Department for
Business, Energy
& Industrial Strategy

Heat Networks Skills Review

Technical annex – project literature review

May 2020

Acknowledgements

This study required the support and contribution of a range of stakeholders in the heat network industry, including ESCos, consultancies, housing associations, local authorities, membership associations and training providers. We are grateful for their input into our interviews and workshops.

We would like to thank the project team at BEIS, who provided direction and management throughout the course of the study. Particular thanks are reserved for Melissa Vogeley, Brett Hagen and Christopher Garner.

And final thanks are due to Kelly Greer at ACE Research, part of the Association for Decentralised Energy, and Dr. Tanja Groth at SWECO, our partners in the design and conduct of the research.

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Contents

Literature Review

A total of 76 documents were reviewed. This included 7 white (peer reviewed academic) documents and 69 grey (industry) documents. A list of all documents can be found in Appendix A. A summary of the literature is contained within this section of the report, whilst a comprehensive overview can be found in Appendix B.

This literature was identified by the BEIS heat networks team, from within the research team and from stakeholders that participated in this research.

It is important to note the limitations with the literature reviewed. There were only 18 documents that specifically related to skills provisions in the heat network sector, but these were not in depth studies.. While the focus was on literature relating to the heat network sector, the team also reviewed literature from the wider energy and engineering sectors, those sectors with transferable skills and those sectors that have experienced high growth. These sectors included heat pump manufacturing, solar power and solar thermal development, nuclear, offshore wind development and combined heat and power manufacturing.

Introduction

The literature describes the heat network sector and its supply chain as being relatively immature[1] [2], which could be one reason behind the limited literature specific to skills issues in the sector[3].

The literature describes the policy and support interventions that have been implemented by the UK government and devolved administrations to support creating a sustainable heat network market and industry[4]. This includes the Renewable Heat Incentive (RHI)[5] and the recent commitment from Treasury surrounding the Green Heat Network Fund (GHNF), both of which have or will continue to support the deployment of low carbon heat networks.

In addition, the literature highlights the encouraging role of programmes such as the Heat Networks Delivery Unit (HNDU)[6], Heat Network Investments Project (HNIP) and the Scottish Government's Low Carbon Infrastructure Transition Programme (LCITP) and the Heat Network Partnership in mitigating skills issues.

"*The HNIP pilot is sending a positive signal to the heat networks market in terms of government support, particularly for the large-scale public sector market. This is reflected in:*

[1] Department of Energy and Climate Change (2009) The potential and costs of district heating networks.
[2] Energy Technologies Institute (2017) Reducing the capital cost of district heat network infrastructure: Summary report from the 'Heat Infrastructure Development' project.
[3] Causal links between the sector being immature and existing and future skills gaps were not defined.
[4] UK Energy Research Centre (2016) Technology and Policy Assessment Best practice in heat decarbonisation policy: A review of the international experience of policies to promote the uptake of low-carbon heat supply.
[5] The RHI, launched in 2014 operated across England, Wales and Scotland. A separate RHI scheme ran in Northern Ireland between 2012 and 2016.
[6] Carbon Connect (2015) Policy for Heat: Transforming the system.

growing interest from consultants and technologists and greater confidence to invest in skills, expertise and marketing" [7].

However, one strong theme from the literature was the need for stable and long-term energy policy, which many reports referenced as having been lacking[8] [9] [10] [11] [12] [13] [14] [15] [16]. This is required to create certainty for investors to expand the heat network supply chain[17] [18] and to help facilitate the development and provision of 'green skills'[19].

"*A stable policy framework and direction of travel will help to provide the long-term policy certainty that is needed to raise awareness and help skills and supply chains develop*"[20].

In addition to policy interventions, the literature calls for the continuation of government innovation funding and support offerings, and for continued support for the communication and coordination between industry and those involved in the training and skills sector[21] [22] [23] [24].

Noting that heat networks can only fulfil their potential if the sector is mobilised quickly to meet the scale of change needed within policy, research from the Energy Technologies Institute (ETI)[25] notes that "*the skills base in the UK needs to be coordinated and supported to increase capacity rapidly, ensuring that best practice is both achieved and incrementally improved through innovation and learning*". Coordination and collaboration between government and industry is crucial. The report therefore calls for the UK and devolved governments to provide frameworks to support demonstration, knowledge transfer and skills development to deliver a low-cost energy system that meets the 2050 emissions targets.

[7] Department for Business, Energy and Industrial Strategy (2018) Heat networks Investment Project Evaluation, Pilot Process Evaluation Report (BEIS Research Paper Number 1).
[8] Webb, J., Hawkey, D., Tingey, M., Kerr, A., Lovell, H., McCone, D. & Winskel, M. (2014) Heat and the city - Exploring affordable, low carbon community heating in cold climate cities.
[9] UK Energy Research Centre (2018) Incumbency in the UK heat sector: implications for low-carbon heating.
[10] Committee on Climate Change (2018) An independent assessment of the UK's Clean Growth Strategy: From ambition to action.
[11] Committee on Climate Change (2019) Net-Zero: technical report.
[12] Committee on Climate Change (2019) UK housing: Fit for the future?
[13] European Centre for the Development of Vocational Training (2018) Skills for green jobs in the UK.
[14] Zekaria, Y. and Chitchyan, R. (2019) Skills Shortage Assessment Models – Literature Review Summary.
[15] Carbon Connect (2015) Policy for Heat: Transforming the system.
[16] Off-Gas Grid Industry Group (2020) Skills and training to decarbonise heating.
[17] Carbon Connect (2015) Policy for Heat: Transforming the system.
[18] Energy Technologies Institute (2018) District Heat networks in the UK: Potential, barriers and opportunities.
[19] ECORYS (2011) Research Study to Determine the Skills Required to Support Potential Economic Growth in the Northern Ireland Sustainable Energy Sector, Final Report.
[20] Committee on Climate Change (2019) UK housing: Fit for the future?
[21] ECORYS (2011) Research Study to Determine the Skills Required to Support Potential Economic Growth in the Northern Ireland Sustainable Energy Sector, Final Report.
[22] Energy Technologies Institute (2018) District Heat networks in the UK: Potential, barriers and opportunities.
[23] Hawkey, D. J. C. (2012). District heating in the UK: A Technological Innovation Systems analysis. Environmental Innovation and Societal Transitions, 5, 19-32.
[24] Carbon Connect (2015) Policy for Heat: Transforming the system.
[25] Energy Technologies Institute (2018) District Heat networks in the UK: Potential, barriers and opportunities.

Several documents detail the risk of not tackling skills-based barriers on the deployment of low carbon technologies, including heat networks[26] [27] [28] [29]. A lack of expertise and immature supply chains may raise the costs of deploying heat networks, leading to a lack of flexibility in system extensions and the failure to deliver on intended environmental and social benefits[30] [31] [32] [33] [34] [35] [36] [37].

Sector Profile

The literature identifies a lack of diversity within the energy and engineering sectors. Whilst there was no literature specifically covering diversity within the heat network sector, it is likely that the sector also suffers from a lack of diversity given its symbiotic relationship with the energy and engineering sectors.

The lack of diversity means that the sectors struggle to attract a diverse workforce, which not only reduces the talent pool available but also reduces the attractiveness of the sector overall, further limiting the labour pool available[38] [39]. While attempts have been made to address the imbalances across gender, ethnicity and disabilities, progress has been disappointingly slow and that a concerted effort is required in the future[40].

"*Reducing both gender and race inequality is key to addressing the damaging shortage of engineering skills in the UK economy*" [41].

Research also details how underrepresentation of women in senior roles - rather than unequal pay - is the single largest cause of the gender pay gap for engineers[42]. This research also highlights that there is a "*serious diversity deficit*" within the engineering profession, with females making up 12% of the workforce and only 9% of the profession categorised within the Black, Asian and Minority Ethnic (BAME) group.

[26] Department of Energy and Climate Change (2009) The potential and costs of district heating networks.
[27] Department of Energy and Climate Change and the Department for Business, Innovation & Skills (2015) Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050: Cross Sector Summary.
[28] Committee on Climate Change (2015) Sectoral scenarios for the Fifth Carbon Budget Technical report.
[29] Committee on Climate Change (2015) Research on district heating and local approaches to heat decarbonisation.
[30] Hawkey, D. J. C. (2012). District heating in the UK: A Technological Innovation Systems analysis. Environmental Innovation and Societal Transitions, 5, 19-32.
[31] Department of Energy and Climate Change (2013) Research into barriers to deployment of district heating networks.
[32] Department of Energy and Climate Change (2009) The potential and costs of district heating networks.
[33] UK Energy Research Centre (2016) Technology and Policy Assessment Best practice in heat decarbonisation policy: A review of the international experience of policies to promote the uptake of low-carbon heat supply.
[34] Competition and Markets Authority (2018) Heat networks Market Study: Final report.
[35] Energy Technologies Institute (2018) District Heat networks in the UK: Potential, barriers and opportunities.
[36] Ramboll (2019) Alternative heat solutions: converting a town to low carbon heating.
[37] Zekaria, Y. and Chitchyan, R. (2019) Skills Shortage Assessment Models – Literature Review Summary.
[38] UK Commission for Employment and Skills (2015) Sector insights: skills and performance challenges in the energy sector.
[39] Department of Energy and Climate Change and the Department for Business, Innovation & Skills (2015) Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050: Cross Sector Summary
[40] Royal Academy of Engineering (2020) Closing the engineering gender pay gap.
[41] Ibid.
[42] Ibid. It is important to note that the gender pay gap in the engineering profession is smaller than the UK average. The mean (10.8%) and median (11.4%) pay gap for engineers in the sample analysed is around two thirds the national average (13.3% and 11.4% respectively).

However, this lack of diversity not unique to the energy or the engineering sectors. Diversity is an issue within the construction sector for example. Despite its size, the construction workforce is one of the least diverse in the UK. Mitigating actions to increase gender, ethnicity and disability diversity in the workforce were outlined within the Construction sector deal[43]. This is also true in the nuclear sector, where the Industrial Strategy and the Nuclear Sector Deal aims to increase diversity in the workforce, including increasing female representation by 40% by 2030[44].

Current and future skills needs

There were frequent references with the literature on institutional skills issues, which are prevalent across the energy and engineering sectors[45] [46]. While not all directly linked to heat networks, these broad issues can contribute to uncertainty of demand and may be a significant barrier to deployment of low carbon heat networks. There were concerns that constraints around skills could reduce the achievable level of energy system decarbonisation by 2050[47] [48].

