ibid.
[34] "*Heat Networks Building a Market Framework*",p32, BEIS, January 2020.

This seems to us to be, in principle, wrong: where a regulatory framework provides certainty over required outcomes, then companies wishing to participate in that market need to utilise their own entrepreneurial creativity to find commercial opportunities to do so profitably. Overcoming the fractured stakeholder landscape in order to allow compliance to a licencing regime is a commercial opportunity for companies to solve. Local authorities already use Special Purpose Vehicles such as ESCOs, and within the existing licencing model, for gas and electricity, businesses often sub-contract by partnering with a licenced supplier.

Q6. Which entity should be responsible and accountable for regulatory compliance, particularly where the heat supplier and heat network operator are not the same entity? Please explain why you think this.

BEIS identifies a number of potential candidates to be the regulated entity: the asset owner; the project sponsor; the developer; the network operator; or the heat supplier.

Given the complicated stakeholder framework in the heat network market, and the wide difference of scale of network schemes then different entities may be appropriate for different schemes. However, every scheme should have a regulated entity who is a licenced supplier, with appropriate contractual relationships with the other stakeholders. Whoever has the contractual relationship with the end customer should have a regulatory requirement to make clear to the customer who the licenced supplier is.

Q7. Do you agree that consumer protection requirements during the operation and maintenance project stage should be regulated, such as pricing, transparency and quality of service?

We believe that, as a question of principle, the regulatory protections afforded to customers of heat networks should not be inferior to the protections enjoyed by domestic customers of the current gas network. The Licencing regime employed for the gas network includes customer protections for pricing, transparency and quality of service, and equivalent protection should be extended to heat network customers. We support the mechanism used in the Netherlands, where prices for heat networks are capped at the price of gas heating.

Given the more vulnerable social profile of heat network customers, and the fact that they have no contractual leverage, there is a structural danger that lack of price regulation contributes both to fuel poverty and inequality. This needs to be addressed by regulation.

Many heat network customers enjoy heating bills below the comparator price of an individual gas boiler. However, CMA report that '*there is evidence of great variation in pricing in the heat network sector, with pockets of heat network consumers paying high annual prices, including consumers paying more than £1,000, or even £2,000, per year*.' [35] They note that heat network providers face little competitive pressure to offer reasonable prices, reliable supply and high quality of service.

Comparing prices in the networks they surveyed, CMA found that compared to average prices to run a comparator independent gas boiler, 8% of heat networks charged more; 6% charged over 10%

[35] "*Heat Networks Market Study*", p31, CMA, op cit.

more, and 3% charged over 25% more. When compared not to average gas prices, but the best gas prices available, then 17% of heat networks charged more, and 13% charged over 10% more.[36]

Higher unit prices and total charges were more often associated with private networks and with metered networks, and CMA argues that there is a risk that the factors which drive excessive prices could become embedded as the sector grows. [37] CMA note these factors as being: the conflicting interests of property developers, heat network operators and customers; that monopoly supply gives consumers no commercial leverage; and the low transparency behind billing and pricing. [38]

An area which requires further research relating to pricing is the technology and fuel supplying the heat. As the BEIS consultation document states, most heat networks currently in the UK are fuelled by natural gas (Methane) CHPs. [39] In this document the terms CHP and cogeneration are used interchangeably, following industry practice. The BEIS survey of 2013 [40] indicates that this is true of larger district networks, 64% of which are cogeneration systems.[41] For a well-designed, properly dimensioned and efficiently run CHP plant, fuelled by natural gas, then it would be expected that heat costs would be lower than for individual gas boilers. However, this cost efficiency cannot be assumed when using other technologies and fuels.

The push from BEIS to encourage a decarbonisation of heat networks may lower the average efficiency of the sector; so when heat networks employ other technology then costs to customers can be expected to rise.

We are particularly concerned that while distribution networks that deliver gas and electricity to homes and businesses are subject to licence conditions that obligate them to respond within 24 hours to any such interruption in supply, heat suppliers are not subject to such obligations, and worryingly, given the high proportion of vulnerable customers, only 32% of operators offer a priority reconnection for vulnerable customers in the case that supply is interrupted. [42] A greater proportion of heat network customers had experienced a loss of heating in the last 12 months (37% compared to 24% of consumers not served by a heat network), and 32% of all networks had experienced an interruption to the supply of heating and/or hot water in 2016. [43]

A further concern, given the public policy objective of promoting heat networks to achieve reductions in carbon emissions is that Citizens Advice found that a third of the systems reported on in their survey did not have a minimum level of efficiency, which not only has the potential to

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[36] "*Heat Networks Market Study*", p38, CMA, op cit.

[37] "*Heat Networks Market Study*", pp 6-7, CMA, op cit.

[38] "*Heat Networks Market Study*", p 5, CMA, op cit.

[39] "*Heat Networks Building a Market Framework*", op cit.

[40] "*Summary Evidence on District Heating Networks in the UK*", Department of Energy and Climate Change, 2013, https://www.gov.uk/government/publications/summary-evidence-on-district-heating-networks-in-the-uk

[41] "*Summary Evidence on District Heating Networks in the UK*", Ibid. However, where small communal networks are also taken into account, as they were in the BEIS report in 2013, it showed the average number of dwellings connected to UK heat networks was only 35, mainly in older installations, and only 3% of systems are CHP systems.

[42] "*District heating networks – analysis of information request*". Citizens Advice, op cit.

[43] "*Heat Networks Market Study*", p42, CMA, op cit.

adversely affect customers' bills, but also to impact their efficiency from the perspective of carbon emissions. [44]

Q8. Should there be a de minimis threshold below which a) very small domestic schemes and/or b) non-domestic schemes with very few domestic consumers are exempted from any of the regulatory requirements proposed in this framework? Please explain why you think this.

We believe that, as a question of principle, the regulatory protections afforded to customers of heat networks should not be inferior to the protections enjoyed by domestic customers of the current gas network. The protections should apply to all heat network customers regardless of the size of the network.

Given the complicated stakeholder framework in the heat network market, and the wide difference of scale of network schemes then different arrangements may be appropriate to be the licenced supplier for different schemes. However, every scheme should have a regulated entity who is a licenced supplier, with appropriate contractual relationships with the other stakeholders. Whoever has the contractual relationship with the end customer should have a regulatory requirement to make clear to the customer who the licenced supplier is.

Q9. Should there be a size threshold above which larger schemes are subject to more detailed regulation and scrutiny? If so, what type of threshold would you consider most appropriate?

We believe that, as a question of principle, the regulatory protections afforded to customers of heat networks should not be inferior to the protections enjoyed by domestic customers of the current gas network. The protections should apply to all heat network customers regardless of the size of the network.

