UNIVERSITY OF EXETER

Heat Network Strategies for the West End of East Devon
FINAL DRAFT

CENTRE FOR ENERGY AND THE ENVIRONMENT

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CENTRE FOR ENERGY AND THE ENVIRONMENT

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Management Summary

In 2014 the Intergovernmental Panel on Climate Change (IPCC) stated that warming of the climate system is unequivocal. The Climate Change Act commits the UK to reducing emissions by at least 80% in 2050 from 1990 levels. Buildings are responsible for over half of all carbon emissions in the UK and limiting emissions from new buildings is an important carbon reduction policy lever.

In November 2007 the Exeter and East Devon Projects Team commissioned Element Energy to undertake a strategic analysis of energy and carbon dioxide (CO_2) emissions from the new developments in Exeter and East Devon Growth Point over the period to 2020. That report made the economic case for a district energy solution for the emerging Cranbrook new community in East Devon's West End. It was found that in larger scale development, adopting a site-wide solution (district heating and biomass combined heat and power) would be significantly cheaper than abating carbon at a household level when targeting levels 5 and 6 of the Code for Sustainable Homes.

Since that study much has happened. A site-wide district heating network at Cranbrook, one of the few true zero carbon on-site developments in the country, is being delivered by E.ON with 1,200 homes and the first commercial buildings on the neighbouring Skypark connected to the scheme. The scale of development in the West End of East Devon has grown. Element Energy considered 3,500 homes at Cranbrook whereas a swath of up to 12,000 homes and business premises are now being planned from Monkerton just west of the M5 out to the proposed eastern extension of Cranbrook.

The Centre for Energy and the Environment (CEE) has been commissioned by East Devon District Council to examine the strategies for the heat networks in the West End of East Devon, accounting for the increase in scale of the developments, changes to national and local energy and planning policy/legislation and the current stage of heat network development. The developments considered by the study comprise Cranbrook and its planned extensions totalling some 7.600 homes, housing to the North/East of Pinhoe (i.e. at Pinn Court Farm and Old Court Farm), Tithebarn Green/Mosshayne, Skypark, Science Park, the Intermodal Freight Terminal (IMFT) and Monkerton (which lies in Exeter rather than East Devon, but contributes to site-wide solutions spanning both districts). The Monkerton area comprises some 4,260 homes. Total non-domestic floor area is some 400,000m^2.

National policy has evolved significantly since "Building a Greener Future" in 2007 where the then Government stated that new dwellings would be "zero carbon" from 2016. Since then, Part L has been updated twice with the 2010 change resulting in a 25% reduction in carbon emissions from new dwellings and non-domestic buildings and the 2013 change resulting in a further 6% reduction for homes (to 29% on 2006 Part L) and 9% reduction for non-domestic buildings. Further revisions to Part L were planned for 2016 and 2019. However in July 2015 the Government announced that it did "not intend to precede with the zero carbon Allowable Solutions carbon offsetting scheme, or the proposed 2016 increase in onsite energy efficiency standards". Locally, Exeter's 2010 Core Strategy requires new homes build from 2103 onwards to achieve a 44% CO_2 reduction on 2006 Part L. This and a policy which requires connection to heat networks has supported the provision of district heating at Monkerton which is likely to extend to the surrounding developments in the adjacent parts of East Devon. East Devon's 2015 Local Plan includes support for district heating and decentralised energy particularly at Cranbrook and Pinhoe.

The heat networks at Cranbrook and Monkerton are operated by E.ON under long term concession agreements. Both networks are currently gas fuelled. A 0.5MWe gas CHP is operating at Skypark with the remaining heat being provided by gas boilers. There is a Section 106 (s106) commitment to provide 2MWe and 2.4MWth of wood fuelled biomass CHP at the Skypark Energy Centre. However, electricity grid constrains in the south west region are likely to delay installation until 2020. A private wire connection to the Lidl distribution centre due to be constructed some 600m for the Skypark Energy Centre may enable acceleration of an additional 1MWe gas CHP. The France-Alderney-Britain electricity interconnector (FABlink) converter station which may be located close to Exeter Airport provides the opportunity to recover 5-7MWth of waste heat.

Initial plans at Monkerton are predominantly based on gas CHP which is supplemented by a 0.5MWth biomass boiler. A private wire connection to the Met Office supercomputer site would enable the 0.5MWe of gas CHP need in 2018/19 to be installed ahead of the relaxation of grid constraints. Waste heat recovery from the next generation of supercomputer at the Met Office site offers the potential for additional low carbon heat from 2020/21.

Four scenarios, a gas base case and three different combinations of constraints and opportunities at each site have been assessed for two electricity grid CO_2 emissions factors. The results show that CO_2 savings achieved are dependent not only on the technologies adopted at the energy centres which supply the heat networks but also on the carbon intensity of electricity available from the national grid. As more renewable electricity is fed into the grid its CO_2 content falls. When this happens the CO_2 benefit of producing electricity from CHP falls correspondingly. Because CO_2 savings are allocated to co-produced heat this results in the CO_2 content of heat rising.

Using a constant electricity emission factor gas CHP (only) provides a 33% CO_2 savings on heat at Skypark/Cranbrook and a 30% saving on heat at Monkerton. When compared with total base case emissions (heat and electricity) the savings are more modest (11% and 12% respectively). However, when DECC's declining grid emissions intensity factors are used little or no reduction is achieved. This highlights the need for heat networks to plan strategies for further decarbonisation beyond gas CHP. Fortunately both the Skypark and Monkerton Energy Centres have existing carbon reduction strategies and the potential for further measures.

Grid constrains in the South West have essentially halted the deployment of new decentralised electricity generation schemes in the region until 2020. The use of private wire connection to local electricity loads has the potential to bring forward the commissioning of gas CHP at both energy centres. However, the emission reductions achieved are relatively small with the benefit being more marked at Skypark than at Monkerton (total savings of 5,200 tCO_2 versus 1,718 tCO_2at a constant grid emission factor).

The impact of the s106 commitment to employ 2MWe wood based biomass CHP at the Skypark Energy Centre is significant. Long term reductions compared to the gas CHP only case are 6,000tCO_2/y in the constant emissions factor case and 5,200tCO_2/y using the DECC time series. Total emission reductions compared to the Base Case are 10,700 tCO_2/y (a 75% reduction on the heat Base Case and 25% of total Base Case) and 5,345/year (38% of heat Base Case and 17% of total Base Case) respectively. The relatively small impact of biomass CHP on overall emissions at the Skypark Energy Centre highlights that the 2MWe capacity was sized to achieve true zero carbon in the first 2,900 homes and not the non-domestic buildings or the subsequent phases of housing at Cranbrook which are now being planned.

Use of recovered heat from FABlink increases the decarbonisation of heat at Cranbrook from between 75% and 82% under the constant grid emission factor. The increase is more marked under the time series emissions factors where emissions savings rise from 38% to 76%. Given the assumptions about the need for gas boiler peaking and back-up these percentages are as close as it is practical to get to heat decarbonisation. However, the reduction on total emissions are much lower; 28% and 35%.

At Monkerton, the addition of a 0.5MWth biomass boiler to gas CHP and the consequent 0.2MWe reduction in gas CHP capacity enables a 14% and 3% reduction on total CO_2 emissions over the Base Case using the constant and time series gird emissions factors respectively. Limiting gas CHP to 0.5 MWe and using recovered heat from the Met Office supercomputer form 2020 increases these percentages to 18% and 21%. As at Cranbrook, the impact of using recovered heat improves under the times series emissions factors.

These reductions demonstrate the ability of heat networks to collect heat from a variety of technologies and illustrates the potential for the migration from fossil fuel gas fired CHP towards renewable and waste heat resource. The FABlink and Met Office examples show practical cases of how using heat pumps to exploit waste heat can not only reduce CO_2 emissions also provide key linkages between future heat and electricity network infrastructure allowing the virtual storage of electricity in heat networks. However, there is also a need for overarching strategic planning of adjoining heat networks to make provision for interconnection to enable the scaling up of renewable energy technologies to deliver increased CO_2 emissions reduction. This is illustrated in the West End because, while the combined total emission reduction from the heat opportunities achieves 25% / 31%, this reduction falls well short of the 2010 zero carbon commitment at Cranbrook. Further emissions reduction at both developments requires the generation of more renewable electricity on site. Such a reduction could be achieved using a larger biomass CHP installation. An alternative single solution case could involve 20MWe biomass CHP installed in 5MWe stages which served both Cranbrook and Monkerton. This scheme would generate additional heat which would be available from 2025 for further new development in the vicinity and/or for an expanded Exeter city network.