There were calls for a greater understanding of the actual skills that are required in jobs across the energy sector, factors that contribute to shortages of these skills, and techniques and models to forecast skills shortages[49]. By improving the forecasting of knowledge and skills in the labour market, the UK can better prepare the sector to provide training and education and facilitate the successful transition to a low carbon economy.

"*Skills-led strategies to support the green transition can serve as a driver of change in their own right: availability of suitably skilled workforce attracts investors in green industries; and environmental awareness encouraged through education and training boosts demand for green products and services. Identifying and anticipating skills needed for the green and low-carbon economy must precede training decisions so that skills acquired are relevant for the labour market.*"[50]

However, it was also recognised that there are difficulties in focussing the efforts of training to meet the skills needs of existing, new and evolving markets. Decisions that need to be made surrounding skills provisions are made difficult due a lack of sufficiently good statistical information[51].

Literature identified an 'ill-equipped skills system' and a lack of adequate training to enable workers to move from high to low-carbon employment[52].

[43] Department of Energy and Climate Change Strategy (2018) Construction Sector Deal.
[44] Nuclear Skills Strategy Group (2018) Skills planning to drive sector mobility: Strategic plan update.
[45] UK Commission for Employment and Skills (2015) Sector insights: skills and performance challenges in the energy sector.
[46] Royal Academy of Engineering (2020) Closing the engineering gender pay gap.
[47] Committee on Climate Change (2018) Analysis of Alternative UK Heat Decarbonisation Pathways.
[48] Ramboll (2019) Alternative heat solutions: converting a town to low carbon heating.
[49] Zekaria, Y. and Chitchyan, R. (2019) Skills Shortage Assessment Models – Literature Review Summary.
[50] International Labour Organization (2011) Anticipating skills needs for the low-carbon economy.
[51] Ibid.
[52] Institute for Public Policy Research (2019) A just transition. Realising the opportunities of decarbonisation in the North of England.

While UK PLC has many of the skills needed to deploy low carbon technologies, the literature highlighted notable gaps, uncertainties in the size of the workforce required and the timeframe for deployment[53].

An estimated 81,000 jobs could be created nationally in the heat network sector by 2030[54], however these opportunities will not be realised if the skills system is not better supported. There were calls for the continuation of funding to enable the development of training courses and continued help in coordinating between industry and those involved in the training and skills sectors.

The literature notes how experienced workers are moving out of the energy industry, due to retirement[55] or to transfer to another sector, and are not being replaced in sufficient numbers or with sufficient speed. This is leaving gaps in the higher layers of the energy sector[56].

Meanwhile a lack of STEM graduates joining the sector has led to gaps in the middle layers of the workforce[57]. This research found that a majority of respondents considered that there were not enough individuals studying STEM subjects at undergraduate or postgraduate level. The reasons given for this imbalance were around a range of perceptions that the costs of studying for a degree (and potentially a masters) are high, that cheaper overseas study options led to students staying overseas once qualified, the entry criteria for STEM degrees being too obstructive and the general perception that STEM subjects are 'difficult'. While research undertaken by UKCES found that there was not an overall shortage of STEM graduates, over 40 per cent of STEM graduates work in non-STEM occupations and that graduates may be attracted into more lucrative sectors such as financial services.

While some reports concluded that that there has been no concerted support at a national level to resolve decarbonisation skills issues, nor any attempts to facilitate action at a regional or local level[58] [59], the government has recommended a review of skills across building, heat and ventilation supply chains, alongside a nationwide training programme to upskill the existing workforce[60]. This activity will cut across heat and ventilation supply chains to determine the roles of government, industry and the wider supply chain to ensure that supply is able to meet demand. In addition, the government is working with industry to invest £34 million into a national retraining scheme and has committed to improve technical education standards.

While not always in the role of heat network sponsors, the essential role of local government (and the wider public sector) as key stakeholders in the successful deployment of heat

[53] Engineering Construction Industry Training Board (2020) Towards Net Zero: The implications of the transition to net zero emissions for the Engineering and Construction Industry.
[54] Institute for Public Policy Research (2017) Piping hot – the opportunity for heat networks in a new industrial strategy.
[55] Department of Energy and Climate Change and the Department for Business, Innovation & Skills (2015) Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050: Cross Sector Summary.
[56] UK Commission for Employment and Skills (2015) Sector insights: skills and performance challenges in the energy sector.
[57] Ibid
[58] Department of Energy and Climate Change (2009) The potential and costs of district heating networks. While a relatively old document, the issues identified in the research are still valid.
[59] Institute for Public Policy Research (2019) A just transition. Realising the opportunities of decarbonisation in the North of England.
[60] Department for Business, Energy and Industrial Strategy (2019) Leading on clean growth: government response to the Committee on Climate Change 2019 progress report to Parliament - Reducing UK emissions.

networks is frequently described in the literature[61] [62] [63]. However, the literature highlights a lack of skills and resources within local government as important barriers to deployment[64] [65] [66].

There were also calls for an accreditation scheme to develop the skills needed to build and operate new heat networks, ensuring networks deliver intended benefits and an efficient and a good service for customers[67]. While the Chartered Institution of Building Services Engineers' (CIBSE) accreditation is highlighted in the literature, one report notes that "*the course in its current form does not provide, nor does it intend to provide, sufficient training or accreditation for engineers to become qualified experts in this field*".

Another recommendation was to establish a District Heating Knowledge Centre, to co-ordinate research, training and dissemination, boost innovation across the sector and encourage recognised qualifications to build the skills base. It was thought that this activity would lead to heat network schemes being more cost-effective and efficient[68].

There were also calls for the UK Government to use initiatives under the Construction Sector Deal and Buildings Grand Challenge Mission (both of which include commitments to drive up quality) to tackle low-carbon skills gaps[69]. This would include new support mechanisms to train designers, builders and installers in low-carbon heating, energy efficiency, ventilation and thermal comfort. The report recommends "*that a fully-fledged UK strategy for decarbonised heat must be developed in 2020*" and that as part of this strategy, "*a nationwide training programme to upskill the existing workforce is recommended".*

The UK Government have committed to publishing a Heat and Buildings Strategy in the near future. In addition, the Treasury have outlined a commitment in the Spring 2020 budget to spend £270 million on a Green Heat Network Fund (GHNF) from 2022 to support the deployment of low carbon heat networks.

[61] Department of Energy and Climate Change (2009) The potential and costs of district heating networks.
[62] Hawkey, D. J. C. (2012). District heating in the UK: A Technological Innovation Systems analysis. Environmental Innovation and Societal Transitions, 5, 19-32.
[63] Webb, J., Hawkey, D., Tingey, M., Kerr, A., Lovell, H., McCone, D. & Winskel, M. (2014) Heat and the city - Exploring affordable, low carbon community heating in cold climate cities.
[64] Department for Business, Energy and Industrial Strategy (2016) Heat networks Investment Project Consultation Government Response (Capital funding for building heat networks).
[65] UK Energy Research Centre (2016) Technology and Policy Assessment Best practice in heat decarbonisation policy: A review of the international experience of policies to promote the uptake of low-carbon heat supply.
[66] Institute for Public Policy Research (2017) Piping hot – the opportunity for heat networks in a new industrial strategy.
[67] Competition and Markets Authority (2018) Heat networks Market Study: Final report.
[68] Energy Technologies Institute (2017) Reducing the capital cost of district heat network infrastructure: Summary report from the 'Heat Infrastructure Development' project.
[69] Committee on Climate Change (2019) UK housing: Fit for the future?

Appendix A: *Literature Summary*

White literature reviewed

Year of publication	Title	Specific to heat networks?	Included in this research
2012	Background Report on EU-27 District Heating and Cooling Potentials, Barriers, Best Practice and Measures of Promotion	Y	N
2012	District heating in the UK: A Technological Innovation Systems analysis.	Y	Y
2014	Heat and the city – Exploring affordable, low carbon community heating in cold climate cities	N	Y
2018	Key skills and training needs of the D2N2 Low Carbon & Environmental Goods & Services Sector	N	Y
2018	Residential heat pump installations: the role of vocational education and training	N	N
2019	Skills Shortage Assessment Models – Literature Review Summary	N	Y
2019	The hydrogen economy and jobs of the future	N	N

Grey literature reviewed

Year of publication	Title	Specific to heat networks?	Included in this research
2009	The potential and costs of district heating networks	Y	Y
2010	Training Provision in Large Scale Wind Renewables	N	Y
2011	Anticipating skills needs for the low-carbon economy	N	Y
2011	Research Study to Determine the Skills Required to Support Potential Economic Growth in the Northern Ireland Sustainable Energy Sector	N	Y
2013	BUILD UP Skills Denmark: National roadmap	N	Y
2013	Research into barriers to deployment of district heating networks	Y	Y

Year of publication	Title	Specific to heat networks?	Included in this research
2014	London Heat Network Manual	Y	N
2015	Assessment of the Costs, Performance, and Characteristics of UK Heat networks	Y	Y
2015	Evaluation of the Heat Networks Delivery Unit - Interim report covering wave 1 research	Y	N
2015	Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050: Cross Sector Summary	N	Y
2015	Green collar nation: a Just Transition to a low carbon economy	N	N
2015	Green skills and innovation for inclusive growth	N	N
2015	Policy for Heat: Transforming the system	N	Y
2015	Research on district heating and local approaches to heat decarbonisation	Y	Y
2015	Sector insights: skills and performance challenges in the energy sector	N	Y
2015	Sectoral scenarios for the Fifth Carbon Budget, Technical report	N	Y
2016	Barriers and Enablers to Recovering Surplus Heat in Industry – A qualitative study of the experiences of heat recovery in the UK energy intensive industries	N	Y
2016	Heat networks Investment Project Consultation Government Response (Capital funding for building heat networks)	Y	Y
2016	Strategic challenges facing the district heating industry towards 2020	Y	Y
2016	Technology and Policy Assessment – Best practice in heat decarbonisation policy: A review of the international experience of policies to promote the uptake of low-carbon heat supply	N	Y
2016	UK spatial district heating analysis	N	N
2017	Nuclear Workforce Assessment	N	Y
2017	Piping hot – the opportunity for heat networks in a new industrial strategy	Y	Y
2017	Reducing the capital cost of district heat network infrastructure: Summary report from the Heat Infrastructure Development project	Y	Y
2017	Regulation and planning of district heating in Denmark	Y	Y

