

Heat & Energy Efficiency Strategies, and Regulation of District Heating

Response to Consultation from the Heat and the City Research Team, University of Edinburgh

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Q1. Do you agree that local authorities should have a duty to produce and implement a Local Heat & Energy Efficiency Strategy (LHEES) as outlined above? Please explain your view.

Discussions of the Short life Working Group on Regulation of District Heating (DH) and the Inverness and Edinburgh public consultation events on Local Heat & Energy Efficiency Strategies (LHEES) and regulation of district heating, which we convened on behalf of Government, generated broad agreement that local authorities (LAs) should have a duty to produce and implement a LHEES.

Main reasons are:

- The urgent need for comprehensive, sustained action at area scale to reduce the use of energy in buildings, and to advance the decarbonisation of heating, in line with Scotland's climate change mitigation targets and goals for affordable warmth and energy security.
- The need for local and regional political leadership to raise the public profile and priority of local heat and energy efficiency and DH
- LAs are critical to such action, because of their local democratic role, knowledge of locality, planning powers and related duties, and their key cross-sector coordinating and enabling role.
- LAs have the necessary long term commitment to the area
- LAs are broadly trusted by the local population
- LAs have responsibilities for local economic development and regeneration, and the motivation to create jobs and attract businesses to improve LA revenues.
- Implementation of comprehensive LHEES can contribute significantly to local economic objectives for employment, skills development and business investment
- A statutory duty is needed because the current voluntary arrangements do not create the necessary obligation for comprehensive action, and because the duty would provide the missing basis for allocation of sufficient local resources, including changes in central government funding for local authorities.

Care must however be taken to ensure that a new LHEES duty is not treated simply as an additional, centrally imposed, burden, to be dealt with as a low priority after other responsibilities have been met. It must also be introduced as a means of supporting, enabling and extending, rather than duplicating, other duties in relation to Local Development Plans, housing, existing planning and building regulations,

fuel poverty and climate change.

However, development of LHEES cannot be understood as *solely* a local issue because what happens with heat locally will increasingly have impacts beyond the local level. To date, energy efficiency and low carbon heat interventions have had significant impacts on the buildings receiving them, but have been marginal in relation to the wider energy system. The draft Climate Change Plan suggests energy efficiency in domestic buildings will continue to have a marginal system-level impact, reducing demand for energy by only about 6% by 2032. (Though other analyses may well contest this as too limited. Government analysis of decarbonisation of the German building stock, generally regarded as more energy efficient than the UK's, suggests at least a 36% reduction in final energy demand is required for their targets, and a 54% reduction is the technical limit.¹) For sustainable heat, as the consultation notes to date district heating schemes have been small relative to heat demand in Scottish districts (and are better described as heat networks serving a handful of buildings under single ownership). Renewable heat deployment has increased with RHI support, but nonetheless represents a small proportion of heat for buildings and has had little impact on incumbent gas or electricity systems. In both the draft Climate Change Plan and this consultation the Scottish Government expresses its intention that low carbon heat deployment be accelerated to a far more significant scale. This will have a number of implications:

- Widespread deployment of low carbon heat will have impacts on the wider energy system. Presentation by Robert Sansom at Imperial college (and others subsequently) of the scale of heat demand compared with electricity demand² has led to a shared understanding among policy makers that simple “electrification” of heat will create significant cost for the future power system. While heat electrification (including deployment of heat pumps) remains marginal, these effects can be ignored from the perspective of energy system management. As penetration becomes more significant, interactions become more acute and, for example, the levelised cost of heat for the next building to convert to a heat pump may be significantly higher than it was for the first building, reflecting the aggregate costs to the power system. However, electricity is not the only example of interactions with heat

¹ BMWi (2015) *Energy Efficiency Strategy for Buildings: Methods for Achieving a Virtually Climate-Neutral Building Stock*, Federal Ministry of Economic Affairs and Energy, Berlin, available: <http://www.bmwi.de/Redaktion/EN/Publikationen/energy-efficiency-strategy-buildings.html> [accessed 10 Feb 2017].

² Sansom, R. (2014) *Decarbonising Low Grade Heat for a Low Carbon Future*, PhD thesis, available: <https://spiral.imperial.ac.uk/bitstream/10044/1/25503/1/Sansom-R-2015-PhD-Thesis.pdf> [accessed 13 Sep 2016]. See, for example, chart 2 of DECC (2012) *The Future of Heating: A Strategic Framework for Low Carbon Heat*, available: http://www.decc.gov.uk/en/content/cms/meeting_energy/heat_strategy/heat_strategy.aspx [accessed 11 Apr 2012].

changing with increasing deployment. The marginal availability of bioenergy resources for heating is likely to change with greater use of bioenergy, both for heat and non-heat applications. The deployment of large-scale heat pumps connected to district heating could be significant to making use of intermittent renewable electricity generation. Declining use of the gas network would mean fixed costs would be spread over fewer units of energy and fewer users meaning cost per unit/user would increase.

- The implications of LHEES in a local authority area cannot, therefore, be understood in isolation from all the other LHEESs and the broader energy strategy. LHEES development requires analysis of the aggregate impact of all LHEES visions across Scotland. That is, Scottish Government (or some other nation-wide body) needs to provide more than methodological guidance and scrutiny to local actors: it must also share responsibility with local actors for understanding the impacts of LHEES plans in the context of other LHEESs and the wider energy strategy. This function could be invested in a Scottish Energy Company (along the lines of a national energy agency), which could potentially be jointly owned by local authorities and Scottish Government to support coherence across levels and mutual commitment.

Here is one approach that could be taken to develop LHEES as shared responsibility between national and local actors.

1. The first part of developing LHEES would be to establish a long-term area-based vision for heat supply technologies in the LHEES area. To build in understanding of energy system-wide impacts of different choices, these visions would initially be constructed (in draft form) using the Scottish TIMES model and the heat map. This vision will show some areas of uncertainty where it isn't clear *at this stage* what the appropriate technology will be in the long run, but other areas would be identified more clearly as suitable/unsuitable for particular approaches (see below).
2. Local authorities (or regional bodies if appropriate) receive these long term visions as proposals from SG. Local actors analyse them in light of local knowledge (including envisaged changes to local settlement/land use patterns, existing heat/carbon/energy plans, local obstructions to infrastructure, etc.). During this process the long term vision would be modified through agreement between LA and Scottish Government. The process would be iterative as Scottish Government would assess the impact of changes to each LHEES against the wider modelling framework.

What would a LHEES long-range vision look like? If its timescale is 20 years and it is established in 2020, its end point will already be eight years after the date by which the draft Climate Change Plan suggests 80% of domestic heat is supplied by low carbon technologies. We may as well imagine, therefore, LHEES setting out a vision for 100% conversion to low carbon technologies by the end of their period.

However, due to system interactions and a range of uncertainties, it will not be possible to state with certainty in 2020 how every building in an area will be heated

in 2040. This could be handled by constructing a range of analytic scenarios which would identify optimal heat supply configurations according to different assumptions for critical variables (such as the success or failure of CCS). By generating multiple scenarios, areas where the optimal choice of technology (in socioeconomic terms) is robust against different plausible assumptions could be identified. These areas would be labelled as 'no regrets' choices for that technology, while other areas which are allocated to the technology in some but not all scenarios would be identified as 'uncertain'. Figure 1 illustrates what this could look like for use of zero-carbon gas Edinburgh using data from the Scottish Heat map, (zones have been selected on the basis of heat density analysis and an arbitrary definition of where a technology might be viable or not – the purpose of the figure is simply to illustrate how development of a long-term vision in LHEES might work, rather than to make any specific proposals about either Edinburgh or zero-carbon gas).

