Just Warmth: Developing Equitable and Sustainable District Heating Systems in Scotland

Baker, Keith; Mould, Ron

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JUST WARMTH: DEVELOPING EQUITABLE AND SUSTAINABLE DISTRICT HEATING SYSTEMS IN SCOTLAND

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hello@common.scot

AUTHOR

Dr Keith Baker is a Researcher at the Built Environment Asset Management Centre, Glasgow Caledonian University, Co-founder of the Energy Poverty Research initiative, and a member of Common Weal's Energy Working Group.

Dr Ron Mould is a Co-founder of the Energy Poverty Research initiative and a member of Common Weal's Energy Working Group.

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KEY POINTS

Common Weal is of the view that:

— The current system under which DHS projects are commissioned, designed and implemented is a critical and substantial barrier to the successful development and deployment of heat networks in Scotland. There is now an urgent need for the Scottish Government to re-think its approach to strategic planning for DHS. This is entirely within the scope of currently devolved powers, and the development of publicly-owned National Energy Company (NEC) presents a number of significant opportunities for addressing these policy failures. Following on from our previous work, this new paper discusses how the NEC should operate in partnership with a Scottish Energy Development Agency (SEDA) and a public National Energy Service (NES) to maximise the benefits of investment in new DHS projects. Our full proposals for the NES will be outlined in our next policy paper.

— The Scottish Government has, to date, failed to learn from the evidence from other countries which have developed successful and sustainable DHS and heat networks, particularly Denmark. What evidence from successful projects elsewhere shows is that using multi-technology approaches, particularly those combining large scale solar thermal with sustainable biomass and inter-seasonal heat storage and heat recovery technologies, must become a central theme in the future development of DHS in Scotland. However, sadly, such thinking currently appears to be completely beyond the Scottish's Government's thinking.

— The Scottish Government has, to date, critically failed to understand and address the impact of policy silos on efforts to develop DHS, heat networks, and other the energy infrastructure that will be essential for securing a green energy future for our country. DHS is a prime example of this as the legislation and support needed to deliver successful projects cuts across a particularly wide range of policy remits.

— Strategic planning for the future development of DHS and heat networks in Scotland must be directed nationally and delivered locally, but the

Scottish Government must ensure all devolved responsibilities, particularly those placed on local authorities, are suitably funded and resourced. The selection of priority projects must be carried out at a national level and must be based on robust and holistic analyses, using real data to identify locations where the potential to deliver both direct and indirect benefits to local communities is greatest. These analyses should also identify locations where the existence or development of renewable and low carbon energy sources (and fuel supply chains) can support the regeneration of deprived areas whilst reducing Scotland's greenhouse gas emissions.

— The adoption of multi-technology approaches to the development and deployment of heat networks should be central to delivering a Scottish DHS revolution. Recovering waste heat and utilising local site-specific renewable resources should be seen as key priorities for strategic planning for new schemes, and energy from waste (EfW) systems will require consideration relative to other options for providing heat and managing waste. However, the combined solar thermal, sustainable biomass and inter-seasonal heat storage model now gaining traction across Europe provides a highly replicable, flexible and cost-effective technological option.

— The development of local, sustainable biomass supply chains to provide fuel for new DHS schemes itself presents significant opportunities to leverage direct and co-benefits for job creation, recreation, tourism, enhancing biodiversity, tackling climate change and fuel poverty, and regenerating deprived rural and remote areas of Scotland. This is an opportunity Scotland cannot afford to miss.

— Finally, this policy paper proposes a set of comprehensive and holistic assessment criteria to ensure the benefits of new projects best meet the needs of national and local policy agendas, and of local communities. These assessment criteria would be implemented using essentially the same approach to that adopted for strategic environmental assessment, and the data and information collated as part of this process could be visualised using geographical information systems (GIS) to aid the interpretation of the evidence by non-specialists. All the relevant data needs and sources are available to the Scottish Government, and the collation and analysis of this and related data would be a key role of the SEDA. As ever, we welcome further comment and engagement from all those seeking to secure an environmentally, economically, and socially equitable energy future for Scotland.

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PREFACE

In February 2019 Common Weal set out our vision for the design and development of Scotland's publicly-owned national energy company (NEC) and a Scottish Energy Development Agency (SEDA), which would act as a strategic body to prioritise and direct the development of new energy generation projects and associated infrastructure and fuel supply chain needs[1]. In this paper we highlighted the particularly complex problem of how to better enable to development of district heating systems (DHS) and heat networks, and how considerable benefits to this could be unlocked through the roles of these organisations in Scotland's energy future.

This new paper builds directly on this report, as well as our previous report on energy performance certificates[2], by reviewing the evidence for how sustainable, low / zero-carbon DHS projects have been developed elsewhere in the world, particularly in Denmark, and proposing a set of criteria for designing and delivering successful DHS projects in Scotland. The concerns raised in this report, and our proposals for addressing them, are entirely within the powers and responsibilities currently devolved to the Scottish Government. However, as recognised in our previous papers, we are of the view that there are clear and substantial benefits to be had from the full devolution of all energy powers to Scotland, and more still from becoming an independent country within the European Union.

The purpose of this paper is to highlight key barriers to the successful deployment of new DHS in Scotland, conduct an extensive review of evidence on how they should be addressed, and to outline a set of criteria for use as part of strategic planning and procurement to leverage new DHS projects. These criteria have been developed in consultation with other experts with specialist knowledge of developing and deploying DHS, and are intended to deliver new DHS and heat networks that best meet the needs of Scotland's agendas for climate change, energy, employment, regeneration, fuel poverty, and community empowerment. Furthermore, the data needs for assessing these criteria can already be met from sources available to the Scottish Government. As always, we would welcome further comments from other experts and stakeholders as to how these proposals can be refined and implemented.

INTRODUCTION

District heating is the term used for networks of insulated pipes that supply heat, usually in the form of steam or hot water, from one or more energy centres to homes and buildings in the local area. District heating networks can vary significantly in scale, from projects with single energy sources feeding as few as two or three homes, up to networks with multiple energy centres and heat storage and recovery technologies that serving whole communities, commercial districts and industrial areas.

District heating systems (DHS) are an ancient form of heating buildings that has its roots at least as far back as Roman hypocausts, with evidence for district heating systems being found in numerous archaeological and historical records from around the world[3,4,5,6,7,8,9]. However, its more modern form, using a boiler as a central heat source, was first described by Scottish engineer Robert Buchanan in the early 1800s[10,11]. The oldest operating district heating system is in the village of Chaude-Aigues, central France which exploits the near surface geothermal resource. More recently, Thomas Edison advocated district heating as a means to improve the profitability of electricity generation, as part of which he established the New York City district heating system which has operated continuously from 1882[12].