Given the complicated stakeholder framework in the heat network market, and the wide difference of scale of network schemes then different arrangements may be appropriate for different schemes. However, every scheme should have a regulated entity who is a licenced supplier, with appropriate contractual relationships with the other stakeholders. Whoever has the contractual relationship with the end customer should have a regulatory requirement to make clear to the customer who the licenced supplier is.

Q10. Should an optional licence be available for entities seeking rights and powers? If not, what other approaches could be considered?

We have no view on this.

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[44] "*District heating Networks Analysis of information request, January 2016*", P14, Citizens Advice, op cit.

Q11. Are there any other adjustments that could be made to the proposed model to enable it to work better?

We believe that, as a question of principle, the regulatory protections afforded to customers of heat networks should not be inferior to the protections enjoyed by domestic customers of the current gas network. Ofgem currently operates a licencing model for water and sewerage, gas, and electricity. We believe that such a licence model should be employed for heat networks.

Q12. Are there circumstances in which transitionary arrangements should be introduced? If so, in what circumstances might these apply and for what length of period?

We believe that, as a question of principle, the regulatory protections afforded to customers of heat networks should not be inferior to the protections enjoyed by domestic customers of the current gas network. All heat networks should be subject to the consumer protection elements of the regulatory framework.

However, compliance may prove challenging for the current endowment of legacy heat networks. The CMA found that dwellings served by heat networks are predominantly flats (94%) and have two or fewer bedrooms (86%), and that around 75% were more than 15 years old; 79% are communal schemes (accounting for 56% of dwellings); 21% district heating schemes (44% of dwellings); Only 13% of networks and 27% of dwellings are metered (where individual heat charges directly relate to individual heat consumption), and there is a median of 31 dwellings per network, with three quarters of schemes supplying fewer than 45 dwellings. [45]

Further research should be undertaken in consultation with the operators of older, smaller systems to understand the challenges that they face, and the timescales required by them to bring their networks up to code.

Emerging business models

Q13. Do you consider our proposed approach sufficiently flexible to accommodate emerging business models, including unbundling of different components of a heat network? If not, please suggest ways in which we could ensure alternative business models are not precluded.

We believe that, as a question of principle, the regulatory protections afforded to customers of heat networks should not be inferior to the protections enjoyed by domestic customers of the current gas network. Ofgem currently operates a licencing model for water and sewerage, gas, and electricity. We believe that such a licence model should be employed for heat networks.

Given the complicated stakeholder framework in the heat network market, and the wide difference of scale of network schemes then different arrangements may be appropriate for different schemes. However, every scheme should have a regulated entity who is a licenced supplier, with appropriate contractual relationships with the other stakeholders. Whoever has the contractual relationship with

[45] "*Heat Networks Market Study*", CMA, p,34, op cit.

the end customer should have a regulatory requirement to make clear to the customer who the licenced supplier is.

We believe that this flexibility is sufficient to allow different and innovative business models to be employed.

Enforcement powers

Q14. How should government and the regulator ensure that enforcement action is proportionate and targeted? Are there particular considerations for not for profit schemes?

We believe that, as a question of principle, the regulatory protections afforded to customers of heat networks should not be inferior to the protections enjoyed by domestic customers of the current gas network. We therefore support Ofgem having equivalent enforcement as regulator of heat networks as it currently has in the electricity and gas markets.

We believe that the consumer protection and public policy objectives of regulation are equally valid whether the operator or licensed supplier is a commercial or not for profit entity.

Q15. Do you agree that imposing fines and removing a licence/authorisation are an appropriate and adequate set of enforcement actions for the regulator of the heat network market?

We believe that, as a question of principle, the regulatory protections afforded to customers of heat networks should not be inferior to the protections enjoyed by domestic customers of the current gas network. We also believe that heat network customers should not pay more than domestic gas customers, and we therefore support the mechanism used in the Netherlands, where prices for heat networks are capped at the price of gas heating.

Where these two principles are not followed then there is a danger that expanding the number of heat networks will contribute to the growth of both fuel poverty and inequality. Price capping would constrain any heat network operator from passing the cost of fines on to the customer, which is in principle correct, as it is the heat operator that is at fault, not the customer.

BEIS observes that there are a large number of smaller companies operating in the heat network market that have a constrained ability to fund unplanned for costs such as fines. While in principle the customer protection aspects of regulations should apply to all heat networks, we accept that a transitional period may be necessary for older and smaller systems to bring themselves towards compliance.

The regulator has discretion to issue enforcement order to rectify instances of non-compliance, and where operator rectifies their non-compliance, then the regulator may consider it proportionate to take no further action. However, where an operator fails to rectify a non-compliance, or where the non-compliance is egregious, then customer protection considerations should be more important than the commercial viability of the non-compliant operator. This approach necessitates a robust step in mechanism.

Q16. Do you agree that the regulator should have powers to impose penalties at the entity level which are proportionate to its size, in a scenario where there are repeated or systemic failures across multiple schemes owned or operated by the same entity?

Yes.

Q17. Do you agree that the regulator should have powers to revoke an authorisation for single networks owned or operated within a group scenario, so that the entity would still be authorised or licensed to operate those networks within the group that remain in compliance? If not, what alternative approach might the regulator take?

Yes.

Q18. If compliance issues are more widespread within the group of networks owned or operated by the same entity, do you agree that the regulator should be able to revoke the authorisation or licence for the entity as a whole covering its entire group of networks? If not, what alternative approach might the regulator take?

Yes.

Q19. Do you agree that individual domestic consumers should have access to ombudsman services for redress? Do you have any views as to which ombudsman is best placed to provide this function for heat networks?

We consider that individual domestic customers of heat networks should have recourse to the Energy Ombudsman.

Step-in Arrangements

Q20. Do you agree that step-in arrangements are necessary both to cover the risk of stranded consumers and as a deterrent against sustained failure to meet the regulatory requirements? If not, why?

The requirement for step in arrangements very clearly illustrates how customers of heat networks are inherently disadvantaged compared to domestic gas customers. For the gas and electricity markets, a supplier may cease to operate or lose their licence, but the gas or electricity will continue to flow through the distribution network into the end consumer's property.

Gas and electricity customers are also assured of the quality of their supply, both through the regulatory framework, and because they are customers of well-established supply industries relying upon mature technology and national and international infrastructure endowments.

In contrast, heat networks may be relying upon innovative technology, and there is little assurance that networks will have been appropriately designed, dimensioned or implemented.

There needs to be consideration of how to remedy failings that are due to a heat network being inherently technically incapable of meeting its requirements, such that it needs to be replaced, or where significant remedial work is required. In the case of the gas and electricity markets, the costs of any remedial technical works are spread across literally millions of customers, each of which therefore only bears minimal risk. There is no obvious answer of how this would be paid for where a heat network is technically not fit for purpose, such that it requires expensive intervention.