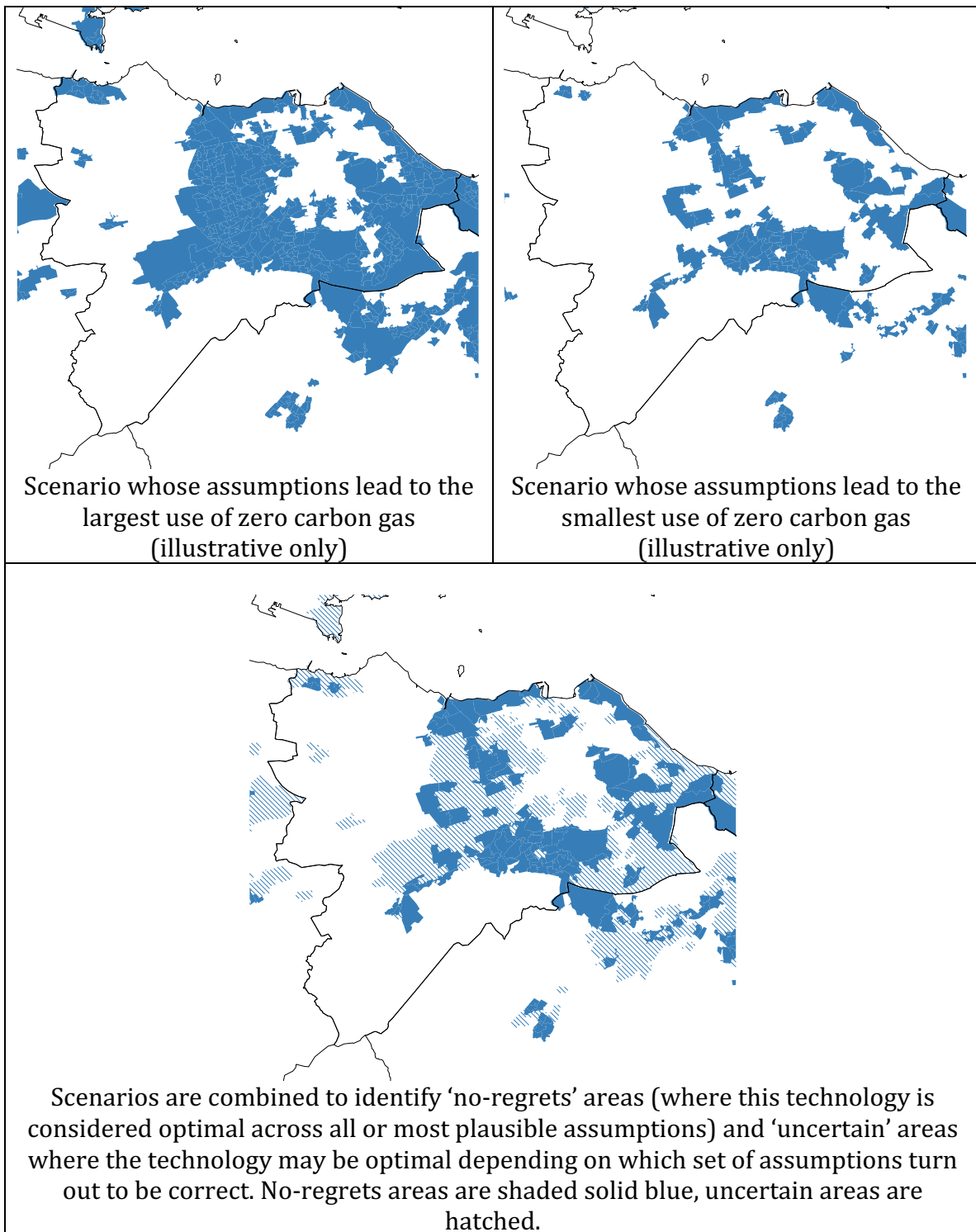


Figure 1. Illustration of how a long-term (20 year) vision for heat supply technologies could be developed. In this case (blue) use of zero carbon gas is considered.

Figure 2 goes on to combine long-range visions for different technologies. LHEES of this form would allow local authorities and other actors to align their understanding and expectation of how heat supply in their area would be comprehensively

decarbonised. The plots in these figures are only illustrative, but the LHEES visions, by extending across whole territories, should aim to broaden actors' understanding beyond near-term or organisation-specific opportunities.

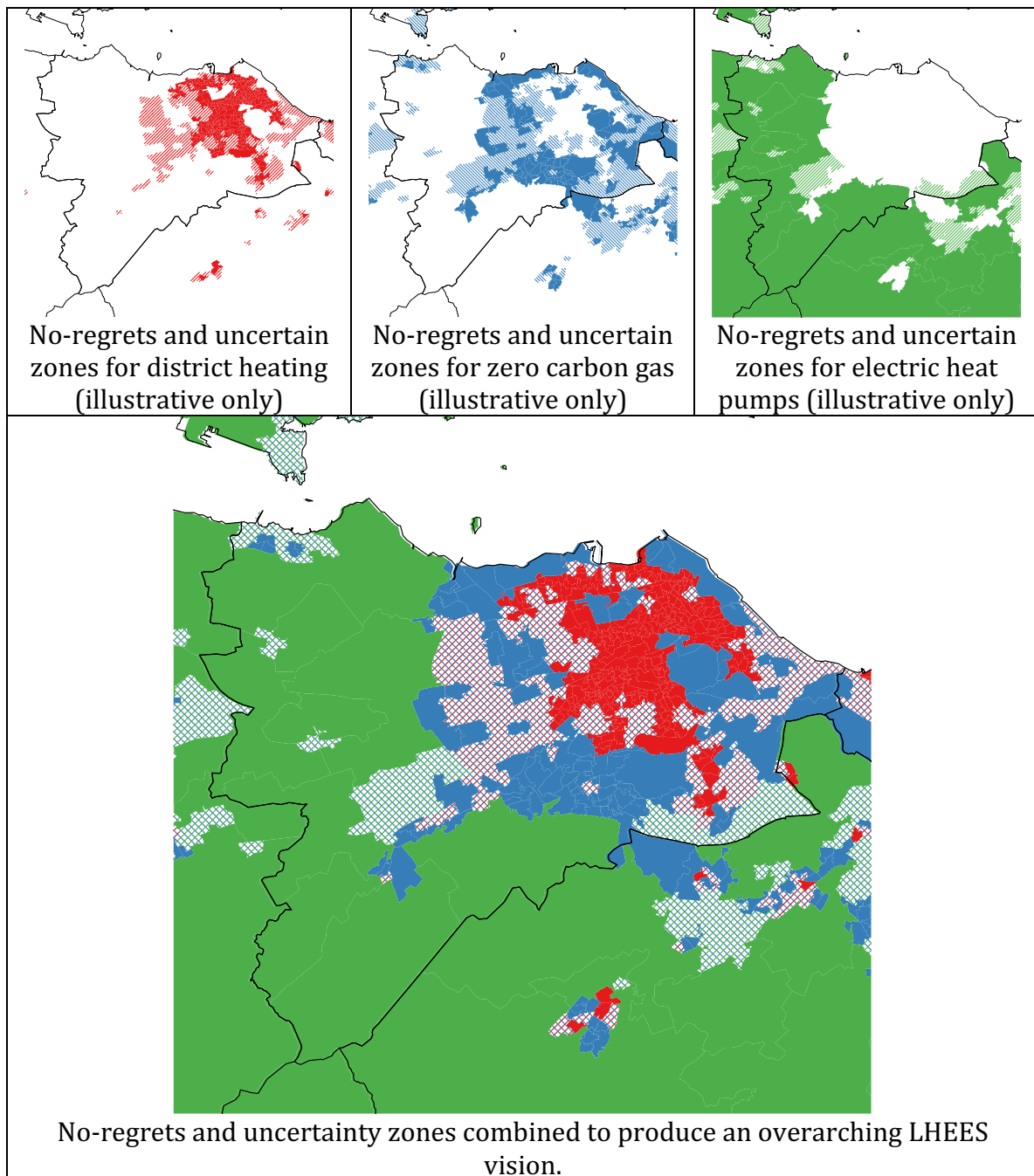


Figure 2. Illustration of how a long-term (20 year) vision for heat supply technologies could be developed. Here district heating, zero-carbon gas and heat pump zones (both 'no regrets' and 'uncertain' zones) are superimposed to create a single area-based vision.

LHEES may end up setting out very significant changes to local infrastructure configurations. The consultation document notes there is a balance to be struck between the resources needed for LHEES development and for delivery of the

programmes identified in the strategy. However, LHEES will potentially have very significant widespread impacts on local communities, both in terms of energy supply to their buildings, but also the local impacts of developing new infrastructure, the creation of new local business opportunities, and potentially compulsory changes to heating. So far LHEES have been discussed in small expert forums and in this consultation. To build legitimacy for the content of the strategies, it will be important to open up their development to meaningful local public consultation.

LHEES development will need to be sensitive to a range of uncertainties, including technology development, skills and supply chain development and the evolution of relative costs. LHEES could also be positioned as a means of addressing these uncertainties by creating mechanisms to plan area-based pilots/experiments to reveal/drive down costs of different options. For example, one limiting factor in building-scale heat pump deployment is the lack of trained installers: most heating engineers work in specific areas and see little benefit investing in heat pump skills as demand is so low compared with gas boilers. Heat pump zones (with adequate policy support) could contribute market-pull for skills development and other supply chain improvements.