Russia leads the world for the deployment of DHS, with over 17,000 schemes serving over 44 million customers; whilst the largest individual scheme is in New York, where 170km of pipes heat 1,800 buildings, including the Empire State Building and the United Nations. However, many of these older schemes are inefficient and use fossil fuels as heat sources, and it is Europe, and particularly Denmark, which leads the world in the development of low carbon and sustainable district heating schemes[13].

The heat supplied by DHS can come from a wide variety of sources, producing significantly different amounts of emissions. In Russia and the post-Communist countries of eastern and central Europe district heating networks are generally older, inefficient and fuelled by coal and natural gas[14], and even in Germany coal is used to supply around 47% of the heat delivered by DHS developments[15]. However, DHS networks can be supplied by a wide range of heat sources, including gas, biogas and biomass boilers, solar thermal panels, energy from waste plants, geothermal sources, heat pumps (which can also be used to provide district cooling), anaerobic digestion plants, and fuel cells[16]. Heat exchangers can also be used to recover waste heat from industrial plants and processes, as well as from losses within a larger DHS; and batteries, boreholes, gravel-lined covered reservoirs, and other technologies can also be used for short-term and inter-seasonal heat storage[17].

The UK has over 14,000 heat networks with over 492,000 connections, over 90% of which are domestic, but only 6% of these networks are in Scotland. Around 85% of the UK's systems were constructed before 1990, with many built to heat homes in the new residential estates and blocks of flats constructed to house the post-war baby boomers. However, this association with undesirable poor-quality housing is one factor that may explain its decline in popularity until the 2000s, after which the UK has seen a renewed interest in the technology, with 30% of the UK's large installations built after the turn of the century[18]. As a result, public awareness is very low, with a recent government study reporting awareness sitting at around 17%. However, perhaps reflecting a younger and more energy aware generation, almost half of those aware of DHS view it positively, and over half of them would be likely or very likely to connect to a system[19]. This, at least, is a positive sign for the future development of DHS if Scotland can learn from countries such as the Netherlands, which has moved from a low to high awareness of DHS, with several major cities now planning to develop extensive and inter-connected heat networks[20].

Fortunately for the Scottish Government, deploying new DHS isn't further complicated by a lack of sufficiently devolved powers, although we have previously highlighted a number of powers which would require further devolution to realise the ambitions behind the National Energy Company. However, in order to maximise the potential of DHS the Scottish Government should learn from successful projects elsewhere and seek to enable the capacity of local authorities to enter into partnerships with private and third sector organisations, and do more to direct and deliver appropriate support and expertise to the responsible departments within local authorities.

EXAMPLES OF SUCCESSFUL DISTRICT HEATING SCHEMES

Denmark leads the world in developing sustainable DHS, with major installations combining large-scale solar thermal installations with sustainable biomass and inter-seasonal heat storage. The largest of these are at Dronninglund ($26MW_{th}$)[21], and Marstal on the island of Aeroe ($23MW_{th}$)[22], which use gravel-lined covered reservoirs for heat storage[23], whilst the $13MW_{th}$ installations at Braedstrup uses boreholes. Indeed, the infrastructure is so ubiquitous that over 60% of households are supplied by DHS, rising to 98% in Copenhagen, where the development of modern local heat networks has been in full swing for over one hundred years. Only Iceland, with its huge geothermal resources, has a higher national penetration of DHS networks (95% of households), whilst Sweden, Finland and Lithuania make up the top five.

Elsewhere in Northern Europe, Sweden is home to another frequently cited example of best practice in urban heat networks, the redevelopment of Hammarby Sjöstad in Stockholm. Hammarby's system was designed using an approach that had waste recovery at its very heart, to the extent of recovering heat from waste water[24,25]. In common with the Danish successes, Sweden has benefited significantly from a similar culture of ownership by and for the public good, resulting in strong public support for the development. However, and unlike in Denmark, DHS is largely fuelled by biomass in urban areas and heat pumps in rural areas, where smaller installations also compete with solar photovoltaics, which also benefit from stronger financial incentives[26]. And despite its northern latitude and reliance on abundant sources of hydropower even Norway is now making significant investments in using solar thermal as part of such combined-technology approaches to designing heat networks. In 2011 the estimated capacity was a mere 13MWh[27] however, in 2012 the development of a large installation to supply the Lillestrøm district heating system added 4GWh to capacity[28]. And this multi-technology technology approach is now spreading across Europe, with a significant new development in Graz, Austria[29].

This approach of using large-scale solar thermal, which supplies around 50% of the heat to Dronninglund, combined with gas, biogas or biomass and heat storage and recovery, remains largely unheard of in Scotland. However, the combination of zero carbon energy from solar thermal and the development of sustainable local supply chains for biomass would unlock substantial opportunities for both reducing emissions and delivering a range of environmental, social and economic co-benefits to the country[30].

This missed opportunity to develop multi-technology DHS networks, which in Scotland could also extend to the development of new anaerobic digestion systems to use locally-sourced bio-waste to provide heat to local communities not connected to the gas grid, represents a critical failing of Scottish energy policy, but it is not the only one that has stymied the development of successful projects.

In the next section, we look specifically at what can be learned from Denmark, and how Scotland could, over time, become another world-leader in developing sustainable DHS and heat networks.

LESSONS FROM DENMARK'S DISTRICT HEATING REVOLUTION

Aside from Iceland, which uses heat from its substantial geothermal resources as a source for its heat networks, Denmark leads the world in developing sustainable district heating systems, and has set an example for others to follow. The country now has six large central district heating areas, with a total heat production of approximately 60 petajoules (PJ) per year. There are also around 400 smaller decentralised district heating areas, supplying an additional 75 PJ per year. In 2013, the total production of district heating in Denmark amounted to 134 PJ, 72.8% of which was produced in cogeneration with electricity (CHP), saving around 30% of fuel compared with separate generation of heat and power. The Danish Energy Agency notes that the inclusion of heat storage in all district heating areas has been central to its many successes[31].

Another critical factor in Denmark's DHS revolution has been the adoption of a succession of Heat Supply Acts (HSAs), beginning as far back as 1979, when local authorities were first required to zone areas for the development of new networks. The HSAs are built around four key principles:

— Local authorities / municipalities are responsible for the approval of new heat supply projects;

— Local authorities / municipalities have to make sure that project with the highest socioeconomic benefits is chosen;

— Production of heat must, if possible, be produced as combined heat and power;

— The collective heat supply price must offer consumer prices based on "true costs", meaning that the heat price cannot be higher or lower than the actual heat production costs[32].

This approach has since been adopted in a limited fashion by the Scottish Government but critically, and contrary to recommendations, it has paid scant attention to assessing the full socio-economic benefits of DHS projects and shied away from regulating to require connection and co-location of waste heat sources with existing and new housing[33].