The fact that gas customers are inherently better protected than heat network customers regarding step in, is a reason to oppose any future mandatory transition of gas customers to a heat network connection. It would also not be in the interest of gas consumers for them to pay for remedial work for failing heat networks through general taxation.

Q21. Do you have any examples of approaches we should be considering as we develop the step-in arrangements?

Step in arrangements need careful consideration. In some cases, there may be customer service, billing or equipment maintenance issues that are relatively straightforward to address. Where the heat source is fuelled by gas or electricity then the physical supply may not be jeopardised by a change of ownership, however, a heat source relying upon, for example, biofuel or diesel, which has to be ordered and delivered to site as a commodity may suffer supply interruptions.

For this reason, in order to guarantee equivalent assurance of continued supply comparable to the gas and electricity networks, it would be necessary for each heat network to have a planned succession plan for a step in by an identified operator of last resort, and fuel supply contingency plans. The risk for smaller operators could be addressed by this being indemnified by insurance.

Protecting consumers Transparency

Q22. Do you agree that the provision of minimum information would help consumers in making decisions at pre-contractual stages of property transactions?

Given that customers of heat networks are locked into long term contractual commitments, it is surprising how little choice those customers have whether or not to enter into the contract. Social housing tenants often have little choice on which accommodation to accept, and private owner occupiers are not always advised that the dwelling they are considering is on a heat network. We are opposed to customers being compelled to join a heat network, as the provision for customers is inferior to that enjoyed by domestic gas customers.

According to CMA, key information for customers lacks transparency both before and after moving into a property. [46] Matters such as contract duration, exclusivity and relative pricing of heat networks compared to other energy options are often not considered by customers until after they have decided to move into a property.[47] There is currently no requirement for the performance of heat networks to be included in Energy Performance Certificates through the regulations which govern property sales disclosure.

[46] "*Heat Networks Market Study*", p 5, CMA, op cit.
[47] "*Heat Networks Market Study*", p 9, CMA, op cit.

Which?'s report details dissatisfaction over misleading claims about prices made before customers joined heat networks [48], and the CMA reports that for private properties often vague information is given about the heating being "green" or "eco-friendly" with no mention of it being a heat network; prospective social housing tenants often receive little information, with information about heating costs being bundled into utility service costs. Most customers only appreciate that a heat network is a different model of heating once they move in, and even then, the information is often inadequate.

Many owner occupiers only learn they are on a heat network after they have completed the purchase. [49]

We are also concerned that claims about a particular heat network being "green" or "low carbon" are not evidenced or substantiated.

Q23. Do you agree that heat suppliers should be responsible for developing information and guidance for prospective consumers? If yes, what minimum information should be included?

The overwhelming majority of domestic heating customers in the UK use gas, and they are accustomed to the choices that they enjoy due to the operation of the liberalised energy market. We therefore believe that it is necessary for prospective customers to be advised that they would be connecting to a heat network and that they are effectively faced with a monopoly supply.

We also expect any claims of the heat networks decarbonisation credentials, or claims that it will be lower cost, to be evidenced and substantiated.

Q24. How can we ensure new consumers receive or have access to information about the heat network before moving into the property?

We have no view on this.

Q25. Do you agree that the market framework should regulate and enforce the provision of information during residency?

Yes.

Pricing

Q26. Do you agree that the regulator should have powers to mandate and enforce price transparency? Can you foresee any unintended consequences of this?

We believe that, as a question of principle, the regulatory protections afforded to customers of heat networks should not be inferior to the protections enjoyed by domestic customers of the current gas network. We also believe that heat network customers should not pay more for their heating than domestic gas customers, and we therefore support the mechanism used in the Netherlands, where prices for heat networks are capped at the price of gas heating.

[48] "*Turning up the heat: The experience of district heating consumers*", Which?, op cit.
[49] "*Heat Networks Market Study*", pp 65 -66, CMA, op cit.

Nevertheless, in a well-designed, correctly dimensioned, properly implemented and efficiently run heat network, especially one employing a natural gas fuelled CHP, it would be expected in many cases that costs may be less than the comparator costs of gas heating. In these cases, we would expect such savings to be passed onto the customers, and therefore price transparency is necessary for all domestic heat network customers to allow customers to be assured that they are receiving a fair price.

Q27. What are the current barriers to publishing and maintaining accurate information on fixed charges, unit rates and tariffs? What are the main reasons for information on pricing not being available at present?

We have no view on this.

Q28. Do you agree that there should be clear, consistent rules on what costs should be recovered through fixed and variable charges?

Yes.

Q29. Do you agree that the regulator should have powers to undertake investigations on pricing and to enforce directions and remedy actions, where there is sufficient evidence that these could lower prices for consumers?

Yes.

Q30. Do you agree that price regulation in the form of a price cap or regulation of profits should not be implemented at this point in time? Please explain your answer.

We believe that, as a question of principle, the regulatory protections afforded to customers of heat networks should not be inferior to the protections enjoyed by domestic customers of the current gas network. We also believe that heat network customers should not pay more for heat than domestic gas customers, and we therefore support the mechanism used in the Netherlands, where prices for heat networks are capped at the price of gas heating.

Evidence shows that customers supplied by heat networks includes a higher proportion of vulnerable or financially precarious people then in the general population; and they are significantly more likely to be in social housing.

Given that local authorities connecting buildings under their direct or indirect control is one of the anchors of demand for heat networks, the high proportion of customers in social housing is likely to be a sustained trend, and given the residualisation of social housing towards families in more difficult circumstances, then heat network customers are likely to remain, on average, a more vulnerable cohort.

Over four in ten (44%) heat network customers were retired; the equivalent figure for the wider population was only 14%. The survey also identified that among the heat network population, 40%

were classified as vulnerable consumers and roughly a quarter (27%) identified themselves as financially struggling. [50]

Comparing end user prices is more complex than might be expected, due to the UK's heterogenous housing stock, differing energy efficiencies of households, different usage patterns, and the fact that heat networks can rely on diverse technologies; [51] heat networks are often employed in high-rise buildings that do not benefit from a gas supply to individual dwellings, due to both safety and installation cost considerations, so their cost comparator may be relatively expensive electric heating. [52] The report from Which? also observes that the term 'electric heating' can include a number of different technologies, such as electric combi boilers, immersion heaters, storage heaters or heat pumps, which further complicates comparisons.

Compared to individual electric heating, then a heat network may be more efficient, and offer lower prices, thus contributing to the alleviation of fuel poverty. The case with replacing individual gas boilers with a heat network is not so straight forward. Which?'s example compares average costs (based upon the period 2010 to 2016) from gas heating, and a heating network. Entire life costs for gas average at between 9.55 and 11.60 p/kWh; compared to between 5.51 and 14.94 p/kWh for district heating, covering a wide range. However, it needs to be remembered that currently most heat networks in the UK are fuelled by natural gas (Methane) CHPs.[53] The BEIS survey of 2013[54] indicates that this is true of larger district networks, 64% of which are cogeneration systems.[55] It is therefore not surprising that the CMA found that average prices on the large majority of heat networks within their sample were close to or lower than the price of the comparator of individual gas boilers, [56] as gas fired CHP is known to be thermally and energy efficient.