As the West End is planned it is important that these potential carbon and energy solutions are developed alongside the growth in the area. In particular it is critical that land is reserved for a variety of possible eventualities including:

- large scale biomass CHP at a site able to serve Cranbrook and Monkerton
- heat network interconnection between Cranbrook, Monkerton and Exeter city networks
- private wire electricity routes to Lidl and the Met Office supercomputer sites
- heat network routes from/to the FABlink interconnector site and provision for heat recovery and heat pump equipment at the FEBlink site
- heat network routes to the Met Office supercomputer site and provision for heat recovery and heat pump equipment at the Met Office site
- solar thermal ground arrays sites adjacent to energy centres

Contents

1. Introduction and Background

In 2014 the Intergovernmental Panel on Climate Change (IPCC) stated[1] that warming of the climate system is unequivocal and that since the 1950s, many of the observed changes are unprecedented over decades to millennia and that the anthropogenic emissions are extremely likely to have been the dominant cause of the observed warming since the mid-20th century. Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change requires substantial and sustained reductions in greenhouse gas emissions and this, together with adaptation, will reduce climate change risks. Substantial emissions reductions over the next few decades not only reduces climate risks in the 21st century and beyond but increases the prospects for effective adaptation and reduces the costs and challenges of mitigation in the longer term thereby contributing to climate-resilient pathways for sustainable development.

The Climate Change Act[2] commits the UK to reducing emissions by at least 80% in 2050 from 1990 levels, including making progress through legally binding 5-year carbon budgets. Buildings are responsible for over half of all carbon emissions in the UK[3] and limiting emissions from new buildings is one part of the government's carbon reduction policies; DECC has estimated[4] that together, Part L 2002 and 2006 had saved 8.3 TWh and 1.9 $MtCO_2$ by 2010 which represented nearly a quarter of the total savings from all energy efficiency improvement programmes and policies in the private and public sectors. In addition it is projected[5] that 10 to 38 TWh of low carbon heat will be delivered through local heat networks by 2030.

The importance of providing a true low carbon pathway for the UK housing stock is underlined by Professor Brenda Boardman's observation that "the present levels of demolition" "imply a stock lifetime of 1,300 years"[6]. Each new build house connected to the gas network represents a long term source of carbon emissions and an opportunity for emissions reduction foregone.

In November 2007 the Exeter and East Devon Projects Team commissioned Element Energy to undertake a strategic analysis of energy and carbon dioxide (CO_2) emissions from the new developments in Exeter and East Devon Growth Point over the period to 2020[7]. That report made the economic case for a district energy solution for the emerging Cranbrook new community in East Devon's West End. It was found that in larger scale development, adopting a site-wide solution would be significantly cheaper than abating carbon at a household level when targeting levels 5 and 6 of the Code for Sustainable Homes. Whilst a district heating system was not planned for the first phase of development at Cranbrook, it was argued that early investment in a district heating network would benefit the economics of future phases.

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[1] IPPC Climate Change 2014 Synthesis Report, Summary for Policymakers

[2] Climate Change Act 2008

[3] DECC 2014 2013 UK Greenhouse Gas Emissions, Provisional Figures and 2012 UK Greenhouse Gas Emissions, Final Figures by Fuel Type and End-User. From table 5 Business emissions are 178.3 $MtCO_{2e}$, Residential emission are 145.3 $MtCO_{2e}$, total emissions are 575.4 $MtCO_{2e}$; therefore buildings account for 56% of end-use emissions.

[4] DECC, July 2011, UK Report on Articles 4 and 14 of the EU End-use Efficiency and Energy Services Directive (ESD)

[5] HM Government 2011, The Carbon Plan: Delivering our low carbon future

[6] Boardman et al, 2005, 40% House

[7] Element Energy 2008, East of Exeter Growth Point: Energy Strategy

Since the study considerable progress has been made delivering schemes in the Exeter area:

- The study formed the basis of a successful application for £4.1m of grant funding for the Cranbrook biomass CHP scheme; one of the few zero carbon on-site developments in the country. E.ON, the scheme operator, has currently connected 1,200 homes and the first commercial buildings on the neighbouring Skypark.
- The scale of development in the West End of East Devon has grown. Element Energy considered 3,500 homes at Cranbrook whereas a swath of up to 12,000 homes and business premises are now being planned from Monkerton (in Exeter just west of the M5) out to eastern extension of Cranbrook.
- A second E.ON district heating and CHP scheme is now underway at Monkerton. Importantly this scheme is going ahead without grant funding.
- Other DH schemes are planned elsewhere in Exeter area including a retrofit scheme connecting the major public sector heat loads in the city and a separate heat network which will use steam from the Marsh Barton energy from waste plant to supply heat to some 2,500 new homes planned in the south west of the city and across the boundary in Teignbridge.

However, the intervening period to 2015 planning aspirations for zero carbon homes onsite envisaged in "Building a Greener Future"[8] in 2007 were watered down by as much as 80% (from 100% of all emissions to as low as 44% of regulated emissions) as it was recognised that it would not be possible for all homes, for example a single city infill, to feasibly reach a true zero carbon standard. Then, in July 2015 the Government announced that it would not implement zero carbon and that no further tightening of Part L of building regulation would take place beyond the 29% reduction on 2006 Part L set out in Part L 2014.

However, it is important to recognise that because building regulations apply to all new homes they represent the lowest common denominator. As the Element Energy study showed, development at scale has the potential to achieve greater CO_2 emissions reduction at the same cost. This has been recognised by the numerous district heating schemes which are coming forward in the greater Exeter area.

The development of heat networks is supported by DECC's 2013 UK heat strategy[9,10]. Heat represents 44% of UK energy use and of this 51% is used in homes. The UK lags the rest of Europe in the use of renewable heat (Figure 1). DECC's work shows that while heat networks currently serve some 2% of heat demand, this could rise to up to 20% of UK domestic heat demand by 2030.

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8 CLG 2007, Building a Greener Future

9 DECC, 2012, The Future of Heating: A strategic framework for low carbon heat in the UK

10 DECC, 2013, The Future of Heating: Meeting the challenge

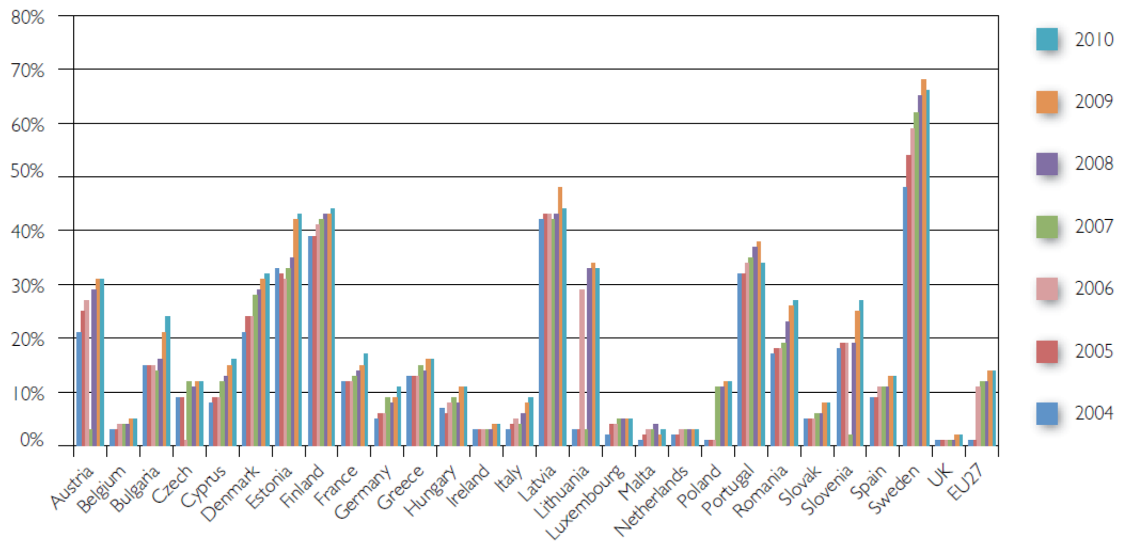

Figure 1: Percentage of heating and cooling from renewables across the EU (DECC)

The Centre for Energy and the Environment (CEE) has been commissioned by East Devon District Council to examine strategies for the heat networks for the West End of East Devon, accounting for the increase in scale of the developments, changes to national and local energy and planning policy/legislation and the current stage of heat network development.

