Heat network skills in Scotland

Skills gaps and training needs
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Abstract

Upscaling the use of low carbon district heating in Scotland will create new demands on the supply chains needed to design, install, commission and maintain these networks. A recent stakeholder workshop suggested there are already a range of skills gaps creating challenges in the sector, covering areas of project management, heat network design, installation and optimisation, as well as technical operation and maintenance.

This research develops a detailed picture of the skills gaps in the heat network supply chain using interviews with nine heat network operators and managers from both rural and urban networks in Scotland. A high-level review of existing teaching and training provision in Scotland's colleges and universities is also presented, informed by interviews with lecturers and college curriculum leads from nine institutions, to identify opportunities for expanding existing training and teaching provision to meet the future needs of the Scottish heat networks industry.

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Executive Summary

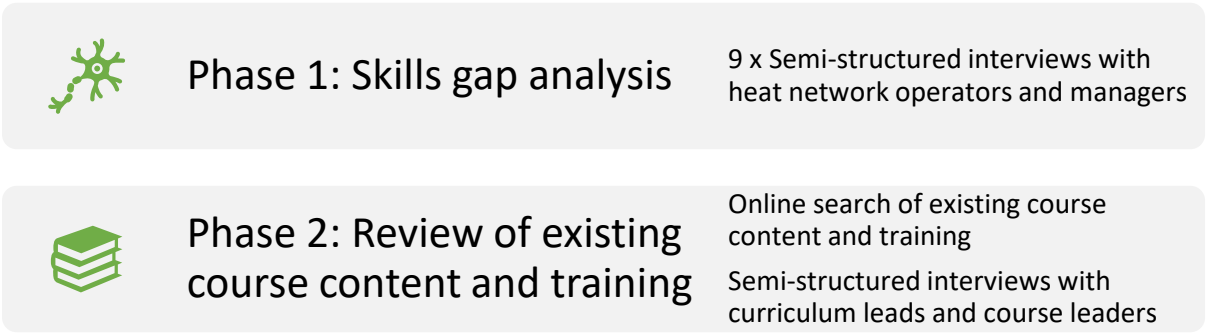
Growing the capacity of low carbon district heating in Scotland will create new demands on the supply chains needed to design, install, commission and maintain these networks. A workshop to discuss heat network skills gaps was held in November 2019, bringing together over 40 heat network practitioners including product suppliers, energy companies, local authorities, consultancies and public sector organisations. The workshop outputs highlighted a range of skills gaps already creating challenges in the sector, covering areas of project management, heat network design, installation and optimisation, as well as technical operation and maintenance.

This research builds on the outputs from the workshop to address the following objectives:

- To identify and understand more details about existing skills gaps in the Scottish heat network supply chain;
- To review existing teaching provision of heat network skills in Scottish colleges and universities.
- To compile a list of college and universities with an interest and the potential to expand their curriculum content on heat networks to begin to address skill gaps.

Method

The research was conducted in two phases using semi-structured interviews with heat network practitioners, college and university lecturers, combined with an online review of available courses:



Phase 1: Skills gap analysis

A full list of the skills gaps identified by the research is presented in section 3.8 (Table 1), categorised by: project management of heat network delivery & operation; heat network design; installation and optimisation of heat networks, and technical operation and maintenance.

The analysis suggests that:

- The current informal or ad-hoc approach to training risks inconsistent and weak standards and a lack of awareness of potential for decarbonisation options. There is currently no benchmarking of formal accreditation of training standards.
- Skills gaps are being filled through the use of specialist heat network contractors, however, this risks:
    - A lack of in-house capacity development which could hinder longer-term planning and expansion of networks.

    - A limited capacity in the supply chain to meet any future demand increases; (and potentially higher costs)
- Skills gaps were particularly acute in rural and island areas of Scotland, where it was often not possible to access specialist contractors to carry out works because they did not exist in the local area and it was not cost effective for contractors to travel from further afield for smaller-cost value jobs
- Developing teaching for low carbon heat network skills will be particularly important in the coming years, including designing and installing for low and ambient temperature networks; making use of large-scale (or smaller modular assembly) heat pumps and waste heat sources, thermal storage; highly efficient digitalised networks; and retrofitting into older building stock.
- There is a need for non-technical training on heat networks for project administrators/managers and other practitioners supporting heat network development and operation such as board members, financial managers, planning officers, procurement officers and lawyers. The research also highlighted a training gap for staff undertaking customer and stakeholder engagement activities for encouraging network connections and behaviour change.

Phase 2: Review of existing course content and training

There was significant scope and interest from the interviewed college and university lecturers to expand the curriculum on heat networks.

- At college level, curriculums already cover relevant skills that can be easily adapted and applied to installing heat networks. There is a need to provide more practical experience of applying these skills, as well as design and specification requirements for low carbon, low temperature networks.
- At university level, existing teaching on heat networks was concentrated within final year undergraduate and masters level dissertation topics, as well as a limited number of specialist applied courses focused on buildings. There is an opportunity for more linking with local heat networks to enhance teaching and make use of real-life data within student research projects.

Recommendations

Based on an analysis of these interviews and course reviews, four colleges and two universities were identified as priority institutions for exploring the potential of developing specialist heat network training centres.

The following colleges were selected due to their existing course content on heat networks, as well as opportunities to deliver practical teaching due to an existing heat network connection on the college campus or proximity to a heat network:

- Glasgow Kelvin College
- West College Scotland
- Edinburgh College
- South Lanarkshire College

Two universities were highlighted for priority consideration due to their existing course content and reputation within the building services and facilities management industries.

- Glasgow Caledonian University
- Heriot-Watt University

(Several other academic institutions which did not participate in the interviews could also be suitable and would be worth exploring, particularly in rural areas where supply chain gaps are acute).

A set of general recommendations was also made for supporting the expansion of training provision in Scotland for meeting the needs of the heat network sector in the coming years.

Specialist heat network training centres

- Consider setting up one or two specialist heat network training centres within colleges and universities to pool resources and student demand; delivering stand-alone short-courses and / or optional modules for existing courses, linked with opportunities for hands-on learning, addressing the key skills gaps outlined in Table 1 (section 3.8).
- The Energy Skills Partnership Scotland could play an invaluable role in facilitating training development in the college sector given their experience delivering similar objectives with other low carbon technologies.
- Additional focus should be given to rural colleges that are within proximity of existing networks areas to implement the general recommendations below and consider offering funding to support rural contractors to attend training courses.

General recommendations

- Facilitate collaboration between the heat network industry and colleges and universities to enable sharing of case studies, data for dissertation projects, site visits, student placements, industry guest lectures and graduate job opportunities.
    - 'Train-the-trainer' CPD opportunities for lecturers. At college level, this could focus on the requirements for installation and maintenance of innovative low carbon, low temperature networks. At university level, this could focus on design of low carbon heat networks and their integration into regional decarbonisation planning, with a particular consideration of the challenges of retrofitting networks.
- There is potential for the heat network industry to coordinate efforts to shape new curriculum content and ensure any new heat network training courses are viable with a steady student demand. Actions might include:
    - Commitments to provide student numbers to participate in relevant training courses delivered by the centre
    - Representing the industry on college and university advisory panels and to input into the development of new heat network course content.

1 Introduction

Heat networks have an important role to play as part of a mix of technologies for meeting Scotland's 2045 net-zero carbon target. They are made up of a centralised heat supply and a series of pipes which deliver heat to multiple buildings in a local area, or multiple dwellings within a single building. The Scottish Government has put in place a number of policy measures to support the increased development of new low carbon heat networks. The 2020/2021 Scottish Government Budget allocated £50 million for a Heat Networks Early Adapters Fund to 'enable local authorities to bring forward investment ready heat networks' [1]. Most recently, the Heat Networks Scotland Bill was laid before parliament on 2nd March 2020, setting out a range of policies to stimulate development of new low carbon heat networks as part of a planned transition to a net-zero carbon energy system, while ensuring standards and protections for heat network customers [2].

Upscaling the capacity of district heating will create new demands on the supply chains needed to design, install, commission and maintain these networks. Initial findings of Scottish Government Impact Assessment [3], carried out of the Heat Networks Bill, found that practitioners were experiencing a number of challenges and skills gaps. These included:

- Higher prices than within continental mainly Europe due to a lack of competition and capacity within the UK supply chain.
- A limited number of contractors with experience of working on heat networks.
- Particular concerns about a lack of qualified, local contractors to service rural networks, driving up the costs in these areas as much as 40-50% higher compared to the central belt of Scotland where most of the supply chain was currently found to be located.

This report, commissioned by the Energy Saving Trust and Scottish Government, aims to give an in-depth analysis of the current experiences of practitioners working in this specifically Scottish context, in order to identify existing skills gaps in heat network supply chains, and to assess the potential for developing training provision within colleges and universities to fills these gaps[1].

1.1 Background

Skills gaps in the heat network supply chain have been recognised by heat network managers and product manufacturers for several years. This has led to a range of training and up-skilling solutions led both by local public sector actors, private training centres and product manufacturers across the UK.

Fulfilling these training needs have also been viewed as a local economic opportunity by local authorities. For example, Stoke-on-Trent College founded the Heat Academy in 2014 in partnership with their Local Enterprise Partnership as part of the city's vision to create "a low carbon and low cost heat energy to Stoke-on-Trent which will have a positive impact on the social welfare of the city's residents, but which will also create local investment, training and employment opportunities over the next 25-50 years" [4]. The skills training academy includes courses on building services engineering, mechanical, electrical and civil engineering, extrusion

[1] This research is complemented by a research project taking place in parallel, commissioned by the UK Government's Department for Business, Energy and Industrial Strategy (BEIS), which covers the whole of the UK, but draws on primary data predominantly from England and Wales. The findings of this UK-wide research are reviewed in the discussion section of this report to note relevant findings, similarities and differences.

welding, plumbing, electrical installation, heating and ventilation, highways maintenance and groundworks (construction operations).