Given the higher proportion of financially precarious and vulnerable customers in the heat network sector, and given the lack of meaningful consumer choice in becoming a heat network customer, then we believe there is a strong case for a price cap. The experience in the Netherlands has been that heat network operators have complained that they are forced to lower prices when gas prices fall, and this may disadvantage them if they do not use gas as a fuel. [57] However, where heat networks are being encouraged as a question of public policy as an alternative and replacement for domestic gas, it is reasonable to ensure that potential operators design their systems so that they do not operate to the financial disadvantage of customers, therefore a price cap based on domestic gas prices is reasonable and proportionate.

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[50] "*BEIS Heat Networks Consumer Survey, BEIS research paper Number 27*", pp 17-18. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/665447/HNCS_Results_Report_-_FINAL.pdf

[51] "*United Kingdom housing energy fact file*", Palmer J and Cooper I, Department of Energy and Climate Change, 2013

[52] "*Turning up the heat: The experience of district heating consumers*", Which?, op cit.

[53] "*Heat Networks Building a Market Framework*", ibid.

[54] "*Summary Evidence on District Heating Networks in the UK*", Department of Energy and Climate Change, 2013, https://www.gov.uk/government/publications/summary-evidence-on-district-heating-networks-in-the-uk

[55] "*Summary Evidence on District Heating Networks in the UK*", Ibid. However, where small communal networks are also taken into account, as they were in the BEIS report in 2013, it showed the average number of dwellings connected to UK heat networks was only 35, mainly in older installations, and only 3% of systems are CHP systems.

[56] "*Heat Networks Market Study*", p 38, CMA, op cit.

[57] "*Heat Networks Market Study*", p 23, CMA, op cit.

Q31. What might cause price regulation to become an appropriate intervention in future? What evidence would be required to demonstrate this?

We believe that, as a question of principle, the regulatory protections afforded to customers of heat networks should not be inferior to the protections enjoyed by domestic customers of the current gas network. We also believe that heat network customers should not pay more than domestic gas customers, and we therefore support the mechanism used in the Netherlands, where prices for heat networks are capped at the price of gas heating.

We believe that price regulation should be introduced as soon as reasonably practicable.

Quality of Service Standards

Q32. Do you agree that consumers on heat networks should have comparable levels of service and protection as consumers in other regulated utilities? How do we ensure the associated compliance costs of such protections remain proportionate?

We believe that, as a question of principle, the regulatory protections afforded to customers of heat networks should not be inferior to the protections enjoyed by domestic customers of the current gas network, and this should also extend to quality of service.

The regulatory framework must provide certainty over required outcomes, in which companies wishing to participate in the heat network market need to utilise their own entrepreneurial creativity to find commercial opportunities to do so profitably. Overcoming the fractured stakeholder landscape in order to allow compliance to a licencing regime is a commercial opportunity for companies to solve.

Q33. Do you agree that minimum standards should be outcome-based to allow the regulator scope to implement these flexibly and proportionately depending on the size and nature of different schemes? Are there other ways these outcomes could be achieved?

Ofgem, has already taken steps in moving from prescriptive rules to outcomes-based principles, and further reforms are being considered. These reforms are not inconsistent with the licencing regime.

Technical Standards

Q34. Do you agree that all new schemes should be subject to minimum technical standards (once developed), given the potential impact on system performance and end consumers?

The heat sector market has a number of distinctive characteristics that strongly require minimum technical standards.

1. It is being deliberately promoted by the government, who are seeking its expansion at the expense of the domestic gas market, which itself is regulated to high technical standards, and which enjoys significant customer confidence.

2. Government support is predicated upon presumption that heat networks inherently provide lower carbon energy at lower cost for consumers. Given the significant financial and practical government support for heat networks, then it is reasonable that the technical credentials are validated.

3. Heat networks are experienced by their customers as natural monopolies.

4. Customers may be compelled to connect to a heat network through local authority zoning and planning requirements; or be effectively compelled to become customers as social housing tenants with limited real choice.

5. Where a heat network is technically deficient, then the customers of that deficient network have no remedy, and even remedial “step in” action through a regulatory body will be expensive, and inconvenient for customers.

6. A disproportionate number of heat network customers are vulnerable, or facing financial difficulties, and underperforming heat networks may contribute to fuel poverty and inequality.

7. Technologies employed in the existing gas market are mature and well established, whereas new and innovative technologies are likely to be considered by heat networks, which should therefore be required to demonstrate that they meet technical standards.

8. The requirement to meet technical standards should be applied to all heat networks, district and communal, and to both ambient networks, and ambient loop networks.

Q35. How could we ensure the impact of minimum technical standards on new small communal networks is proportionate?

All manufacturing companies, whatever their size, are already required to demonstrate conformity to a wide range of minimum technical standards, as part of the cost of doing business, such as, for example, RoHS, WEEE and EMC compliance. Engineering companies that participate in competitive tendering, particularly those tendering for entities bound by the public procurement directive, are already proficient at ensuring regulatory compliance, and at maintaining the technical records to demonstrate that compliance through tendering.

The heat network market includes a relatively small number of large and complex prestige projects, where significant bespoke engineering effort may be required to demonstrate standards compliance. However, new and small communal heating projects are unlikely to be fully bespoke. The core technology behind the heat source, especially where employing mature technology such as CHP, will be effectively off the shelf, and the piping network and HIUs are well understood. Companies tendering to design and install small communal heat networks will be able to spread the costs of compliance over multiple systems.

The project engineering and design requirements for a small communal heat network are well understood, and several companies can offer a turnkey bid, including all necessary consultancy and compliance services, at a competitive price. [58] Small networks, such as ambient loop networks, may be particularly susceptible to the impact of poor design decisions leading to higher customer running costs, [59] and therefore should be regulated by standards for their design and implementation.

However, it should be noted that while standards conformity should be a relatively straightforward exercise for a professional and suitably competent engineering company, that does not mean that such compliance is trivial. Often the challenges will be non-technical, in that the company will provide a system that conforms to the customer's technical requirement, but the technical requirement was derived from an inappropriate functional requirement. This is particularly a problem where the contract is awarded by competitive tender, where tenderers will know that the contract will be awarded on price, even if they have doubts about the specification being asked for.

The CMA has raised the potential concern that a property developer could have the incentive to design and build a network which has cheaper up-front costs at the expense of higher long-run operation and maintenance costs. [60] A communal heat network that is installed by a property developer simply to tick the box of a planning restriction by a local authority may not be suitably dimensioned.