Unlike the Scottish Government, which does not yet see the provision of cooling as a policy priority[34], the Danish Government is already planning for adapting to the 2-3% rise in temperatures predicted for Copenhagen by 2050, which is already reaching 35˚C in the summer. Two cooling networks utilising a mix of seawater and abstraction cooling from district heating have been developed and are expected to save around 14,000 tonnes of carbon dioxide per year[35].

With its established DHS market, Denmark certainly has much from which Scotland can learn, and where Denmark is now in terms of market penetration and legislation is a commendable goal for Scotland to aspire to. However, simply lifting Denmark's ethos, legislation and regulation now and forcing them into a completely different fiscal and politico-social environment in Scotland is likely to create friction. Indeed, we have to ask ourselves if Denmark had applied its current legislation in the early 1900s would their DHS sector have expanded as it did? If Scotland is to learn from Denmark, we should be looking at the history of DHS in Denmark and identifying the tipping points in the development of the DHS sector.

Table 1. Key dates in the development of district heat systems in Denmark

	Denmark	Scotland
1800		Coal gas for street lighting was first installed in London in 1807 and rapidly became the norm in large cities throughout the UK. Town gas networks were first installed in Edinburgh in 1818 and Glasgow in 1817.

1900	Industrial expansion	Denmark's first district heating power plant opened in Frederiksberg in 1903. Initially the heat fed a hospital, children's home and a poor house. The Frederiksberg system was seen as success and other Danish municipalities developed small scale DHS, often using diesel generators.	Expanding market	Development of town gas networks.
1920		As electricity generation became centralised into larger plants the demand to build municipal based CHP diminished however, there was an established market for heat and that demand continued to be met.	Stagnant market. About 4% of heat demand from DHS.	
1940				Gas industry nationalised.
1950				Clean Air Act pushes households away from coal to using gas as a means of heating and cooking.
1960	Technology push	The next step that increased the development of DHS came in the 1960s with the technological advances in affordable insulated pipe work and new waste to energy plants being built.	Expanding market	Natural gas is introduced into the market, cheaper than town gas it gains popularity.
1970	Socio-political and financial push	The fuel crisis hits in 1972/73. The costs of fuel increases and fossil fuels are less readily available. Danish municipalities react to fuel shortages by introducing regulation on energy efficiency including a preference for DHS use. **Zoning legislation is introduced in 1979 under Denmark's first heat planning law, which incentivised the development of DHS for heat and gas networks for cooking.**	Expanding market **Around 30% of domestic heat demand met from DHS.**	The last of the town gasworks closes. From 1967 to 1977 all burners in the UK are converted or replaced with new equipment that can burn natural gas, at a cost of £100m.

1980	Environmental and financial push	Expanding networks connect to each other creating multi-nodal DHS. Established market with multiple ownership models for plant. In 1989, Dronninglund becomes the first DHS system in the country to install natural gas-driven engines for combined heat and power production		British Gas privatised in 1986.
2000		In 2005 Dronninglund begins the replacement of natural gas with renewable energy (e.g. biomass and large scale solar thermal).		
2010			Above 60% of heat demand from DHS.	DHS remains an emergent sector in Scotland. Scotland's local authorities face challenges over funding.

Sources: Audit Scotland, 2019[36]; Danish Energy Agency, n.d.[37]; Plan Energi and Niras, 2015[38].

Table 1 summarises the history of the development of DHS and heat networks in Denmark, set against some key events in Scottish history. The Danish sector is over a hundred years old and is generally considered to have started in 1903 in Frederiksberg, a municipality lying to the west of Copenhagen. Frederiksberg had developed as a municipality through industrialisation, and in the late 1800s there was growing concern for the amount of waste building up. In 1896 an incinerator for municipal waste had been built in Hamburg, and after waste was sent to Germany and tested for its combustibility in the Hamburg incinerator the first waste to energy plant in Denmark was built in Frederiksberg, producing both electricity and heat.

Scotland and Denmark currently are in very different positions in relation to DHS. Scotland's aspiration is to achieve 11% of non-domestic heat demand from renewable sources by 2020[39], 1.5TWh of Scotland's heat demand to be delivered by district or communal heating, and to have 40,000 homes connected by 2020[40]. In 2012 the total heat demand of Scotland was 82,722GWh and, though declining, 1.5TWh (1,500 GWh) will be somewhere between 10 and 20% of total demand in 2020. Denmark was supplying over 30% of its heat demand from DHS as far back as the 1970s, and now supplies over 60%[41].

Scotland's aspiration is that this should be a well-regulated sector that does not disadvantage consumers, but at the same time ensures returns on investment that are a sufficient encouragement to investors. Denmark is viewed as an example of such a good regime and it is without doubt that the Danes can teach Scotland a great deal, one key example of this being the need to stage in regulation whilst the sector develops, rather than simply adopting the current Danish model.

Implementing a regulatory regime designed to fit a mature sector may be sufficient detriment to kill a nascent sector. Without regulation we place some of our most vulnerable householders at risk of exploitation. Scotland must map a finely balanced path between these two important drivers. The importance of regulation is not doubted, but what Scotland has failed to examine and discuss is when this regulation should be implemented. We must ask what would have happened to the sector in Denmark if they had implemented any current legislation earlier. The timing of new regulation in Scotland should be dependent on the level of development of the sector, notwithstanding the impacts of exceptional circumstances such as fuel crises, such as that which hit Denmark in the 1970s.

In addition to the time frame for the development and implementation of key legislation we must also compare the ownership of DHS assets by municipalities in Denmark which is rooted in the earliest history of DHS there. Danish municipalities will invest in DHS assets with long pay back periods of 20 or more years. From our own experience in the field, in Scotland financial officers will generally only consider pay back periods that do not exceed 12 years, and so without acknowledgement of the time scales in legislative development and a viable funding mechanism Scotland is likely to struggle to meet its aspirations.

COSTING AND VALUING DHS AND HEAT NETWORKS

Calculating the costs of district heating systems and networks is a highly complex and highly project-specific task which is open to significant uncertainties, and also exposes another flaw in the Scottish Government's adherence to a competition-led approach to deployment over a strategy-led approach. These uncertainties include, but are not limited to:

— The types, energy performances, thermal efficiencies, capacities, limitations, and other technical characteristics of the heat (and electricity) generation technologies, and of the distribution and supply infrastructure;

— The technical specification of the distribution pipes;

— The number, types, density, energy performance, and other technical characteristics of the buildings to be connected;

— The characteristics of the building uses (domestic, commercial, industrial, etc) and of the needs and lifestyles of their occupants;

— The availability, locations, and costs of connecting waste heat sources and fixed sources of renewable heating and cooling (geothermal hotspots, water bodies, etc);

— The effects of climate change on building energy demand and the risks to energy supply and distribution of extreme weather events;

— Future changes in technology and infrastructure costs;

— Future changes in fuel prices and availability;

— Future changes in the grid electricity mix.