In light of these perceived skills gaps and potential economic opportunities, an initial workshop was hosted by Scottish Government and Energy Saving Trust in November 2019 to discuss heat network skills in Scotland, bringing together over 40 key people from across 30 organisations including product suppliers, energy companies, local authorities, consultancies and public sector organisations. Attendance at the event was high, indicating a demand from practitioners to address the issue. The workshop attendees developed a list of particular skills gaps in the Scottish supply chain and suggested there was a need for a more strategic training provision to support the sector.

1.2 Research objectives

Building on the findings from this initial workshop, this research project sought to deliver on the following objectives:

1. To identify existing skills gaps in the Scottish heat network supply chains.
2. To review existing teaching provision of heat network skills in Scottish colleges and universities.
3. To compile a list of college and universities with an interest and the potential to expand their curriculum content on heat networks to begin to address skill gaps.

1.3 UK Government BEIS-commissioned research into heat network skills

This research is complemented by a research project taking place in parallel, commissioned by the UK Government's Department for Business, Energy and Industrial Strategy (BEIS). The 'Heat Network Skills Review' [5], was undertaken over similar timescales and drawing on primary data predominantly from England and Wales so as not to duplicate the findings of this Scottish research, but also considering UK-wide statistics. The broader scope of the report highlights some important findings that are relevant to Scotland and the findings of this report:

- A sector profile exercise highlighted the challenge of developing heat network skills because the sector sits "at the interface of a range of other sectors, particularly energy, engineering and construction" (p9., BEIS 2020). These other sectors experience their own skills gaps, creating a competitive environment for the heat network sector to recruit key personnel with relevant skills. The report recommends embedding content on heat networks, and heat decarbonisation more generally, into relevant university and college curriculums in order influence where people see as an attractive job destination after they graduate and to promote the sector.
- Non-specialist practitioners, such as local authority energy officers, procurement officers or financial managers, often play an influential role in bringing forward district heating projects to development. This means that training provision should not only be focused on traditional education and training routes, but also on continuous professional development that can be undertaken as people apply their wider skills to heat network projects. The report also highlights an opportunity to engage with "professional bodies and industry bodies, including those relatively peripheral to the sector such as those responsible for Urban Planning, Surveying and Architecture, to work towards including the knowledge on heat networks within their existing professional standards, qualifications and accreditations" (p 14).

2 Method

The research was conducted in two phases (see Figure 1). The first phase used nine semi-structured interviews with heat network operators and managers from a range of rural and urban heat networks across Scotland who were leading the operation and maintenance of existing heat networks, or in the late stages of extending or developing a new network. The interviews lasted approximately 30 minutes and covered three areas:

- Where practitioners developed their own skills and experience of developing, operating and maintaining heat networks in Scotland.
- The skills of staff and contractors that worked on their heat network projects.
- Their perceptions of current skills gaps in Scotland.

Interviewees were provided with a list of skills gaps identified at the initial workshop held in November 2019. This included a list of 25 different skills categorised into four areas: project management of heat network delivery; heat network design; installation and optimisation of heat networks; and operation and maintenance.

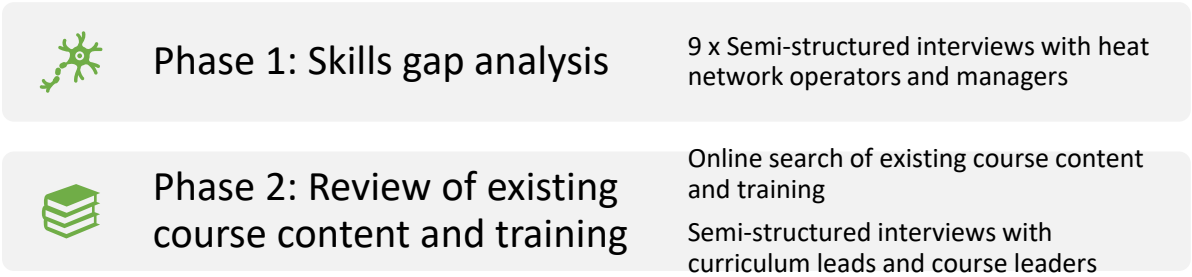


Figure 1: Summary of the two phases of the research method.

The interviews were conducted with representatives from the following organisations:

- The University of Edinburgh
- University of Strathclyde
- West Highland Housing Association
- Shetland Heat Energy and Power
- Aberdeen Heat and Power
- West Dunbartonshire Council
- Dundee City Council
- Fife Council
- Vattenfall UK

In addition, survey questions were emailed to all attendees of the initial workshop. One response was received from a representative from Rehau Ltd (a supplier of polymer heat distribution pipes). This response has also been included within the analysis presented below.

The second phase of research reviewed existing courses and training relevant to heat networks and assessed the potential of colleges and universities to host specialist centres for heat network training; aiming to address current heat network skills gaps in Scotland.
Figure 2 summarises the process for carrying out this review.

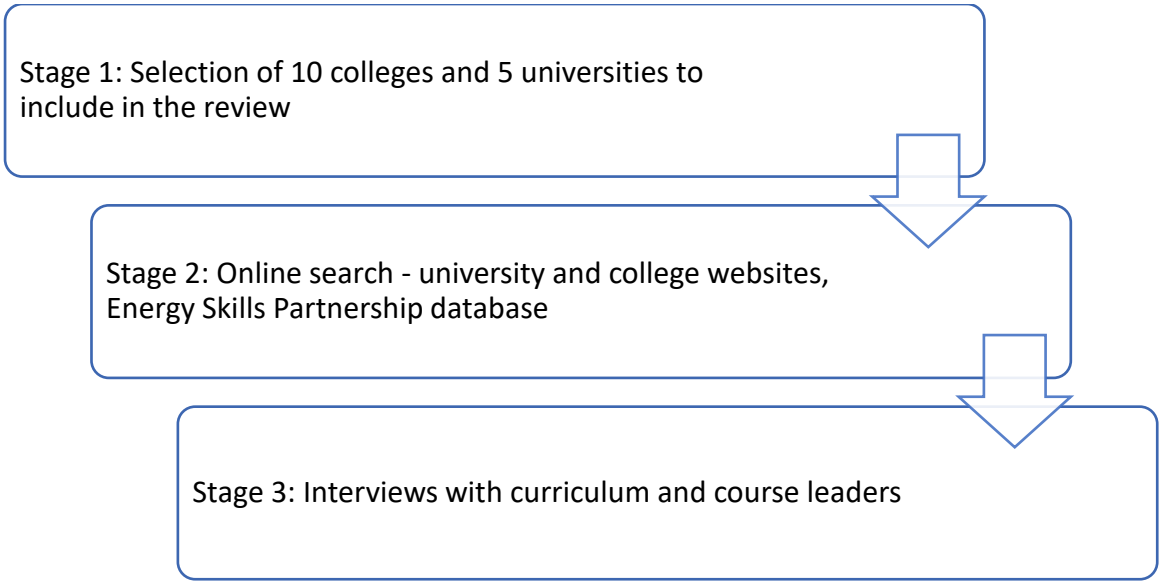


Figure 2: Process for reviewing the existing and potential for heat network training provision in Scotland

In **stage 1**, due to the limited time and resources available to conduct the research project, (and in order to maximise the local benefits of potential training) 4 universities and 13 colleges were selected from across Scotland to include within the review based on their proximity to existing heat networks already in operation and those in development (see section 4.1), indicating the geographical areas where there was most likely to be demand for heat network skills.

Stage 2 involved an online search of the selected college and university websites, alongside the Energy Skills Partnership directory of courses (https://directory.esp-scotland.ac.uk), to identify existing courses that were directly or indirectly related to heat networks[2]. The course search parameters were focused on the list of relevant courses identified as potentially relevant to heat network skills gaps in Table 1.

Stage 3: Where possible, this information was supplemented with a series of 9 semi-structured interviews with curriculum and course leads from both colleges and universities. The interviews were conducted via telephone and explored the following themes:

- The content and approach to teaching of existing courses with direct and indirect relevance to heat networks
- Perceived demand for relevant skills in the job market
- The potential for expanding curriculum content to include heat network skills

An invitation to participate in research interviews was sent out to all relevant college curriculum leads via the Scottish Energy Skills Partnership. Eight colleges responded, of which six took part in interviews (see list of colleges below). University course directors and relevant lecturers were identified via online searches of university websites for researchers with an interest in heat, as well as via recommendations from heat network managers about where they knew there was existing course content on heat networks. Due to time constraints, only four universities were invited to take part in interviews.

[2] Courses were classed as 'directly' related where they specifically covered some aspect of heat networks. Courses were 'indirectly' related where they covered skills and concepts useful to heat networks but did not cover heat networks specifically.

The interviews were conducted with representatives from the following institutions:

Colleges

- Dumfries and Galloway College
- Edinburgh College
- Glasgow Kelvin College
- West College Scotland
- West Lanarkshire College
- West Lothian College

Two more colleges responded to the invitation to participate in the research but did not take part in interviews due to the Covid-19 crisis.

Universities

- Heriot-Watt University
- Glasgow Caledonian University
- Edinburgh University

Lecturers from Strathclyde University also responded via email to research questions.

Analysis of these interviews does not provide a complete review of the available courses and opportunities at institutions within Scotland, but instead is intended to provide an indication of existing course content that is taught and opportunities and challenges that may exist for expanding this provision to cover heat network skills gaps.

Based on analysis from these 3 stages, recommendations were made about potential strategic locations for developing specialist heat network training centres, and the necessary steps that would be required to do this (section 5).