The study's aims are to:

- Estimate the build trajectory for the area;
- Estimate building energy use and carbon dioxide emissions;
- Analyse heat network strategies for new development to further reduce CO_2 emissions;
- Understand the potential for innovative energy solutions such as heat recovery from the Met Office supercomputer;
- Recommend a strategy for the heat networks and estimate potential carbon savings which such a strategy could deliver.

The developments considered will include Cranbrook and its planned extensions, housing to the North/East of Pinhoe (i.e. at Pinn Court Farm and Old Court Farm), Tithebarn Green/Mosshayne, Skypark, Science Park, the Intermodal Freight Terminal (IMFT) and Monkerton (which lies in Exeter rather than East Devon, but may contribute to potential site-wide solutions spanning both districts).

A map of the development within the scope of this study is shown in Figure 2.

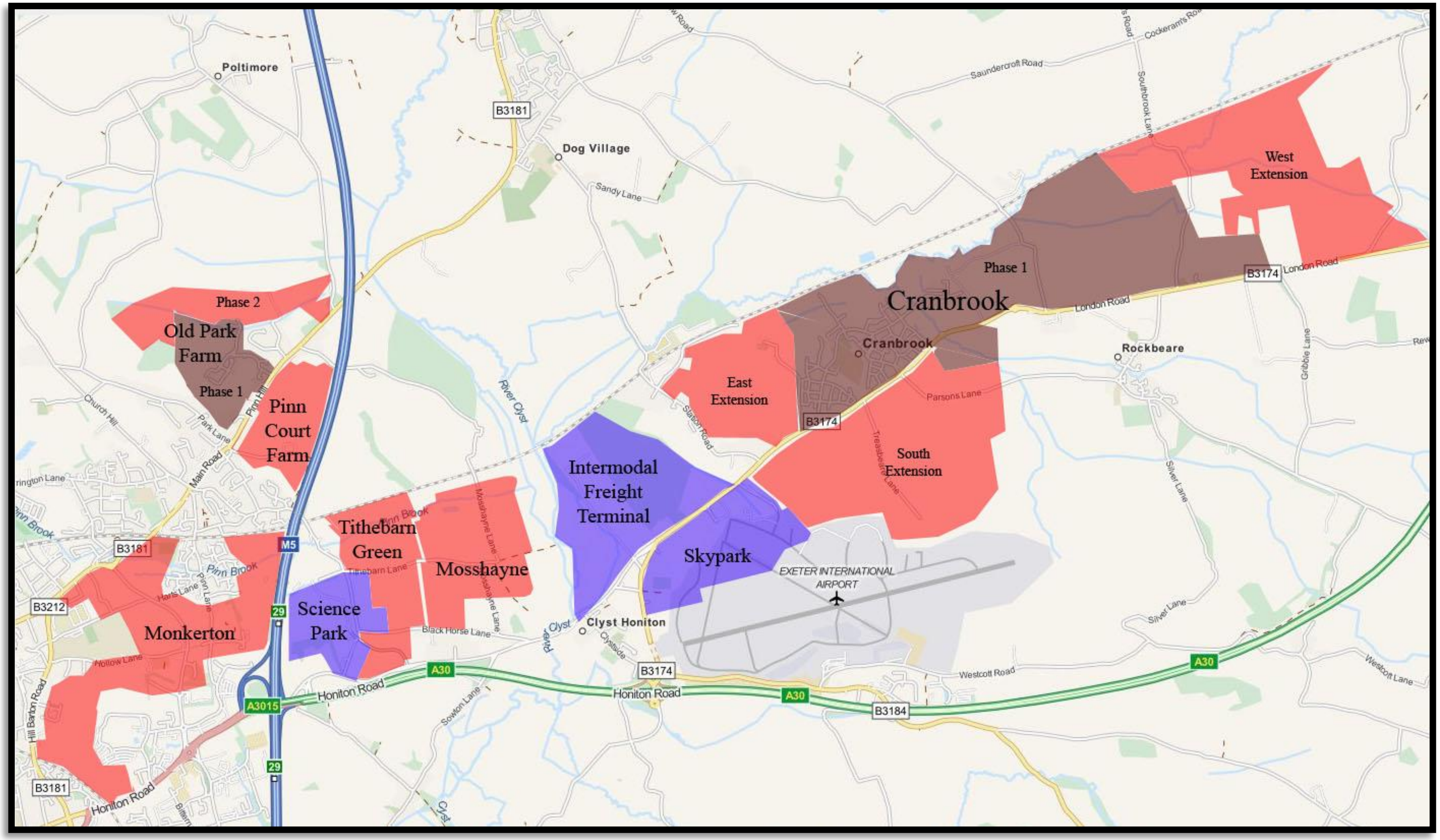

Figure 2: Map showing location of new development to the East of Exeter

2. Description of Developments at the West End of East Devon

2.1 Description of Sites

2.1.1 Cranbrook

Initial planning permission at Cranbrook was granted for 2,900 homes. This was subsequently extended by a further 587 dwellings taking the total to 3,487[11]. Approximately 1,200 homes have already been constructed, together with a primary school, secondary school, shops and community facilities. These and those buildings yet to be built will all connect to the district heating scheme powered by gas fired CHP and gas boilers located at the E.ON Energy Centre at the northern corner of the nearby Skypark. Biomass CHP is due to be commissioned once Cranbrook reaches 2000 homes. Applications have been received for future expansion of Cranbrook to the east, west and south (the Northern edge of Cranbrook is bound by the railway). The eastern expansion is due to contain 1,750 homes, 1,250 m^2 of B1/B2[12] space, a primary school, 1,000 m^2 shop and a restaurant and community centre (unspecified floor areas). The western expansion is due to contain 820 homes, a primary school and a community centre (unspecified floor areas). The southern expansion is due to contain 1,550 homes, 40,000 m^2 of B1/B2 space, a primary school and a local centre (unspecified floor areas). If these applications proceed there will be a total of some 7,600 homes at Cranbrook.

2.1.2 Skypark

Skypark sits immediately to the north of the airport, and will contain approximately 140,000 m^2 of a mix of office space and light/general industrial space. In addition, permission has been approved for 5,633 m^2 of B8[13] use and there is provision for a 150 bed hotel and a pub. All buildings on Skypark are committed to connect to E.ON's district heating network.

2.1.3 Intermodal Freight Terminal

The IMFT was planned to provide a rail road interchange for bulk transport of containers. Sainsbury's Supermarkets Ltd. had planned to build a 49,000 m^2 warehouse, but subsequently announced that the site was surplus to requirements. The site has now been acquired by Lidl and it is assumed for the purposes of this study that it will comprise 65,000 m^2 of B8 (distribution/warehouse) building.

2.1.4 Science Park

The Exeter Science Park sits at the Junction 29 of the M5 and will contain predominantly R&D office accommodation across five clusters of building. An office building and Phase 1 of the Science Park building have already been constructed, and both are "district heating ready". The site also hosts the Met Office supercomputer hall and Collaboration Building which are both currently under construction. Appendix A contains further details of the potential connection of the Met Office facilities to district energy systems in the vicinity. In total, the floor area at Science Park will be in the region of 76,000 m^2, which will also include a hotel, a shop, a restaurant, conference facilities and a crèche (in addition to the R&D space).