The creation of LHEES should also serve to broaden understandings of how heat is expected to develop in local areas. To date sustainable heat initiatives have largely focused on assembling opportunities within peculiar niches in the incumbent system (such as the difficulty running gas pipes through multi-storey flats). The development of LHEES represents an opportunity to move beyond this incremental approach, away from constructing projects principally by reference to existing energy systems and towards an approach that understands near term activity as contributing to the coherence of future systems.

Q1b. What are your views on the appropriate geographical scale for the preparation of LHEES? Should each local authority produce a single strategy for its area, or would it be possible for local authorities to work together to prepare strategies jointly for a wider area?

The LHEES needs to address low carbon heat and energy efficiency improvements for every building in the LA area. There are however likely to be areas where regional strategies are most effective for integrated action on energy efficiency and heat infrastructure. This could include smaller councils working with a larger LA or a number of smaller councils collaborating, and/or a logic based on economies of scale in low carbon heat infrastructures such as heat networks, where major heat loads may cross LA boundaries.

Below are some specific examples and suggestions for organising cross-LA working:

- Greater Glasgow is potentially the site of new integrated infrastructure developments that cross local authority borders. Figure 3 represents a rough

analysis based on heat density of demand in the Greater Glasgow settlement³. A significant cluster of high density heat demand is situated to the north of the Clyde, but there may also be areas suitable for district heating in Paisley (Renfrewshire), Bearsden and Milngavie (East Dunbartonshire). Furthermore, depending on the degree of penetration of district heating these areas outside Glasgow City Council could link in with a city centre network. For Glasgow, then, while near term opportunities for heat network development are likely to focus on the city centre, the long term strategy should be coordinated with neighbouring authorities to ensure coherence in heat network development.

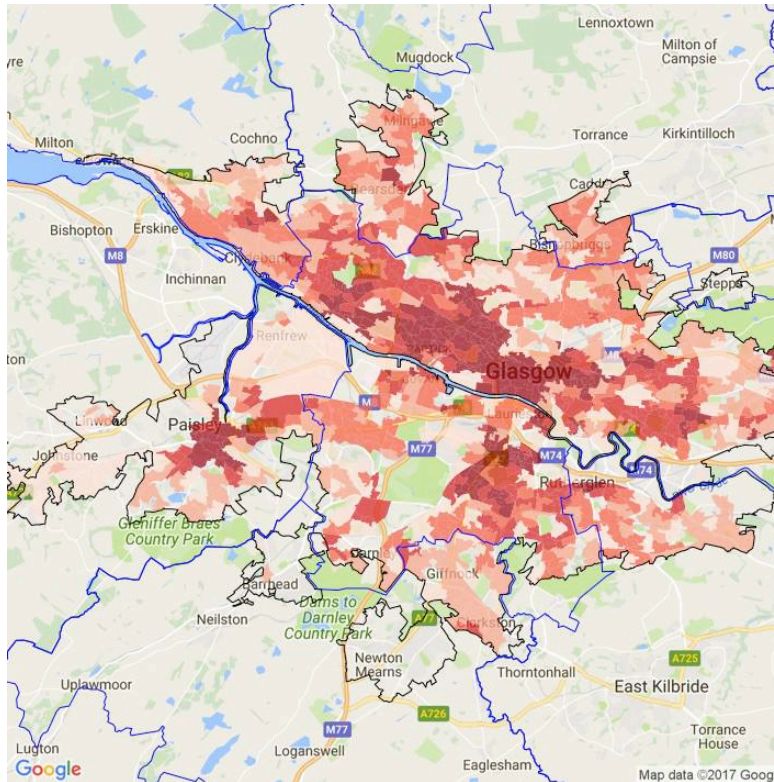


Figure 3. Heat density plot based on data zones within the Greater Glasgow settlement representing Scottish heat map data. Colours correspond to zones whose heat density crosses a particular threshold. Thresholds are set by reference to all of Scottish heat demand to represent 10% (darkest red), 20%, 30%, 40% and 50% (palest red) of total heat demand. So if, for example, 30% of Scottish heat were connected to district heating solely on the basis of heat density all zones in the first three grades of red would be district heating zones. The boundary of Greater Glasgow settlement is shown in black, and local authority borders are in blue.

- From a district heating perspective there is also a need for coordination between Edinburgh and its neighbours. If, as the energy strategy assumes, bioenergy power generation with CCS is developed in Scotland, consideration should be given to locating a power station at the site of the old Cockenzie

³ Thresholds are set by reference to all heat demand in the Scottish heat map and represent 10%, 20%, 30%, 40% and 50% of overall heat demand. This is a very rudimentary analysis and is presented just to illustrate what might happen with LHEES development.

coal-fired generator (existing grid connections, access to North Sea for sequestration, coastal location can accept biomass shipments, and proximity to Edinburgh creates opportunity for significant heat off-take). A new energy from waste facility is being developed at Millerhill as a joint project between Edinburgh and Midlothian, and both councils have ideas for how the heat could be used. An early priority for LHEES in this area could be to ensure both authorities regard the Millerhill plant as one node in a more extensive system, rather than as a limited heat source over which they are in competition.

- By comparing the spatial distribution of heat demand across different densities, we can categorise LA areas as either having generally higher heat density than the whole of Scotland, as having similar heat density, or as having lower heat density (Figure 4). This kind of rough analysis could be the starting point for exploring similarities in the issues different LAs face and establishing joint approaches where possible. For example, LAs with generally lower heat density there may be considerable opportunities for joint working on supporting, for example, deployment of heat pumps. This kind of division of effort may also help concentrate resources on areas where impacts are likely to be greatest and foster learning that can then be used elsewhere (in this example, urban authorities might put relatively less effort during early years into supporting heat pumps, relying on future spillovers from the work in less dense areas).

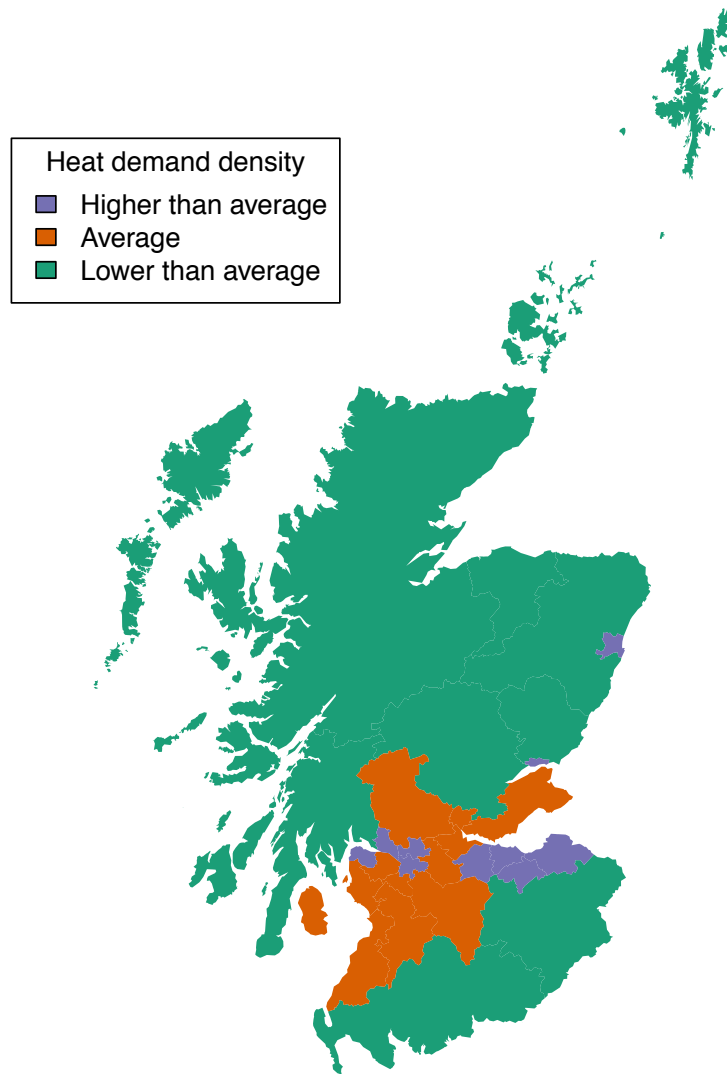


Figure 4. Scottish local authority areas categorised by their distribution of heat demand across heat density.