3 Results – Skills Gap Analysis

The first phase of this research involved a skills gap analysis to develop a more in depth understanding of the heat network skills training needs in Scotland. A thematic analysis of the nine interviews conducted with heat network managers was conducted to identify important themes relevant to understanding heat network skills development needs in Scotland. The following section discusses each arising theme in turn.

3.1 Existing skills and experience of heat network practitioners

The interviewed heat network practitioners had a range of experience levels ranging from never having worked on a heat network until their current role, to having over 40 years of experience working on different systems. Their heat network skills and knowledge were predominantly learnt on the job, adapting expertise from other engineering areas including mechanical, electrical and sub-sea engineering as well as building services and social housing management (of those interviewed here, three interviewees came from a background in social housing management). Those practitioners with longer-term experience of heat networks had spent much of their career managing existing, high-temperature steam heat networks in hospital and university buildings, including decommissioning existing network connections to install decentralised building-level gas boilers.

No one interviewed had formal qualifications or training in relation to heat networks, although some practitioners had undertaken short courses, workshops and international study trips (including site visits) to deepen their knowledge. These sources of training and continuous professional development mentioned by interviewees included:

- In-house skills for on-going maintenance of networks were developed through shadowing the contractors responsible for the design and install contractors, or specific training courses delivered by suppliers of key parts such as heat interface units.
- Technical workshops led by trade groups including Nordic Heat and the Danish Board of District Heating (DBDH) (Continuous Professional Development (CPD), not qualifications).
- Workshops run through the Scottish Heat Network Partnership enabled learning and sharing of experience with other practitioners.
- Chartered Institution of Building Services Engineers (CIBSE) guidance and news articles provided ideas for good practice and inspiration for more innovative approaches to heat supply solutions. CIBSE also offer heat network training courses, although none of the interviewees in this research mentioned undertaking them as part of their own professional development.

A challenge of this organic approach to knowledge development is that there is potential for a variation in the level of understanding and expertise of key decision makers responsible for developing and managing networks, leading to missed opportunities.

- In one case, an interviewee felt that learning on-the-job had led to a missed opportunity to install a heat network in a multi-functional redevelopment project due to the time taken understanding the potential options.
- Two interviewees commented that although practitioners possessed a basic understanding of heat network design concepts, there was a still a significant lack of understanding of the design needs for low carbon heat networks required for meeting net-zero ambitions, in particular low temperature systems and the specifications needed in buildings connected to such systems.

There was a significant reliance on external expertise for delivering high standards of design, installation, commissioning, and operation, particularly in relation to low carbon heat networks. The following themes explore interviewees' experiences to date of accessing this expertise throughout the design, delivery, operation and maintenance of networks.

3.2 Accessing skills through specialist contractors

Multiple interviewees procured contractors offering all-in-one packages of design, build and operate. These contracts were dominated by a few specialist companies, who were then able to draw on their wider pool of in-house staff across the UK to deliver on heat network specific issues, whilst sub-contracting to local contractors on more general works. In these cases, interviewees felt that there were no skills gaps directly affecting their projects because they could rely on the contractor's ability to provide key skills as and when required.

- One interviewee stated that without the experience and capacity of these specialist contractors then it would not be possible to find alternatives with the necessary skills and knowledge to install the equipment.
- Another interviewee highlighted the value of using a specialist contractor for overcoming network development challenges such as retrofitting district heating pipes under public roads, where it was difficult locating existing utilities and liaising with relevant departments in local authorities to gain access to dig. They had also experienced difficulty with a civil engineering contractor that had not worked on installing district heating piping into public places as they did not have the necessary health and safety awareness to manage the public use of the space alongside the works taking place.

For networks that had chosen to procure an all-in-one package to develop and operating their networks, these specialist contractors were an important source of experience and expertise that outsourced challenges caused by skills gaps in the market. However, given this approach was also felt to be the only option available to many of the network managers, this creates a risk of over reliance on these few specialist companies, potentially with increased costs due to the lack of competition in the market, along with potential challenges scrutinising their work due to a lack of in-house knowledge.

3.3 Applying general skills to heat network installation and maintenance

A number of transferable or general skill sets were mentioned by interviewees as relevant to heat network installation and maintenance. These included mechanical and electrical engineering, plumbing, and highways and maintenance. Pipe welding was a critical skill to the successful installation and efficient functioning of a network with steel pipes (although it was noted that use of polymer pipes could reduce the need for pipe welding in future developments).

- One interviewee described how a highly skilled welder was more important to them than specific heat network pipe welding training. However, this relied on local availability and affordability of skilled welders.
- In the installation of one network, the pipe supplier worked with the local contractors to train them in the specific requirements for welding and muffing of their pipes at installation. This was something that the pipe supplier routinely did in the UK market as they were aware that contractors did not usually have experience of heat network pipe installation.
- A polymer pipe supplier, operating across Europe, trained their UK staff using their in-house experience from other countries. This included training their sales and technical

team on heat network design principles in order to be able to advise their UK clients effectively. They also offered CIBSE-approved CPD courses to contractors working on heat network installation for the first time.
- Skilled personnel from other areas of the energy sector such as oil and gas were mentioned as having relevant transferable skills that could be applied to heat networks with a small amount of additional training.

3.4 Design and management for zero-carbon heat networks

The design of zero and low carbon heat networks was highlighted as a critical skill gap. Three separate interviewees suggested that in order to meet future, net-zero carbon ambitions, network design would need to be much more innovative than it is currently. They felt that, although there were some consultants with the necessary experience and knowledge, particularly of feasibility studies for these types of networks, they were limited in number and some lacked practical experience in seeing projects through to commissioning and operation. Learning from international experience was highlighted as a critical way to overcome this challenge.

Specific challenges for zero- and low- carbon heat network design that were mentioned included:

- A lack of experience of key technologies important for low and zero carbon heat networks such as thermal storage (for both heating and cooling), heat recovery with ambient loop networks, dynamic control and monitoring of networks, and in-depth knowledge of heat pumps such as working fluids and ways of extracting heat.
- A lack of experience converting existing high temperature networks often with fossil fuel-based heat sources, such as gas CHP plants, to low carbon lower temperature heat sources
- Design of low temperature networks, particularly for retrofitting of old Scottish buildings. This included a gap in building retrofit knowledge of how to adapt buildings for connection to low temperature heat networks, as well as how to procure the design of new buildings compatible with such networks.
- Designing and managing digitalised energy systems with electrified heat to enable use of heat stores to balance electricity networks and to maximise efficiency of networks

A general understanding of the potential options and requirements of low carbon heat networks amongst energy practitioners and decision makers was also thought to be critical to enable the interlinking of local visions for meeting net zero across neighbouring organisations. At present, there was felt to be variable knowledge levels which meant it was difficult to develop long-term plans for networks.

One interviewee explained how they felt that the limited experience and knowledge of low carbon heat networks led to a risk adverse attitude among design consultants which prevented them from recommending innovative solutions. The consultants they had worked with reverted to solutions they had tried and tested elsewhere rather than considering more novel solutions that the interviewee felt might have better future-proofed the network.

There were several examples of scheme developments where the network design was conducted by a separate consultant from the building and operation contractors, aiming to ensure schemes were designed appropriately for their specific context rather than delivered in a familiar design to the build contractor. The consultants commissioned to do this work had previous experience of network design that was trusted by the interviewees and external

funders supporting the projects. This was felt to be especially important for moving beyond more familiar high temperature networks with CHP / boiler plants, towards innovative low and ambient temperature network design, making use of lesser used heat supply technologies and waste heat, thermal storage and sizing the network correctly for future proofing. In two cases, the original design of the network was created using in-house expertise, and then verified using external consultants before being approved for development.

Non-technical energy practitioners

In addition, two interviewees highlighted the important role of non-energy practitioners in the management, design and development of heat networks. These practitioners also needed more training provision, particularly on zero- and low- carbon heat networks. For example, one local authority had encountered a lack of understanding and resistance to heat network development from their own local authority planning department. Project administration, procurement, board governance and legal services were other critical areas that required some specific knowledge for application to heat networks. For example, financial modelling for district heating was singled out as a key skills risk because it was dependent on assumptions which were context specific and judgement-based, requiring the financial manager to have knowledge and experience of heat networks. Although a useful tool had been developed by the Scottish Futures Trust, the interviewee felt that a degree of specialist knowledge and experience was still required by financial managers for use within financial decision making that their in-house finance team did not have. Understanding and applying financial models for low or zero carbon networks was thought to be particularly challenging.

3.5 Existing approaches to training

One approach to overcoming heat network skills gaps was for network developers and operators to provide some form of training to their contractors to ensure they had the relevant specialist skills.

Rural and island areas

In rural and island areas, network operators highlighted that it was often not possible to access specialist contractors to carry out maintenance works or small-scale network extensions because they did not exist in the local area and it was not cost effective for contractors to travel from further afield for their small-cost value jobs.

- One scheme manager reported that when the network had first been built, local contractors were sent to training courses in Denmark on how to maintain the network. As time had passed, many of these original contractors had retired, but it was not worth conducting another phase of training with new contractors since they only had small maintenance requirements at present. Instead, new contractors, such as plumbers and electricians conducting maintenance work on HIUs in domestic properties, were invited into the heat network company's office for informal training.
- Another network manager reported that working with new contractors required close supervision from in-house staff and works often took longer to complete and could result in a higher cost for the works than might have otherwise been the case in less remote areas.

Cooperation with local training providers

Two interviewees reported taking proactive steps to collaborate with local training providers (one with a local college and one with a private training provider) in order to develop training for non-specialist contractors in heat network skills before working on their network. Such

training qualifications had the potential to be a criterion that could be specified when tendering for work that complied with public sector procurement rules.

- In the case of one interviewee, the availability of a training course had resulted in a local firm training a number of staff and going on to win multiple contracts to work on the network as it expanded. The network manager hoped that availability of training might give more contractors the confidence to bid for the work and increase competition in the market.
- The other interviewee did not provide in-house training for any staff at present but was considering how to address skills gaps in the future, potentially through working with local colleges, providing paid internships and working with others across the heat networks sector to develop a strategic approach (e.g. a skills framework for training).