[11] This has been referred to as "Cranbrook 3,487" within this report
[12] Taken in this report to mean light industrial units
[13] B8 is the planning use category for storage or distribution centres

2.1.5 Tithebarn Green & Mosshayne

To the east, immediately adjacent to the Science Park site are the Tithebarn Green and Mosshayne developments. Tithebarn Green will comprise 580 homes together with almost 9,000 m^2 of office space, a shop, restaurant, pub, restaurant and healthcare facility. Mosshayne will contain 900 homes and a 420 place primary school.

2.1.6 North of Pinhoe

There are two housing developments at the northern edge of Pinhoe. The first of these is Pinn Court Farm which is bound by the M5 and Pinn Lane. It will comprise 430 homes, two 60 bed-space nursing homes and a community building. The Old Park Farm site sits on the opposite side of Pinn Lane. The first phase of the development has already been approved and the scheme has been delivered without district heating. Phase 2 sits to the rear (north) of phase 1 and will contain a further 350 homes.

2.1.7 Monkerton and Hill Barton

Monkerton and Hill Barton are situated in Exeter in predominantly greenfield land bound by the main rail line to London Waterloo to the north, the M5 to the east, the A3015/Honiton Road and Exeter to Exmouth rail line to the south and the City's outer bypass (the B3181) to the west. There are around 1,800 homes in the planning pipeline that will be connected to a district heating scheme which is being delivery by E.ON. There is a planned employment site at Honiton Road though the existing outline consent means that it has not been considered to be connected to the network, though a proposed new primary school has been included. 50 completed dwellings at Hill Barton are connected to the gas network. The Monkerton Energy Centre will be located on land owned by Devon County Council immediately to the north west of the Tithebarn Lane Bridge. It is anticipated that this energy centre will also serve Science Park, Tithebarn Green and Mosshayne a total of some 4,260 homes.

2.2 Phasing and Build Out Rates

There are no formal projections for development at each site. Estimated build-out rates for each of the various sites were established based on total allocated numbers, and informal discussions with East Devon District Council and Exeter City Council. Whilst care was taken to ensure that the construction programmes represented our best estimates, given the nature of property development the actual programme will differ. Summary graphs showing cumulative number of dwellings and non-domestic floor area to 2031 are shown Figure 3 and Figure 4.

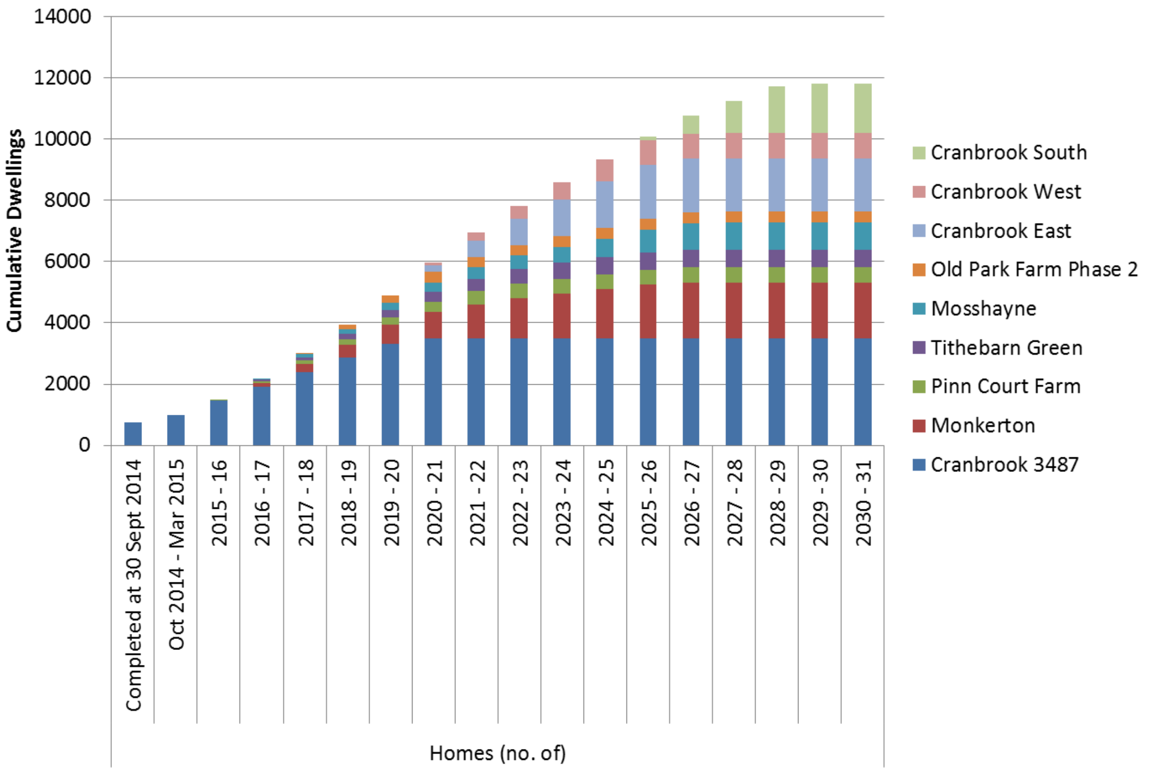

Figure 3: Cumulative number of dwellings across all sites considered within the study to 2031

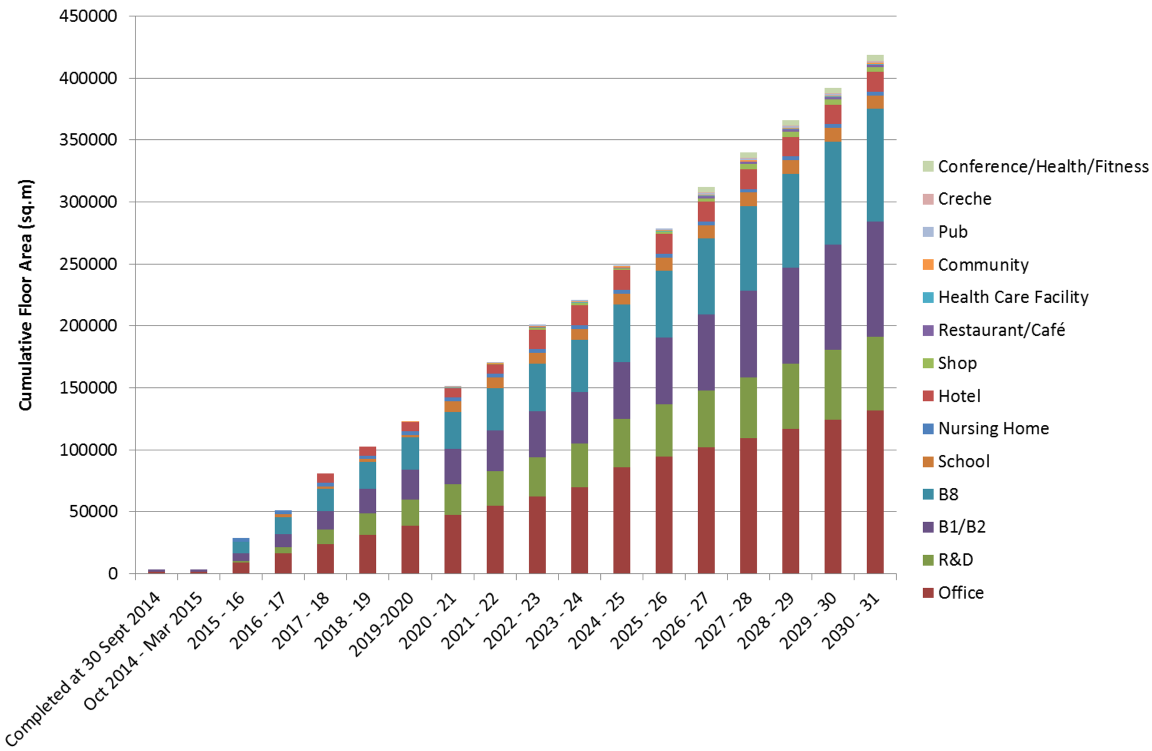

Figure 4: Cumulative non-domestic development across all sites considered within the study to 2031

2.3 Housing Mix

Detailed planning applications were not available for the sites under consideration, and therefore the mix of house types was not known. Layouts from sections of Cranbrook were provided by the council and these were analysed to establish the number and size of each proposed house type. An example layout is shown in Figure 5. The layouts captured 354 dwellings in total which were allocated to broad house category type as identified by the Zero Carbon Hub in their analysis of the zero carbon homes policy i.e. detached, semi-detached, mid-terrace or apartment. This was then used to establish an area weighted "average" house for the development. This resulted in a dwelling with a gross internal area of 88.2 m^2 and a hypothetical composition of 40% detached, 40% semi-detached, 13% terraced and 7% apartment (by area[14]). It was assumed that this "average" house was applicable to each housing development considered within this analysis.