These uncertainties mean that any civil servant or politician currently judging the benefits of competing projects will require, as a minimum, a substantial knowledge of how the figures they are presented with have been calculated; the nature and degree of uncertainties in the methodologies used to develop them; and an understanding of how these do and do not relate to other figures produced for competing projects that may be significantly different in nature, scope and scale. As such, we are strongly of the view that any who do understand the significance of the expertise needed (from non-specialists) could not favour retaining the current competition-led approach.

These uncertainties are difficult enough to assess in single technology systems and become manifestly greater in the multi-technology systems being pioneered in countries such as Denmark, Sweden and Norway however, with these many caveats in mind we are able to present some approximate costs for DHS and heat networks.

Table 2 is adapted from a 2009 report by consultants Pöyry, Faber Maunsell & AECOM, who calculated the costs per MWh of heat and CO_2 savings from a range of technologies, as applied to different scales of heating and to an average home constructed by aggregating and weighting data for the UK's housing stock, and set against a 2009 baseline costs and the UK grid electricity mix (for 2009)[42]. The figures should be understood to be approximate and time-limited.

The Pöyry report also contains references to the costs of DHS in Vienna and Sheffield. The Sheffield system, which in 2009 served approximately 70,000 dwellings and was largely fed by energy from waste, was costed at £6,100 - £7,200 per household. The Vienna system, which in 2009 served approximately 270,000 normal density dwellings and was fed by a mix of energy from waste, biomass (from woodchips) and biogas was costed at £5,500 - £6,700 per household, although this has now expanded to cover approximately 350,000 flats and 6,800 large customers[43]. This expansion would appear to explain the lower cost per household of £5,000 quoted by one of the experts consulted as part of producing this report[44].

The same source also provided an approximate figure of £7,000 per household for low to very low-density dwellings in Denmark (e.g. Marstal). The key point to note here being the relatively small difference in costs between connecting households in urban and rural areas, in that whilst urban areas present economies of scale through having higher housing densities, they also present added costs in the form of the need to install infrastructure under hard standing environments, compared to dwellings surrounded by soft natural environments. As such, the apparent misconception amongst Scottish policymakers that the costs of developing DHS and heat networks in rural and island areas needs to be challenged and countered, and set against the additional benefits and co-benefits that could be accrued to communities in these areas.

Table 2. Cost of heat and emissions savings for different technologies, 2009

Technologies and Network Sizes	£/MWh of heat	Carbon savings compared to the baseline ($kgCO^2$ per year)
Baseline cost (gas boilers and electric heating)	70	0
Standalone renewable energy technologies		
Solar thermal	80	400
Air source heat pumps	115	-100
Ground source heat pumps	125	450
Individual biomass boilers	130	2600
Small scale district heating networks		
Anaerobic digestion CHP	245	5100
Community boiler biomass	115	2600
Community boiler natural gas	100	100
Small engine natural gas CHP	120	1000
Small biomass air turbine CHP	150	3600
Medium-scale district heating networks		
Medium biomass steam turbine CHP	125	3100

Large engine natural gas CHP	105	1600
Large scale district heating networks		
Waste heat	90	1800
Large biomass steam turbine CHP	120	3700
Energy from waste incineration CHP	205	2900
Medium CCGT natural gas CHP	110	2300
Small CCGT natural gas CHP	115	2000

Source: Pöyry, Faber Maunsell & AECOM, 2009[45]

Notes: Figures are for 2009. Costs based on an average / composite UK dwelling based on the composition of the UK's housing stock. Figures do not account for effective cost savings, e.g. where old systems have to be replaced as part of general maintenance.

However, what the Pöyry figures don't include are the costs and savings from the integration of large scale solar thermal arrays and heat storage, which evidence from Denmark and elsewhere is showing to be critical to the development of successful and sustainable DHS and heat networks.

Evidence from developments across Europe points to the generation costs from large scale solar thermal arrays being around 30 to 50 €/MWh, with the potential (when supported by inter-seasonal heat storage) to exceed 50% of energy demand from this plentiful zero-carbon resource[46,47]. Although caution must be applied when comparing figures that are almost a decade apart, and allowing for the higher proportion of renewable electricity generation from Scotland in the UK baseline, it is also necessary to allow for changes in the costs and efficiencies of solar thermal technologies.

The third essential component to this successful model, inter-seasonal heat storage technologies, serve to maximise the energy demand that can be met throughout the year by solar thermal arrays. Typically, heat is stored in gravel-lined covered tanks, reservoirs, boreholes, earth banks or aquifers. Being a relatively new approach with significant time needed between project inception and reporting the first year of data, there is little evidence available on comparable costs for heat supplied from inter-seasonal storage technologies. A 2010 paper covering fourteen projects across Europe using water tanks and gravel-lined pits reported costs ranging from under 100 €/MWh to over 400 €/MWh[48]. However, more recently, Ramboll report that the economies of scale enabled by their world's largest underground thermal storage pit, a 200,000 m^3 pit in Vojens, Denmark, can deliver heat from solar thermal in winter at costs competitive with gas boilers, and that the plant is purely commercial without any subsidies except the indirect subsidy in terms of energy tax on gas[49].

The need for land for constructing solar thermal arrays and heat storage facilities naturally poses some restrictions, or added costs in the form of higher land prices in and near urban areas, and these would need to be factored into any Scotland-specific figures. However, this again serves to equivalise the costs of deploying multi-technology heat networks between urban areas and the fuel poor rural and island areas where the benefits and co-benefits of deploying new networks will be the greatest.

Finally, it is important to note that none of these figures are adjusted for the savings to the wider economy from providing co-benefits, such as improving householders' health and tackling fuel poverty[50]. However, the Danish Energy Agency requires socio-economic assessments to be conducted on all projects as part of apportioning support, a key task which would be substantially enabled by the establishment of an SEDA.

Therefore, based on the available evidence on costs and energy savings, along with the views of other experts consulted as part of drafting this policy paper, we are able to conclude that:

— The integration of waste heat sources into new and existing heat networks should be seen as a cost and carbon-effective easy win, and one which would be substantially enabled by the adoption of a Heat Supply Law.

— The Danish / European model of sustainable biomass, large scale solar thermal, and heat storage district heating provides a robust, cost-effective, replicable and scalable technology solution.

— Although the wide range of variables and uncertainties means any generalised cost estimates are open to significant margins of error, the costs of new heat networks are falling and may now be reaching as low as £5,000 per household (excluding any necessary upgrades from the meter inwards). This is comparable with a standard (3kW) household solar photovoltaic system.

— Although we have not commented directly on alternative heat sources (geothermal, water bodies, flooded mine workings, etc) as these are highly site-specific, the use of these zero carbon sources should naturally be prioritised as part of the Scottish Government's wider efforts to tackle climate change.