For these reasons, we believe that even for small systems, the suitability of the functional requirement should be independently verified against a minimum technical standard to ensure fitness for purpose, based upon a survey of the buildings and dwellings to be heated, and the analysis of required heating load. The regulatory costs are necessary for customer protection, and to reduce future risk for any operator of last resort that may need to step in for a system that is not fit for purpose. This sector of the market is higher volume, and many of the designs will be similar, and therefore the costs of compliance can be spread over several systems.

Q36. Do you agree that regulated entities should demonstrate they are compliant through an accredited certification scheme?

In principle we believe that the quality of performance of heat networks should be required to meet the same standard as the gas network. However, we do agree with BEIS that the approach of having the UK's National Accreditation Body (UKAS) take responsibility for monitoring organisations offering a certification function is suitable, and would have the advantage that Ofgem would not be required to develop the technical understanding and resources.

We do agree that regulated certification schemes should be mandated to ensure that regulated entities must demonstrate their network was designed and built in compliance with technical standards in order to meet authorisation requirements.

However, in addition we believe that as the government's promotion of heat networks is predicated upon promoting decarbonisation, then the design of networks should be validated against their

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[58] "*Cogeneration, a Users' Guide*", David Flin. The Institute of Engineering and Technology, 2010, pp 55-96.
[59] "*Has Gas had its day*", Berridge R. Installer Online, May 2020. https://www.installeronline.co.uk/gas-day-rob-berridge-takes-look/?fbclid=IwAR2Po_FO8WOmO4A0Ygo5XVX-sxUpv9SaUNqL9rkn6VGKS8-QOAESG32Wl9o#
[60] "*Heat Networks Market Study*", pp 49-50, CMA, op cit.

potential for decarbonisation. The necessary technical expertise for this certification function could also be spread across different monitoring organisations who are accredited by UKAS.

Q37. What do you consider to be the most appropriate approach to setting the technical standards?

We believe that, in principle, an objective of technical standards should be to ensure that customers of heat networks enjoy equivalent performance that domestic customers of the gas network enjoy. In addition, we believe that as government promotion of heat networks is to achieve decarbonisation, then the design of networks should be validated against their potential for decarbonisation.

However, standardisation has other advantages. There is a substantial potential export market for heat network technology, and the sector currently employs around 100000 persons across Europe.[61] Several technology sectors have benefited from standardisation, which promotes customer confidence, and also allows disrupter companies to enter the market.

The aim should be to develop a British Standard (BS) with the export orienated aim of promoting it as a European standard (EN) and international standard (ISO). However, the need for standardisation cannot wait for this relatively slow process, the ADE-CIPSE code of practice is already mandated for systems receiving funding from the Greater London Authority or BEIS and has merit. In parallel with the development of a British Standard, the existing code of practice could be worked up as a Publicly Available Specification (PAS) by the British Standards Institution (BSI). We do believe that this should apply to all networks regardless of size, including ambient loop networks.

The development of technical standards is not a "black box" process, and draft standards emerge as part of an iterative process which involves manufacturers and other stake holders; and manufacturers and system integrators therefore typically work to the draft standards, so that by the time formal standards are adopted, industry best practice has already converged towards it.

We strongly believe that in addition to technical standards for heat network technology, there needs to be a standardised approach to evaluating and validating decarbonisation potential, especially as manufacturers' claims may be optimistic. Given that government support for the expansion of heat networks is to achieve a public policy objective of reducing carbon emissions, and that to achieve this end the government is committed to significant financial support, and also local authority compulsion of consumers to connect to networks, then it is necessary to evaluate whether the public policy objective is actually achieved, it is proportionate to expect that the proposed gain in decarbonisation should be scrutinised, particularly for large district networks that are underwritten by not only public money, but also zoning and other planning compulsion.

District heat systems, like any complex system, generate waste, including solid, liquid and gaseous emissions. The majority of significant district heating schemes include cogeneration, and multiple sources of heat energy. Considerable work has been done by companies, government agencies and researchers to evaluate the waste (including CO_2) of such systems that have multiple inputs and products, but there is no consensus; different methods produce different results, and they are often

[61] *"CODE 2 Cogeneration Observatory and Dissemination Europe"* COGEN EUROPE, http://www.code2-project.eu/wp-content/uploads/CODE-2-European-Cogeneration-Roadmap.pdf, 2015

too complex to convince decision and policy makers of their benefits. [62] It is therefore necessary for the UK to standardise upon a shared analytical approach.

The European Parliament issued a directive in February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market. [63] Also, the European Committee for Standardization (CEN) and European Committee for Electrotechnical Standardization (CENELEC) put forth in 2004 a workshop agreement manual [64] for determination of CHP. These documents are widely accepted for analysing the primary energy savings due to cogeneration.

However, while useful, these European standards and guidance manual are limited to cogeneration systems, rather than more general heat networks, a broader analytical approach is therefore required.

Professor Marc Rosen from the University of Ontario Institute of Technology, and a former President of the Engineering Institute of Canada, has proposed that incorporating thermodynamic analysis as inputs to these European regulations would strengthen them markedly, and also thermodynamic analysis is suitable for other multigeneration systems, such as heat networks.[65]

In addition to thermodynamic analysis, district energy systems can be modelled and optimised using energy equilibrium models. [66] There are several algorithms for their solution, including the well-known Project Independence Evaluation System (PIES) algorithm of Ahn and Hogan. [67] The energy equilibrium model can be set up, formulated, and solved within software called the Waterloo Energy Modelling System (WATEMS). [68]

Many methods can also be used to analyse the economic impacts of implementing heat networks, for example, analysis of the present worth of partial social welfare change or analysis of payback-period: CO2 emission levels, can be introduced into these model systems. [69]

While such thermodynamic analysis and energy equilibrium modelling may seem daunting to non-specialists, this is expertise that can be brought in on a consultancy basis. Large projects would justify a bespoke analysis, and smaller communal projects would be able to use an analysis based upon a generic model, such that the costs could be borne over several systems. If the UK develops a consultancy capability for analysing decarbonisation potential through regulating the heat network sector, then this consultancy sector could anticipate significant export opportunities.

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[62] Rosen and Koohi-Fayegh, pp 185 – 187, op cit.

[63] European Parliament. Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the Promotion of Cogeneration Based on a Useful Heat Demand in the Internal Energy Market and Amending Directive 92/42/EEC. Off J Eur Union 2004;L52(47):50–60.

[64] CEN/CENELEC Workshop Agreement Manual for Determination of Combined Heat and Power (CHP). CWA 45547, European Committee for Standardization (CEN) and European Committee for Electrotechnical Standardization (CENELEC), Brussels; 2004.

[65] Rosen and Koohi-Fayegh, p213, op cit.

[66] Rosen and Koohi-Fayegh, pp 213 - 237, op cit.