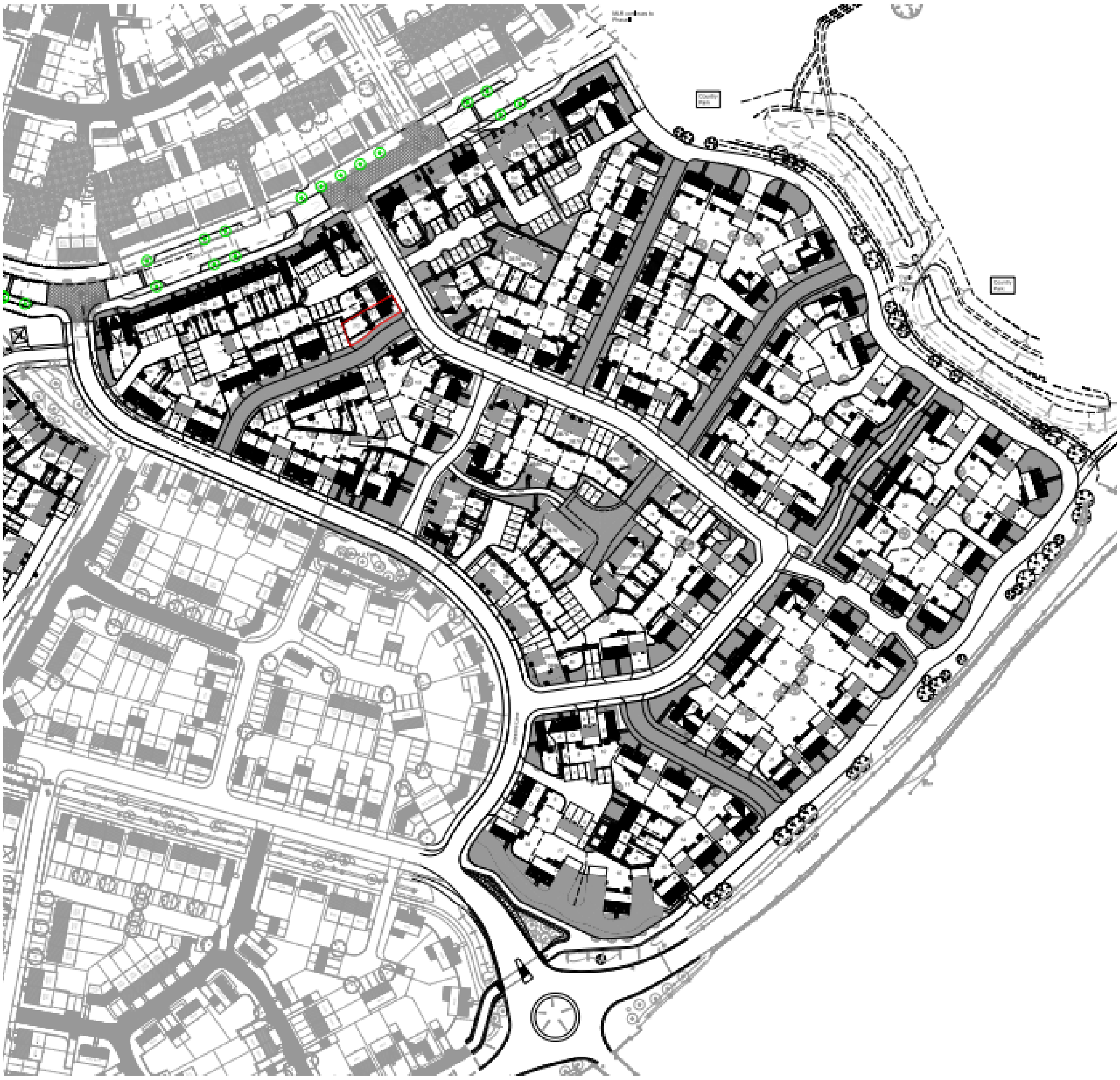

Figure 5: Part of the layout at Cranbrook used to determine the "typical" housing mix for development across the study area

[14] By number of dwellings, the ratios were 28% detached, 45% semi-detached, 16% terrace and 10% apartment.

3. National and Local Policy Framework

The energy performance of new development is covered by both local planning policy and the building regulations .

Exeter's 2010 Core Strategy requires new homes build from 2013 onwards to achieve a 44% CO_2 reduction on 2006 Part L. This and a policy which requires connection to heat networks has supported the provision of district heating at Monkerton which is likely to extend to the surrounding developments in the adjacent parts of East Devon.

The adopted East Devon Local Plan 2013 - 2031[15] contains policies (Strategies 38 to 40) that require that developments:

- of more than 10 dwellings or 1,000m^2 of commercial space meet at least CSH 4 and BREEAM "Very Good" (Strategy 38) and where viable connect to any existing or proposed Decentralised Energy Network (Strategy 40)
- in the West End and those over 4ha ore 200 dwellings elsewhere in East Devon achieve levels of sustainability in advance of those set out nationally (Strategy 38)
- over 4 ha or 200 homes where there is no existing Decentralised Energy Network should evaluate the potential for such systems and implement them where they are viable over the life of the developments in the locality

However, changes to national policy (i.e. following the Housing Standards Review [HSR] held over the summer of 2013) mean that the authority will not be able to set energy performance standards in advance of the national timetable, though the HSR covered only housing and these restrictions do not apply to non-domestic development.

Section 7 of the Local Plan addresses development in the West End. Strategy 11 requires the co-ordinated provision of low carbon heat and power supply and Strategy 12, which covers Cranbrook, states that the existing district heating system will provide for the combined heat and power needs of the town as it expands to 6,300 homes. Strategy 13, Development North of Blackhorse/Redhayes states that the scheme will comprise energy infrastructure, including a heat and energy network to achieve low and zero carbon development. Development of an urban extension at Pinhoe in Strategy 14 states that it will incorporate the reduction of carbon emissions through measures including micro generation and decentralised energy.

As part of commitments already in place under existing planning permissions, the first 2,900 dwellings at Cranbrook will connect to the district heating scheme. In addition the Skypark energy centre is required to provide a zero carbon biomass source which will provide 2MWe of electrical capacity and 2.4MWth of heat capacity.

The Monkerton development will meet the 44% CO_2 reduction required under Exeter City Council's local planning policy through gas fuelled combined heat and power and district heating.

The existing heat networks at Cranbrook and Monkerton combined with the local plan policies above highlight that the existing district heating network infrastructure are an opportunity for other development coming forward in the locality to both meet and exceed energy or carbon performance requirements.

[15] http://eastdevon.gov.uk/planning/planning-policy/emerging-plans-and-policies/the-new-local-plan/local-plan-adoption/

Nationally, the energy and carbon performance of new development is governed by Part L of the building regulations – the Conservation of Fuel and Power – with Part L1A covering new dwellings and Part L2A covering new non-domestic buildings. Part L is the main instrument used to improve energy performance and reduce carbon dioxide emissions from new development in order to meet national policy objectives. In "Building a Greener Future"[8] in 2007 the then Government stated that new dwellings would be "zero carbon" from 2016. Since then, Part L has been updated in 2010 and again in April 2014 (a delay of one year from the original timetabled update in 2013). The 2010 change resulted in a 25% reduction in carbon emissions from new dwellings and non-domestic buildings[16] and the 2013 resulted in a further 6% reduction for homes (to 29% on 2006 Part L) and 9% reduction for non-domestic buildings. Further revisions to Part L were planned for 2016 and 2019. However in July 2015 the Government announced that it did "not intend to proceed with the zero carbon Allowable Solutions carbon offsetting scheme, or the proposed 2016 increase in onsite energy efficiency standards"[17].