The consultation recognises that preparation of LHEES requires both dedicated staff time and specific technical skills. Some authorities already hold some of these in-house, but most do not. Local authorities and Scottish Government should consider establishing a support unit, perhaps as a jointly owned entity, to facilitate establishment of shared capacities for LHEES development. Such a body could draw on existing structures and programmes established by the Heat Networks Partnership, draw on local authorities' in-house expertise (e.g. through secondments) as well as contribute to other aspects of heat policy which similarly cut across local and national issues. For example, a recent report to the Scottish Cities Alliance argues that the best way for local authorities to handle energy statements submitted to planning authorities by major developments would be establishment of a central advisory service. Similarly where LHEES development requires procurement of external services, the problems arising from 32 authorities simultaneously seeking to procure the same consultants could be avoided by

establishing a joint procurement scheme (for example, building on the District Energy Procurement Agency proposed by practitioner Michael King and inspired by the Swedish Varmek model).

However, while partnership working and joint effort will be important, it will also be critical to maintain a close link between LHEES and local government. The implementation side of LHEES in particular will interact with processes at a local authority scale. Area-based energy efficiency programmes are already managed by local authorities, and issues such as street breaking are embedded in council departments. (Street breaking is important both to mitigate the impacts of new construction development, but also for the local authority to identify opportunities to find synergies between heat infrastructure development and other works. For example, had it had a clear LHEES in place, Edinburgh Council may have been able to build significant enabling infrastructure for district heating at the same time as streets were excavated for the new trams.)

Q2. Do you agree with the proposed scope and content for LHEES? In particular do you agree LHEES should (a) set targets for energy efficiency and decarbonisation and (b) include a costed, phased delivery programme that will meet local targets? Please explain your views.

We agree with proposed scope and content, including (a) setting targets for energy efficiency and decarbonisation and (b) including a costed, phased delivery programme.

The reason for this is that LHEES must not be merely aspirational; specific targets, timetables and costings will lend substance to the strategy, and drive the programme of work needed for implementation. The LHEES must be a high profile component of LA action; targets against timetables and costs are one means to ensure visibility and resource allocation.

To ensure that LHEES can be implemented there should be new requirements for collaboration between public bodies (Government, NHS, Higher & Further Education, Enterprise and other public agencies), cross-sector consultation and citizen engagement in strategy development.

LHEES also need to work in coordination with national government and its agencies to ensure:

- that technical resources do not need to be duplicated in every LA,
- shared procurement to keep costs down, streamline processes, and avoid counter-productive competition between LAs where prices may increase as a result
- consistent standards of planning and implementation
- shared learning on best practice.
- Use of a robust standardised methodology for socio-economic assessment which

is applied consistently

- Consistency over the relative emphasis to be given to energy efficiency of buildings and heat decarbonisation, and the means of integration at locality scale
- Shared understanding of the relative priority to be given to reducing fuel poverty and investing in low carbon heating systems.

Q3. Please provide any evidence you have regarding the data available (or that could be available) to local authorities that would be useful or key to preparing and implementing such plans beyond the Scotland Heat Map and the EPC Register (including data held both within and outwith the public sector).

As argued above, development of LHEES will have impacts on understanding how heat decarbonisation will interact with other energy system developments. While it is important to draw as much useful data into LHEES development, LHEES should also be understood as creating important information resources that are currently lacking in Scotland. They will provide much clearer understanding of the potential for different technologies according to different assumptions.

To support this understanding, it will be helpful for the Scottish Government to offer clarity over the meaning and purpose of socioeconomic assessment. We suggest the meaning should be a comprehensive assessment of all the costs and benefits to society (not specific groups) these costs and benefits are to be understood as real costs/benefits (such as using up non-renewable resources), should include externalities (costs and benefits that arise but are not paid for) and should exclude transfers (such as taxes where costs to one group are balanced by benefits to others). The purpose is twofold: to inform decision making by public authorities in a way that accounts for as wide a range of issues in an impartial manner; and as the conduit through which debates about public authority decision making are channelled.

Socioeconomic analysis in relation to district heating would be one way of making judgements that account for differential business tax rates paid by heat networks and gas distribution networks. A socioeconomic analysis should compare costs and benefits of gas vs DH exclusive of taxes. If the benefits of DH outweigh gas when taxes are excluded but the judgement is reversed by inclusion of taxes (as some district heating operators suggest) this would indicate a collectively suboptimal decision is being made *because* of the tax difference, and would invite consideration of how this “distortion” could be relieved (for example by increasing the tax burden of the gas system or reducing taxes on DH).

Socioeconomic analysis should be embedded in the aggregate LHEES analysis. This would be the arbiter of what counterfactual a given option should be compared against and should be used to transmit system-wide costs/benefits through to the local level. The consultation proposes socioeconomic analysis at a variety of

different levels, including area and local. If the meaning of socioeconomic analysis implies all costs and benefits are taken into account, analysis at a local or project level will have to take into account costs related to the broader energy system. For example, the counterfactual cost to *not* installing a technology identified by LHEES should not be continuing use of natural gas, but the costs of a decarbonisation scenario that does not include the technology being considered. As argued above, these costs are complex and interactive.

Q4. What are your views on the broad principles for regulation outlined above? What else do we need to consider? What should be prioritised in cases where principles may not always be compatible?

The business model for DH should be included in the regulatory principles. The Non-profit model has been shown to be a key component in countries where there is high penetration of heat networks (e.g. Denmark). Equally evaluations of existing for-profit models under concession models in the UK especially PFI in education and health have shown that they have not delivered value for money to the public, and have led to higher costs of finance than through other financing mechanisms, resulted in complex contracts which prohibit amendment (such as to accommodate new energy infrastructure) and which ultimately do not transfer risk from the public sector (for review see House of Commons Library Briefing Paper 6007 13 May 2015).

The costs of financing district heating infrastructure at commercial rates would be a very significant component of overall costs of district heating. The National Comprehensive Assessment⁴ found the “potential” for district heating increased by more than 6 times (from 7% to 45% of heat demand) when the costs of finance were reduced to the social discount rate (which the National Audit Office⁵ notes is in turn higher than government borrowing costs). The impact of returns on capital investment can be illustrated with simple arithmetic. If infrastructure costs have to be repaid over 25 years, revenues must be adequate to cover 4% of capital costs per year. At 3.5% return (the Green Book social discount rate) revenue would have to cover 6%, and at a 10% return revenues would have to almost double to 11% of

⁴ Ricardo Energy and Environment (2015) The National Comprehensive Assessment of the Potential for Combined Heat and Power and District Heating and Cooling in the UK: Report for DECC, available: <https://www.gov.uk/government/publications/the-national-comprehensive-assessment-of-the-potential-for-combined-heat-and-power-and-district-heating-and-cooling-in-the-uk> [accessed 4 Nov 2016].

⁵ National Audit Office (2013) Review of the VFM Assessment Process for PFI, Briefing for the House of Commons Treasury Select Committee, available: <https://www.nao.org.uk/wp-content/uploads/2014/01/Review-of-VFM-assessment-process-for-PFI1.pdf> [accessed 10 May 2016].

capital costs per year. For longer repayment periods (commensurate with the lifetime of heat network assets) the effect is even more acute. In further developing its district heating policy and LHEES, Scottish Government should ensure it has clearly understood the impacts of using commercial finance for district heating infrastructure and compared these with using public finance. In particular, it should not simply assume that commercial investment returns should be brought into line with returns available to gas and electricity distribution networks: at around 8% these are already a point of contention⁶, and would contribute a more significant element of consumer bills for the relatively capital intense infrastructure of district heating. Socioeconomic analysis will be important in making this judgement, as a means by which questions of the best use of Scotland's resources can be posed and debated.

The regulation of district energy is often presented in the UK as stifling local initiative, but development of new district energy systems has typically required a regulatory framework. Norway, for example, operates a licensing regime for district heating designed to operate in a liberalised market (see Hawkey and Webb, 2014). Regulation can build market confidence and reduce perceived risk, without unduly restricting responsiveness of projects to local conditions.

Q5. What are the key principles or approaches that should inform how our regulatory approach manages risk for district heating across the whole system?

Our research on local authority engagement in district energy finds that regulation of district energy is likely aid in building market confidence and reduce perceived risk (see Hawkey et al, 2016; Tingey, Webb and Hawkey 2017).

A long term policy and strategy combined with a clear investment programme are likely to reduce risk when delivered alongside access to low cost finance, and regulatory standards on technical standards and consumer protection. Introduction of a central energy efficiency fund dedicated to investment in localised energy provisions and services, offering low interest, long-term loans, and reducing investment risk by supporting a portfolio of projects (HNIP in England and Wales is an exemplary indicator). Principles to inform development are likely to be available from local experience with other funds such as the NHS Carbon and Energy fund, Salix finance or the Scottish Central Energy Efficiency fund. These or similar funds could be restructured to include a requirement to maximize impact beyond the public estate.