[67] "*On convergence of the PIES algorithm for computing equilibria*", Ahn BH, Hogan WW. Oper Res, 1982;30(2):281–300.

[68] Rosen and Koohi-Fayegh, p 238, op cit.

[69] Rosen and Koohi-Fayegh, pp 237-246, op cit.

Q38. Are there examples of the roll out of technical standards or the introduction of compliance schemes which you consider particularly relevant from other markets or technologies?

We believe that a formal technical standards regime is necessary for customer protection, which is particularly important in the heat network market, given the lack of contractual freedom of customers to disconnect, and the fact that the customer base is more vulnerable and financially precarious than the general population.

We believe that arguments must be resisted which claim the cost of standards compliance is unduly burdensome for smaller companies, or for companies implementing smaller, communal networks. The broader arguments in favour of standardisation should therefore be positively considered.

The benefits of standardisation can be seen for various examples. In the telecommunications sector, the TETRA standards for Digital Mobile Radio were developed by a collaboration between manufacturers working through the European Telecommunications Standards Institute (ETSI); and were adopted as European (EN) standards. Standards compliance is demonstrated through testing by independent test facilities, under the auspices of the TCCA (formerly the TETRA Association), which is funded by all major manufacturers and other stakeholders. [70] TCCA has contracted the ISCOM (Istituto Superiore delle Comunicazioni e tecnologie dell'Informazione), laboratory of the Italian Ministry of Communications to act as this outside certification body, to conduct the testing sessions and to issue the certificates. [71]

The model is therefore:

1. Technical standards were drawn up by committees of leading manufacturers' experts, and other stake holders (including state agencies): the manufacturers worked in parallel to develop solutions based upon the draft standards, while at the same time working through the European standards agency (in this case, ETSI) for the formal adoption of a series of standards.
2. Operators of relevant telecommunications systems are authorised by the relevant national regulatory bodies only to operate systems that comply with standards, i.e. the regulatory and technical compliance aspects of standards are conducted by separate bodies.
3. The administration of compliance testing is undertaken by the trade association (in this case, TCCA) of manufacturers, as in a multivendor environment, each manufacturer has a stake in maintaining the integrity of the standards.
4. The technical performance of compliance testing is undertaken by an independently accredited laboratory, testing being paid for by the manufacturers of the equipment being assessed.
5. The accreditation of the laboratory is handled by national standards accreditation bodies, in the UK this is our National Accreditation Body (UKAS)

It should be noted that the TETRA example is based upon an authorisation rather than a licencing model for regulation, and while authorisation is appropriate for the telecommunications sector, we believe that a licencing model is more appropriate for heating networks.

[70] "*Digital Mobile Telecommunications and the TETRA System*", Dunlop, Girma and Irvine, Wiley, 2000,
[71] https://tcca.info/interoperability/tetra-interoperability-certificates/, TCCA, website recovered May 2020.

As a result of this standardisation, the TETRA system gained a huge competitive advantage and much greater international market share compared to technically equivalent systems, such as the French TETRAPOL, or American APCO25 technologies, which remained proprietary. In addition, in a market that had traditionally been dominated by a few, large multinational companies, ability to demonstrate standards compliance allowed sufficient customer reassurance for the relatively small British company, Simoco, to secure a majority of UK police radio sales.

Another example of standards successfully supporting innovation is the regulatory regime for cosmetic products [72] where a Cosmetic Product Safety Report must be conducted by a competent testing body and registered through the Cosmetic Products Notification Portal (CPNP). This not only provides a level playing field for cosmetic manufacturers of all sizes, but allows start up and disrupter companies to enter the market through a relatively inexpensive and clearly understood route, and gain product accreditation and safety testing that can be verified by potential customers. The technical aspects of gaining testing and compliance have created a commercial opportunity for the provision of specialist consultancy, often offered by the same companies who provide wholesale raw materials for the cosmetic industry, and at relatively low cost: an example of such a company offering both cosmetic ingredients and consultancy is the Soap Kitchen.

Rights and powers

We take no view on Q39, Q40, Q41 or Q42.

Access rights

We take no view on Q43, Q44, or Q45.

Street works

We take no view on Q46 or Q47.

Rights to lay pipes under the roadway

We take no view on Q48.

Permitted development

We take no view on Q49 or Q50.

[72] REGULATION (EC) No 1223/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

Consultation rights

We take no view on Q51 or Q52.

Linear obstacle rights

We take no view on Q53.

Decarbonisation of heat networks

Q54. Do you agree that consumers should have access to information on the energy performance and percentage of low-carbon generation of their network?

Yes, we do agree that this is useful. Given that government support for the expansion of heat networks is to achieve a public policy objective of reducing carbon emissions, and that to achieve this end the government is committed to significant financial support, and also local authority compulsion of consumers to connect to networks, then it is necessary to evaluate whether the public policy objective is actually achieved, it is proportionate to expect that the proposed gain in decarbonisation should be scrutinised, particularly for large district networks that are underwritten by not only public money, but also zoning and other planning compulsion.

However, for this to be meaningful, the information provided needs to be data of high quality. There is a danger, particularly we have observed with the heat pump industry, of manufacturers' sales froth being treated as good coin.
Information provided should therefore clearly state the basis of the calculation, and should also not conflate overall system efficiencies with efficiencies for each individual customer.

Q55. Do you agree that regulation is necessary to encourage decarbonisation of heat networks over the period to 2050? Are there alternative means by which government could act to support the decarbonisation of heat networks?

We are concerned that an evidence-based approach towards meeting global decarbonisation targets by 2050 is in danger of being crowded out by emotional pressure from lobby groups, with escalating demands that disregard feasibility, cost effectiveness and proportionality.

Earth's environment involves a complex carbon lifecycle, and to achieve net zero it is not necessary to drop emissions to nothing, it is necessary to reduce them to the level where photosynthesis and plant growth can absorb them. Some use of fossil fuels is unavoidable, for example, natural gas is a vital raw material for producing nitrogen fertiliser, without which the supportable world human population would be 40% lower. Steel making is responsible for 10% of greenhouse gases, which requires coke as a raw material, and poverty can only be addressed in developing countries by expanding steel production. Rice production is one of the largest producers of greenhouse methane emissions, but feeds millions.

We are concerned that there is an ill-considered conflating of two objectives, energy efficient heat networks, and decarbonisation, that should be regarded as separate and complementary. The overall energy savings from a natural gas fuelled CHP feeding a heat network may be superior to the energy savings contributed by, for example, a water sourced heat pump network, especially where the heat pump will not be able to rely solely upon renewable energy.