Year of publication	Title	Specific to heat networks?	Included in this research
2017	The economic impact of hydrogen and fuel cells in the UK	N	N
2018	Accelerating green finance: green finance taskforce report	N	N
2018	An independent assessment of the UK's Clean Growth Strategy: From ambition to action	N	Y
2018	Analysis of Alternative UK Heat Decarbonisation Pathways	N	Y
2018	Clean Growth: Transforming Heating – Overview of Current Evidence	N	Y
2018	Construction Sector Deal	N	Y
2018	District heat networks in the UK: Potential, barriers and opportunities	Y	Y
2018	Estimating the cost-reduction impact of the Heat Network Investment Project on future heat networks	Y	Y
2018	Heat networks: delivering a market framework	Y	Y
2018	Heat Networks Investment Project Evaluation – Pilot Process Evaluation Report (BEIS Research Paper Number 1)	Y	Y
2018	Heat Network Investment Project supply chain meeting	Y	N
2018	Heat Networks Market Study: Final report	Y	Y
2018	Incumbency in the UK heat sector: implications for low-carbon heating	Y	Y
2018	Infrastructure finance review – Insights for district heat network investment in the UK	Y	Y
2018	Low Carbon Heat: heat Pumps in London	Y	N
2018	Skills for green jobs in the UK	N	Y
2018	Skills for green jobs: an update	N	N
2018	Skills planning to drive sector mobility: Strategic plan update	N	N
2018	Stakeholder engagement in heat networks: a guide for project managers	Y	Y
2018	Skills planning to drive sector mobility: Strategic plan update	N	Y

Year of publication	Title	Specific to heat networks?	Included in this research
2018	Talent 2050: Engineering Skills and Education for the Future	N	Y
2018	World Employment Social Outlook	N	N
2019	A just transition. Realising the opportunities of decarbonisation in the North of England	N	Y
2019	Alternative heat solutions: converting a town to low carbon heating	N	Y
2019	Energy Trends	Y	N
2019	Heat Network Quarterly pipeline	Y	N
2019	Heat Network Skills Workshop	Y	Y
2019	Installer Survey Results	N	N
2019	Living Carbon Free - Exploring what a net-zero target means for households	N	N
2019	Migration and construction - The view from employers, recruiters and non–UK born workers in 2019	N	N
2019	Net-Zero: technical report	N	Y
2019	Skills and training to decarbonise heating – Off Gas Grid Council Installer Skills Paper	N	Y
2019	UK housing: Fit for the future?	N	Y
2020	Bridging the skills gap	N	Y
2020	Closing the engineering gender pay gap	N	Y
2020	Heat Network Industry Council	Y	Y
2020	Plan for £7bn investment into NW low carbon skills	N	Y
2020	Towards Net Zero: The implications of the transition to net zero emissions for the Engineering and Construction Industry	N	Y
Unknown	CITB levy analysis	N	N
Unknown	European Supply Chain Forum	N	N
Unknown	UK's first National District Heat Skills Academy	Y	Y
Not published	Heat network skills in Scotland	Y	Y

Year of publication	Title	Specific to heat networks?	Included in this research
Not published	Building Skills for Net Zero Emissions How will the climate emergency affect you and your business?	N	Y
Not published	Heat Pump Manufacturing Supply Chain Research Project	N	N

Appendix B: Literature Review

This section details the findings from each of the pieces of literature included in the review. They are ordered alphabetically by author, and full details of the references, together with other literature referred to in the text here, can be found in the bibliography in Appendix D.

Policy for Heat: Transforming the system

Carbon Connect (2015)

This Carbon Connect policy briefing calls on government to set out a range of polices to decarbonise the heat sector. A range of technologies, including heat pumps, district heating and Combined Heat and Power (CHP) are referenced.

The briefing highlights that the deployment of district heat networks in the UK has been too slow, suggesting that this is due to a lack of an overarching strategy from the Government.

It calls for central Government to play an essential role in ensuring that local government are supported with the adequate skills, knowledge and resources to plan and implement local heat strategies. The report highlights the role of the BEIS Heat Networks Delivery Unit (HNDU) in providing a useful model of how this can work. It calls for the extension of the remit of the HNDU beyond the feasibility stages of projects, which can help ensure that local government have access to the support they need to deploy heat networks.

Estimating the cost-reduction impact of the Heat Network Investment Project on future heat networks

Carbon Trust (2018)

This research details a set of projections of the likely impact of the Heat Network Investment Project (HNIP).

The report considers opportunities for cost reduction through supply chains and competition. By increasing competition in the civil engineering industry, the report suggests that existing UK engineering companies will establish specialised departments and up-skill civil engineers to compete more effectively for heat networks market share.

The Carbon Trust calls for local government to identify gaps in the local supply chain, ensuring that there is an appropriate supply chain of industry stakeholders in place.

Training Provision in Large Scale Wind Renewables

CARD Group (2010)

This collaborative renewable energy research project from 2010 involved several Sector Skills Councils, including Construction Skills and Summit Skills, and aimed to highlight the skills and

training issues affecting large scale wind-energy generation. The research was supported by the Department for Employment and Learning (DEL) in Northern Ireland.

The report describes how the more mature onshore wind sector division has a better understanding of the skills and experience required to meet challenging 2020 targets in comparison to the less mature offshore wind sector.

Employees move into the wind sector 'sideways' (moving from a related industry) or directly (from university of college). The research notes that "*few people have the desired skills*" and "*fewer still have the necessary experience*", which makes recruitment in the sector difficult. Individuals possessing a mix of business management experience and technical competence are described as "*elusive*".

The research encountered a lack of consensus amongst stakeholders over what qualifications were desirable to enter the sector, but they did see the need to work closely with educational organisations to develop effective courses.

There was consensus that training should "contain adequate opportunities to develop on-site experience". Apprenticeships and graduate placement programmes were identified as a key employer priority to support on-site experience opportunities and build practical skills and knowledge in the sector.

The report concludes that skills are already taught in more 'traditional' educational courses that requires renewables content, and it is therefore important that education and training providers do not 'reinvent the wheel'. Providers should look at the content and combination of courses and introduce a wind energy generation perspective to these.

The report suggests that education providers' role is both to supply industry demand and to lead research and development, and by "anticipating industry trends, educators will continue to facilitate and make possible sectoral growth and innovation".

Given the rapid growth and expansion of the sector, the report acknowledges the potential difficulties in the supply of a skilled and experienced workforce to keep pace with demand, but also that education providers and employers alike were recognising "*the importance of taking a long-term approach to the skills issues*". This included influencing the uptake of STEM subjects in schools and fostering an interest in wind industry careers.

Research on district heating and local approaches to heat decarbonisation

Committee on Climate Change (2015)

The Committee on Climate Change (CCC) commissioned Element Energy, Frontier Economics and Imperial College London to carry out research on district heating and local approaches to heat decarbonisation. The analysis was used to refresh the CCC's scenarios on low carbon heat from district heating and inform their advice to government regarding the 5th Carbon Budget.

The research details barriers to heat networks, including institutional issues around skills, that could prevent the deployment of heat networks in their central scenario (15 MtCO2 /year of carbon emissions savings achieved by 2050).

The research calls for a period of capacity building, training and skills development within the local supply chain in order to support the rapid deployment of heat networks.

Sectoral scenarios for the Fifth Carbon Budget, Technical report

Committee on Climate Change (2015)

The CCC's Technical Report describes the scenarios used by the Committee to inform its judgements on the cost-effective path to the fifth carbon budget. The report identifies key barriers to uptake of heat networks which are contributing to uncertainty of demand. These include high capital costs, issues around coordination and ownership, misaligned policy incentives, lack of carbon pricing, a lack of consumer interest and trust and skills.

Referencing research into district heating and local approaches to heat decarbonisation[70], the report highlights shortages in local resources, skills and knowledge.

Analysis of Alternative UK Heat Decarbonisation Pathways

Committee on Climate Change (2018)

This report for the CCC by Imperial College provides an analysis of heat decarbonisation pathways in the UK. While primarily focussing on hydrogen and electric heating, district heating options are considered.

The research notes that any constraints on build rates, such as financing, materials or skills issues could reduce the achievable level of energy system decarbonisation by 2050. The report does not consider skills, education or training gaps.

An independent assessment of the UK's Clean Growth Strategy: From ambition to action

Committee on Climate Change (2018)

This report sets out the likely pathways to achieving 2050 climate change targets and aligns these against shortcomings of existing policies. The document covers the spectrum of clean growth technologies and their associated policies. The CCC notes that the Clean Growth Strategy "*provides little commitment to a low-carbon supply mix in heat networks*".

Net-Zero: technical report

Committee on Climate Change (2019)

[70] Committee on Climate Change (2015) Research on District Heating

The Committee on Climate Change's Net Zero report details how heat networks currently provide 2% of UK heat demand, yet the ambition is for this to increase to 18%. An interim target of 10% by 2035 will enable a smooth roll out of networks.

The report acknowledges the skills gap in the energy sector, noting that "*rapid changes in UK Government policy have inhibited supply change and skills development in building design, construction and in the installation of new measures.*"

The report recommends "*that a fully-fledged UK strategy for decarbonised heat must be developed in 2020*" and that as part of this strategy, "*a nationwide training programme to upskill the existing workforce is recommended".*

The UK Government responded to the CCC in late 2019[71] noting consideration for specific standards and skills across heat and ventilation. The response notes extensive stakeholder engagement activity with "heating installers to understand the existing supply chain's ability to deliver low carbon heat installations". The outcome of this engagement will be the determination of the crucial roles for the devolved administrations, installers and the wider supply chain to ensure that demand for heat installation can be met.

UK housing: Fit for the future?

Committee on Climate Change (2019)

This Committee on Climate Change (CCC) report assesses the measures that need to be adopted in the housing sector to manage climate change impact and reduce greenhouse gas emissions.

The report acknowledges the skills gap in the energy sector, noting that the "*chopping and changing of UK Government policy has inhibited skills development in housing design, construction and in the installation of new measures*".

The CCC calls for the UK Government to use initiatives under the Construction Sector Deal and Buildings Grand Challenge Mission (both of which include commitments to drive up quality) to tackle this low-carbon skills gap. This would include new support mechanisms to train designers, builders and installers in low-carbon heating, energy efficiency, ventilation and thermal comfort.

The report notes that "*the low uptake of the heat pumps is linked to low awareness, financing constraints, concerns around disruption and difficulty in finding trusted installers with the right skills.*" It calls for professional standards and skills across the building, heat and ventilation supply trades to be reviewed, with a nationwide training programme to upskill the existing workforce and expand the supply chain.

The CCC notes that "*a stable policy framework and direction of travel will help to provide the long-term policy certainty that is needed to raise awareness and help skills and supply chains develop*".