— Similarly, evidence on the costs of integrating cooling remains scarce however, such additional costs will need to be set against the costs (and carbon costs) and energy demand from the increasing use of other forms of cooling in a warming climate.

These conclusions fundamentally underpin the criteria presented later in this paper, which could be implemented as part of a similar standardised approach as to that used for strategic environmental assessment[51].

DEVELOPING DISTRICT HEATING SYSTEMS IN SCOTLAND

The Scottish Government has set itself the target of delivering 1.5TWh of heat demand from district or 'communal' heating[52], yet differences in how data has been gathered and statistics are reported (e.g. by household connections, specific fuel types, etc) and incomplete data[53,54] mean that in practice it is currently difficult to accurately gauge progress against this target. A cynic would suggest one reason for this is that policymakers are concerned that the national picture is not an optimistic one. It's far easier for them to point to specific examples of operational systems in places such as Aberdeen[55], Calside (Renfrewshire)[56], Dundee[57], Edinburgh[58], Lerwick (Shetland)[59], and Glasgow, where the public profile of DHS was raised by its incorporation in the design of the athletes' village for the 2014 Commonwealth Games[60]; and essentially leave it to industry and local authorities to come up with new projects and compete for funding.

Another, critical, problem here is that the Scottish Indices of Multiple Deprivation (SIMD) and the Home Energy Efficiency Database (HEED) are used by the Scottish Government when apportioning funding, yet both have been widely criticised as measures for targeting fuel poor householders and energy inefficient homes[61,62,63,64,65,66]. All of this serves to obfuscate the detail of what is, and isn't, actually happening.

Finally, another critical problem is the almost complete lack of attention paid to technology choices by the Scottish Government and its advisory bodies. A recent report by ClimateXChange Scotland on lessons from European regulation and practice pays no attention to technology choice as a factor in the successes, or otherwise, of the countries covered[67]. This lack of attention is also evident at Westminster, for example the recent Committee on Climate Change report on housing makes no mention of large scale solar thermal and thermal storage in relation to district heating[68]. Yet we have found that, along with heat recovery, the development of sustainable multi-technology systems deployed in Denmark, Sweden, Norway and Austria has been central to putting them at the forefront of the new DHS revolution.

As we discussed in our previous paper on the development of Scotland's National Energy Company[69], there is an urgent need to establish a strategic body (a Scottish Energy Development Agency) to direct and enable the development of energy infrastructure, generation and sustainable fuel supply chains. The needs that would be met by the SEDA, which would be based closely on the Danish Energy Agency, are of particular importance to the development of DHS for a number of reasons, but they centre on the need to draw data, information and expertise from a wide range of sources and specialist fields. This needs to be used as part of national strategic planning to identify and prioritise opportunities for new DHS projects that offer the greatest environmental, social and economic benefits, whilst also being technically feasible and supporting wider local and national policy objectives. Sadly, the will to engage with this need for strategic national planning for DHS is currently absent from Scottish Government thinking under its proposals for Local Heat & Energy Efficiency Strategies and regulation of district and communal heating[70].

We must question the targeting of DHS developments into the lowest income urban areas and the capacity to deliver the assumed benefits in these areas, given that we know that these areas have the lowest fuel spends[71] and will remain so after the capital-intensive intervention of a DHS install. In order for new DHS developments to deliver the benefits the Scottish Government is seeking to achieve they must deliver on two fundamental opposing issues:

— In order to address the negative health and well-being impacts of fuel poverty it is necessary to increase the fuel use of these households;

— In order to mitigate the carbon footprint, the householders must achieve their desired heat with the same or less fuel than they currently do.

The carbon savings are ‘achieved’ through assuming that the householders maintain a suitable heating pattern before and after the installation of the DHS. That is in despite of the evidence that contradicts this assumption[72]. It is evident that we have policy built in the face of reality.

Acting as energy suppliers and managing large plants are not the normal functions of registered social landlords (RSL). Even within local authorities the Housing departments generally do not have the expertise to manage large plant - from speaking directly to housing staff at local authorities we have found that, although the management of the plant is usually retained within housing teams, the teams are reliant on corporate property staff for guidance, support and often resolving problems they find they have backed themselves into. This support and the resources required to manage a DHS effectively are not planned for and therefore not covered by funding allocations, and this need would be better met by the involvement of a specialist national partner (i.e. the National Energy Company). The failure to address this means that the under-resourced, under-experienced Housing teams stumble from one problem to the next, attempting to resolve them, ignore them or outsource them without any strategic capacity to plan and understand the implications of poor choices for them and the residents.

Under the conditions where DHS projects are expected to deliver on conflicting issues, commissioned by those that lack the expertise to manage them and without the assessment and allocation of the essential resources to sustain the systems, it is inevitable that DHS will fail to meet expectations and needs.

Following on from this, we have consulted with other experts to scope out a set of criteria for what would define a successful DHS project in Scotland, the data needs for which could be met through integrating existing sources into a common SEA-type assessment system, and which could also be visualised using a geographical information system.

THE NEED FOR STRATEGIC PLANNING: THE ROLES OF THE NATIONAL ENERGY COMPANY AND SCOTTISH ENERGY DEVELOPMENT AGENCY

In our previous paper on the National Energy Company[73] we set out Common Weal’s proposals for both the development of the NEC and the need for a parallel Scottish Energy Development Agency, which should serve as a strategic body for directing and enabling the development of energy infrastructure, generation and sustainable fuel supply chains.

The the need for the SEDA is made most strongly by the evidence on how to develop successful DHS and heat networks due to the nature and volume of data which needs to be brought to bear as part of strategic planning for successful DHS projects, and the associated costs of this. Whilst, under our proposals, the NEC would not be required to be a partner in all projects, it would be able to join consortia to compete for projects and, as capacity builds within the NEC, it's unique nature would make it a very attractive partner of first resort. However, the NEC would be able to provide financial security through holding the long-term (20-30 year) debt commonly required for larger DHS projects, whilst also retaining full or majority ownership of the capital assets until this is paid off. Then once the projects have paid off this debt the financial gains would be kept in the public purse within the NEC or through the transfer of assets to the local authority, and / or kept within local communities through the transfer of assets to the partnering community organisation(s).

Such strategic planning and direction by the Scottish Government and the SEDA, supported by a Heat Supply Act, would fall under planning legislation and so is already within the Scottish Government's powers. This would serve to overcome five key needs to enable the development of district heating in the UK identified in a recent report from the Heat and the City project:

— The need to equip local government with the powers and resources to develop and enforce local heat and energy efficiency strategies;

— The need to make use of more advanced models and tools to enable the scaling up of heat networks and maximisation of the numbers of connections;

— The need for a 'requirement to connect' (i.e. HSA legislation) to maximise the financial viability and minimise investor risk in projects;

— The need to use concession zones with licenses to incentivise developers to invest in future proofing systems and plan for future expansion;

— The need for greater consumer protection, including full transparency of financial data to allow assessment of company profits, and the establishment of standards for heat network business accounting[74].