⁶ Moore, S. (2015) Many Happy Returns?, Citizens Advice UK, available: [/about-us/policy/policy-research-topics/consumer-policy-research/consumer-policy-research/many-happy-returns/](https://www.citizensadvice.org.uk/about-us/policy/policy-research-topics/consumer-policy-research/consumer-policy-research/many-happy-returns/) [accessed 22 Mar 2017].

The Government should avoid treating risk as solely a financial phenomenon. The most important principle underlying its approach to risk mitigation should be ensuring policy objectives (climate mitigation, energy security, affordable energy, etc.) are achieved. Regulations that mitigate risk should, in theory, lower the cost of capital by affording investors greater confidence in projected revenues, and this would provide one route to financing schemes that better meet public objectives. However, commercial investment in district heating is not the only means of financing the infrastructure (public investment, potentially supported by specific borrowing is an alternative), and risk is not the only factor shaping the availability of commercial finance (for example, institutional investors willing to accept low returns over long periods typically require very large investment packages).

A guiding principle to consider, in line with other public infrastructure, is that the costs are socialised e.g. DH would benefit from major public investment, and the costs of renewal are shared across Scotland. In this case, public ownership of the asset is a key factor. This approach is also likely to be more attractive to commercial district heating developers whose expertise lies in design and construction of heat networks

Q6. What are your views on local authorities having the power through LHEES to zone areas for district heating? Please provide any relevant evidence.

In principle, LAs are appropriate bodies to be responsible for zoning areas for DH, but need to make such decisions as part of a coordinated process across Scotland, managed for example by an agency of central government. Some LA areas may be unsuited to DH, because of lack of spatial concentration of heat loads and/or absence of identifiable low carbon heat sources such as surplus heat from industry or thermal treatment of waste, or access to water or ground heat sources.

Q7. How should district heating zones be identified? For example, how should national targets, socioeconomic analysis, local priorities feed in to the designation of zones within the strategy?

There should not be any presumption that every LA area will have one or more DH zones.

In addition, the economies of scale and high initial capital cost associated with heat network infrastructure may mean national decisions about capital investment are needed.

Zones need to be areas where there is high heat density, diverse heat loads and local sources of low carbon heat. This would mean that DH infrastructure and services are most likely to contribute measurably to sustainable low carbon heat targets and development is more likely to be financially viable.

If the counterfactual used for socio-economic assessment is methane gas central heating, however, and the operator has to pay back costs of investment from heat revenues, new district heating (DH) infrastructure is unlikely to offer a competitive price for heating and hot water. This is because gas network infrastructure is long established, benefited from major public investment, and costs of renewal are shared across the whole population of users. Uncertainty about the future of the gas grid, and unknown comparator costs of conversion of the grid to low carbon fuels, means that Scottish Government need to work now with UK Government and the regulator to make decisions about the gas grid, carbon taxes on methane gas and the appropriate cost comparators for use in socio-economic assessments. This is fundamental to planning and zoning for DH.

DH zones should be construed as stepping stones on the way to fulfilment of the long-term vision articulated in LHEES. Creating zones that will make a meaningful contribution to achieving LHEES will clarify the scale of challenge, which will probably mean going well beyond the niche scale of development that to date has characterised district heating development. As an illustration, Figure 5 returns to our hypothetical LHEES vision and adds hypothetical district heating zones.

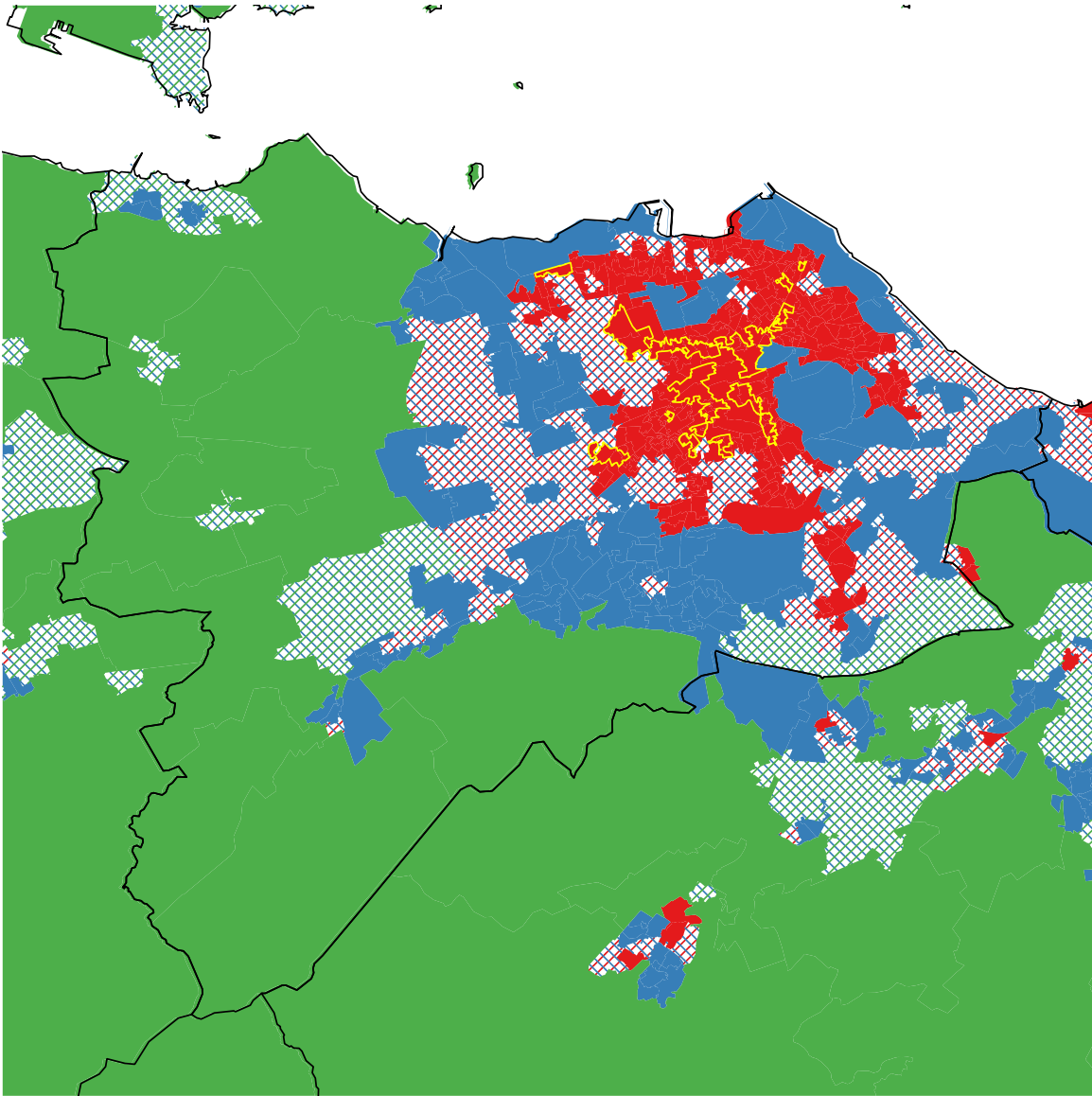


Figure 5. Illustration of what a LHEES vision may look like, including district heating zones in yellow. These would be near-term priorities for district heating development. While the attribution of different zones to technologies in the plot is based on arbitrarily selected heat density levels, the yellow district heating zones have been selected at a heat density level that would represent just 3.5% of Scotland's heat demand (half the relatively low potential identified in the National Comprehensive Assessment).

Q8. What are your views on taking district heating zones, or parts of district heating zones, and establishing an exclusive concession for either private- or public-sector heat network developers to fulfil that part of the LHEES? How will this alter the risk profile of district heating development?

A concession would link a project developer, via a LHEES, to both national and local policy objectives. This form of concession would be more comprehensive than the kinds of concession in place in the UK (e.g. Engie's concessions in Birmingham or SSE's concession at the Wyndford estate in Glasgow). Existing concessions grant an

operator contractual rights to supply heat to a relatively narrowly defined set of buildings. The aim of concessions derived from LHEES would be to develop district heating in a more comprehensive fashion across a specified area.