[71] Department for Business, Energy and Industrial Strategy (2019) Leading on Clean Growth

Heat Networks Market Study: Final report

Competition and Markets Authority (2018)

The Competition and Markets Authority (CMA) calls for better protection of heat network customers through the enforcement of technical standards and an accreditation scheme. This regime would make it easier to build the range of skills required within the heat network sector.

The report notes that landlords and property management companies do not typically have the skills needed to operate heat networks, which has led to outsourcing of operation, metering and billing services to specialist companies. This results in increased service charges, which are passed to customers.

The CMA report identifies that a better-trained workforce can result in heat networks being designed and constructed to deliver intended environmental and social benefits.

In addressing the drivers of poor outcomes for heat network customers, the CMA calls for:

- The implementation of minimum technical standards as a necessary step to protect customers from poorly designed, built and operated heat networks. (These technical standards would need to be codified clearly and made mandatory for the construction and operation of all new heat networks).
- An accreditation scheme to develop the skills needed to build and operate new heat networks, ensuring networks deliver intended benefits and an efficient and good service for customers. The CMA suggests that over time, existing networks should also be required to move towards compliance with such standards.
- The sector continuing activity around a voluntary quality assurance scheme to ensure that heat networks are built to sufficiently high standards and to improve the quality of service received by customers.

This report also details how some private and public sector organisations involved in commissioning and building heat networks raised concerns that there was a lack of engineers with the requisite skillset and experience to design, build and operate heat networks to a sufficiently high standard. These respondents recommended that a certification scheme for qualified personnel would add significant value to this industry.

While CIBSE accreditation for the heat network consultants course is referenced by the CMA, the report notes that "*the course in its current form does not provide, nor does it intend to provide, sufficient training or accreditation for engineers to become qualified experts in this field*".

Fjernvarmens strategiske udfordringer frem til 2020 (Strategic challenges facing the district heating industry towards 2020)

Danish District Heating Association (2016)

This Danish District Heating Association report provides an assessment of the strategic challenges facing the industry in Denmark and outlines the expected skills and capacity shortages affecting the future development of the sector. This includes:

- New technologies (eg. geothermal, solar, biogas, heat pumps, centralised combined heat and power, energy from waste).
- New business models.
- A lack of knowledge of the electricity markets (both generation and consumption). In particular, there is a lack of higher competencies in system balancing).
- Many networks are facing a generational shift at a governance level (boards), but also with technical delivery.
- A lack of prioritisation and budgeting for ongoing training of both existing personnel and board members.
- A lack of ability to think in a long-term, strategic sense which is increasingly becoming important to achieve intermediate and ultimate objectives for networks.

BUILD UP Skills Denmark: National roadmap

Danish Energy Agency (2013)

Build Up Skills Denmark is part of the Intelligent Energy – Europe (IEE) program, supporting energy optimisation and the use of renewable energy across the 27 EU countries and Norway, Switzerland and Macedonia. The primary focus of the Build Up Skills project is around competence levels of craftsmen in the construction sector. The project is divided into two pillars:

- Pillar I – National mapping and roadmap.
- Pillar II – Development of education programmes and modules.

The goal of the national roadmap is to ensure that the Danish labour force possesses sufficient competencies relating to energy efficiency and the use of renewable energy technologies in buildings so that Denmark can meet its 2020 targets within EU legislation.

The report concludes that in maintaining the status quo there would be a shortfall of up to 13,100 skilled construction craftsmen across Denmark, and that current competency levels are insufficient and a key barrier to meeting 2020 goals.

The roadmap presents recommendations aimed at overcoming barriers, including:

- Increasing the workforce supply, with the current workforce upskilling through further education and training and by minimising the loss of skilled employees to other sectors.
- Increasing awareness of the value of upgrading professional skills.
- Increasing awareness of where enterprises and employees can upskill.
- A systematic skills upgrade in energy topics for teachers in the adult vocational training system.
- Further development of a quality assurance system for the assessment and assurance of specialist teacher competences in energy topics.

Regulation and planning of district heating in Denmark

Danish Energy Agency (2017)

This research details the progression of stable Danish energy policy from the late 1970s that has supported the expansion of heat networks in the country, with 63% of Danish homes connected to district heating schemes.

Policy since the 1970s focused on security of supply and reducing the country's dependence on oil, the structure of the Danish sector, including ownership of networks and regulation, and how delivery is focused on long term investment, rather than short-term financing.

Barriers and Enablers to Recovering Surplus Heat in Industry - A qualitative study of the experiences of heat recovery in the UK energy intensive industries

Department for Business, Energy and Industrial Strategy (2016)

This report is a qualitative study of the experiences of heat recovery in the UK energy intensive industries.

A lack of commercial and corporate skills to assess the paybacks of projects was noted.

Heat Networks Investment Project Consultation Government Response (Capital funding for building heat networks)

Department for Business, Energy and Industrial Strategy (2016)

BEIS' response to the Heat Networks Investment Project Consultation details respondents' views on the skills gaps within the heat networks sector.

Respondents highlighted that local government often lacks the internal expertise to undertake complex and technical procurement exercises, presenting challenges in funding additional specialist support. The solution proposed was that a technical assistance grant could be provided to ensure that resources were made available to those councils facing skills or capacity gaps in their workforce.

Responses to a question on monitoring called for a series of quantitative and qualitative indicators to measure the success of the transition to a self-sustaining heat networks market. This included the number of skilled contractors, manufacturers and other organisations and the extent of training in place to deliver the capacity, knowledge and skills to deploy and operate heat networks.

Respondents to a question requesting evidence on what could facilitate or impede the transition to a self-sustaining market, suggested that "*market transformation programmes must carefully consider the gaps in the supply chain, particularly skills gaps and what the role of the programme must be in addressing these. The boundaries of the programme's involvement in the market are subtle. Some gaps may be addressed through natural market forces when*

there is clear and consistent demand but this will likely not happen in the programme timescales without specific and dedicated effort."

Clean Growth: Transforming Heating – Overview of Current Evidence

Department for Business, Energy and Industrial Strategy (2018)

This literature review details the options for decarbonising heat in the UK. District heating is one of several options included within the research.

The report notes that "*studies discussing the deployment of low carbon heating technologies implicitly assume the development of the relevant markets, including the necessary supply chains and skilled labour. However, at least in a UK context, there is limited analysis discussing how this can be achieved."*

Skills shortages are referenced in relation to many of the options for decarbonising heat.

The research references Carbon Connect's recommendations in its policy briefing[72] which notes that "*investors require long-term policy certainty to have the confidence to grow supply chains*" and reiterates Hawkey's research[73] that suggested that "*greater certainty over the existence and extent of future support schemes could have enhanced the growth of the relevant supply chains and skills for heat networks*".

This review also identifies the global market opportunities from being a leader in the transition to low carbon heat.

Construction Sector Deal

Department for Business, Energy and Industrial Strategy (2018)

The Construction Sector Deal sets out an ambitious partnership between the industry and the government that aims to transform the sector's productivity through innovative technologies and a more highly skilled workforce.

The deal sets out how the industry will attract, train and retain a more skilled workforce, and how it will meet the demographic challenge of a workforce where nearly a third of workers are aged over 50.

The document refers to reforming the Construction Industry Training Board (CITB) to ensure a strategic focus on future skills needs

The document also focuses on increasing diversity in the workforce. Despite its size, the construction workforce is one of the least diverse in the UK. The sector deal refers to the sector working to increase diversity with regards to gender, ethnicity and disability.

[72] See Carbon Connect (2015)
[73] See Hawkey, D. J. C. (2012).

Heat networks: delivering a market framework

Department for Business, Energy and Industrial Strategy (2018)

This report details how the Heat Network Investment Project (HNIP) will improve skills and capability within the heat networks market, but notes how the UK supply chain will need to grow significantly in order to meet the demands of the Clean Growth Strategy.

Heat Networks Investment Project Evaluation – Pilot Process Evaluation Report (BEIS Research Paper Number 1)

Department for Business, Energy and Industrial Strategy (2018)

This report details the findings from evaluation research into the administration, delivery and influence of the HNIP pilot scheme.

Stakeholders interviewed as part of the evaluation noted an "*emerging shortage in the supply of knowledge and skills (within local authorities, technical consultants, financial consultants, design services, procurement, construction and commissioning)*". The report goes on to note that this "*may keep costs high, raise concerns about quality, and affect delivery*".

In addition, the report details the views of respondents who considered that the HNIP pilot was "*sending a positive signal to the heat networks market*" and that this has been reflected in greater confidence to invest in skills and expertise.

Infrastructure finance review - Insights for district heat network investment in the UK

Department for Business, Energy and Industrial Strategy (2018)

This report was aimed at supporting the heat network sector to understand investors' perspectives. The research deals primarily with financing of schemes, revenue, lending, credit ratings and returns, but does not reference skills shortages, supply chain issues or education and training needs.

Stakeholder engagement in heat networks: a guide for project managers

Department for Business, Energy and Industrial Strategy (2018)

This guidance is aimed at heat network development managers, and was compiled by the Carbon Trust, CAG Consultants and SE2 on behalf BEIS.

There are a number of softer skills required for the effective deployment of heat networks. For example, stakeholder engagement is critical for a number of reasons; securing interest in and knowledge of the potential benefits of connecting to a heat network; accessing building energy

data to help inform accurate sizing and design of the heat network; and to ensure successful and timely project delivery. This requires not only expertise in best practice stakeholder engagement for infrastructure delivery, but also expertise in the design and delivery of heat networks. As heat networks currently have a relatively small market share and the sector has low margins in line with similar utility infrastructure business operating in a low risk environment (profitability comes with scale and absolute profit is as much a consideration as marginal profit), professional stakeholder engagement managers have little incentive to invest the time and resources to develop the technical understanding necessary for successful transfer of their skills from another infrastructure sector to heat networks.

Recommending that heat network project managers maintain stakeholder engagement as one of their key themes throughout a project, this guidance details the stakeholders that are often involved in projects and advises how to engage effectively with stakeholders, noting the need for both communication and negotiation skills and calling on delivery contractors to provide stakeholder engagement as part of their service.

The potential and costs of district heating networks

Department of Energy and Climate Change (DECC) (2009)

The aim of this DECC study from 2009 was to identify the potential costs and benefits of district heating, assess the technical potential in the UK and consider the economic and non-economic barriers to further investment and deployment. The research supported ongoing policy work to encourage the expansion of district heating. While a relatively old document, the issues identified in the research are still valid.