Sustained market demand for these specialist skills was highlighted as important, in tandem with training provision, as gaps in activity due to the slow development and expansion of networks had also resulted in skilled personnel moving on or losing their jobs and therefore being unavailable to work on future projects and creating a new skills gap.

Current skills gaps are being filled through ad-hoc training provision for local contractors. Training is provided through a range of approaches including informal, in-house training, training from suppliers, and private providers. Formal training and qualifications may be able to reduce the burden on network operators to develop these solutions themselves and establish consistent standards. In addition, local training provision or funding support will be important in rural areas where contractors may be unable or unwilling to invest in travelling long distances for more formal training for work that represent only a small proportion of their income.

3.6 Skills for installation, commissioning and maintenance of innovative technologies

Many of the skills required for installation of heat networks were considered to be easily transferable from the existing skills of contractors. However, interviewees reported that, where their schemes were making use of more innovative technologies such as large-scale water-source heat pumps, biomass boilers, solar thermal and PV as part of their network heat supply, even the specialist heat network contractors often did not yet have experience doing similar projects. To date the majority of schemes had consisted of high temperature networks with large heat plants from gas-fired CHP or boilers or energy from waste plants.

- In one case, an interviewee described how they had worked on an on-going basis with their contractor to resolve issues with the inefficient functioning of their network. They felt that the contractor had learnt a lot from working on their project and had since adapted their scheme design with other biomass boiler projects to include thermal storage in the system to meet peak heat demand with a smaller boiler size.

3.7 Customer engagement

Engagement with heat network customers was highlighted as another important skills gap, especially by interviewees responsible for networks with domestic customers. This included marketing and awareness raising to encourage initial connections as well as on-going engagement around maintenance and energy efficient behaviours.

- One interviewee described how a significant amount of staff time was taken up supporting customers through the repair of their home's heat interface unit. The network operator wanted to ensure the works were completed correctly, since errors

could affect the efficiency of the network as a whole. They were not confident that all local plumbers would have the skills to do the works to an appropriate standard.

- Another network operator had found that stakeholder and community engagement skills had played an important role in the success of the project, where staff had been transferred from another area of community engagement work to support the project.

3.8 Summary of identified heat network skills gaps in Scotland

Table 1 summarises the list of skills gaps that were identified through the stakeholder workshop and interviews with heat network operators. Interviewees were presented with the list of skills gaps identified at the November workshop and asked to add things they felt were missing or needed further comment. The right hand column of the table lists college and university courses that would have the potential to contain relevant content to each skill gap (this list was used to review the existing and potential heat network training provision in Scotland presented in section 4.2).

Table 1: Heat network skills gaps in Scotland, categorised by 'Project management of heat network delivery and operation'; 'Design'; 'Installation and optimisation of heat networks'; and 'Technical operation and maintenance'.

Skills gap	Relevant to: University	Relevant to: College	Courses with potentially relevant content
Gap: Project management of heat network delivery and operation			
Understanding of heat network design principles by project managers	Y	Y	Engineering - Building services, Energy systems, sustainable energy
How to procure relevant contractors	Y		Public administration, policy, project management, business, engineering project management
Quality management (QA) for heat networks	Y		Construction management, building services engineering
Quantity surveying for heat networks	Y		Construction management, building services engineering
Financial management of heat network projects	Y		Accountancy - energy projects
Stakeholder engagement, communication and marketing throughout the project planning, contracting, installation, commissioning and operation - e.g. Retrofitting pipes into public roads (circumnavigating other services) - e.g. Health and safety of carrying out works in busy, public places	-		Planning, Health and safety, project management
Customer engagement Marketing to potential new customers (including householders and other end users) Communication to consumers during rollout of new DH systems Training customers (particularly householders) on how to use and maintain the system once it is installed (including behaviour change)	Y		Marketing and communications, sustainable behaviours, psychology
Understanding and designing utility contracts	Y		Contract law, project management, business
Overview understanding of owning and running a heat network for board members: do's and don'ts, setting fair heat tariffs, regulatory obligations - e.g. licensing, heat trust	Y		Specialist course, engineering project management
Gap: Design			
Design Engineers - In-depth understanding of the design of heat networks, including: Commissioning of systems to maximise delivery of heat to end users	Y		Engineering - Building services, Energy systems, sustainable energy

Skills gap	Relevant to: University	Relevant to: College	Courses with potentially relevant content
Most efficient design of pipe routes			
Low temperature (4th generation) networks			
Designing for a range of heat sources including heat pump technologies, geothermal systems and 5th generation district heating and cooling smart technology Interconnection with a wider digitalised energy system to allow electricity network balancing with thermal stores Design for retrofit of networks into older buildings			
Gap: Installation and optimisation of heat networks:			
<u>External network heat distribution system</u>			
Extrusion welding for steel pipes.		Y	Welding
Pipe installation (both mains and internals) including leak detection systems.	Y	Y	Civil engineering, construction
Installing/interconnecting polymer pipes		Y	Civil engineering, construction
Smart technology – knowledge of how relevant products work and how to install them correctly		Y	Electrician, plumbing
Ability to install heat interface units (HIU's)			
Installation of heat pump technologies (air, ground, water)			
<u>Internal building heat distribution system</u>			
Commissioning of internal heating systems (HIUs and radiators)		Y	Plumbing
Ability to install and calibrate bespoke metering systems		Y	Plumbing
Training on understanding of design principles	Y	Y	Engineering
Ability to calibrate internals with flow return requirements with differential pressures	Y	Y	Engineering
Gap: Technical operation and maintenance			
Ability to maintain heat interface units (HIU's) – e.g. plumbers		Y	Plumbing
Ability to calibrate and maintain bespoke metering systems		Y	Plumbing

Skills gap	Relevant to: University	Relevant to: College	Courses with potentially relevant content
Proper understanding of building energy management systems (BEMS)	Y	Y	Building services engineering, plumbing
Ability to calibrate internals with flow return requirements with differential pressures	Y	Y	Building services engineering, plumbing
Understanding of heat network design principles	Y	Y	Building services engineering, plumbing
Understanding the operation and control of low temp heating and cooling distribution systems	Y	Y	Building services engineering, plumbing

4 Results – Review of existing and potential heat network training provision

The second phase of this research involved a review of the existing course content and training in Scottish colleges and universities. A selection of colleges and universities were included in the review based on their proximity to heat networks (both in operation and in development). An online search of relevant courses was conducted, in conjunction with nine semi-structured interviews with university and college course directors and lecturers. Each of these stages are presented in turn in the following sections of the report.

4.1 Stage 1: Selection of colleges and universities for review

Colleges and universities were selected for inclusion in the review based upon their proximity to existing heat networks in operation or in development[3]. Table 2 shows two maps of Scotland comparing the location of heat networks currently in development and operational with the location of college and university campuses. Table 3 displays this information in numerical form, indicating the size of each heat network to provide an indicator of the amount of potential demand for skilled personnel to support the design, build, operation and maintenance of each network.

Colleges and Universities were selected for inclusion within the review based upon:

- The number of heat networks in development in their area – representing the highest likelihood of demand for heat network skills from local contractors
- The number of heat networks in operation – suggesting a potential demand for skills related to operation and maintenance of networks.
- The size of networks in the area (where known) – a greater number of large networks suggests a potential greater demand for skills in the area.
- Remote and rural locations where the development of local skills had been highlighted as important by interviewees in phase one of the research
- Interest from college curriculum leads who responded for a general request for interview in relation to the project (indicating an interest in future heat network skills teaching).

The colleges and universities selected for inclusion in the review were as follows:

Colleges

- Borders College
- Dumfries and Galloway College
- Dundee and Angus College
- Edinburgh College
- Fife College
- Glasgow Kelvin College
- Moray College UHI
- NESCOL
- Shetland College UHI
- South Lanarkshire College

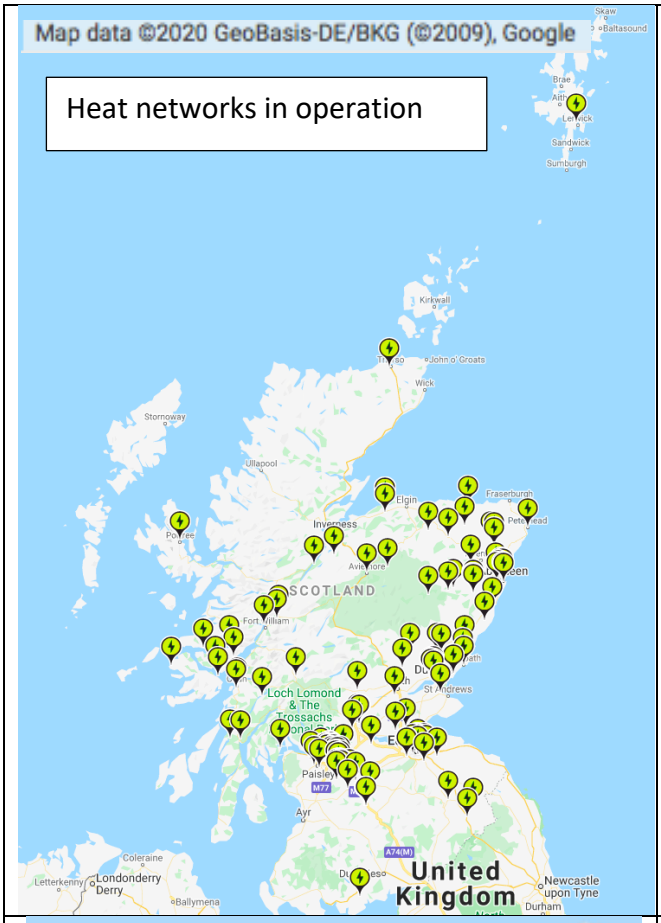
[3] Existing and in development heat network locations were determined using the Heat Network Partnership Scotland database and project funding awarded through the Scottish Government's Low Carbon Infrastructure Transition Fund and district heating loan fund.