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[16] For non-domestic buildings the overall carbon reduction is an aggregate reduction for all non-domestic buildings based on an assumed build mix i.e. greater carbon reduction within some building use types have been used to offset lower reduction in other building types, in order to most cost-effectively achieve the overall reduction target at a national level.

[17] HM Treasury, *Fixing the foundations: Creating a more prosperous nation*, July 2015

4. Local Energy Opportunities and Constraints

4.1 Current Heat Networks

Heat networks are established at Cranbrook and Monkerton with long concessions (ca. 80 years) and agreement from the developers that there should be no natural gas on these sites. Extension of these networks to subsequent phases of Cranbrook and from Monkerton east to the Science Park, Tithebarn Green and Mosshayne developments and north to Pinn Court Farm and Old Park Farm Phase 2 is anticipated.

4.2 Commitment to Biomass CHP at the Skypark Energy Centre

The Skypark energy centre s106 requires that at 2,000 homes there should be a wood based biomass CHP plant generating 2MWe and 2.4MWth. These capacities were calculated to deliver true zero carbon for the first 2,900 homes at Cranbrook. The timing of the delivery of biomass CHP at Cranbrook is influenced by the development of the heat load (particularly at Skypark where build out is behind that initially planned) and regional electricity grid constraints (see below) and installation before 2020 therefore seems unlikely.

4.3 Grid Generation Constraints

In March 2015 Wester Power Distribution (WPD) announced a network capacity restriction as a result of capacity shortage in its 132kV “F Route” between Bridgewater and Seabank in Bristol which effects all new connection in Devon[18]. The restriction applies to all generator connections requiring works at HV (i.e. 6.6kV or 11kV or above) and takes the form of a delay of 3 to 6 years, subject to planning approval and the completion of National Grid’s 400kV works for a double-circuit route between Hinkly Point and Seabank. As CHP engines likely to be installed in the West End of East Devon would, if connected to the grid, require works at HV this restriction has immediate effect.

4.4 Private Wire Electricity Connections

Large electricity loads adjacent to CPH facilities give the potential for direct electrical connection from the CHP to the electricity user by a “private wire”. While there is an additional up-front capital cost of laying the private wire, not using the grid avoids use of system transmission charges for the power purchaser which, if shared with the supplier, can make the arrangement financially beneficial to both. Importantly private wire connection enables the deployment of CHP capacity despite the presence of gird constraints in the area. This said, it should be noted that while the early addition of CHP capacity will reduce CO_2 emissions earlier than would otherwise have been the case, private wire supply in itself does not materially reduce CO_2 emissions.

4.4.1 Lidl Distribution Centre

In January 2016 the site on the Intermodal Freight Terminal allocation prepared for a distribution warehouse by Sainsbury’s was acquired by Lidl. The site is some 600m from the Skypark energy centre (see Figure 6 below). The Lidl building is anticipated to be some 65,000m^2. Comparison with a similar distribution warehouse[19] suggests that the building will require some ca. 1MWe (assumed constant base load).

[18] See https://www.westernpower.co.uk/docs/connections/Generation/Generation-capacity-map/Distributed-Generation-EHV-Constraint-Maps/WPD-South-West-network-capacity-restriction.aspx

[19] 17% of the electricity needed by Morrisons 75,000m^2 Bridgwater distribution centre in the summer months is provided by a 970kWp PV array. However the system is over performing prediction by 13.5%. PV tool

Figure 6: Map showing the proximity of the Skypark energy centre and the distribution site acquire by Lidl (image courtesy of Google)

A private wire supplying this electrical demand gives scope for the Skypark energy centre to increase its CHP capacity from the 0.5 MWe currently installed to 1.5MWe without the need for further grid capacity. This mitigates some of the WPD grid capacity constraints although the requirement of the Lidl warehouse does not enable the 2.0MWe capacity required by the Skypark s106 to be installed before the grid constraint is likely to be lifted in 2020.

4.4.2 Met Office Supercomputer

The new Met Office supercomputer currently under construction at the north eastern end of the Redhayes pedestrian /cycle bridge will need up 3.6 to 4MWe capacity (assumed constant base load). The Monkerton energy centre site is 800m to the north across the Tithebarne road bridge. The capacity requirement of the supercomputer is greater than the likely installed CHP capacity at the Monkerton energy centre. This situation implies that WPD grid constraints are unlikely to affect the Monkerton energy centre (see Appendix 1 for further details).

4.5 Local heat Sources

4.5.1 Project Sunshine

Some European countries, notably Denmark and Germany, use large scale solar thermal arrays to generate heat for district heating networks. In the UK DECC is funding Project Sunshine, a £1.2m heat network demonstration project at Cranbrook which will use a combination of 2,000m^2 solar thermal array, a 750kWth heat pump and thermal storage which will demonstrate how such a semi-commercial scale combined system will perform in the UK. Construction of the project was completed in the spring of 2016 and the operational demonstration phase is expected to continue until at least March 2017. The performance of the heat pump in upgrading lower temperature heat to the 80-90°C needed to input heat into the heat network is potentially important for other local heat supply projects (see below).

PVGIS suggests monthly summer electricity consumption for array of 113MWh which if exceed by 13.5% gives 128kWh or site consumption of 750MWh giving annul production of 9,000MWh or average capacity of 1MWe. This capacity estimate is supported by enquires to Lidl made by EON.

4.5.2 Met Office Supercomputer

Much of the 3.6 to 4MWe energy used by the Met Office supercomputer is emitted as heat. The Cray computer being installed in the first phase of the Science Park building will be traditionally cooled. However, the next supercomputer, which it is anticipated will be installed in 2020, will consider the potential for using this waste heat in combination with a heat pump to upgrade the heat to the 85°C needed to contribute heat into the Monkerton heat network.

4.5.3 FABlink

The France-Alderney-Britain (FAB) electrical interconnector project is to build an underwater electrical interconnector. The project will consist of two pairs of electrical cables, a converter station at each end, and connections into the high voltage grids at each end. It will travel nearly 220 km between the electrical substations in Menuel, on the Cotentin peninsula in France, and Exeter. The interconnector capacity is 1400MW. As well as enabling greater interconnection between France and the UK the project is also designed to provide a route to market for marine renewable energy planned to be constructed in the seas around Alderney. Construction of the interconnector is scheduled to commence in 2018 and it is expected to become operational in 2020.

FABlink has identified a site near Exeter airport for its UK converter station. The converter station changes the direct current (DC) used in the link cable to the alternating current (AC) required to put the power onto the national grid. The DC-AC conversion process generates heat. Typically air cooling is used to cool heated water from the converters (at 40-50°C) to a lower return temperature (typically 25-30°C). The energy extracted from this water is 5-7MWth for 90% of the year.