The study refers to a lack of local expertise and immature supply chains, which in turn may raise the costs of procuring district heating. The research notes evidence that development costs in the UK are higher than in more established district heating markets due to limitations in supply chains and perceived skills shortages, suggesting this cost uplift is more than double those in European countries with established sectors. The study suggests that the difference in civil costs has been attributed a to lack of experience in laying district heating mains.

The research highlights concerns around the availability of UK companies to provide appropriate design of schemes; installation and maintenance services; geographic coverage of required services; and training and awareness among architects, engineers and plumbers.

In addition, the study also defines the role of the public sector in the successful deployment of district heating networks. This includes local government's role in planning for new build developments, as well as the relationship local government has with Social Housing Providers (SHPs) and other public sector institutions that can be beneficial in the development of local schemes. While local government has an essential role in delivery, they themselves may be a barrier to deployment. The report calls for planning officers to be upskilled in heating options for new build and refurbishment development.

Research into barriers to deployment of district heating networks

Department of Energy and Climate Change (2013)

This research study, conducted by the Buildings Research Establishment (BRE), the University of Edinburgh and the Centre for Sustainable Energy (CSE) details the skills gaps across a range of actors in the district heating network sector.

The report notes that limited knowledge within local councils has led to a reliance on consultants to provide both technical and financial assessment support. This can lead to difficulties in procurement of district heating, including how to develop a strong specification and the evaluation of commercial responses, and contracting.

The study also identifies that consultants lack commercial awareness and the technical knowledge of mechanical and electrical designers employed by property developers. This can result in "*over-complicated designs with negative implications such as over-pricing and lack of flexibility in system extension*". The research notes that there are relatively few people with experience of actually designing district heating schemes in the UK.

Finally, the report notes the reliance on dedicated sub-contractors to install district heating pipework, with a general lack of skilled labour to lay pipes.

While a relatively old document, the issues identified in the research are still valid, however it is important to note that progress has been made around commercial and technical knowledge of consultants.

Assessment of the Costs, Performance, and Characteristics of UK Heat networks

Department of Energy and Climate Change (2015)

DECC commissioned research into the cost, performance, and characteristics of heating provided by heat networks to better estimate the economic potential of heat network development in the UK. This study did not include references relating to skills.

Evaluation of the Heat Networks Delivery Unit - Interim report covering wave 1 research

- **Department of Energy and Climate Change (2015)**

This evaluation of HNDU notes that "*interviewees highlighted that, when HNDU was successful, the primary outcomes were improved local authority officer capability to progress heat network development and improvements in the quality and comprehensiveness of heat network studies (e.g. feasibility studies). Occasionally, these led to a number of different secondary outcomes, including improvements in organisational capability on heat network development within a local authority, or increased senior-level buy-in*", and also in reducing councils' reliance on consultants to provide technical and financial assessment support.

Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050: Cross Sector Summary

Department of Energy and Climate Change and the Department for Business, Innovation & Skills (2015)

This report forms a cross-sector summary of eight Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050. These reports present the potential for, and challenges of, realising carbon dioxide emissions reductions across sectors, while maintaining their competitiveness.

Whilst not specific to the heat networks sector, the report does include a chapter on people and skills. The study identifies that an ageing workforce and shortage of engineers across several sectors is likely to present a barrier to finding innovative ways to decarbonise.

These roadmaps have collated and evidenced shortages or limited availability in a range of skills that can stall decarbonisation and energy efficiency progress. This includes:

- Operational and maintenance skills that can enable incremental improvements in energy efficiency;
- The ability to develop projects, including the articulation of a viable business case;
- Research, Development & Deployment (RD&D) skills, such as the development of successful partnerships with equipment manufacturers, technical centres and academia;
- Technical and engineering skills relating to specific processes and technologies;
- Engagement with senior leaders, so that they understand the challenges in terms of skills and how they can develop and deploy the skills needed to tackle the challenges ahead.

There is also a reference to the lack of diversity within the sector, which not only reduces the talent pool available, it also reduces the attractiveness of the sector overall, whilst a shortage of marketing and communication skills could mean that other career paths outside the energy sector may appeal more to graduates.

Research Study to Determine the Skills Required to Support Potential Economic Growth in the Northern Ireland Sustainable Energy Sector

ECORYS (2011)

This report by the Department for Employment and Learning (DEL) in Northern Ireland sought to assess the skills required over the next decade to support the growth of the Sustainable Energy (SE) sector and to identify the short, medium and long-term actions needed to ensure that the supply of skills is sufficient to meet the predicted growth of this sector.

A survey of SE companies found that the majority of respondents did not perceive a problem in meeting skills requirements. However, the report concludes that this is unlikely to continue in

the long term. The report identifies the need to re-skill the existing workforce and a maintain an ongoing supply of new entrants with a range of STEM skills.

While not specific to heat networks, district heating is referenced within the Integrated Building Technology (IBT) sub-sector. Under the report's central skills demand scenario, relatively small skills gaps were expected, and it was considered that these gaps could be bridged through increasing the intake on existing courses.

Government policy clarity and subsidies were considered crucial to maintaining the rate of growth in this sub-sector.

The report describes the ideal scenario, which is to match skills supply with demand. This will require close co-operation to avoid over providing skills (ensuring that skilled workers have employment opportunities rather than leaving the sector or looking for work outside Northern Ireland), and possible use of public funding to pump prime the skill supply (to develop and fund courses in expectation of future demand). The report was cautious about the use of public funding to provide this capacity as there could be no guaranteed employment opportunities in Northern Ireland, but it could provide a skills export opportunity.

The report calls for the promotion, development and delivery of apprenticeships in the SE sector through joint working between industry, the FE Sector, the relevant National Skills Academies and the SSCs; the promotion of the SE sector in STEM subjects; and joint working with the Scottish and UK Governments in the development of skills policies.

Reducing the capital cost of district heat network infrastructure: Summary report from the Heat Infrastructure Development project

Energy Technologies Institute (2017)

This report details eight 'route maps' to deploying heat networks to the quality and scale required to meet UK heat decarbonisation targets.

The research calls for streamlining heat network designs and installation processes in order to reduce costs of a typical scheme by 38%.

One recommendation from the ETI is to establish a District Heating Knowledge Centre, to co-ordinate research, training and dissemination, boost innovation across the sector and encourage recognised qualifications to build the skills base.

The report does acknowledge that the supply chain in the is 'not mature' yet in the UK.

District heat networks in the UK: Potential, barriers and opportunities

Energy Technologies Institute (2018)

This Energy Technologies Institute (ETI) research suggests that "*capital costs of developing heat networks at scale could be up to 30 to 40% lower if the sector were to use eight cost-saving 'route maps' which would cut costs of pipework, installation and connections*".

Noting that heat networks can only fulfil their potential if the sector is mobilised quickly to meet the scale of change needed, "*the skills base in the UK needs to be coordinated and supported to increase capacity rapidly, ensuring that best practice is both achieved and incrementally improved through innovation and learning*". Coordination and collaboration between government and industry is crucial.

The report calls for the UK and devolved governments to provide frameworks to support demonstration, knowledge transfer and skills development to deliver a low-cost energy system that meets the 2050 emissions targets.

Towards Net Zero: The implications of the transition to net zero emissions for the Engineering and Construction Industry

Engineering Construction Industry Training Board (2020)

The Engineering Construction Industry Training Board (ECITB) commissioned research to identify the implications of decarbonisation for the engineering and construction industry. Heat networks are not specifically referenced in the context of skills.

The report identifies the potential for over £40bn in revenues for the industry by 2050, alongside a number of critical challenges that must be met to make the switch to low carbon technologies. The research considers that while UK PLC has many of the skills needed to deploy low carbon technologies, there are notable gaps. In addition, there are uncertainties in the size of the workforce required and the timeframe for deployment.

The report concludes that the industry must harness existing expertise and repurpose these skills to tackle the net zero challenge.

Skills for green jobs in the UK

European Centre of the Development of Vocational Training (2018)

While not specific to heat networks, this European Centre of the Development of Vocational Training (CEDEFOP) report highlights that "*Green skills and employment have typically not been prioritised in UK policy*" and that "*there are no UK-wide anticipation activities for green skills or jobs*". CEDEFOP suggests that the lack of focus in this area has been attributed to the limited number of obvious green jobs available in the UK".

The research also details the fragmented nature of occupational standards, different institutional arrangements across England, Wales, Scotland and Northern Ireland and the lack of a national active labour market programme to focus on developing skills for the green economy.

District heating in the UK: A Technological Innovation Systems analysis

Hawkey, D. J. C. (2012)

This paper outlines some of the principal challenges to significantly increasing the deployment of district heating in the UK.

Hawkey identifies that the lack of skills within local government is a key issue in the deployment of networks. Noting how UK local government have not been directly involved in energy provision since the 1940s until very recently, they "*often lack necessary in-house resources, namely technical, legal, and commercial skills and expertise*".

"While district heating networks are inherently local infrastructures, they are positioned in regulatory and market contexts organised at larger spatial scales, making geography an important factor and coordination across spatial scales an important policy area for accelerated deployment".

The author therefore calls for local government to show leadership and develop in house capability to support the greater deployment networks, identifying a number of 'key blocking' mechanisms that need to be resolved, such as lack of resources and weak incentives to undertake non-statutory energy planning and development.

The paper suggests that an increase in the number of local authorities facilitating the deployment of heat networks could potentially increase the effectiveness of knowledge networks; thus increasing confidence in growth, which could then stimulate investment in skills and supply chains.

The paper also details the failure of grant funding programmes to stimulate cost reductions in the deployment of networks, and low confidence in future support programmes has resulted in increased costs through the lack of investment in skills and the supply chain.

The author calls for "*greater certainty over the existence and extent of future support schemes*" to enhance the growth of the relevant supply chains and skills for heat networks.

Hawkey calls this failure to create a positive externality significant, noting that the relatively small scale of the district heating sector in the UK means that equipment is often imported (particularly insulated pipes), and other costs are high relative to other European countries.

Hawkey suggests that policy makers can resolve this barrier by ensuring support programmes are tailored to improving overall system performance and that there are embedded and ongoing monitoring processes to identify potential issues.

Piping hot – the opportunity for heat networks in a new industrial strategy

Institute for Public Policy Research (2017)

This IPPR research examines the potential scale of investment and job creation that the heat network sector could generate.

The report notes that due to the limited number of existing heat network schemes, there is a skills and knowledge gap within the sector.

IPPR estimated that 81,000 jobs could be created by the heat networks sector by 2030.

The report calls for training on how to appraise heat network projects linked to the development of a procurement agency that would act on behalf of local government.