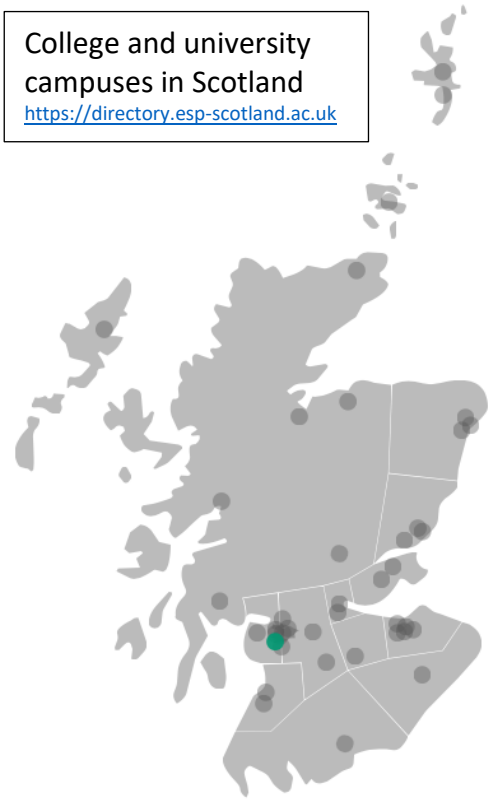
- West College Scotland
- West Highland College UHI
- West Lothian College

Universities

- Glasgow Caledonian University
- Heriot-Watt University
- University of Edinburgh
- University of Strathclyde

Table 2: Map of Scotland comparing the location of heat networks (listed as 'in development' or 'operational') with the location of college and university campuses. (Please note that the networks listed as 'in development' according to the latest available databases may now be operational). The information in this table was drawn from the Heat Network Partnership Scotland database and project funding awarded through the Scottish Government's Low Carbon Infrastructure Transition Fund (data accessed 01/02/2020).





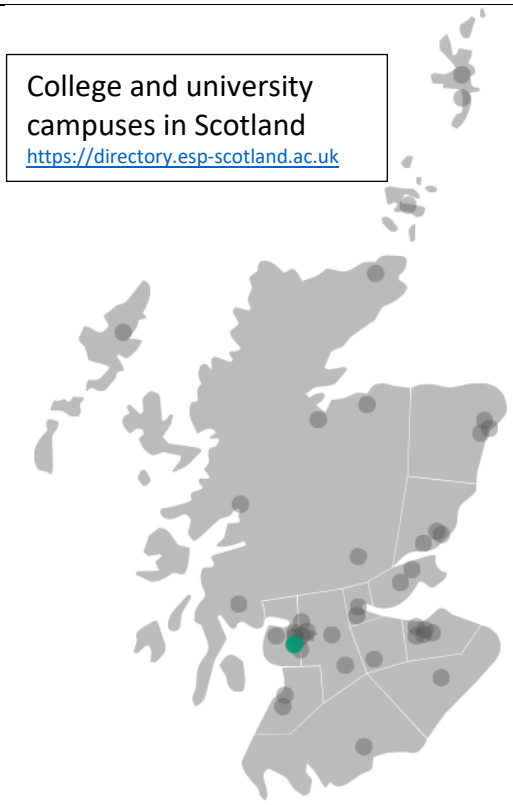


Table 3: Comparison of the number of heat networks in operation and in development (categorised by size according to information from the Heat Network Partnership directory where possible), with local colleges and universities for each region in Scotland

Region	Institutions		Heat networks								
			Operating					In development			
	Colleges	Universities	Micro	Small / medium	Large	Size unknown	Total	Small / medium	Large	Size unknown	Total
Highlands and Isles	Perth College UHI Argyll College UHI West Highland College UHI Inverness College UHI Moray College UHI North Highland College UHI Less Castle College UHI Orkney College UHI NAFC Marine Centre UHI Shetland College UHI		2	4		20	**26**			5	**5**
Aberdeen and Aberdeenshire	NESCOL - North East Scotland College	Aberdeen University Robert Gordon University		5	2	17	**24**			7	**7**
Tayside	Dundee and Angus College	University of Dundee Abertay University		4	3	4	**11**	1	1	1	**3**
West	West College Scotland			2		2	**4**		1	3	**4**
Glasgow	City of Glasgow College Glasgow Kelvin College Glasgow Clyde College	University of Strathclyde University of Glasgow Glasgow Caledonian University	1	14	3	2	**20**		1	4	**5**
Lanarkshire	New College Lanarkshire South Lanarkshire College			9	3	2	**14**			2	**2**
Forth Valley	Forth Valley College	Stirling University		1	1	2	**4**		1		**1**
Fife	Fife College	St Andrews University			2	2	**4**		1	1	**2**
Ayrshire	Ayrshire College	University of the West of Scotland					**0**			1	**1**
West Lothian	West Lothian College						**0**		1		**1**
Edinburgh and Lothians	Edinburgh College	Edinburgh University Queen Margaret University Heriot-Watt University Edinburgh Napier University		3	2	5	**10**		1	2	**3**
Dumfries and Galloway	Dumfries & Galloway College					1	**1**			1	**1**
Borders	Borders College			1		2	**3**			3	**3**

4.2 Stage 2: Online search of existing course provision

Table 4 and Table 5 present the results of an online review of relevant courses currently provided at the selected Scottish colleges and universities. Using the college and university websites and the Energy Skills Partnership Scotland Directory (https://directory.esp-scotland.ac.uk) to find courses that might be directly or indirectly relevant to heat networks. These included energy, engineering, construction, architecture and building design, building services. Courses were judged to be relevant based upon the interviews with heat network managers and course lecturers. The tables below are unlikely to provide a complete list of relevant courses but provide an indication of the range of courses available at each institution.

Table 4: List of potentially relevant courses identified by an online search of college websites and the Energy Skills Partnership Scotland directory. Interviews were conducted with a representative from colleges marked with (*).

College	Potentially relevant courses	Notes
Borders College	Renewable energy, society and the environment; Renewable Energy Sources and Energy Efficiency Methods; Ground Source Heat Pumps Renewable Awareness; Biomass Renewable Awareness; BIM (Building Information Modelling) technology; Plumbing (an introduction, Level 3); Electrical Engineering HNC, NC (SCQF Level 5, Level 6)	
Dumfries and Galloway College*	Heat pump systems (BPEC), Solid Biomass (BPEC), Solar thermal hot water systems (BPEC), Unvented hot water storage systems (BPEC), Electrical power engineering (Wind turbines) (SCQF Level 6), Renewable energy systems (SCQF Level 8), Electrical engineering (SCQF Level 5, 6, 7, 8), Engineering maintenance (SCQF level 6), Engineering fabrication and welding (SCQF level 5, 6), Plumbing (SCQF Level 5)	The college has a renewables hub on the campus for hands-on teaching of its renewable energy courses.
Dundee and Angus College	Solar domestic hot water heating (SCQF Level 5), BPEC Unvented hot water cylinders (SCQF Level 5), Certificate renewable energy (SCQF Level 6), Built Environment (HNC SCQF Level 7), Civil, Electrical, Mechanical engineering (SCQF Level 5, 6, HNC SCQF Level 7); Civil engineering (HND SCQF Level 8), Fabrication and welding (SVQ Level 3 SCQF Level 6), Certified welding (SCQF Level 6)	
Edinburgh College*	Civil, Electrical and electronic engineering, Mechanical (HNC, HND), Building services engineering (HNC), Energy and Environmental Engineering (including HND Engineering Systems with Renewables), Engineering systems (HNC), Fabrication and welding engineering (EAL SPEO SVQ2), Heating and Ventilation: Industrial and Commercial Installation (SVQ3 Level 3), Measurement and control engineering (HNC)	They are one of only two courses in Scotland that deliver large-scale heating and ventilation courses, although very little content on low carbon heat delivery is currently covered. They have a campus located near to the large Midlothian heat network currently in development.
Fife College	Electrical engineering, (SCQF Level 5, 6, HNC Level 7, HND Level 8), Mechanical engineering (SCQF Level 6, HND SCQF Level 8), Petroleum engineering (HNC SCQF Level 7), Wind turbine maintenance (SCQF level 6), Built environment – National certificate (SCQF Level 6), Quantity surveying (HNC and HND SCQF Level 7, 8), Fabrication and welding and inspection (HNC SCQF Level 7), Building services – plumbing and electrical (SCQF Level 5)	
Glasgow Kelvin College*	Heating and ventilation industrial & commercial installation (SCQF level 5); Plumbing (SVQ level 3 - SCQF level 7); Refrigeration, air conditioning and heat pump systems (SCQF level 5); Building services engineering (NC / HNC SCQF level 6, 7); Civil, electrical and mechanical engineering (NC / HNC / HND - SCQF level 6, 7 and 8); Construction management (HNC SCQF level 7);	They are one of only two courses in Scotland that deliver large-scale heating and ventilation courses. There is existing content on heat networks in their Building services course.