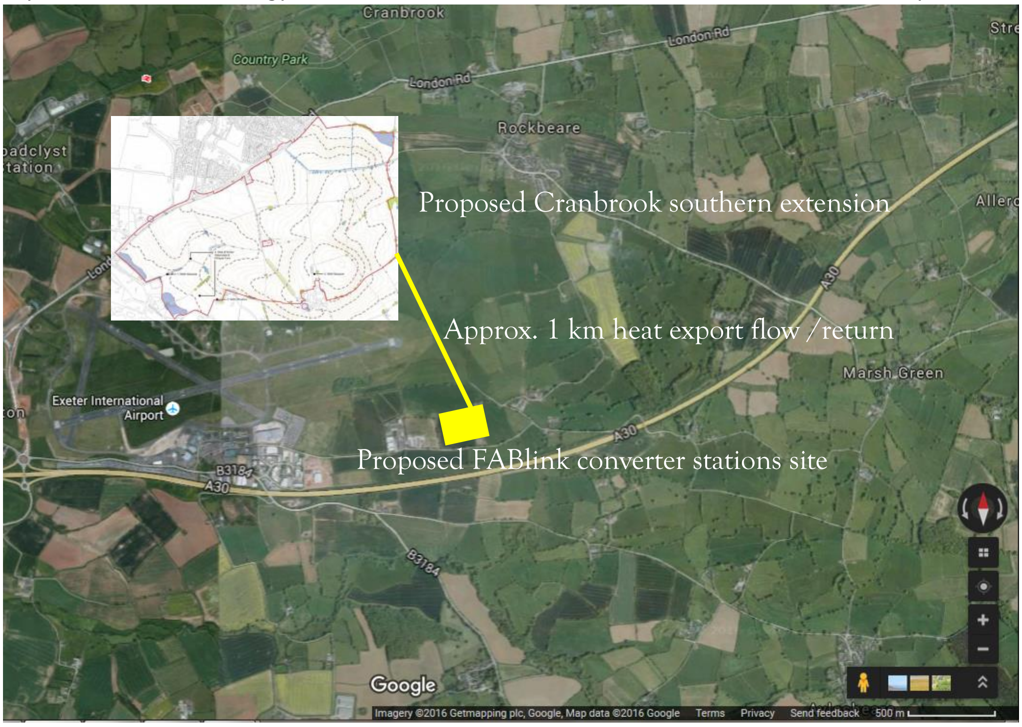

Figure 7: Map showing the proximity of the FABlink converter site to Cranbrook South Extension (image courtesy of Google)

Figure 7 shows the proposed FABlink converter station site and its proximity to the southern extension of Cranbrook. There is potential to use a heat pump to upgrade the cooling water flow temperature to 85°C and install 1km of heat pipes to supply this heat to the Cranbrook district heating scheme.

5. Modelling of Scenarios for the Study Area

5.1 Assessing Heat Demand

In order to establish energy demand from new development in the study area, calculations were undertaken for a "typical" sized dwelling (i.e. the area weighted average dwelling within the study area) and for the full range of non-residential development. These calculations were undertaken following the principles of Part L of the Building Regulations (i.e. SAP and SBEM) together with known carbon compliance targets for both dwellings and non-residential buildings. These calculations resulted in the energy demand for each building type broken down by end uses which were applied to the previously established development projections. Each development was applied to one of the two energy centres as follows:

- Skypark Energy Centre: Cranbrook (all phases), Skypark, Science Park totalling 7,600 homes at full build out.
- Monkerton Energy Centre: Tithebarn Green, Mosshayne, Pinn Court Farm, Old Park Farm Phase 2, Monkerton totalling some 4,260 homes at full build out.
- The Intermodal Freight Terminal was assumed to have only a very limited demand for heat (for office space within the building) and so was not assumed to connect to either of the energy centres.

It is important to note that process loads in non-residential building are not included. Examples of process loads include electrical load for cooling at the Intermodal Freight Terminal and the Met Office supercomputer on Science Park.

The resultant projections for cumulative annual heat demand for each energy centre are shown in Figure 8. These were taken forward in the next section to analyse the impact of various energy supply strategies, including utilising specific local opportunities.

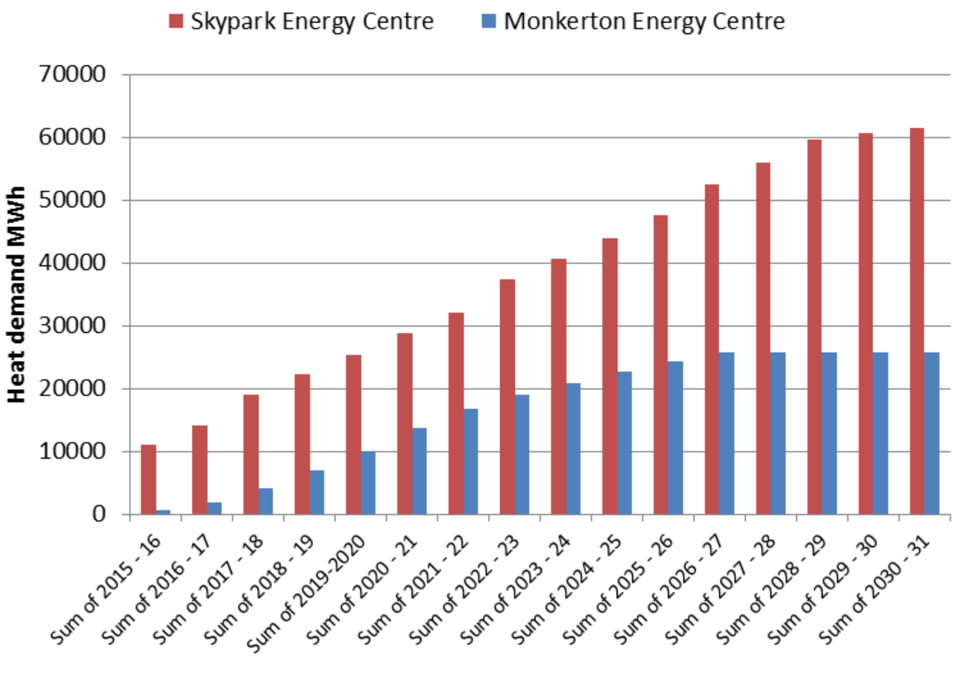

Figure 8: Cumulative heat demand across both energy centres up to 2031

5.2 Developing Heat Supply Scenarios

A set of energy supply scenarios which incrementally reduce CO_2 emissions have been developed for the two heat networks with the aim of comparing each scenario to the base case of individual gas boilers in homes[20].

5.2.1 Skypark / Cranbrook Heat Network

To meet current heat demand the Skypark Energy Centre has a 0.5MWe gas CHP unit and back up and peaking gas boilers. Heat demand is rising and more CHP will be needed. However, this is constrained by electricity grid capacity. Skypark Scenario 1 assumes that all future CHP is gas fired and that additional gas CHP cannot be installed until 2020/21. Back up and peaking gas boilers remain in place. The final installed gas CHP capacity assumed is 4MWe.

Private wire to the Lidl distribution centre would enable an additional 1MWe of CHP capacity to be installed. Like Skypark Scenario 1, Scenario 2 assumes that only gas CHP is installed but that private wire enables 1MWe of capacity to be brought forward to 2017/18. Back up and peaking gas boilers remain in place and, as with Scenario 1, the final installed gas CHP capacity assumed is 4MWe.

Skypark Scenario 3 takes Scenario 2 and overlays the delivery of Zero Carbon for the first 2,900 homes at Cranbrook. This is achieved by the requirement in the Skypark Energy Centre s106 for wood fuel biomass CHP to be installed with a capacity of 2.0MWe and 2.4MWth. This is assumed to occur in one year when grid capacity becomes available in 2020/21 and coincides with the build-up of sufficient heat demand to justify this step up in capacity. Back up and peaking gas boilers remain in place and final installed gas CHP capacity is 3MWe.

Although currently uncertain, additional heat from the FABlink project has been modelled as Skypark Scenario 4. FABlink is assumed to be completed in 2020/21 at which point gas CHP would be decommissions and the 2MWe biomass CHP and FABlink waste heat would provide the bulk of the network's heat supply. Back up and peaking gas boilers remain in place. FABlink supplies heat directly into the heat network from the FABlink site with initial heat capacity (including the contribution from the heat pump) of 1.2MWth and a final capacity of 4.7MWth. Large scale solar thermal would be a potential alternative to FABlink should Project Sunshine prove successful.

5.2.2 Monkerton Heat Network

Monkerton Scenario 1 assumes that the development is heated with natural gas boilers until grid constraints ease in 2020/21 when a 1.2MWe gas CHP is installed at the Energy Centre. Final installed gas CHP capacity is assumed to be 1.7MWe.

In Scenario 2 a private wire connection to the Met Office supercomputer site is assumed to provide sufficient demand to absorb the 0.5MWe gas CHP required to serve Monkerton's developing heat load in 2018/19 and 2019/20. In 2020/21 CHP capacity increases to 1.2MWe as per Monkerton Scenario 1 and develops the same final gas CHP capacity of 1.7MWe.