Back in 2004, two climate scientists from Princeton, Stephen Pacala and Robert Socolow, published a paper in the journal, Science, [73] which recognised that to prevent anthropogenic climate change it is necessary to reduce emissions and keep them low: the divergence between the projected growth of emissions achieved by "business as usual", and the flat path achieved by mitigation, they described as the "stabilization triangle". Given the immense scale of the task, they proposed that the stabilisation triangle should be conceptualised as several complementary smaller wedges, each of which would reduce carbon emissions by one billion tonnes of carbon, and each of which represents a different contribution to decarbonisation, for example the installation of one million 2 MW windfarms to replace an equivalent capacity of coal fuelled electricity generation would comprise a "wedge", and the tripling of the world's nuclear fission capacity would comprise another "wedge".

It is not necessary to agree with the precise quantification of the goal, or with the balance of the different mitigation strategies, and Princeton University's Carbon Mitigation Initiative explores different options. [74] However, the strength of the technique is that not all eggs are in the same basket. Three of the conceptually distinct wedges comprise: increasing the contribution from renewable electricity and fuels; improving energy efficiency and conservation; and switching to lower carbon fuels. All of these strategies can be employed through the implementation of district networks.

Flin argues that the following strategies can be employed to reduce the carbon impact of power generation: [75]

- *using renewable energies that generate electricity with a minimum of emissions;*
- *switching from high to lower CO2-emitting fuels (such as replacing coal with gas);*
- *using carbon sequestration, which collects and stores CO2 to prevent it from entering the atmosphere;*
- *using energy conservation, which reduces the energy required to produce the effect; customers buy energy for what it can do rather than for the energy itself;*
- *using cogeneration, sometimes called combined heat and power (CHP), which improves the efficiency of energy produced. As a result, the use of cogeneration means that less fuel is used, and therefore fewer emissions produced, in generating the same amount of energy. Cogeneration produces more energy from less fuel.*

It is therefore concerning that the BEIS consultation document for heat networks does not explicitly acknowledge the contribution from cogeneration, nor recognise that natural gas employed with cogeneration is a particularly efficient mechanism for producing usable heat. This contrasts with the European framework, where legislation has included specific measures to encourage the wider use

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[73] https://cmi.princeton.edu/wp-content/uploads/2020/01/Stabilization_Wedges_-Solving_the_Climate_Problem_for_the_Next_50_Years_with_Current_Technologies_Science.pdf , Pacala and Socolow, Science vol 305, pp 968-972, 2004.
[74] https://cmi.princeton.edu/about/ Princeton University's Carbon Mitigation Initiative, retrieved May 2020.
[75] Flin, p11, op cit.

of high-efficiency CHP in the EU since 2004, when the CHP Directive 2004/08/EC was introduced as a measure for improving security of supply and energy efficiency. [76]

The BEIS consultation document tilts towards an excessive and overly optimistic emphasis on renewables, without recognition of the huge challenges in seeking to both fully decarbonise electricity generation, while simultaneously shifting both domestic heating and motor transport towards electricity.

According to BEIS: "*As we move towards 2050, we know that meeting our climate targets will require a transition from gas-fired networks to lower carbon alternatives such as large heat-pumps, hydrogen or waste-heat recovery*". [77] There are a lot of assumptions in this statement that are open to challenge, and the impact on consumer heating costs may be substantial. Based upon reasonable engineering assumptions, it is estimated that shifting 20% of domestic heating from individual natural gas boilers to electric powered heat pumps would also require additional electricity generating capacity, estimated at £28 billion. [78] Both the new electricity capacity, and the write-off of gas industry capital have to be factored as energy inputs into the overall Energy Return on Energy Investment (EROEI) for heating networks.

There is also no recognition that natural gas employed in the current network for domestic supply, used in space heating, hot water and cooking, is itself efficient, using a clean, cheap and convenient fuel, and that natural gas is the lowest carbon fossil fuel. Given that district networks will not be universally fuelled by renewables, then it cannot be reliably assumed that they will be result in a lower carbon outcome than would be achieved by maintaining the current domestic gas endowment, particularly if domestic consumers were encouraged to modify their usage patterns, and with the future expansion of biomethane, and potentially hydrogen into the supply. Given the contribution that natural gas makes to affordable heating, it is likely that a wholesale decarbonisation of domestic heating at the point of use would result in increased fuel poverty and inequality.

It should also be noted that decarbonisation at point of use, by removing natural gas from direct use in heating in favour of heating powered by electricity generated elsewhere, is not necessarily the same as decarbonisation at a system level. For example, Dr Andrei Ter-Gazarian, senior research associate for Moscow Power Engineering, has recently advocated using electric powered heating in heat networks as a mechanism for replacing natural gas by cheaper coal, which would actually increase carbon emissions by conscious design. [79] Generally, such global context of decarbonisation needs to be considered when asking for financial sacrifices from UK consumers.

We are therefore opposed to a policy presumption that decarbonisation of heat is inevitable, when other social and economic changes could be used to provide equivalent greenhouse gas reductions, without passing dramatically higher costs to domestic consumers.

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[76] *"CODE 2 Cogeneration Observatory and Dissemination Europe"* COGEN EUROPE, op cit.

[77] "*Heat Networks Building a Market Framework*", p75, op cit.

[78] "*Transition to heat pumps for domestic heating, a critical evaluation*", anewman consulting, unpublished report for GMB trade union, 2020.

[79] "*Energy Storage for Power Systems, 3rd Edition",* Ter-Gazarian A., p250, The Institution of Engineering and Technology, 2020.

Waste-heat sources

Q56. How could the Environmental Permitting Regulations be amended to ensure that waste-heat sources connect to networks when it is cost-effective and feasible to do so? What do you consider are the main barriers for waste heat sources to be connected to heat networks?

While there is a legitimate public policy objective of preventing industrial heat from being wasted, providing input into heat networks is not the only mechanism for using that heat. COGEN EUROPE observes that: [80]

> *[The] United Kingdom [has] a large share of industry where steam is an important energy carrier, such as oil refineries, chemicals, pulp and paper, and food and beverages. Within those sectors, where steam is dominant, there is a large potential for CHP.*

Where the waste heat is generated sufficiently proximate to buildings that need heating, then the heat could be fed into a district network, however, COGEN EUROPE are correct that the steam could instead be used for bottom cycling electricity generation, directly using the steam to drive a turbine. This may well be a more thermally efficient use of the waste heat than input into a heat network. For example, the Daily Telegraph recently reported on the scope for bottom cycled CHP from hospital waste heat. [81]

Using industrial waste heat for bottom cycled cogeneration has the advantage that it is far easier to carry electricity for long distances than heat, and therefore the industrial processes can be further away from urban areas.

Any proposed modification to environmental regulation should therefore consider whether the alternative option of bottom cycled cogeneration is feasible before promoting waste heat sources being connected to a heat network.

Q57. Which sources of industrial and commercial heat could government bring within the scope of the Environmental Permitting Regulations in addition to the sources already being identified?