The same report also identifies three key challenges that would also be addressed by a Danish-style approach to strategic planning and deployment:

Uncertainty around future demand and cherry-picking of sites

Uncertainties over future energy demand, prices, changes in energy policy, and a range of other factors encourages risk-adverse decision-making by developers and investors, which works against the needs for maximising network connections and future-proofing (e.g. through investment in technologies such as energy storage). Strategic planning by the SEDA would serve to provide developers and investors with transparent and comparable assessments of the costs and benefits of the heat networks that the SEDA seeks to deploy. This removes the substantial cost inefficiencies of the current national competition for projects, and the difficulties posed by non-specialists needing to assess figures from different proposals. It would also leverage developers away from a risk-adverse attitude as the emphasis on tenders would be to maximise the benefits and future-proofing of their proposals.

Limited local powers for strategic heat and energy efficiency planning, particularly for retrofitting into existing buildings

Local authorities have long been at loggerheads with the Scottish Government over policies, such as its vision for gas and electricity networks[75], which have increasingly devolved responsibilities to local authorities without assessing and providing sufficient resources and support to deliver on them, and with scant attention to the need for strategic regional planning to direct and develop appropriate energy technologies and infrastructure for local regions and communities[76].

A Scottish HSA would provide local authorities with a legal instrument to require significant producers of waste heat to connect to a heat network, to direct the development of new heat networks to where their benefits will be greatest, and to direct planning authorities to prioritise the co-location of new domestic, public and commercial buildings with sources of waste and renewable heat. The SEDA would serve to prioritise and commission the most promising projects, and ensure that the funding, resources, and necessary enforcement powers fully meet the needs of all those involved in developing and delivering these projects.

Lack of enforcement of design standards and customer protection

The SEDA would be able to proscribe (minimum) design standards and other requirements that must be met as part of delivering new DHS projects, and robustly assess the risks of any tenders not meeting them It would be able to intervene in the event of any disputes between project partners and other stakeholders, including the public, and enforce relevant regulations such as the HSA on behalf of local authorities. Greater consumer protection would be enabled through the SEDA providing greater transparency to the commissioning and contracting process, and through working in partnership with a National Energy Service[77].

The ideal outcome here would be to leverage the formation of new community energy supply companies (community ESCos) however, we recognise that this is not a one size fits all solution where local capacity is lacking. Therefore, one or more of the National Energy Company, local authorities, or other not-for-profit partners (e.g. housing associations) may be better placed to provide long term ownership and management, depending on local and / or project-specific circumstances.

SUPPORTING THE FUEL POOR AND OTHERWISE VULNERABLE: THE ROLE OF A NATIONAL ENERGY SERVICE IN PLANNING AND DEPLOYING NEW DHS

As discussed in our previous papers on Energy Performance Certificates[78] and the National Energy Company, a public National Energy Service is needed to form a third pillar for delivering on Scotland's ambitions for society and its energy future. As regards the development of successful DHS projects, the NES would serve as a supplier of data and analyses to enable the SEDA to strategically plan support for DHS to maximise the delivery of social, health and welfare benefits to those communities who would benefit most from connection to heat networks. Furthermore, where the NEC is a partner in delivering a new project (and we would expect it to have some role in most or all new DHS projects) these will benefit from direct access to the data held by the NES (subject to all relevant restrictions) and so be able to design and manage DHS schemes highly locally and accurately.

Whilst the assessment of social benefits and targeting communities where these would be greatest is only one subset of our proposed criteria for developing successful DHS projects, the NES would be involved throughout the lifetime of every project. Once a consortium has received a contract to begin developing a project the NES would work with the consortium to engage local residents with the benefits it will bring, and ensure they understand the nature of the disruption that would be caused to their communities and by connecting their own homes to the network. Furthermore, the NES, working through locally-based staff, would actively support particularly vulnerable householders through the connection process, for example through helping organise respite care for those who would benefit from being decanted during an installation.

Then, once the project is operational, these staff would continue to act as trusted intermediaries to monitor the benefits to the householders and use the specialist knowledge and experience they will have developed to address any problems householders may be having and ensure all receive the maximum possible benefits. Thus, also addressing the risk that the poorest and most vulnerable may be 'left behind' by technologies, even when they are provided with them.

Our full proposals for the National Energy Service will be set out in a subsequent policy paper.

SECURING SUSTAINABLE SUPPLY CHAINS: DHS AND AN ALTERNATIVE VISION FOR LAND USE

Of all energy technologies, the development of sustainable DHS is by far the most intricately linked with the changes we will need to make to the way we use and manage the Scottish landscape to secure our social, economic and environmental future.

Wherever possible, new DHS and heat network projects should seek to maximise the use of waste heat, minimise heat losses using heat recovery and energy storage technologies, and capitalise on the availability of local renewable heat sources, such as geothermal hotspots[79], flooded mine-workings[80], and major water bodies[81]. However, these are highly site-specific resources and it is likely that many new projects will need to source significant proportions of their heat from, in order of preference: small and large scale solar thermal; combined heat and power (CHP), anaerobic digestion (AD), and thermal hydrolysis plants fuelled by sustainable, locally-sourced biomass and biofuels; and, where the only other option is landfilling, energy from waste (EfW) plants.

In a previous policy paper that proposes an alternative vision for Scotland's grouse moors[82], Common Weal has calculated the annual gross value added (GVA) per hectare for different land uses. Of these, solar PV farms offer the highest GVA of any energy technology at £10,952 per hectare, and biomass offers a GVA of £2,596. However, some forms of biomass and biofuels, particularly the redevelopment of native woodlands for sustainable forestry products, provide additional value as land for recreation, tourism, and enhancing biodiversity[83].

Whilst wherever possible DHS and heat networks should maximise the use of renewable energy technologies and the recovery of waste heat it is likely, as per the Danish experience, that a substantial proportion of projects will require new fuel supplies. This is another issue that the Scottish Government has so far failed to grasp in any degree of detail, to the point that that latest (2016) Land Use Strategy actually backtracks on the previous (2011) version by failing to mention biomass or biofuels specifically at all[84]. Furthermore, and echoing some of the points made earlier in this paper, the previous strategy was both light on detail and heavy on placing the task of implementing the strategy on public bodies[85].

Over in the Energy and Climate Change Directorate the Scottish Energy Strategy also makes scant mention of the development of biomass and biofuels, and instead commits the Scottish Government to developing yet another sub-set of policies in the form of a Bioenergy Action Plan to meet a set of loosely worded principles[86]. And finally, over in the Local Government and Communities Directorate we find a 2013 planning guidance document on woody biomass which, whilst also outlining a loose set of principles, notes that these are "suggested areas of focus for planning authorities"[87]. Again, we see a 'strategy' that amounts to little more than minimal direction and a heavy emphasis on abrogating its responsibilities to public bodies.