A just transition. Realising the opportunities of decarbonisation in the North of England

Institute for Public Policy Research (2019)

This Institute for Public Policy Research (IPPR) report considers the challenges in meeting decarbonisation targets in the North of England.

Noting how "*granular labour market information is crucial to understand how well the skills system will be able to supply anticipated growth in the low-carbon energy sector",* IPPR recommends a comprehensive devolved skills audit is undertaken.

IPPR called for:

- A consistent approach to training across the energy sector through the implementation of an Energy Skills Competency Accord. IPPR notes that this approach would need to be supported by legislation and regulations that required certain technical standards and outcomes to be met rather than prescribing a particular method.
- Greater consistency across policy so that in-demand occupations are included within the range of courses which T levels are intended to cover, in order to reflect skills needs.
- Devolving education and skills funding. Any unspent levy funds should be fully devolved to Local Enterprise Partnerships (LEPs) (rather than being retained by the Treasury or directed by it).
- Training standards, which are being developed by bodies such as the Engineering Construction Industry Training Board (ECITB), to be made available to those who are unemployed.
- Reforming the apprenticeship levy so that it is set at 0.5% of payroll for mid-sized firms and 1% for firms with 250 or more employees. This will increase the scope of employers required to make contributions.
- Raising the profile of the sector, promoting diversity and supporting graduate retention in the north of England by requiring that companies above a threshold size should be required to actively promote STEM subjects in schools.

Companies in the low-carbon energy sector noted that they were already struggling to fill vacancies. A majority of respondents to IPPR's energy skills survey said that vacancies were partly a result of a lack of applicants with high-level skills such as engineering, and partly due to the length of time required to train people. Leaving gaps unfilled will further delay growth in the low-carbon energy sector.

The IPPR report notes that while some of the workforce have transferrable skills, and industry initiatives are helping workers move to the low-carbon energy sector, there is no concerted support at a national level to resolve issues or any attempts to facilitate action at a regional or local level. The research details the strong competition for skills between sub-sectors and, given the regularity with which workers move around within the energy sector, this leads to limited appetite for companies to provide training and 'sector leakage' where there is an oversupply of STEM graduates in non-STEM-related fields of work.

However, in its response to the CCC's 2019 progress report to Parliament[74], the government recommended a review of skills across building, heat and ventilation supply chains, alongside a nationwide training programme to upskill the existing workforce. This document also details the government's planned activity across heat and ventilation supply chains, including extensive stakeholder engagement activities, to determine the roles of government, industry and the wider supply chain to ensure that supply is able to meet demand.

Detailing shortages in key skills such as engineering, the report highlights how some organisations in the low-carbon sector are resorting to the 'gig-economy' through hiring independent contractors. IPPR recommends that such insecure employment practices should not become the accepted employment model in the low-carbon energy sector.

The report notes that many of those employed in carbon-based generation have highly transferrable skills that will be needed in the low-carbon energy sector, and highlights the vital role of a supportive skills system to provide appropriate training to facilitate this transition. "*Without appropriate training, a vicious cycle ensues: if workers, do not receive appropriate training, skills gaps in the low-carbon energy sector will widen. This will lead to slower growth in the industry as a whole, which in turn will limit the number of opportunities for workers to transition from high to low-carbon employment*".

IPPR suggests involving trade unions in the process of determining a just transition policy. The report notes that the Trades Union Congress (TUC) is committed to decarbonising the power system, sharing a desire to boost productivity and involving skills training to give unemployed workers the opportunity to find new, high quality employment.

The vast majority of respondents to IPPR's energy skills survey stated that policy certainty was 'extremely important' to the future of the industry, yet none thought it was currently sufficient. IPPR notes that projecting future job demands are difficult without long-term policy certainty, but that all projections point towards a substantial increase in demand in employment in the sector.

The report suggests that the distinction between academic skills and vocational skills will become more blurred in the future and 'whole skills' approaches will need to be adopted.

The research also states that there are only a limited number of training courses being offered with technical skills and knowledge that are specific to the low-carbon energy sector which limits existing technicians' ability to upskill.

[74] Department for Business, Energy and Industrial Strategy (2019) Leading on Clean Growth

Anticipating skills needs for the low-carbon economy

International Labour Organization (ILO) (2011)

This ILO report considers the difficulties of deciding which training will be required in new and evolving markets. The study specifically refers to the difficulties in making such decisions due to research on skill needs for green economies being "compromised by a lack of sufficiently good statistical information".

The report also notes that "skills-led strategies to support the green transition can serve as a driver of change in their own right: availability of suitably skilled workforce attracts investors in green industries; and environmental awareness encouraged through education and training boosts demand for green products and services. Identifying and anticipating skills needed for the green and low-carbon economy must precede training decisions so that skills acquired are relevant for the labour market."

The report identifies a series of actors who use information on skills requirements. This includes:

- Education and training providers who need to update curricula, establish or upscale training delivery;
- Employers and employees to implement HR development strategies and development plans;
- Vocational guidance and employment service professionals who may be advising potential employees; and
- Policy makers and labour market information professionals to help inform policy decisions.

The research concludes that *"while anticipating skill needs for the low carbon economy is complex, and poses significant challenges, it can be done. Difficulties with definitions of occupations and sectors, shortcomings in statistics, problems with defining a green job, and differences in the dynamics of employment in different types of green activity can all be overcome. Collaboration between governments employers and workers' organizations, contributes to the identification of the right issues to research, to high quality analysis and to the effective implementation of skills policies and actions based on the research."*

Talent 2050: Engineering Skills and Education for the Future

National Centre for Universities and Business (2018)

The National Centre for Universities and Business (NCUB) develops, supports and promotes world-class collaboration between universities and business across the UK. While not focussed specifically on energy or the heat network sectors, this report identifies barriers and bottlenecks to the UK competing in international markets.

NCUB calls for:

- A drive for more diverse workforces to avoid engineering skills shortages, which reaches beyond existing STEM employees.
- Consider more inclusive approaches to recruitment, basing decisions on the potential for employees to gain the right skills.
- The Institute for Apprenticeships and Government to reconsider the requirement for employers to take apprentices to Level 2 in English and Maths, so that employers can be actively encouraged to develop young people who display practical talents.
- Efforts to upskill and reskill are fully supported for those already in employment, and that regionally tailored solutions are appropriate for Small and Medium Sized Enterprises (SMEs) as well as large corporations.

Skills planning to drive sector mobility: Strategic plan update

Nuclear Skills Strategy Group (2018)

This report reflects the work of the Nuclear Skills Strategy Group (NSSG) in developing the People commitments in the Industrial Strategy and the Nuclear Sector Deal.

The NSSG works with major employers, government, regulators and trades unions to address the sector's skills challenge:

- To ensure the sector can meet the demand for more than 100,000 skilled jobs needed in the UK by 2021.
- To build a more diverse workforce – including 40% female representation by 2030
- To grow our pool of Subject Matter Experts, to replace those retiring.

Nuclear Workforce Assessment

Nuclear Skills Strategy Group (2019)

The NSSG Labour Market Information (LMI) group co-ordinates intelligence to inform the decisions of the NSSG. This includes the production of the Nuclear Workforce Assessment report, regional, sub-sectoral and thematic reports and disseminating information on current and future employment patterns in the sector (such as the potential supply of skilled people within the sector, the education and training 'pipeline' and the potential flows from related sectors. This activity is used to inform the analysis of the demand for skilled employees.

The group's Nuclear Workforce Assessment (NWA) is the sector's annual forecast of skills supply and demand to 2030 and beyond. It provides the sector with the evidence to develop the key skills interventions to deliver the targets set out in the Nuclear Sector Deal, helping to underpin decisions around strategic interventions and investment to close skills gaps.

Key skills and training needs of the D2N2 low carbon and environmental goods and services (LCEGS) sector

Paterson, F., Baranova, P., Neary, S., Hanson, J. Clarke, L., Wond, T., Lee, A., Gill, J., Gallotta, B., Eisen, M. and Nesterova, I. (2018)

Low Carbon was one of eight priority business sectors identified by the Local Enterprise Partnership for Derby, Derbyshire, Nottingham and Nottinghamshire (D2N2 LEP) Strategic Economic Plan (2014 – 2023).

This report identifies skills-based barriers and bottlenecks at a local level and considers the role of the LEP in facilitating change.

This study set out to:

- Establish the key skills required now and in the future by the LCEGS sector in D2N2;
- Map existing training provision, including how the workforce is currently recruited, trained and what qualifications are available locally;
- Establish the needs of key sector supply chains;
- Identify any skills shortages, gaps in existing provision, barriers and risks for both small and large businesses; and
- Explore how apprenticeships can support the low carbon economy in the D2N2 area to help employers to identify the right frameworks and standards; develop new standards; facilitate engagement and involvement and promote best practice.

Respondents to research interviews noted that there was a shortage of people with the right technical skills, that there are potential employees working in other sectors that have the skills required, that their workforces needed upskilling due to changes in technology and that an aging workforce is a cause for concern.

While not focussed specifically the heat network sector, the report called for long-term, stable energy policy and concluded that that university provision in the local area was sufficient but that this was not true in further education colleges, and that apprenticeship provision should be provider led rather than demand led.

The report offers ten recommendations to link with the D2N2 Science and Innovation Audit, Strategic Economic Plan and forthcoming Local Industrial Strategy. These include investing "*in cross-sector opportunities to build local leadership capacity to accelerate the shift to a local low carbon economy*", Sector Skills Groups to take responsibility for auditing and reviewing LCEGS current and future skills needs to establish priority areas and make recommendations for skills provision in each priority sector and sponsoring local FE Colleges to develop training courses to attract young adults into the LCEGS sector.

Alternative heat solutions: converting a town to low carbon heating

Ramboll (2019)

This Ramboll study focuses on the viability of four alternative, low-carbon heating solutions for an average sized town in the UK. The research reviews techno-economic models to identify the potential costs of converting the town to low carbon heating systems.

The research identifies technical risks in delivering the transition, including the lack of appropriate skills within the supply chain. Highlighting a "*lack of experienced installers, operation and maintenance staff for systems under a national roll out*" the report notes that "*large scale adoption of technologies expected to be affected by a skills shortage*".

Ramboll conclude that while the technical solutions considered in this study are not widely prevalent, they are becoming more common, and in order to deliver a national roll-out the supply chain will need to expand.

Closing the engineering gender pay gap

Royal Academy of Engineering (2020)

This research considers the issues surrounding gender and race inequality in the UK engineering profession, and highlights that the engineering sector has a significant skills shortfall, with 59,000 more engineers needed each year.

While attempts have been made to address diversity imbalances, progress has been slow.