- The task of recruiting users within the area would be a shared responsibility between the concession holder and public authorities. The former would be involved in directly reaching agreements to connect. The latter would support both by regulating for service and technical standards, and by demonstrating public commitment to ensuring the wider LHEES plan, of which the concession would be a clear part, is achieved. (This commitment would include exercising the power to compel strategic buildings to connect to the network, but would extend to formulating policy and programmes through time in support of the wider LHEES.)
- Area-based exclusivity at present may seem like a marginal issue. Scotland does not have hundreds of district heating networks each trying to claim new users in the same territory. However, as district heating becomes more widespread, and if the development model is to allow diverse organisations to grow networks outward from anchor loads, there is potential in future for different schemes to find themselves competing over particular users. While in many domains competition is identified as a route to economic efficiency, in the construction of capital-intensive infrastructure such as district heating the costs are very likely to outweigh the benefits. Speculative investment in network capacity is very costly if the anticipated heat load has been ‘poached’ by a competitor, and once constructed is geographically fixed and difficult to re-use for other purposes.
- An area-based concession, as a mechanism for delivery of LHEES objectives, is not automatically an attractive investment proposition, particularly if prices are benchmarked against current gas prices (which have a number of incumbency-related advantages) rather than the costs of low carbon alternatives. It will likely be necessary to match any concession area with requirements on owners of buildings with major heat loads to connect to the network. Without this requirement, DH investment will not proceed, because there are no guaranteed revenues. Naturally, in the design of concessions public authorities would take into account issues of financial viability, but it would be a mistake to suppose that area-based exclusivity and powers to compel connection will inevitably make fulfilling a concession an attractive *financial* proposition (either to public or private sector actors). There may still be a need for a form of public subsidy to make a concession stack up financially. Decarbonised heat (in general, not just district heating) may overall cost more to Scotland than current use of fossil gas. During a transition from fossil-gas to alternative .

Q8b. Do you agree that local authorities should be responsible for issuing and enforcing concessions in their areas? Please explain your answer.

In principle LAs are appropriate bodies, but would need the necessary resources for the task. They may however be developing and operating heat networks directly, in which case the concession instrument may not be relevant, other than to manage potential deleterious effects of competition between networks.

At least in the immediate future, more cost effective development of skills and capacities for managing any planned developments which are structured as concession contracts may be achieved through a central agency with relevant LAs represented on its Board.

Q9. What considerations should inform the design of concessions (target users, envisaged network growth, concession length, etc.)? Please provide any evidence you have to support your views.

Concessions need to be developed in response to LHEES, and bidders would need to meet socio-economic criteria demonstrating that their proposal would offer the best price for low carbon heat services in the designated area, where heat loads are secured through requirements to connect. LAs currently lack the technical expertise to manage such contracting.

If the assumption is that such concessions would be commercially operated, on similar terms to PFI/ PPP instruments, then it is unlikely that heat tariffs would be geared to 'affordable warmth', suggesting that direct public sector development and ownership may be the least cost route forward.

Q10. What are the implications of zoning and concessions for existing district heating networks?

Existing DH operators could be invited to bid for a wider 'concession' area, given their existing investments. If they are unsuccessful, then their current contract should be allowed to stand to the end of its term.

In developing powers to compel anchor loads to connect to district heating, consideration should be given to how existing heat networks may be incorporated into larger systems, potentially with a backstop of compulsory integration. Many existing network owners would see some benefit in joining a larger system, particularly to the extent this increases their options for operation of their CHP units, so there may be opportunities to incorporate existing networks into concession-based systems run by other operators. However, challenges will arise where a broader system proposes to displace an existing CHP (in turn displacing its owner's revenues from power generation). This already happens to a degree as operators of existing networks based on gas CHP express reluctance to take heat from energy from waste plants owned by different organisations. A compromise could be that existing networks would be required to join a wider 'concession' system at the end of the lifecycle of their existing heat generation asset. This would also help ensure heat is not locked-in to gas CHP in the long term.

New heat networks, developed either under a licencing regime or a concession, should be explicitly alerted to the potential they will in future be required to integrate with other systems. LHEES will help align understandings and expectations around this. Consideration should be given to whether integration of heat networks physically should also mean organisational integration, as there may be economic and process efficiency benefits of having a wider system under single control than establishing myriad organisational interfaces between sub-networks.

Q11. Do you think the broad rights and responsibilities of concession holders set out in this document are appropriate? Why? Please provide any examples or evidence.

Comments raised in the recent public consultation events suggested that credibility of the DH provider is particularly significant given it is a monopoly supplier, and that further consideration and views should be sought on what would make the concession attractive enough for private sector investors.

Q12. How can a balance be struck between ensuring LHEES are responsive to changing conditions while ensuring security and stability in long-term district heating development models?

See responses to Q1 and Q37 for how decision making under uncertainty could be framed through LHEES. In an uncertain environment it would be miraculous if investment decisions made or directed by public authorities actually achieved an optimal outcome. While there may be costs to making decisions and commitments before uncertainties have cleared, these should be set against the potentially greater costs of losing time to develop appropriate heat solutions and of reliance on speculative technologies which turn out to be unviable.

Q13. What should happen to long-term ownership of heat network assets, post-concession?

The assets should be in long term public ownership; this should be aligned with regulatory requirements to identify a heat provider of last resort. This could be the LA or a central government arms length body such as a Scottish Energy Company.

For existing buildings

Q14. What are your views on the opportunities and challenges in connecting anchor loads to new heat networks? In your view, will the scenario set out address these issues and accelerate district heating development? Please explain your answer.

Anchor loads will vary across heat networks and will interact with existing energy infrastructure in localities. For instance, the compulsion to connect was successful in Denmark because the alternative to DH was much more expensive. This suggests DH would be attractive in off gas grid areas. However, off gas rural areas may have

fewer large heat users (though potentially many users for whom it will be financially attractive to connect to DH). In higher density areas, where generally the gas network is more established, the socio-economic assessment will need to produce an attractive and competitive offer. In higher density areas, buildings without gas provision (e.g. multi-storey blocks), may be located in areas where neighbouring properties are served by the gas grid. This will need to be addressed to ensure that area-based schemes, rather than island schemes develop.

Q15. What are your views on the proposed power to compel existing buildings to connect to district heating?

Q15b. Are the broad principles and criteria appropriate? Should other principles or criteria also apply? In particular, what approach should be taken to socio-economic assessment at the project level, prior to a compulsion to connect?

As argued above, socioeconomic assessment at the project level should take into consideration the costs of achieving Scotland-wide energy objectives if the project doesn't go ahead.

If the socioeconomic assessment indicates the proposed mandatory connection is justified, but that a commercial assessment from the perspective either of the building owner/occupant or the heat network operator indicates the connection is not viable, this would indicate that commercial considerations are preventing the optimal use of resources across society. This could provide justification for public intervention, perhaps by subsidising the cost to the building. Indeed, this would be one way of socialising the costs of transitioning to a low/zero carbon system of heat supply. (The logic here is that a low carbon system is not necessarily lower cost than a carbon-based system, but is justified on grounds of climate change as an externality. The costs of shifting to a low carbon system, if concentrated on specific users at specific times may create far more significant barriers to progress than collective absorption of these costs as they arise.)

Q15c. Do you agree that this socio-economic assessment at project level should include an assessment of the impacts on consumers of requirements to connect?

Q15d. Do you agree that local authorities should exercise powers to compel connection of existing buildings (for example when requested by relevant concession holders)?

Please explain your answers.

Q16. Do you agree that mitigating risk by establishing exclusive concessions will lower financing costs and heat prices?

As argued above, exclusive concessions will manage the threat that connection-

competition poses to capital intensive systems, an issue that has potential to become more intense over time if a mixed-delivery approach is pursued. The concessions are also ways of making clear to developers (from public or commercial sectors) what is required of them to contribute to both local and national policy objectives.

Financing costs are one element of heat prices. Economies of scale, the period of financial models and recovery of investment sunk but unused all also contribute. Design of concessions needs to address all these factors.

. **Q16b. How can these regulations be designed to best ensure this happens?**

. **Q16c. What are your views on the time length of concessions in order to attract investment?**

In thinking about this question Scottish Government should consider whether there may be benefits in targeting a *shorter* investment period over which an investor would not recover its entire investment. Instead, a price would be agreed at the beginning of the concession which the investor would receive if the scheme met the concession's criteria. This could give commercial actors a window in which to make a return on their investment, but allow public authorities to "buy out" the network. This would be one route of ensuring as networks grow and are interconnected they do not remain organisationally fragmented. For example, concessions could be established for two adjacent areas, and after five years once the networks have been developed and interconnected, the concession holders would receive a fee and the joint system would be turned over as a new concession (or part of a new concession with further development objectives). The original concession holders would, of course, be free to bid for the larger concession. The fee for the original concession holders would be paid by the new concession holder who in turn would recover it over time through efficient operation and development of the system.