Common Weal is strongly of the view that the impact of these policy silos and the lack of a strategic approach to developing new fuel chains will only serve to hinder the development of successful DHS and heat networks in Scotland. This is a critical failing of Scottish Government policy with potential implications for both securing energy security and Scotland's international reputation as a leader on environmental protection and renewable and low carbon energy.

The development of bioenergy in its many forms has been widely criticised, and whilst entering into that debate is beyond the scope of this paper it probably best viewed as a necessary evil. However, it is important to note that using wood as a fuel for biomass could significantly tarnish Scotland's reputation if a supply-demand gap emerges between the volumes it will need to produce and consume and the country becomes increasingly reliant on imported supplies, with the associated costs to greenhouse gas emissions from shipping. Doing so would leave the Scottish Government at the mercy of relying on the Forest Stewardship Council's FSC label to determine the sustainability of imported supplies, but this has long been subject to serious allegations of greenwashing and providing a cover for trafficking in illegal timber[88]. And again, this is something that that Scottish Government cannot claim to be unaware of from previous experience, not least the proposed development of a biomass plant at Leith Harbour which in 2011 was described by MSP Marco Biagi, who would go on to become the Minister for Local Government and Community Empowerment, as "the worst example of greenwash I've ever seen in Scotland"[89].

Therefore, it is absolutely imperative that Scotland can meet the demand for wood fuel for biomass from existing and all new DHS projects from within its own borders, where it can safely dictate and police its own (and European Union) requirements for sourcing sustainable biomass. However, as we have noted previously in this paper, doing so would open up substantial opportunities for the Scotland, and particularly in deprived rural and island areas. One example of progress is on Orkney, where the Agronomy Institute has recently planted 150,000 willow trees as a pilot towards developing a new local source of sustainable energy that has the potential to deliver a wide range of co-benefits to the islands, which continue to suffer from the highest levels of fuel poverty in the country[90]. However, planting monocrops such as willow, although native, doesn't get us all the way to a truly sustainable solution, which would see the restoration and management of Scotland's woodlands and forests in ways that encourage biodiversity, enhance Scotland's natural beauty, provide new sources of other native timber products, and new opportunities for recreation and tourism.

Finally, we should again stress that biomass is only one component of a range of technological solutions to energy generation that must be harnessed in a coordinated and collective manner. In this case, and again following the Danish experience, the use of large scale solar thermal and heat recovery and storage technologies should be employed to substantially reduce the demand for biomass supplies as part of multi-technology DHS projects.

KEEPING SCOTLAND COOL

Although this paper has largely considered the need to provide heating it is imperative to recognise the fact that climate change will see an increasing demand for cooling. The Scottish Government does not yet see the demand for cooling as a priority climate change risk for Scotland[91], but this short-sighted and short-term thinking again hampers the potential for DHS and heating (and cooling) networks due to the time frames over which they are developed, and will be operational.

Although domestic air conditioners are still fairly uncommon in the UK this, we would argue, is simply because householders make cost-benefit comparisons when investing in new technology and appliances. So, at present, the costs of investing in an air conditioner are generally being seen as greater than the discomfort and inconvenience caused by short, irregular periods of higher temperatures and heatwaves. However, the adoption of successful consumer technologies invariably follows an S-curve, with a slow start followed by rapid mass-market adoption once a tipping point has been reached[92].

Figures for 2016-18 show that the UK's energy demand rises by 350 MW for each degree that temperature rises above 20°C, and National Grid expect that the peak load for air conditioners (alone) will triple over the coming decade[93]. Therefore, whilst it is not yet possible to predict when this tipping point will occur, or whether householders will adopt (or already have adopted) alternative forms of cooling, we can be absolutely confident that household energy demand for cooling will increase as a response to climate change, and that this will not be a simple linear increase.

So, whilst in the short term the perceived need for new DHS projects to provide cooling as well as heating may not be seen as a sufficient risk by policymakers, not incorporating cooling represents, at best, a missed opportunity, and yet another example of the Scottish Government's inability to grasp the need for a holistic and strategic approach for maximising the benefits of new networks.

DEFINING SUCCESSFUL DISTRICT HEATING SCHEMES

If Scotland is to fully realise the potential of DHS networks the significant investment decisions that will need to be made need to be based on comprehensive and holistic assessment criteria to ensure the benefits of new projects best meet the needs of national and local policy agendas, and of local communities.

The following criteria were initially developed by the authors as part of a collaboration with the Danish engineering and design consultancy Ramboll, who have been responsible for developing many of the successful DHS projects covered in this paper. These are presented here as a draft list for further discussion; however, all the relevant data needs and sources are available to the Scottish Government, and the collation and analysis of this and related data would anyway be a key role of the SEDA.

These assessment criteria would be implemented using essentially the same approach to that adopted for strategic environmental assessment[94], and the data and information collated as part of this process could be visualised using geographical information systems (GIS) to aid the interpretation of the evidence by non-specialists.

National and Local Policy Objectives

— Supporting national, regional and local development plans

Development should be consistent with planning and zoning for new and existing housing, industry, business, commerce, conservation, etc.

Supporting and consistent with regeneration and economic development objectives

Where biomass and biofuels will be used as a fuel supply, development should include the establishment and management of fuel supply chains that generate additional benefits in terms of new employment, new economic opportunities from complementary agricultural and forestry products, creating new recreation and tourism opportunities, and enhancing biodiversity.

— Empowering local communities

Development should be in partnership with community and third sector groups, local authorities, and (where appropriate) local housing associations, who should have financial stakes in the networks and be represented at all levels of planning, management and operation.

Environmental Objectives

— Reducing greenhouse gas emissions

Developments should minimise the production of greenhouse gas emissions. Larger developments should seek to maximise the contribution of solar thermal and other renewables, as well as heat storage and recovery technologies, to minimise the contribution of (low carbon) biomass and biofuels. Smaller developments and those with access to geothermal sources or suitable water bodies should aim to eliminate the need for low carbon fuel sources.

— Air quality

Developments should be consistent with meeting local and national air quality objectives and zoning, particularly for NOx and PM_{10} emissions.

— Land use

Developments should be consistent current and future distributions of housing, public buildings, industry, and commercial buildings, in order to maximise both the demand on systems and the heat (including waste heat) available to them, and this should be backed by a Danish-style Heat Planning Law[95,96]. Where biomass, biogas and alternative fuel sources will be used the development of these supplies should maximise the potential of existing local sources and / or include the development of new local supply chains.