College	Potentially relevant courses	Notes
Moray College	Training and assessment for the installations and maintenance of **s**olar thermal hot water systems, Air & Ground Source Heat Pumps (non-refrigerant circuits), wood pellet burning appliances and energy efficiency (QCF Level 3); Electrical and mechanical engineering Engineering (fabrication and welding, Electrical / electronic / Mechanical) (HNC SCQF Level 7, NC Level 5 SCQF Level 6, BEng (Hons); Plumbing (SCQF Level 6)	The college is home to a 'Gas, oils and renewables assessment centre'
NESCOL	Engineering Systems (SCQF level 5); Fabrication and Welding (SCQF Level 5); Heat Transfer and fluid mechanics (SCQF Level 8); Utilisation of electrical energy in buildings (SCQF level 8, distance learning); Performing engineering operations (SVQ Level 2), Mechanical and electrical engineering - Mechanical Maintenance, Fabrication and Welding (SCQF Level 5 and 6, HNC level 6 and 7, HND level 8, Foundation apprenticeship level 6);	
Shetland College UHI	Construction Management (HNC SCQF Level 7) - Includes: Quality in construction, Health and Safety in construction, Building services and introduction, Construction planning	
South Lanarkshire College*	Environmental Technologies (SVQ Level 3) – Include working principles, installation options and regulatory requirements for micro-renewable technologies, water harvesting and recycling technologies including solar thermal hot water systems, solar photovoltaic and heat pump systems; Green Advice Domestic Energy Assessment qualification (QCF level 3 diploma); Ground/Air Source Heat Pump Installer (NVQ Level 3); Construction & Civil Engineering Services (Level 2 Modern Apprenticeship Construction Operations); Construction management (HNC); Domestic unvented hot water storage systems (BPEC); Gas and renewables (BPEC); Quantity Surveying (HNC)	Was an early adopter of delivering teaching on low carbon home building techniques. Built a low carbon home prototype for use in teaching in 2010 which includes use of a ground source heat pump.
West College Scotland*	Advanced craft carpentry and joinery - covers sustainable building technologies as part of a wide range of topics (SCQF level 7); Construction management (HNC SCQF level 7); Build Environment – includes Domestic Building Service, Groundworks and Substructure Technology, Sustainable Design for Architecture (SCQF level 6); Plumbing (SCQF level 4); Fabrication, welding and inspection (HNC SCQF Level 7 and NC SCQF Level 6); Mechanical and electrical engineering (HNC SCQF Level 7 and NC SCQF Level 6); Engineering systems – covers renewable energy systems (HNC SCQF Level 7)	The plumbing course currently includes content on heat networks. In addition, their Clydebank campus is connected to the West Dunbartonshire Heat network and the college plans to develop teaching content around that.
West Highland College	Construction skills certificate - Includes: Plumbing, electrical, 2-week work placement in industry	
West Lothian College*	Construction technology – built environment (HNC SCQF Level 5, 6 and 7); Construction management (HNC SCQF level 7); Architectural technology (HNC SCQF Level 7); Engineering systems (NC /HNC / HND - SCQF Level 6, 7 and 8); Civil and mechanical engineering (NC /HNC / HND - SCQF Level 6, 7 and 8); Fabrication and welding (NC Level 5); Plumbing (SCQF level 5);	They are bidding to become a specialist centre for teaching of insulation and energy efficiency for pre-1919 buildings, including setting up hands-on teaching buildings for testing and installing technologies.

Table 5: List of potentially relevant courses identified by an online search of university websites.

University	Potentially relevant courses	Notes
Glasgow Caledonian University	Building Services Engineering (BEng Hons, MSc), Degree Apprenticeship Construction and Built Environment (Quantity Surveying) (BSc Hons), Construction management (BSc Hons), Environment and Civil engineering (BSc Hons), Environmental Management (BSc Hons), Mechanical Systems Engineering (BSc Hons, MEng), Electrical Power Engineering (BSc Hons, MEng), Electrical and electronic engineering (BSc Hons, MEng)	The Building Services courses went into detail about heat network optimisation and management. This course accepted part-time students who often came from industry with experience of working on heat networks. Undergraduate modules that covered heat networks included: 3rd year - energy and building module 4th year - energy design module. Other teaching covered fuel poverty, heat mapping and urban heat islands
Heriot-Watt University	Energy (MSc), Renewable Energy Engineering (MSc), Energy Economics (MSc), Urban Energy (Research PhD, MSc), Sustainable Urban Management (MSc), Urban Regional Planning (MSc), Urban Strategies and Design (MSc), Mechanical Engineering and Energy engineering (BEng Hons, MEng), Chemical Engineering and Energy Engineering (BEng Hons), Institute of Mechanical Process and Energy Engineering (Research MSc, PhD), Civil Engineering and construction management (BSc Hons, MEng), Architectural Engineering (BSc Hons, MEng)	Heat network content was embedded into courses in various forms including modules on environmental modelling, building design, thermal studies. Group design projects and student dissertations also often focused on low carbon heat provision and heat networks, normally working with a local real-life building as a case study.
University of Edinburgh	Civil and environmental engineering, electronics and electrical engineering, mechanical engineering, Structural engineering with architecture (BEng Hons, MEng), Environmental geoscience (BSc Hons), Carbon Management (MSc), Energy Systems (Research masters), Energy, society and sustainability (MSc), Environmental sustainability (MSc), GeoEnergy (MSc), Global environment challenges (MSc), Sustainable energy systems (MSc), Advanced sustainable design (MSc), Infrastructure and environment (Research Masters)	Teaching on heat networks was covered in a number of Masters courses including Carbon management (MSc) and GeoEnergy (MSc) and some engineering courses. Dissertation topics focused on heat networks in detail including non-technical aspects such as public perceptions and stakeholder engagement.
University of Strathclyde	Civil and environmental engineering, Electronic and electrical engineering, Mechanical engineering (with financial management), (BEng Hons, MEng); Sustainable engineering: Renewable energy systems and the environment (MSc); Energy systems innovation (MSc); Electrical energy systems (MSc); Electrical Power and energy systems (MSc); Global energy management (MSc); Advanced mechanical engineering and energy systems (MSc); Sustainable engineering: Architecture and ecology (MSc); Architectural studies (BSc Hons); Environmental entrepreneurship (MSc); Geoenvironmental engineering (Research Masters); Hydrogeology (MSc); Systems Engineering Management (EngD, MSc); Urban design (MSc); Technology policy and management (MSc); Sustainable and Environmental Studies (MSc);	There were courses with a significant heat and buildings focus, as well as engineering modules which covered relevant topics including topics on the future of energy and low carbon heating. Heat networks were also popular as a Masters dissertation topic on Sustainable and Environmental Studies, and Environmental Entrepreneurship. A number of course leaders were looking to expand their teaching content on heat networks.

4.2.1 Other sources of existing training

The scope of the course review in this research was restricted to college and universities, however, other sources of training were mentioned by interviewees:

- Training provided by suppliers / manufacturers:
  - CPD on district heating design principles (CIBSE approved)
  - Installer training to new contractors getting involved in heat networks using their products
- Training by a private training provider was in development at the time this research was conducted (February 2020):
  - Course 1: for qualified plumbers about installing HIUs in the home.
  - Course 2: 1-day course for new board members or project managers, providing a basic background and understanding of heat networks, including what it is, how it works, and basic design concepts.
- CIBSE Heat networks code of practice training course – two-day training course

As discussed in section 3.5, these other sources of training played an important part in up-skilling practitioners looking to transfer existing professional skills to work on heat networks. This form of training may also be the most appropriate format for some training needs such as introductory courses for new board members and project managers who do not need in-depth technical knowledge.

4.3 Stage 3: Interviews with curriculum and course leaders

Analysis of the interviews conducted with curriculum and course leaders is presented in two parts: College teaching and university teaching. Interviews aimed to understand in more detail the existing and planned course content in relation to heat networks, and what might need to be done in order to include key heat network skills gaps in relevant areas of the curriculum.

4.3.1 Analysis - College teaching

There was a strong interest from the interviewed college lecturers to explore the options for expanding curriculums on heat networks, with one interviewee stating that “there needs to be a serious change in apprenticeship programmes to make sure we are future proofing apprentices that are coming into the industry.” The role that local contractors play in influencing the general public in their heating technology decisions was also recognised, highlighting the need for a greater awareness of heat networks amongst professionals across the country. The following sections discuss the existing course content, demand for courses and skills, and potential routes to shaping the curriculum in colleges.

Existing course content

Installation and maintenance skills

In general, transferable skills for the **installation and management** of heat networks were thought to be well taught already, although heat networks were not always covered specifically, and it was recognised that there was an opportunity to expand some of the training to meet heat network industry needs.

- There was some existing course content on heat networks in two of the colleges interviewed (Glasgow Kelvin College Building Services HND and West College Plumbing vocational courses). Interviewees highlighted that this content had not

been formally updated for approximately 15 years and teaching currently focused on the installation and management of traditional fossil fuel powered, high temperature heat networks and included content on Heat Interface Units (HIUs). Updates to the course content had been provided informally by the lecturers to keep the technologies relevant (e.g. covering anaerobic digester as a heat source).

- Low carbon heat sources were not covered in relation to heat networks, and neither were low temperature systems. However, a module on sustainable energy technologies had recently been updated and made a core module of plumbing courses focusing on household-scale technologies, after work lead by the Energy Skills Partnership Scotland[4]. This included installation of air source and ground source heat pumps, solar thermal and solar PV, under-floor heating and smart controls. Although this covered technologies applied at a small scale, the skills were thought to be transferrable to heat networks.
- Two colleges (Glasgow Kelvin College and Edinburgh College) currently run courses on larger scale heating, cooling and ventilation installations for industrial & commercial use but these courses did not include low carbon technologies.
- General pipe fitting and welding skills were taught widely, although not specifically in relation to heat networks. Two colleges (Glasgow Kelvin and Edinburgh Colleges) covered pipe fitting and welding[5] for industrial-scale heating installations. Use of polymer pipes in heat networks could reduce the need for welding of steel pipes in the future but would require their own set of training currently provided as CPD training by a polymer pipe supplier (see section 1.5 'Other sources of existing training').