Q17. Do you agree that compelling existing buildings to connect to district heating would mitigate heat demand risk, lower financing costs and help create an attractive investment proposition for district heating developers and financial institutions?

Yes. But as argued above, Scottish Government should not see risk only through the lens of commercial finance. Even if public finance is used for district heating, mitigating risk will be important and the backstop of compulsory connection will help ensure investment (whatever its source) is not wasted.

During consultation events a number of participants distinguished between compulsion to connect to district heating and compulsion to use the system. If the purpose of compulsory district heating connection is to anchor a heat network's financial/business model then what is most important is a compulsion to pay for the fixed costs of district heating supply (of which a large part is recovery of capital cost). (NB, fixed costs should not be confused with standing charges as energy retail models may apportion some fixed costs to users on the basis of their consumption

level.) This could be achieved in various ways, not all of which would even require the building to physically connect to the network (though, of course, this would be regarded as a perverse outcome). For example, a local charge could be levied on anchor loads' heat consumption which would be waived if they used the district heating supply.

Q17b. Could you provide evidence of how much they would be lowered?

Danish district heating companies, supported by a legacy of users who joined through compulsory connection and whose charges are kept competitive against alternatives through the energy taxation regime, are able to borrow directly from financial markets sometimes at rates that beat public finance.

Q17c. How can these regulations be designed to best ensure this happens?

Q18. What are your views on the relationship between LHEES and local development plans and how planning policy and development management should support the anticipated role of LHEES for new buildings?

. **Please explain your answer.**

New development should not become a future retrofit problem. Scotland already has a major retrofit challenge on its hands. Low carbon heat retrofit will likely be the most significant issue for LHEES, and consequently it is unlikely that the demand side of LHEES will be significantly driven by local development plans. Nonetheless, establishment of long-range visions and technology zones through LHEES will support alignment of new development with low carbon future energy systems. One particular issue is current discussion about using planning policy to require new developments to be 'district heating ready'. This formulation should be regarded as a temporary solution to be replaced with new development having district heating at construction, and this will be more straightforward with robust LHEES in place.

Existing industrial plant

Q19. What challenges and opportunities do you see for existing industrial plant to connect and sell waste heat to nearby district heat networks, both now and in the future?

. **Q19b. What barriers have industries experienced in the ability to sell their heat under current market conditions?**

Industrial plant owners and managers we have spoken to are interested in supplying surplus heat for the benefit of their local communities. However the absence of large scale heat network infrastructure is the principal stumbling block. Connecting an industrial site to an existing network means when surplus heat is available it can displace other (more costly / higher carbon) heat generators on the system. The addition of surplus industrial heat does not increase the requirement

for backup generation on the system, nor does it require guarantees from the industrial plant that heat will be available. Attempts in Scotland to build new district heating systems on the basis of industrial heat have failed precisely because industry cannot give these guarantees, and the challenge of creating heat backup (sited on the industrial site) is prohibitive.

Q20. What are your views on requiring existing industrial plant, with the potential to supply surplus heat, to make data available to public authorities? Please provide any relevant evidence.

Q21. Under these proposed new arrangements, do you think that an enabling approach, perhaps using voluntary mediation, will be successful? How can we best encourage existing industrial plant to supply waste heat to a district heating network?

The potential for surplus heat export rather than on-site use is unknown, so the requirement that industries provide data will be important. Currently the concentration of supplier risk on industries being asked to be the anchor supply point for new district heating networks is the major obstacle. If Scotland is successful in developing significant heat networks with multiple supply points, integration of industry will become organisationally much less challenging. Public authorities' understanding of what the appropriate timing of different forms of engagement with industry should become clearer both with better data on industrial surplus heat supply potential, and clearer plans for the roll out of district heating through LHEES and the regulatory package considered in the consultation.

. Q21b. Which public authority should carry out the role of voluntary mediation?

Q22. Do you agree that in some circumstances (if requested), compulsory mediation is needed?

Q22b. Do you agree that if compulsory mediation was not successful, then a more directive approach should be used?

Q22c. Which public authority should carry out the role of compulsory mediation or direction?

New industrial plant

Q23. What are your views on requiring new industrial plant to be 'district heating-ready'?

The focus of the consultation appears to be on manufacturing industry. However, the Special Working Group's recommendation also referenced energy industries. The draft Climate Change Plan and the draft Energy Strategy both envisage a number of new energy technologies with considerable potential for surplus heat

offtake. These include BECCS and the production of low carbon gas, either hydrogen or biogas. These industries do not yet exist and their development should take into account locations where surplus heat can be used. The process of developing LHEES should consider both the surplus heat potential of these technologies as well as their other energy products.

Q24. What would be the most appropriate way of ensuring that new industrial buildings connect to district heating networks? What role can zoning within LHEES play in this?

Q25. Do you agree that as district heating becomes more widespread it will need to become a licensed activity? Please explain your answer.

Licencing of district heating is necessary to ensure high cost infrastructure, constructed with public support (whether financial or in the form of the supportive regulatory interventions outlined in the consultation) is adequate to the pressing challenge of heat decarbonisation. This is because the urgency of heat targets leaves little room for error and a licencing regime will be a more robust way of regulating district heating standards than a minimum standards without a licencing mechanism.

Consumer protection in the context of monopoly supply will also be an important part of district heating licencing. Scottish Government must work with UK government as a matter of urgency to find a way of embedding consumer protection within a licencing regime for district heating in Scotland that is compatible with devolution.

Consumer protection standards for users of district heating should not put consumers at a disadvantage relative to users of other energy systems. This implies not only that gas and electricity consumer codes be transposed to district heating. Consumers of gas and electricity are, in theory, protected from some monopoly abuses by their freedom to switch suppliers. District heating systems, being smaller scale, using fewer heat sources and having a closer interdependence between infrastructure and generation, affords little opportunity for retail competition: suppliers are not able to broker sufficiently different wholesale contracts to meaningfully offer choice to users. Consequently we know of no examples worldwide of a district heating scheme where users are free to choose from a range of suppliers (though, of course, as complex organisational arrangements there are many other ways in which competition can feature in district heating models). The lack of consumer-switching for district heating necessitates closer scrutiny of potential monopoly abuse, if only because without this consumers will become distrustful of systems they perceive as non-transparent and into which they are effectively locked. Experience elsewhere indicates that the financial returns operators make on district heating can become an important site of contention, particularly where prices are indexed against non-district heating alternatives. District heating customers whose principal source of heat is energy from waste, for

example, object if their heat prices rise because wholesale gas prices (to which the district heating company is not exposed) also rise. There are various ways the issue of perceived-excess in returns can be mitigated: in Denmark non-profit business models are used, and in the Netherlands financial accounting rules ensure transparency and comparability in the returns being extracted from heat customers.

Q26. What technical standards and consumer protection measures should be part of standard district heating licence conditions? How should these relate to existing schemes?

The priority for technical standards should be future-proofing the energy system to ensure energy services can continue to be delivered in future as Scotland transitions away from dependence on fossil fuels. Standards should ensure both that the visions set out in LHEES are achievable, and that the lifecycle costs and benefits of heat networks, judged on a socioeconomic basis rather than a commercial basis, are optimised. As social discount rates are generally lower than private discount rates this implies accepting high upfront costs for long-lived benefits. Translated into technical specifications, this means, for example, using relatively high-specification materials whose energy performance will remain high over a long period.

Q27. What are your views on using a licensing system to confer enabling powers on operators, and what enabling powers are required?

Q28. What principles, objectives and other considerations should guide the development of a Scottish district heating licence?

Q29. What drawbacks or challenges might a licensing system create? How could these be minimised?

Q30. Do you have views on who should issue District Heating Licenses and ensure that technical standards are being met?

Q31. Would the benefits of the concession area outweigh the costs of the licensing arrangements?

Q33. Please provide any evidence you have regarding:

a) analytical skills, resources and techniques that could support development of LHEES, particularly where these are not currently used by local government

b) the anticipated cost of preparing LHEES

c) the additional skills and resources needed to meet the requirements of the potential local authority role of district heating regulation.

Q34. What support and resources will local authorities need to produce LHEES and implement the potential local authority role of district heating regulation, and which organisations do you think are best placed to provide these? Please explain your views.

Support and resources include

- Appointment of skilled staff in LAs;
- Access to funding for feasibility studies and related consultancy work;
- Technical resources and guidance;
- Methods to improve data collection and analysis, including data on residual heat sources, and to set targets against measurable baselines;
- Procurement support.
- Increased resourcing of developmental networks, such as the Heat Network Partnership or the Scottish Cities Alliance, which facilitates skills development and problem solving across LAs and helps to establish best practice.