"Reducing both gender and race inequality is key to addressing the damaging shortage of engineering skills in the UK economy".

The report details how underrepresentation of women in senior roles - rather than unequal pay - is the single largest cause of the gender pay gap for engineers. It is important to note however that the gender pay gap in the engineering profession is smaller than the UK average. The mean (10.8%) and median (11.4%) pay gap for engineers in the sample analysed is around two thirds the national average (13.3% and 11.4% respectively). The report notes that reducing the gap will take a concerted effort within the profession.

The research also highlights that there is a "serious diversity deficit" within the engineering profession: females make up 12% of the workforce and only 9% of the profession come from the Black, Asian and Minority Ethnic (BAME) group. The report concludes that "the pace of change in the diversity of the UK engineering workforce has been disappointingly slow".

The Royal Academy of Engineering recommends actions to close the gender pay gap "*through addressing the retention and progression of women to more senior and higher paid roles*". Effective actions to be taken forward include the implementation of transparent pay structures and grades, reviewing promotion criteria and introducing flexible working for senior roles.

Heat Network Skills Workshop: post workshop feedback report

Scottish Government (2019)

This Scottish Government workshop in 2019 found consensus amongst stakeholders that "*skills gaps/shortages exist within the heat networks sector in Scotland*". Delegates considered the main barriers in this area were market uncertainty, fear of innovation, the cost and commercial case for training, and a lack of understanding of training needs and the importance of the sector.

Delegates considered the main factors that could support the Scottish heat networks sector. These were identified as:

- A supportive policy framework to set the strategic direction of the sector (with realistic targets); delegates noted that the Scottish Government's Heat Networks Bill would bring more certainly and confidence to an unregulated heat network sector.
- Supporting regulation around planning;
- Increased industry collaboration; and
- Long term financing mechanisms; delegates discussed the cessation of the non-domestic Renewable Heat Incentive (RHI), which was felt to be a significant barrier to investment. The role of private sector financing was discussed, with delegates noting the need to use public finance where private investment was lacking or rapid industry growth is required.

A range of skills gaps were identified; from individual specialist skills to multi-skill employee requirements that cut across the traditional skill boundaries such as plumbing and electrical professions. Most delegates agreed that the expansion of the sector meant that more training and upskilling was required to support sustainable sector growth. It was also felt that opportunities for transferable skills could be found within the traditional oil and gas sectors, as well as existing employees within the plumbing and mechanical and electrical engineering sectors.

Delegates agreed that "*it was vital to deliver needs-based training with measurable outputs (i.e. job creation/retention, cost savings for network operators, increased customer satisfaction, more efficient networks)*" and that colleges should develop training and certification approved by manufacturers.

Recommendations included that college courses should include practical (on the job) training, whilst university level engineering courses should incorporate elements of heat networks.

Delegates considered that training courses can be piecemeal and are often delivered in an ad-hoc fashion with a lack of accreditation. Several courses were identified: Heriot Watt, Edinburgh and Strathclyde University master's degree courses include a module on district heating. Fife College's metering and billing/heating interface unit course was also noted, alongside a suggestion that South Lanarkshire College's teaching house could be used to improve knowledge of heat networks.

In addition, delegates discussed the different skill set required for innovative 5th generation heating and cooling networks, and how heat pump application and design skills would need to feature highly in education provisions going forward.

Local government skills gaps were identified, particularly around procurement.

Workshop delegates suggested that a national 'capacity assessment' benchmarking exercise be undertaken to define "*more precisely what skills are available and where the main gaps may lie*" and that this should focus on different generation technologies to understand where future growth areas may require specific skillsets. In addition, delegates called for the Scottish Government to apply procurement requirements around apprenticeships, graduates and training for those heat networks supported by government funding.

Sector insights: skills and performance challenges in the energy sector

UK Commission for Employment and Skills (2015)

This UKCES report covers skills and performance challenges in the wider energy sector and is not specific to heat networks. However, it does provide some high-level findings around skills in the energy sector:

- Skills shortages mean that jobs go unfilled. This leads to delays and the outsourcing of work.
- Experienced workers are moving out of the industry, either through retirement or to transfer to another sector, and are not being replaced in sufficient numbers or with sufficient speed. This is leaving gaps in the higher layers of the energy sector.
- There are not enough STEM graduates joining the sector, resulting in skills shortages and gaps in the middle layer of the workforce[75]. (Over 60% of stakeholder interview respondents stated that there were not enough individuals studying STEM subjects at undergraduate or postgraduate level. The reasons given for this imbalance were around a range of perceptions that the costs of studying for a degree (and potentially a masters) are high, that cheaper overseas study options led to students staying overseas once qualified, the entry criteria for STEM degrees being too obstructive and the general perception that STEM subjects are 'difficult'. While research undertaken by UKCES found that there was not an overall shortage of STEM graduates, over 40 per cent of STEM graduates work in non-STEM occupations and that graduates may be attracted into more lucrative sectors such as financial services).
- The energy sector struggles to attract a diverse workforce, due in part to a perception that the sector is not appealing to women and young people.
- 75% of renewable energy employers said that the renewables market in the UK is unstable due to a lack of consistent policies.
- 20% of employers said there are not enough technical courses available to train employees to the required standard.
- 10% of employers have never heard of National Occupational Standards (NOS), which describe the competencies and knowledge required for various jobs in the sector. Two

[75] The report does note that university and college graduates should not be seen as a substitute for on-the-job technical training.

thirds of stakeholders felt that NOS were too generic, whilst others commented that due to technical innovations in the energy sector, some NOS are outdated.

The report does note that whilst many organisations are demonstrating innovative solutions to plug skills gaps, this work can be undertaken in silos rather than collectively addressing issues with the sector.

Technology and Policy Assessment - Best practice in heat decarbonisation policy: A review of the international experience of policies to promote the uptake of low-carbon heat supply

UK Energy Research Centre (2016)

This UK Energy Research Centre (UKERC) review of the international experience in heat decarbonisation focusses on heat pumps and heat networks.

The report notes that policy interventions, which are crucial in the take-up of low carbon heat solutions, can support the expansion of the skills base.

Highlighting that the UK's short-term and abruptly changing policies for district heating have created uncertainty and perceived risks for both local government and the commercial sector[76], the report does acknowledge that UK grant programmes have led to development activity across the sector. However, low industry confidence in future support schemes has meant investment in skills or supply chains were not triggered. This has led to increased capital costs and lead times[77].

The report highlights success factors in the Danish heat networks market, noting the need for an effective and accessible skills base. While not directly comparable to the UK market[78], competition to fund district heating projects may be explained by stable national energy policy, along with publicly underwritten loans, heat planning, an effective skills base being available, and district heating companies having clear roles and responsibilities and efficient decision making.

The UKERC team also reference research[79] that found providing lower levels of support to the sector could make deployment of heat networks more expensive. Short term and frequently changing policies in the UK were thought to have temporarily driven up development costs rather than the further developing supply chains and skills bases.

Finally, this report also acknowledges that local councils require commercial skills training.

[76] See also. Webb, Jet al (2014)
[77] See also. Hawkey, D. J. C. (2012).
[78] Note that the Danish heat networks market is largely owned by the public sector and is mature in comparison to the UK market. While useful to understand key learnings from this market, it is not directly replicable.
[79] See Webb, J et al (2014)

Incumbency in the UK heat sector: implications for low-carbon heating

UK Energy Research Centre (2018)

This UK Energy Research Centre (UKERC) research, derived from a series of interviews with stakeholders, notes that efforts to decarbonise heat have so far been piecemeal. Due largely to a lack of clarity in government policy and regulatory support, this has resulted in very limited investment in the low carbon heat sector.

Noting that "*incumbent businesses* [in the heat network sector] *can have both positive and negative influences on decarbonisation*" the research notes that while there are examples of companies investing in low carbon energy and driving change, there are also "*examples of incumbents trying to resist change therefore slowing or blocking decarbonisation.*"

Heat and the city - Exploring affordable, low carbon community heating in cold climate cities

Webb, J., Hawkey, D., Tingey, M., Kerr, A., Lovell, H., McCone, D. & Winskel, M. (2014)

This paper comments on how UK policy targets either large-scale low carbon electricity interventions or small-scale interventions to individual buildings and behaviours, whilst ignoring the advantages of area-based solutions. This research addresses 'the missing middle' – city-scale action for sustainable energy.

While this paper does not focus on skills, it does conclude that local government leadership is needed to deploy sustainable heat networks.

Skills Shortage Assessment Models – Literature Review Summary

Zekaria, Y. and Chitchyan, R. (2019)

This paper summarises the findings of an extensive literature review.

It highlights that the transition to local and low carbon energy systems will put notable pressure on the energy industry. This is particularly notable where workforce skill requirements will need to be updated, noting that the adoption of climate change mitigation strategies will create new occupations, and require the 'greening' of existing occupations and the transfer of skills from conventional energy occupations to those in the low carbon field.

The research, which is not specific to heat networks, details how a lack of necessary skills can lead both to project failure and poor-quality projects. In turn this can detrimentally impact on social, economic and environmental project objectives.

The research also details how skills and knowledge are not evenly distributed between regions, which can limit the potential of certain geographic areas from accessing the benefits of low carbon growth.

The authors define skills shortages as a lack of adequately skilled individuals available in the accessible labour market, which leads to difficulties in recruitment. "*This could result from basic lack of people (when unemployment levels are very low), significant geographical imbalances in supply (sufficient skilled people in the labour market but not easily accessible to available jobs), or a genuine shortfall in the number of appropriately skilled individuals – either at new entrant level, or for higher level skilled occupations".*

The research paper then considers the factors noted by previous literature that contributes to skills shortages. These are categorised by the number of references within literature.

Those most frequently referenced within the literature (12-18 times) include:

- Policy and regulation.
- Technology (such as automation).
- Changes in markets due to competitiveness.
- Education standards.
- Significant changes in consumption habits.

Factors referenced within the literature (5-10 times) include:

- The number of training providers (which can also reflect regional skills shortages).
- Job incentives such as wages or location.
- Workforce demographics.
- Funding towards skills and training or research and development (R&D).
- Poor labour market information (where individuals do not know the skills that they need or the number of graduates in the necessary area).
- Business model changes which cause disturbances at a company-level.

Finally, a series of least mentioned factors (1-4 times) include:

- The lag between technological advancement and training and education causing a delay between emerging technologies and those able to use them.
- Geographical mismatches whereby skills may not be evenly distributed.
- The level or quality of training, which could be of a low standard.
- Short-termism, whereby employers only want short-term contracted staff and as such these opportunities lack appeal, causing potential employees to migrate out of the sector or even the country.
- The transferability of skills being so low that individuals have skill sets limited to a single job.
- Brexit, which could divert attention away from existing skills shortages.