In general, there is a good foundation of courses to cover the relevant skills for installation and maintenance of heat networks and there was thought to be potential to develop add-on elements to these existing courses that students could opt in to, giving them specific knowledge and experience with heat network applications and raising awareness of developments in low carbon heat network technologies.

Design skills

An area that was recognised as needing development in the college curriculum was the **design and specification** of low carbon heat networks. For example, how to specify appropriate equipment for use with varying heat demands, heat network temperatures and building types, e.g. how to apply correction factors for radiator sizing for low temperature networks. Linking training on building retrofit to the requirements of low carbon heat networks was another area that could be beneficial to include within the curriculum.

Practical experience

Students on relevant college courses generally had an existing employer with whom they gain practical experience of the skills they are learning. Students' practical work depended on their employer's activities. Understandably, this was influenced by the local context and

[4] The Energy Skills Partnership Scotland is a collaboration of Scotland's colleges and industry partners established to increase Scotland's capability and capacity to deliver the right skills for the energy, engineering and construction sectors to meet industry demand. https://esp-scotland.ac.uk

[5] It should be noted that use of polymer pipes in heat networks could reduce the need for welding of steel pipes in the future.

local economy e.g. a college in an area with new housing developments under construction would receive students focused on applications in housing construction. Only one of the colleges interviewed, Glasgow Kelvin College, reported regularly receiving students that were working on heat networks as part of their practical work.

Hands-on experience on physical sites was seen as an important element of teaching. Multiple colleges had built test-houses on their sites to use for teaching e.g. construction of net-zero homes, installation of air source and ground source heat pumps, solar thermal and PV, battery storage. The had also developed links with manufacturers and suppliers to give students relevant experience of the available technologies in the supply chain. West Lothian College had a bid in to build a specialist hands-on teaching site for teaching retrofitting of energy efficiency to pre-1919 buildings. Only one college campus had a connection to a district heating network they were able to use for teaching (the West College Clydebank campus is now part of West Dunbartonshire Heat network) and were developing plans for teaching content around that.

This suggests it would be beneficial to create opportunities for hands-on learning and teaching about heat networks within courses. This could include guest lectures, site visits and placement opportunities with heat network operators and specialist companies operating in Scotland.

Demand for courses and skills in the job market

Interviewees were asked about the current demand from students and industry for teaching of heat network skills. In general, the current demand for heat network skills in the job market was not seen as high at present, although there was a recognition of the potential for growth in demand and an interest in exploring the potential for expanding training provision. None of the colleges interviewed had received a request for more heat network content in the curriculum from industry. As mentioned above, only Glasgow Kelvin college reported regularly receiving students who worked on heat networks with their employer (the types of networks that students were working on included energy from waste plants, smaller community heating systems, and local authority-owned social housing networks).

Demand for college courses was also thought to be influenced by the level of awareness amongst young people about potential professions. Two interviewees mentioned that courses such as plumbing, electrical engineering and construction were more popular with school graduates than renewables, heating engineering or building services courses. One college reported having to cut their renewables 'skills for work' programme because they did not get sufficient students signing up. Marketing training opportunities to school students was suggested as something that would be potentially beneficial. One interviewee suggested that a course needs a steady demand of approximately 10-15 students per year to make it viable.

Several interviewees emphasised the importance of balancing the coverage of heat networks within the curriculum with demand for these skills in the local job market in order to avoid students undertaking qualifications that did not lead to employment. There had been challenges with job market demand for low carbon skills for some colleges in the past:

- 3 interviewees described a low demand in the local job market for energy efficiency and renewable skills after the feed-in-tariffs had been reduced for microgeneration;
- One interviewee expressed some reluctance to market courses because of the lack of demand in the market;
- In rural areas with a high proportion of sole traders, interviewees reported an interest in training on renewable energy, but the burden of attending a course far away or becoming formally accredited afterwards was often not worth the lost income and fee cost for contractors.

Creating a clearer link between heat network college courses and job / work opportunities will be an important aspect of ensuring the success of any new heat network training programmes. Colleges already proactively seek out links with potential employers and placements to help students into jobs and attract new students, and these links could be strengthened further in relation to heat networks. There is also a role for industry in investing regularly in apprenticeships or staff training opportunities to enable the viability of heat network specialist courses. One interviewee suggested that heat network contractors might not be aware of existing courses that already teach relevant transferable skills. The policy drive for heat network development from Scottish Government was also felt to be crucial to creating greater demand for heat network training and confidence in the sector amongst contractors.

Routes to shaping the curriculum

There was interest from all six college interviewees to explore options for developing and updating heat network course content. Interviewees reported that in the short-term there was potential for lecturers to add heat network content at their own discretion, including potential for inviting guest lectures and taking part in site visits. Several of the lecturers interviewed already had knowledge and experience of working on CHP, oil and coal-fired high temperature heat networks in settings such as hospitals. However, it was felt that 'train-the-trainer' continuous professional development (CPD) provision for lecturers would be beneficial, covering the installation and servicing of innovative low carbon, low temperature networks. Training providers would also need to be made aware of the needs of the heat network sector. The addition of some heat network content in the short-term could provide an evidence base and drive for more formal updates in curriculum content in the longer term.

Formal curriculum reviews are led by the Scottish Skills Council and Scottish Qualifications Authority (SQA), informed by industry representatives. For example, the curriculum for plumbing courses had just been updated, meaning now would be the ideal time to input into the 5 year-cycle of review for the next course update. Consideration should be given to whether heat networks content should be made a compulsory element of certain courses in order to raise awareness within relevant professions and future-proof students' skills for working on low carbon energy systems. Creating elective short courses (e.g. 1 – 2 weeks long) was also suggested as an approach to providing relevant training to students and contractors that wanted to gain specialist heat network skills.

The Energy Skills Partnership Scotland was seen to have an important role in coordinating this process, building on its experience of supporting CPD training for college lecturers and updating compulsory course content to cover micro-renewable technologies in recent years.

4.3.2 Analysis - University teaching

In this section, the interviews with course directors and email correspondence from four Scottish universities (Glasgow Caledonian University, Heriot-Watt University, the University of Edinburgh, and the University of Strathclyde) are used to understand the types of content that currently exist, and how this might be built upon to help to fill gaps in the heat network supply chain in the future. The existing student and job market demand are discussed, followed by suggestions for how to shape university course content to support heat network skills development in the Scottish supply chain. The universities were selected as they were mentioned by heat network practitioners as likely to have existing course content and timeframes of the project did not allow for further interviews. Clearly, the findings presented here do not represent a comprehensive review of university course content in Scotland and any actions to support the general development of more heat network course content in universities should be made available to all Scottish universities.

Existing course content

At undergraduate level, the courses that had content on heat networks were architectural engineering; mechanical engineering; civil and environmental engineering; and building services. The detail that courses went into largely depended on whether the lecturers had research interests involving heat networks. Where a lecturer did not have a specific interest, heat networks were only covered in passing, for example as part of a discussion about approaches to decarbonising heat. The building services course at Glasgow Caledonian University and architectural engineering course at Heriot-Watt University went into more detail about heat networks at undergraduate level, including network specifications, monitoring and optimisation of systems. Heat network concepts were embedded through sharing case studies. E.g. A large power station capturing waste heat to supply surrounding buildings.

Heat networks were taught in more depth at postgraduate level through master's courses which had a building and / or energy focus. Courses from the interviewed universities included Masters of Science (MSc) in GeoEnergy; Carbon management; Environment and development; Energy systems and environment; Infrastructure; Psychology; building design and surveying.

Final year undergraduate and masters dissertations were areas of teaching highlighted by the interviewees as where heat networks were able to be covered in more detail. These took the form of individual and group research projects and often worked with real data from local heat network sites including university campus systems or linking with local public sector-owned networks. Projects considered social aspects of heat networks as well as technical, including working with local authorities to understand stakeholder perceptions and concerns. These topics were thought to be popular amongst students because heat decarbonisation was seen as a locally relevant and challenging topic to explore, with the potential for linking with real-life projects. They also provided lecturers with the opportunity to keep up to date on the latest practice in the heat network sector.

Accessing data to support dissertation projects was sometimes challenging. For example, masters students at one university had had to wait 4 months to receive data for a local authority owned scheme because the company managing the network had wanted to check the data for sensitive information before sharing. There is an opportunity to create better links between heat network operators and university courses to enable research and learning to focus on real life case studies.

The topic of heat decarbonisation and heat networks was also a recognised gap in the curriculum for some courses (e.g. electrical engineering was mentioned at one university) because it did not fit neatly into the discipline boundaries at undergraduate level. In general, it was seen as a difficult subject to teach within undergraduate courses since each heat network had such different parameters it was hard to generalise examples and required students to already have knowledge of a range of areas including economics, psychology, heat supply and distribution options. Despite this, there was significant interest in including heat networks or expanding curriculum content in future course updates.

Demand for courses and skills in the job market

Interviewees reported good job-market demand for students who had studied on their energy and engineering courses, particularly when a dissertation topic had focused on heat networks. Examples of graduate destinations included service and energy engineering companies, consultancies and facilities management roles. The two applied courses of Building Services at Glasgow Caledonian University and Architectural Engineering at Heriot-Watt University were reported to be a key place for industry to recruit well-qualified graduates. Companies came in to present each year to encourage students on these courses to apply to their graduate schemes. Given the timing of this research in the midst of the Covid-19 crisis, interviewees also caveated their answers to caution that this may change going forward.

The building services undergraduate course at Glasgow Caledonian University was unique in that it was run for part-time students. The course attracted part-time students who were looking to increase their skills and knowledge to support their existing professional position e.g. as a building facilities manager. In fact, many of these students regularly worked with heat networks already and were on the course to learn about other aspects of building services.

Routes to shaping the curriculum

Interviewees emphasized that university course content was often predominantly shaped by lecturers' research interests and therefore depended heavily on the lecturer taking the course each year. However, there were also routes to influencing course content through advisory panels, which had representatives from industry and government, as well as the course accreditation process. None of the interviewees reported requests for more heat network content from their advisory panels to date.