— Industry

Where appropriate, developments should seek to maximise the recovery of waste heat from existing industrial sources. Where new industry is planned this should incorporate the development of heat recovery systems for connection to existing or new heat networks. Planning permission for new industry should also include this as an assessment criterion.

— Visual impact

Developments should not contravene planning and environmental restrictions as regards visual impact.

— Water quality

Where water bodies are to be used as a source for heating or cooling this should not be to the detriment of the local aquatic environment, and developments should aim to minimise the impact under all relevant indicators as determined by the Scottish Environmental Protection Agency (SEPA), etc.

— Noise pollution

Developments should minimise noise pollution during both construction and operation, meeting all appropriate local restrictions and conditions.

— Waste

As well as recovering waste heat, developments may seek to utilise local waste supplies as a heat source, particularly the use agricultural and industrial waste to feed anaerobic bio-digestors. In each case the assessment of potential developments should consider the relative environmental impacts of any alternative options for managing these waste streams.

Social

— Fuel poverty

Developments should prioritise the provision of low-cost, renewable and low carbon heating (and cooling) to fuel poor and otherwise vulnerable householders. This assessment of this should include the analysis of real (as opposed to modelled) data on household energy consumption and costs, as well as real data and information on the technical benefits to be gained from connection to a DHS. It should also include an assessment of the co-benefits to the local community and economy of using the project to address the needs of local fuel poor and otherwise vulnerable householders.

— Health

Developments should consider any potential health impacts to householders and local communities, including any emissions from energy centres and impacts on internal air quality and comfort arising from converting properties to using DHS and connecting them to heat networks.

Developments should seek to maximise the provision of heat to householders whose physical and mental health and well-being will benefit most from them. Where groups of such householders can be identified these should be prioritised for the assessment of the benefits connection to a DHS may offer.

Economic

— Whole lifecycle costs

Developments should seek to minimise their whole life costs in terms of greenhouse gas emissions and cost-effectiveness.

— Economic growth

Developments should seek to maximise the creation of skilled employment opportunities through creating new jobs and new demand for skilled labour, and to maximise the retention of skilled labour in areas suffering from depopulation.

— Regeneration of deprived areas

The prioritisation of support for new developments should emphasise the development of projects in deprived communities, particularly in rural and island areas. Developments should seek to maximise the potential new inward investment, the development of local fuel supply chains, job creation, tourism and recreation opportunities, and the enhancement of local biodiversity.

Technical

— Electricity grid impacts

Developments should be consistent with, and support, the needs of the distribution service operators (DSOs) as regards the management, upgrading, reinforcement and expansion of the national electricity grid; as well as with the needs of those developing and managing any local microgrids.

— Gas grid impacts

Developments should be prioritised towards communities off the gas grid, and should seek to maximise the potential of networks for future expansion and the incorporation of new heat sources.

— Retrofitting to existing buildings

Developments should be prioritised towards those where there is the greatest potential to retrofit energy centres and heat recovery technologies into existing buildings, and to retrofit heat networks to supply existing buildings and homes, particularly in deprived areas.

— Technical feasibility

The technical aspects of developing DHS and heat networks requires highly specialist expertise, and so the feasibility of all developments should be assessed by appropriately qualified independent experts.

Whilst conventionally the procurement of new DHS projects involves such assessments to be carried out once the developers have identified potential projects and conducted an options identification and appraisal exercise, the SEDA would adopt much of this workload. Using the data available to it, it would be able to map the real potential of DHS across Scotland at a suitably local level to highlight key opportunities for developing new DHS projects against communities that would most benefit from their development. This would, for example, allow the identification of clusters of fuel poor households living within reach of waste heat sources and / or potential fuel supplies, rural communities where the development of local fuel supply chains has the greatest potential to supply heat, create jobs, and tackle fuel poverty, and highlight geothermal sources and water bodies that could be tapped directly.

Then, and only once the SEDA has set out a number or priority areas / projects that could be delivered under current funding conditions, would consortia be invited to develop proposals to deliver them. The consortia themselves would be required to have the relevant local authority or authorities as partners, as well as one or more organisations representing the communities in which the projects will take place. Both the local authority(ies) and community organisation(s) would be required to be represented at each decision-making stage and level of the projects, and from the inception of the projects. As discussed in our paper on the National Energy Company, this would also address the significant cost inefficiency under the current procurement system, whereby the onus is on those developing projects to at least begin conducting such assessments before funding is secured as part of the competitive process.

CONCLUSIONS

In our previous paper we concluded that the establishment of the Scottish National Energy Company "creates a number of significant and substantial opportunities for enabling the decarbonisation of Scotland's energy supplies, tackling fuel poverty, creating new and skilled employment opportunities, enabling social and economic regeneration of deprived communities (particularly in rural and remote areas), and a number of other co-benefits"[97].

The planning and deployment of successful district heating systems and heat networks is perhaps the most significant of these opportunities, but also the most challenging. This is in no small part due to the sheer diversity of data and specialist expertise, and the level of public and political backing, that has been brought to bear in the development of the world's leading DHS projects. Many of which are in Denmark, and so we reiterate the evidence from our previous work on the need to mirror the Danish approach to developing renewable and low carbon energy supplies. Nevertheless, as Denmark and other countries have shown, this millennia-old form of heating has the potential to bring about radical and long-term benefits to Scotland's environment, economy and society.

It would be easy to sit back and simply criticise the Scottish's Government's lacklustre performance on developing district heating; however, as a 'think and do' tank we have put forward a strategy and a set of draft criteria that, the evidence tells us, would lead to a substantial ramping up of the deployment of sustainable heat networks in areas where their benefits would be the greatest. The data and information necessary to implement these proposals are already available to the Scottish Government, and the necessary powers and responsibilities are already fully devolved however, as we have noted previously, further benefits could accrue to the NEC under greater devolution and independence.

Central to this Scottish DHS revolution should be the adoption of multi-technology approaches to the development and deployment of heat networks. Recovering waste heat and utilising local site-specific renewable resources should be seen as key priorities for strategic planning for new schemes, and energy from waste (EfW) systems will require consideration relative to other options for providing heat and managing waste. However, the combined solar thermal, biomass and inter-seasonal heat storage model now gaining traction across Europe provides a highly replicable technological option, providing that biomass fuel supplies can be sources sustainably, and the development of local supply chains itself presents significant opportunities to leverage direct and co-benefits for job creation, recreation, tourism, enhancing biodiversity, tackling climate change and fuel poverty, and regenerating deprived rural and remote areas of Scotland. This is an opportunity Scotland cannot afford to miss, and the criteria presented here have been developed to ensure the Scottish Government can maximise these benefits and join the group of nations that are leading the world in the development of environmentally responsible, equitable and sustainable district heating systems.

As ever, we welcome further comment and engagement from all those seeking to secure an environmentally, economically, and socially equitable energy future for Scotland.

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