In order to understand skills shortages across the energy system, the paper calls for a greater understanding of the:

- Actual skills that are required in jobs across the energy sector.
- Factors that contribute to shortages of these skills.
- Techniques and models to forecast skills shortages.

Enabling the forecasting of knowledge and skills in the labour market can better prepare the sector to provide training and education and facilitate the successful transition to a low carbon economy.

The authors conclude that there are few models in the literature that was reviewed that directly model skills shortages. Noting that many models estimate the number of future jobs required in certain industries, they highlight that the same models do not look at the actual level of skills available and skills needed. Noting that skills can relate to specific occupations, the authors call for a combination approach that calculates shortages by occupation and considers the skill shortages that may already exist or may emerge in the existing workforce.

Current and future research

Heat Network skills in Scotland: skills gaps and training needs.

Research commissioned by Energy Saving Trust Scotland and Scottish Government, aims to provide an in-depth analysis of the current experiences of heat network practitioners in Scotland.

Building on a 2019 Heat Networks Skills Workshop (see above), this research identifies existing skills gaps in heat network supply chains, as well as assessing the potential for developing training provision within colleges and universities to fills these gaps.

The research, authored by Dr Ruth Bush, Honorary Research Fellow at the University of Edinburgh, is expected to be published in summer 2020.

Building Skills for Net Zero Emissions: How will the climate emergency affect you and your business?

The Construction Industry Training Board (CITB) has recently commissioned research to identify the critical skills barriers and enablers for the achievement of legally binding net zero targets.

The research will involve a skills analysis based on expected net-zero deployment trajectories advised by the Committee on Climate Change (CCC), and will focus on skills to improve the energy performance of both new and existing buildings, as well the anticipated large scale switch to low carbon heating sources.

It will provide clarity on the most significant skills barriers to the delivery of net zero, relating to design, construction and maintenance operations and also the role that workforce skills development can play as an enabler for the decarbonisation of the built environment. It will

also identify the new and emerging jobs and skills that will be needed and how demand for some existing skills will change as we decarbonise.

The objectives of the research include:

- Establishing a baseline of existing evidence.
- Describing the impact of the transition to net zero on the composition of the workforce, against an agreed set of deployment trajectories.
- Assess workforce capacity and capability against deployment trajectories.
- Conduct scenario forecasting and analysis.
- Identify and assess resources (eg. qualifications, training, and assurance of competence).

The research, which started in April, is expected to be completed in summer 2020.

Heat Pump Manufacturing Supply Chain Research Project

This project will set out the practical steps needed to grow the UK heat pump manufacturing supply chain, including hybrid heat pumps, considering synergies with other industries and the possibility to build on the UK's current expertise in the transition away from fossil fuel heating.

The aim of the project will be to

- Investigate the manufacturing supply and value chains for different sectors of the heat pump and related markets.
- Identify where in the heating supply chain the UK has particular expertise that could make it internationally competitive.
- Understand how the UK can become an attractive proposition for heat pump manufacture.
- Gain a realistic understanding of the growth in the heat pump supply chain.
- Determine which policy levers could maximise growth of the UK’s heat pump supply chain.
- Provide recommendations for government intervention.

The research, which started in early 2020, is expected to be completed in summer 2020. The project team were unable to engage with this research project.

Additional literature reviewed

The research team reviewed a wide range of additional literature and data sources.

Working groups and industry engagement

Heat network and Industry Council[80]

The Association for Decentralised Energy (ADE) convened the Heat Network Industry Council (HNIC) in 2018. The group is made up of 14 industry experts, including Siemens (Chair), the ADE, EDF Energy, ENGIE, E.ON, Pinnacle Power, Ramboll, SSE, Switch2, Vattenfall, Veolia, Vital Energi and independent experts.

HNIC is identifying measures both government and industry can take to help create jobs and investment, cut costs and carbon, create smarter cities and drive excellence in customer service and standards.

HNIC was launched on 3rd June 2020[81].

The HNIC vision is that "*By 2050, low carbon heating will be the norm, and heat networks will constitute a key segment of this. It will be normal for homes and businesses in towns and cities to be on heat networks, and consumer awareness of heat networks will be high*".

The HNIC offer to government is that heat networks can offer:

- The investment, skills and supply chain growth necessary for 18% of UK heat demand to be met through heat networks by 2050, including 20,000-35,000 new direct jobs in the sector and investment of up to £50bn into the UK market by 2050;
- Accelerating carbon reduction with net zero carbon commitments for all new schemes by 2030, and for all new and existing heat networks being net zero carbon by 2035;
- Delivering consistent and excellent customer experience for all heat network users, with the overriding principle of treating customers fairly and guaranteed standards of performance; and
- Supporting the creation of smart, liveable cities with city-wide strategic heat network plans for all major cities by 2030, including efficient and low cost, digitally-enabled heat for all networks that will be net contributors to better air quality.

Website searches and news

UK's first National District Heat Skills Academy[82]

Stoke on Trent College announced that they will train workers at the first national District Heat Skills Academy, drawing on expertise from collaboration with Swedish organisations and companies. The heat network industry, such as Nordic Heat, have been supporting this initiative.

[80] www.theade.co.uk/news/press-releases/heat-network-industry-promises-more-jobs-smart-cities-and-a-fix-to-the-deca (Date accessed 18th February 2020)
[81] Heat Network Industry Council: https://www.hnic.uk/ (Date accessed 4th June 2020).
[82] http://heatnetworks.se/uks-first-national-district-heat-skills-academy/ (Date accessed 22nd February 2020).

Plan for £7bn investment into NW low carbon skills[83]

This article describes work being led by the University of Chester and Manchester Metropolitan University. The academic team, along with a range of stakeholders including the Local Enterprise Partnership (LEP), the North West Business Leadership Team (NWBLT) and industry, are bidding to become the UK's first net zero carbon cluster. The project will involve a cluster skills roadmap to seek to understand the skills requirements of industry in the region to facilitate action to the net zero transition.

Professor Joe Howe, chair of the NWHA, executive director at the University of Chester's Thornton Energy Institute and ECITB board member, is quoted as saying:

"*The Net Zero transition is a great opportunity, but it's going to require some significant investment in skills and training*.

"*A major concern is the ageing workforce, so it's important to attract young people into industry. We need to communicate the benefits of a career in this sector and attract school leavers into industry now so we can plan for the skills requirements of the future*.

"*The skills roadmap is being developed to not only gain a further understanding of the challenges we face in this area from a view of both the educators and industry, but we need to develop a tangible pathway to skills to help regions like the North West decarbonise and create opportunities for future generations*.

"*The long term skills demand projections are currently uncertain, the quality of intelligence and forecasting is mixed and the pace of change is fast. However, we know that education and skills will ultimately underpin our ability to reach our ambition of a zero-carbon economy*".

Bridging the skills gap[84]

The Engineering Construction Industry Training Board (ECITB) noted in a recent news article that the engineering construction industry has reached a critical moment.

The article details how the industry has an ageing workforce and there is a great need to engage with young people to fill skills gaps in key areas of need with the implementation of a universal careers education programme with schools and colleges.

ECITB's recent Leading Industry Learning Strategy highlights that over the next decade, £600bn of infrastructure projects across the UK will be built, which in turn will create huge demand for skilled employees and high-quality training across the industry.

Reviewed but not included within the research

The following sources were reviewed by the team, but not considered useful in the context of this research project.

[83] https://www.thebusinessdesk.com/northwest/news/2057285-plan-for-7bn-investment-into-nw-low-carbon-skills (Date accessed 20th March 2020)
[84] Engineering Construction Industry Training Board (2020) Bridging the skills gap https://www.ecitb.org.uk/bridging-the-skills-gap/ (Date accessed 3rd March 2020)

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Appendix C: Glossary of terms

Term	Definition
ADE	The Association for Decentralised Energy
BAME	Black, Asian and Minority Ethnic
BEIS	Department for Business, Energy and Industrial Strategy
BIS	Department for Business, Innovation and Skills
BRE	Buildings Research Establishment
BSE	Building Services Engineering
CCC	Committee on Climate Change
CEDEFOP	European Centre of the Development of Vocational Training
CIBSE	Chartered Institution of Building Services Engineers
CHP	Combined Heat and Power
CMA	Competition and Markets Authority
CPD	Continuing Professional Development
CP1	CIBSE Heat Networks: Code of Practice for the UK
DECC	Department of Energy and Climate Change
DEL	Department for Employment and Learning (Northern Ireland)
DfE	Department for Education
DHVN	District Heating Vanguards Network
ECITB	Engineering Construction Industry Training Board
EEEG	East of England Energy Group
ESCF	European Supply Chain Forum
ESCo	Energy Service Company
ETI	Energy Technologies Institute
EV	Electric Vehicle
GDPR	General Data Protection Regulations
GHNF	Green Heat Network Fund
GLA	Greater London Authority

Term	Definition
GSHPA	Ground Source Heat Pump Association
HIU	Heat Interface Unit
HNC	Higher National Certificate
HND	Higher National Diploma
HNDU	Heat Networks Delivery Unit
HNIP	Heat Networks Investment Project
HVAC	Heating, Ventilation and Air Conditioning
IEE	Intelligent Energy – Europe
ILO	International Labour Organization
IPPR	Institute for Public Policy Research
LCITP	Low Carbon Infrastructure Transition Programme
LCREE	Low Carbon and Renewable Energy Economy
LEP	Local Enterprise Partnership
LMI	Labour Market Information
MAC	Migration Advisory Committee
MHCLG	Ministry of Housing, Communities and Local Government
M&E	Mechanical and Electrical Engineering
NCUB	National Centre for Universities and Business
NESTA	National Endowment for Science, Technology and the Arts
NOS	National Occupational Standards
NSAR	National Skills Academy Rail
NSSG	Nuclear Skills Strategy Group
NVQ	National Vocational Qualifications
NWBLT	North West Business Leadership Team
OfS	Office for Students
ONS	Office for National Statistics
RHI	Renewable Heat Incentive
SIC	Standard Industrial Classification

Term	Definition
SOMS	Sales, Operations and Maintenance Set
SHP	Social Housing Provider
SHNP	Scottish Heat Network Partnership
SOC	Standard Occupational Classification
SSC	Sector Skills Council
STEM	Science, Technology, Engineering and Maths
UK DEA	UK District Energy Association

Appendix D: Literature Review Bibliography

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