Several lecturers expressed an interest in expanding their course content and heat networks and heat decarbonisation in general, particularly if there were identified gaps in knowledge in the supply chain such as low carbon heat network design, city-scale design and retrofit of

heat networks. This required existing modules with relevant content that could be expanded to cover skill gap areas. It was noted that student numbers in the coming academic year were likely to be significantly lower than in previous years due to the Covid-19 crisis and therefore significant new course content was unlikely to be created in the short term.

Other opportunities for increasing relevant heat network content within university courses were through creating links between local heat networks and universities to share data for case studies, dissertations and student site visits or placements. One interviewee suggested that high quality lecture materials could be produced based upon local heat network case studies to enable easy inclusion of relevant content within teaching across universities in Scotland. This would enable potential local site visits and interaction with local stakeholders which students find engaging and useful.

5 Conclusions and recommendations

The following recommendations are based upon the analysis from section 4.2 (online review of relevant courses) and section 4.3 (interviews with course directors), taking into account the skills gaps that were identified in phase 1 of the research (section 3). The recommendations are split into three categories:

- Recommendations that could be implemented within one or two specialist 'heat network training centre(s)' (section 5.1).
- General recommendations that can be implemented across any colleges and universities interested in expanding their course content on heat networks (section 5.2).
- Recommendations for training that could be implemented outside the formal education system (section 5.3)

5.1 Recommendations for specialist heat network training centres

Given that the industry is still small, pooling resources into a small number of specialist heat network training centres could be considered, in order to meet the training needs of the industry at a scale commensurate with the demand for training. As demand for training grows, training courses could be expanded to more institutions. Such an approach would require cooperation across heat network industry actors such as heat network operators and specialist contractors to input into course content and to support course viability by providing a steady student demand.

There are six institutions (four colleges and two universities) recommended below that might be explored as a priority to host such a centre due to their existing course content on heat networks, as well as opportunities to deliver practical teaching due to an existing heat network connection on the college campus or proximity to a heat network.

5.1.1 Priority college institutions

- Glasgow Kelvin College – They have a course on large-scale heating and ventilation, as well as existing content on heat networks in their building services course. In addition, they regularly receive students who work on heat networks within their jobs.

- West College Scotland – Already teaches content on heat networks within plumbing courses. In addition, their Clydebank campus is connected to the West Dunbartonshire Heat network and the college plans to develop teaching content around that.
- Edinburgh College - They have a course on large-scale heating and ventilation, although very little content on low carbon heat delivery is currently covered. They have a campus located near to the large Midlothian heat network currently in development.
- South Lanarkshire College – specialises in skills for low carbon housing construction and retrofitting of energy efficiency measures.

    - Other colleges that could be considered, based upon the analysis in this report, include: Borders College, Dumfries & Galloway College, NESCOL, Dundee & Angus College, Fife College, South Lanarkshire College, Moray College, Shetland UHI, West Lothian College.

At college level, a heat networks training centre might take the form of stand-alone short-courses and / or optional modules for existing courses, linked with opportunities for hands-on learning, addressing the key skills gaps outlined in Table 1 (section 3.8). The centre should focus on establishing common standards of best practice, learning from existing projects where possible. Relevant courses include plumbing, building services, heating and ventilation engineering, highways and maintenance, and energy modules of civil, mechanical and electrical engineering courses. Course content should include building-side design and specifications as well as network and heat supply, particularly linking course content between building retrofit training and low carbon heat solutions (with heat networks forming one part). Specific consideration should also be given to the training requirements for transferring skills from the oil and gas sectors.

The Energy Skills Partnership Scotland was highlighted by multiple interviewees as playing a crucial role in facilitating the development of college-level training delivery in other low carbon technology areas including heat pumps. Their involvement in supporting a similar development for heat networks would clearly be valuable.

Approach in rural areas
It should be noted that focusing on one or two specialist heat network training centres could prove inaccessible to contractors in rural areas located far away from training centres, since the time and costs of undertaking training would be prohibitively high. Ensuring engagement with rural colleges as part of the general recommendations listed in the next section (5.2) would potentially help to overcome this challenge. Funding to cover travel and course costs might also be considered.

5.1.2 Priority university institutions

A heat network training centre at university level could take many forms, with content embedded into a range of subjects and teaching levels. Two universities are highlighted below for priority consideration due to their existing course content and reputation within the building services and facilities management industries. However, given the diversity of courses at university level, new heat network content would need to fit with the wider

learning objectives of courses and one institution would be unlikely to cover all skills gaps. The general recommendations in the next section would likely be particularly important in engaging with universities and addressing skills gaps at university teaching level.

- Glasgow Caledonian University – their Building Services undergraduate and masters level courses cover heat network optimisation and management, including making use of real-life data from the university system and local heat networks.
- Heriot-Watt University – Heat network content is included in modules on environmental modelling, building design, thermal studies within their architectural engineering course. Group design projects and student dissertations also often focus on low carbon heat provision and heat networks.

5.2 General recommendations

The following recommendations would encourage expansion of heat network content within relevant courses at any interested college and university, enabling a general increase in awareness of key heat network skills within relevant professions and subject areas.

It should be noted that there is an expected decline in student numbers next year due to the Covid-19 crisis and this could impact on the creation of new course content in the near term. Timescales for delivering on these recommendations may need to be adjusted to allow for this.

5.2.1 Recommendations to support development of both college and university course content:

There is an opportunity to establish stronger links between the heat network sector and further and higher education institutions, setting up forums to deliver the following recommendations:

- Feedback information about skills gaps to lecturers and curriculum advisory panels to ensure awareness and encourage relevant content to be included. This could include sharing the findings from the heat network skills workshop and this report.
- Develop 'train-the-trainer' CPD opportunities for lecturers. At college level, this could focus on the requirements for installation and maintenance of innovative low carbon, low temperature networks. At university level, this could focus on design of low carbon heat networks and their integration into regional decarbonisation planning, with a particular consideration of the challenges of retrofitting networks.
- Establish routes for inviting guest lectures, arranging site visits, offering student placements and potential job opportunities.

5.2.2 Recommendations to support college course content

- Representatives from the heat network sector should input into the review-cycles of relevant college courses to encourage new content on key heat network skills. This should be informed by experience from any specialist heat network training centres that are set up.
    - Consideration should be given to whether content needs to become a core part of the curriculum, or whether elective add-ons would be sufficient.
    - If and when content needs to become mandatory, college and industry partners will need to work with the Scottish Skills Council and Scottish

Qualifications Authority (SQA) to add elements into compulsory course content

- Targeted marketing of relevant college courses to heat network operators and relevant contractors (particularly if there are local heat networks in development) would be beneficial to encourage contractors to consider upskilling and bidding for work.

5.2.3 Recommendations to support university course content

- Facilitate links between university dissertation supervisors and heat network operators / project managers to enable the sharing of data and information for student projects.
- Work with network managers and lecturers to develop Scottish industry case studies for use as part of university lecture materials, with the potential for student site visits and placements.

5.3 Beyond college and university courses:

This research highlighted a need for introductory training for non-specialist professionals taking on project management / governance / engagement roles within heat network projects. This type of general training is not linked to any particular course or academic discipline and would therefore be suitable for delivery outside of a formal educational setting.

Options for delivering such a course:

- At the time of writing this report, a private training provider was working a heat network operator to deliver such an introductory course for non-technical personnel. The suitability of this course for delivering on the needs of the heat network industry more generally should be considered.
- Such a training course could also be developed and delivered through other industry actors such as the Heat Network Partnership Scotland or the Energy Skills Partnership Scotland

5.4 Conclusion

There were a number of critical skills gaps within the heat networks supply chain that could be detrimental to meeting Scotland's heat decarbonisation net zero emissions target. Although heat networks are not a new technology, there was a lack of formal heat network training or qualifications, and where practitioners did have experience, it was predominantly working with high-temperature, fossil fuel-based networks. The supply chain was over-reliant on a few specialist contractors to deliver new networks, creating risks of capacity issues as the market grows, as well as a lack of skills to enable effective scrutiny to ensure optimum design, delivery and effective operation of networks. Skills gaps in rural and island areas of Scotland were also a challenge, where it was often not possible to access specialist contractors to carry out works because they did not exist in the local area and it was not cost effective to travel from further afield for small-value jobs.

There was significant scope and interest from the college and university lecturers interviewed for this research to expand the curriculum on heat networks. Developing teaching for low carbon heat network skills will be particularly important in the coming

years, including designing and installing for low and ambient temperature networks; making use of large-scale heat pumps and waste heat sources, thermal storage; highly efficient digitalised networks; and retrofitting into older building stock. At college level, curriculums already cover relevant skills that can be easily adapted and applied to installing heat networks, but there is a need to provide more practical experience of applying these skills, as well as design and specification requirements for low carbon, low temperature networks. At university level, existing teaching on heat networks was concentrated within final year undergraduate and masters level dissertation topics, as well as a limited number of specialist applied courses focused on buildings.

The creation of one or two heat network training centres within colleges and universities could be one way to focus efforts to develop new teaching content and meet the needs of the industry as it grows. However, additional support would likely be required to enable contractors in rural areas to access such centres. In general, there is potential for greater collaboration between the heat network industry and colleges and universities to enable sharing of case studies, data for dissertation projects, site visits, student placements, industry guest lectures and graduate job opportunities. There is also an opportunity for the heat network industry to coordinate efforts to shape new curriculum content and ensure any new heat network training courses are viable with a steady student demand.

Finally, there was an important training need identified for non-technical practitioners working on project management, procurement, board governance, financial management and customer engagement. A general introductory training course aimed at non-technical practitioners would greatly support the industry as it grows over the coming years.

6 References

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