Reduced budgets mean that LAs increasingly work as commissioning and contracting organisations and many lack the internal resources and technical capacity to develop comprehensive and workable LHEES. In a 'business as usual' scenario the risk is that LHEES development will take a minimalist approach, because of limited resource allocation. LHEES would then be treated as another short term task or project to be fitted in alongside multiple other projects managed by a small number of officials. The socio-economic and environmental benefits will be correspondingly limited.

Making LHEES effective and ensuring implementation requires local political commitment and LA officials directly responsible for their development and progress against phased timetables. This requires investment in staff, professional development of the LHEES team and direct reporting structures to the CEO and Finance Director and Council's Executive Committee.

Q35. What are your views on how any support should change over the different phases of development, introduction and implementation of any regulation?

Greater resourcing of training and support for LA officials tasked with developing and implementing LHEES will be needed in the early years of a new regulatory framework. The detailed content and criteria used in LHEES will need time to be developed and adjusted with experience. As mentioned in Q34, developmental networks which offer training and guidelines to relevant local authority officials, such as the Heat Network Partnership and the Scottish Cities Alliance, will play an important supporting role during this period.

In addition, some local authorities will be in a better position than others in being able to develop and implement LHEES due to their previous activities, staffing and

team structures. It may therefore take some local authorities longer to develop and embed LHEES into their regular responsibilities. Provision and timescales of support should be designed to adapt to these varying contexts.

Q36. What are your views on the wider regulation of the heat market to ensure decarbonisation?

Consideration needs to be given to how regulatory models can increase uptake and standards across technologies identified in LHEES. In particular, Scotland does not have well-developed building-scale heat pump skills and supply chains. There are various international models that could inform how confidence in heat pumps could be improved as well as making them more attractive to building owners/users.⁷

Q37. What are your views on when decisions should be taken on the future of the gas network?

Decisions need to be made relatively soon if the draft Climate Change Plan targets for 2032 are to be achieved. However, a more precise timeframe should emerge from the development of LHEES across Scotland. Using the approach outlined above (Q1), LHEES should identify no- or low-regret areas for deployment of specific technologies which are robust to a range of different assumptions (including on the availability of zero carbon gas in the existing network) and get on with implementation in those zones. The analyses will give an indication of how far progress can be made before specific decisions become critical.

Given the ambitious 2032 goals for low carbon heat supply there will be little scope to delay development of non-gas supply approaches while uncertainties around the costs and availability of zero carbon gas are resolved. The situation might emerge where users of the gas network will have to switch to non-gas systems before it is clear this is the no-regrets option. This would be the outcome of the following argument:

- Shifting from gas to an alternative in this zone may produce regret in future if zero carbon gas becomes available in sufficient quantities and at affordable costs.
- Staying with gas in this zone may produce greater regret if zero carbon gas does not become available because of the higher costs (or even impossibility)

⁷ Delta Energy and Environment (2013) Policy Measures for Heat Pump Market Growth, Report for Danish Energy Agency, available: http://www.ens.dk/sites/ens.dk/files/forbrug-besparelser/byggeriets-energiforbrug/varmepumper/policy_measures_for_heat_pump_market.pdf [accessed 7 Mar 2016].

of rapidly deploying sufficient alternatives to meet the overarching climate change objectives.

The argument could be likened to an insurance premium: overall the cost may turn out to have been higher than sticking with gas, but the additional cost is justified by avoiding an even more undesirable outcome.

In considering the future of gas, and LHEES planning in general, synergies between approaches should be borne in mind and the advantage to policy objectives of gas infrastructure already being in place should not be overstated:

1. Generation of zero carbon gas (biomethane, steam reforming, electrolysis, etc.) will require new industrial facilities which should be located where their surplus heat can be made use of (e.g. in district heating). Furthermore among competing claims on the use of zero carbon gas (industry, transport, etc.) is backup power generation to handle the intermittency of renewable generators. There are various factors to consider, but overall the efficiency of generating such backup with CHP (and feeding district heating) may be of greater system-wide benefit than power-only.
2. The challenge of converting the existing gas network to a different chemical composition is likely to be more complex than the transition from town gas to natural gas. In 1960 there were 12 million domestic connections to the gas networks across the UK, and by 2012 this had risen to 23 million. More significant is the increase in gas demand per connection, from around 3MWh/household/year in 1960 to around 15MWh/household/year today. This shift reflects the growth in central heating which means both more work per home will be required as complex boilers, not just cooking appliances will need to be adjusted. Opportunities to reconfigure gas users may also be more seasonal than the town-to-natural gas conversion, as daily routines have become more dependent on gas and resistance to temporary loss of service may be more acute in winter than summer.

Q38. Please provide any evidence you have to inform the Scottish Government in informing its thinking in this area.

Heat and the City Resources:

<http://www.heatandthecity.org.uk/resources/documents>

⁸ BEIS: *Historical gas data: gas production and consumption and fuel input 1920 to 2015*.

<https://www.gov.uk/government/statistical-data-sets/historical-gas-data-gas-production-and-consumption-and-fuel-input-1882-to-2011>

⁹ Palmer, J., Cooper, I. (2013) *United Kingdom Housing Energy Fact File 2013*, Department of Energy and Climate Change, available: <https://www.gov.uk/government/publications/united-kingdom-housing-energy-fact-file-2013> [accessed 25 Feb 2014].

UK District Energy Vanguard Network workshop reports:
http://www.heatandthecity.org.uk/dh_vanguards_network

Scottish Heat Network Partnership Practitioner Group workshop reports:
[http://www.heatandthecity.org.uk/about/workshops/scottish heat networks partnership practitioner group](http://www.heatandthecity.org.uk/about/workshops/scottish_heat_networks_partnership_practitioner_group)

Select reports:

- Hawkey D (2016) *District Heating coordination and development: Workshop report*. Edinburgh: University of Edinburgh ([pdf](#))
- Hawkey D, Tingey M, and Webb J (2015) *Next steps for district heating in Scotland: Workshop report*. University of Edinburgh: Edinburgh ([pdf](#))
- Hawkey D (2014) *District Heating and Regulation in Scotland: Workshop report*. Edinburgh: University of Edinburgh ([pdf](#))
- Tingey M (2017) *Local Heat & Energy Efficiency Strategies (LHEES) and Regulation of District Heating: Draft workshop report*. Edinburgh: University of Edinburgh

Lorna Booth and Vasilisa Starodubtseva (2015) *PFI: costs and benefits*, Briefing Paper 6007 13 May 2015. London: House of Commons Library. Available at: <http://researchbriefings.files.parliament.uk/documents/SN06007/SN06007.pdf>

Frontier Economics (2016) *Future Regulation of the Gas Grid*. London: UK Committee on Climate Change. Available at: <https://www.theccc.org.uk/publication/future-regulation-of-the-gas-grid/>

David Hawkey, Janette Webb, Heather Lovell, David McCrone, Margaret Tingey and Mark Winskel (2016) *Sustainable Urban Energy Policy: Heat and the city*. Abingdon: Routledge

David Hawkey and Janette Webb, (2014) District Energy Development in Liberalised Markets: situating UK heat network development in comparison with Dutch and Norwegian Cases. *Technology Analysis and Strategic Management* ([pdf, published version](#))

David Hawkey, *UK Local Authority Vanguards Network response to DECC's Heat Strategy consultation*, May 2012 ([pdf](#))

Margaret Tingey, Janette Webb, and David Hawkey. 2017. Local Authority Engagement in UK Energy Systems: Highlights from Early Findings. UKERC, London and The ETI, Loughborough (available from <http://www.sociology.ed.ac.uk/leukes>)

Janette Webb, David Hawkey and Margaret Tingey (2016) Governing cities for sustainable energy: The UK case. *Cities* ([open access link](#))

Janette Webb and David Hawkey (2016). On (not) assembling a market for sustainable energy: heat network infrastructure and British cities. *Journal of Cultural Economy*, 1–13 ([open access link](#))

Janette Webb (2015) Improvising innovation in UK urban district heating: the convergence of social and environmental agendas in Aberdeen. *Energy Policy* ([doi link](#)) ([pdf](#))

Janette Webb (2014) Evaluating urban energy systems in the UK: the implications for financing heat networks. *Science and Technology Studies*, 27 (3): 47-67. ([pdf](#))

Robin Wiltshire, Michael King (BRE), Janette Webb (University of Edinburgh) and Nick Banks (CSE) (2013) *Research into barriers to deployment of district heating networks*, UK Government Department of Energy and Climate Change, London: URN 13D/073

Q39. Please set out any further views on issues covered in this consultation that you have not already expressed, providing evidence to support your views.