In a minority of cases, waste heat will be generated at a sufficiently high temperature, and with sufficient regularity, to be directly fed into a heat network, more typically though, for example the Marstal system in Denmark [82], or the Islington system in London, [83] waste heat is stored in a Thermal Energy Store (TES) and then retrieved and stepped up to a useful temperature by a heat pump. It is reasonable to assume that the heat pumps will often be powered by electricity from non-renewable sources, therefore, as the study by Buro Happold for the Mayor of London observes "*the*

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[80] *"CODE 2 Cogeneration Observatory and Dissemination Europe"* COGEN EUROPE, op cit.
[81] "*Forget Wind Turbines, here's how we can meet net zero, without derailing the economy*", Paterson O., Daily Telegraph, 4th March 2020, https://www.telegraph.co.uk/news/2020/03/04/forget-wind-turbines-can-meet-net-zero-without-derailing-economy/?WT.mc_id=tmg_share_em
[82] Rosen and Koohi-Fayegh, pp 130-131, op cit.
[83] Heat Networks Investment Project: Case study brochure, BEIS, 2018.

carbon intensity and cost of secondary heat sources are linked to those of the electricity grid". [84] One study based on Danish experience shows that heat pumps are an effective mechanism for addressing intermittency issues created by incorporating renewables sources into a district network.[85] Where heat pumps are used specifically to address gaps in renewably sourced electricity, then inevitably they will be using electricity generated by non-renewable sources.

An overall system evaluation therefore needs to look at the performance of the heat pump, this is even more the case where the heat pump is not retrieving stored waste heat from a TES, but using an ambient water, ground or air source. The well understood performance factor, COP, is the measure of heat pump efficiency. Typically, heat networks currently use CHP, usually gas fired, so when promoting the decarbonisation of heat networks, to remove gas fired CHP and replace with waste heat stepped up by a heat pump, it is necessary to consider the relative thermal efficiency of cogeneration compared to heat pumps.

Rosen and Koohi-Fayegh argue that to properly evaluate the performance characteristics of any system it is insufficient to carry out an analysis based only on energy inputs and outputs, rather it is necessary to carry out a thermodynamic (or exergy) analysis [86] which takes into account the temperature at which the heat output is produced. [87] For district heating, it is the usefulness or quality of an energy quantity, rather than simply the energy quantity itself, that is of value. For example, the heat rejected from the condensers of an electrical generating station, although great in quantity, is of little usefulness since its temperature is only a few degrees above that of the surrounding water or air (i.e., the thermal energy is of low quality). [88]

In non-technical terms, how well a cogeneration plant performs depends upon how much useful heat is produced, at what cost in lost electricity production, compared to an equivalent generator not also being used for heating. More technically: modelling a cogeneration system produces a coefficient of performance, COP_{CHP} , as a function of the heat product output and the degree to which the electricity output is curtailed. [89] COP_{CHP} can be compared to COP of a heat pump, in the special case where electricity production is curtailed 100%, because a heat pump does not generate electricity. This is useful as it allows direct comparison between the thermodynamic performance of a heat pump and of a cogeneration system.

> *This measure of performance treats the cogeneration plant as a heat pump in that a cogeneration plant in general foregoes electrical output to produce useful heat, while a heat pump uses electricity to produce useful heat.* [90]

It is worth noting that, for gas turbine and diesel engines, very little electrical output is curtailed in order to produce useful product heat, so in layperson's terms: for a gas turbine cogeneration plant,

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[84] "*Secondary Heat Study- London's Zero Carbon Energy Resource*", BuroHappold, (2013),: https://www.london.gov.uk/sites/default/files/gla_migrate_files_destination/031250%20GLA%20Secondary%20Heat%20-%20Summary%20Report_0.pdf

[85] "*Towards an intermittency-friendly energy system: comparing electric boilers and heat pumps in distributed cogeneration*". Blarke MB. Applied Energy, 2012; 91(1):349–65.

[86] Rosen and Koohi-Fayegh, *ch2, Thermodynamic analysis: fundamentals, energy and exergy*, pp 9-48, op cit.

[87] Rosen and Koohi-Fayegh, p109, op cit.

[88] Rosen and Koohi-Fayegh, p37, op cit.

[89] Rosen and Koohi-Fayegh, p89, op cit.

[90] Rosen and Koohi-Fayegh, p90, op cit.

you get the useful heat for more or less nothing. This is because the less the potential electrical product is curtailed for a given output of useful heat, the better the COP_{CHP}. This could be described technically such that: where the curtailing of the electrical output tends to zero, then COP_{CHP} increases and asymptotically approaches infinity. [91]

Although outside of the scope of the current consultation, it is notable that the thermal efficiency, COP_{CHP}, of a domestic micro-cogeneration unit may therefore be superior to the efficiency of a heat pump, COP. Micro cogeneration replaces a domestic gas heating boiler with a sterling engine generator that also uses natural gas as fuel, but which produces electricity as well as heat. The UK's 2006 budget made an extra £50 million available to micro-cogeneration under the Low Carbon Building Programme, [92] and it was anticipated that replacing domestic gas boilers with micro cogeneration CHP, as each boiler reached end of life, could cut the typical household energy bill by £150 a year and reduce CO_2 emissions from the household by up to 1.5 tonnes per year. This approach would conserve the domestic gas supply infrastructure, and the gas service industry. The Micro cogeneration unit commercially available from Helec operates, according to its specification, [93] with up to 95% system efficiency.

The distinction made by Professor Rosen is an acute one. Cogeneration **produces** electricity and heat from given fuel inputs, and the efficiency is a product of the curtailing of the potential electrical output in order to create the heat output. In contrast, a heat pump **consumes** electricity that is generated in a separate process.

The electricity consumption of the heat pumps must therefore also factor in the efficiency of its generation and transmission, especially where the electricity used by a heat pump is not from renewable sources, It is reasonable to compare the overall efficiency of the electricity generation and transmission as well as the heat pump itself; compared to the efficiency of a comparator domestic gas boiler, and its supply network. Modern domestic gas boilers for space heating and hot water are rated at around 97% efficient, whereas an efficient combined cycle gas turbine(CCGT) generating electricity would achieve a combined efficiency of the gas and steam cycles of just over 60% [94]; while transport losses (using natural gas to power compressor stations on pipelines) are typically just 2 to 3% for gas, compared to energy loss on high voltage electricity transmission lines of 6 to 7%. [95]

In considering waste heat sources for heat networks, the overall thermal efficiency of gas fired CHP should not be overlooked, which may actually achieve a superior outcome.

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[91] Rosen and Koohi-Fayegh, p92, op cit.
[92] Flin, pp50-51, op cit.
[93] Webpage, Sterling Engine CHP, Helec, https://helec.co.uk/products/stirling-engine-chp/, retrieved May 2020.
[94] "*Natural Gas, Fuel for the 21st Century*", Vaclav Smil, p85, Wiley, 2015.
[95] Smil, ibid, p58.