Monkerton Scenario 3 assumes that a 0.5MWth biomass boiler is installed at the Monkerton Energy Centre in 2017/18. Gas CHP installation is in 2018/19, as per Scenario 2, although heat available from the biomass boiler reduces the final CHP capacity from 1.7MWe to 1.5MWe.

[20] To meet building regulations a small amount of PV is also needs and is included in the calculation of the base case CO_2 emissions.

Waste heat from the next generation supercomputer is assumed to become available in 2020/21. Monkerton Scenario 4 assumes that this displaces all but 0.5MWe of gas CHP which is assumed to be installed in 2018/19 and remain in place until 2030/31. As with Scenario 3 the electricity produced by the CHP is assumed to be used to supply the Met Office (and the heat pump). The Met Office supplies heat directly into the heat network from the supercomputer site with initial heat capacity (including the contribution from the heat pump) of 0.9MWth and a final capacity of 1.6MWth. As at Skypark, large scale solar thermal would be a potential alternative should Project Sunshine prove successful.

5.3 Heat Supply Methodology

The heat delivered from each scenario is matched to the modelled heat demand connected to each energy centre. Heat produced from each energy centre in increased by the network losses. Losses are assumed to be high initially (30%), falling to 10% once the network is supplying more than ca. 20 GWhth.

The capacity for each technology in each scenario is developed assuming that ca.25% of heat will be supplied by ancillary peaking and back up gas boilers. However, while the final technology configurations achieve approximately this level, step increases in capacity mean that there are periods where more or less ancillary gas is used.

Heat and electricity generated by each technology is calculated using the assumptions set out in Table 1.

Technology	Assumptions
Gas boilers	
Efficiency	90%
Gas CHP	
Electrical efficiency	30.8%
Heat efficiency	47.5%
Electrical load factor	0.65
Heat load factor (incl. heat storage)	0.85
Biomass CHP	
Electrical efficiency	23%
Heat efficiency	28%
Electrical load factor	0.55
Heat load factor (incl. heat storage)	0.75
Biomass boiler	
Efficiency	85%
Waste heat recovery	
Heat pump COP	4

Table 1: Heat and electricity technology assumptions

CO_2 emissions are calculated using an emission factor[21] of 0.216 kg/kWh for gas, 0.031kg/kWh for biomass boiler heat and 0.069kg/kWh for heat from biomass CHP. Two alternative electricity emission factors are used; a constant factor of 0.519 kg/kWh and DECC's CHP displaced time series[22] shown in Table 2.

Year	Emissions factor kg/kWh
2015/16	0.331
2016/17	0.345
2017/18	0.349
2018/19	0.349
2019/20	0.349
2020/21	0.332
2021/22	0.329
2022/23	0.381
2023/24	0.319
2024/25	0.338
2025/26	0.326
2026/27	0.341
2027/28	0.341
2028/29	0.304
2029/30	0.318
2030/31	0.318

Table 2: DECC's CHP CO_2 displaced emission factor time series

Electricity generated by CHP technologies is assumed to have the electricity emissions factor. All CO_2 savings are allocated to associated heat.

[21] Emissions factors for gas, biomass and electricity are taken from SAP (ref Technical Papers Supporting SAP 2012, BRE, 2011) with the exception of the DECC CHP CO_2 displaced time series for electricity emissions

[22] DECC CHP CO_2 displaced time series (see https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/389070/LCP_Modelling.pdf)

6. Results and Scenario Comparison

6.1 Skypark/Cranbrook Heat

6.1.1 Heat Model Results

Table 3 summarises the heat model results for Skypark/Cranbrook using a constant electricity emission factor.

Scenario	Description	Total emissions 2016-31 tCO_2	Total savings 2016-31 tCO_2	Annual average savings 2016-31 tCO_2/y	Annual emissions beyond 2031 tCO2/y	Annual savings beyond 2031 tCO_2/y
Base	Individual gas boilers	140,675			14,225	
1	No more CHP until 2020/21	99,022	41,653	2,777	9,524	4,701
2	1 MWe to Lidl in 2017/18	93,868	46,807	3,120	9,524	4,701
3	1 MWe to Lidl in 2017/18 and biomass CHP 2020/21	25,946	114,728	7,649	3,505	10,719
4	1 MWe to Lidl in 2017/18, biomass CHP and FABlink waste heat / heat pump 2020/21	25,792	114,882	7,659	2,528	11,697

Table 3: Skypark / Cranbrook heat CO_2 emissions using a constant emissions factor of 0.519kg CO_2/kWh

The evolution of CO_2 emissions is shown Figure 9.

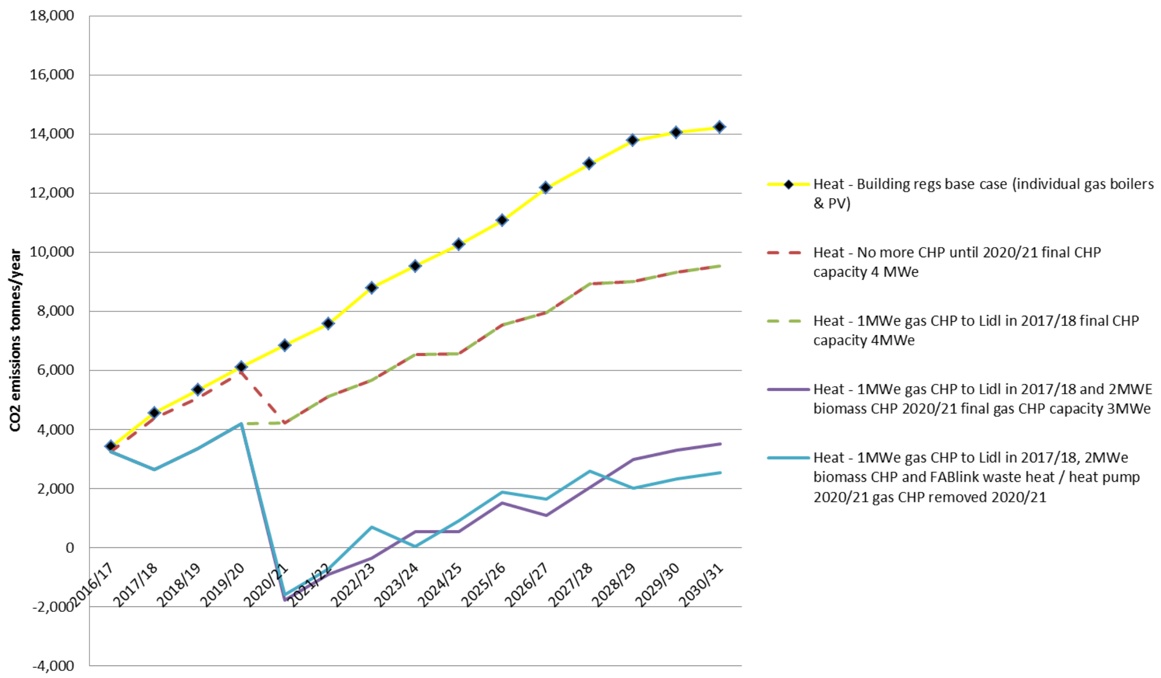

Figure 9: Cumulative annual heat CO_2 emissions from Skypark / Cranbrook using a constant emissions factor of 0.519kg CO_2/kWh

CO_2 emissions figures using DECC's time series for CO_2 displaced are shown in Table 4 and the evolution of CO_2 emissions are shown in Figure 10.

Scenario	Description	Total emissions 2016-31 tCO_2	Total savings 2016-31 tCO_2	Annual average savings 2016-31 tCO_2/y	Annual emissions beyond 2031 tCO2/y	Annual savings beyond 2031 tCO_2/y
Base	Individual gas boilers	140,675			14,225	
1	No more CHP until 2020/21	137,639	3,036	202	14,106	119
2	1 MWe to Lidl in 2017/18	135,385	5,290	353	14,106	119
3	1 MWe to Lidl in 2017/18 and biomass CHP 2020/21	76,614	64,061	4,271	8,880	5,345
4	1 MWe to Lidl in 2017/18, biomass CHP and FABlink waste heat / heat pump 2020/21	43,600	97,074	6,472	3,396	10,829

Table 4: Skypark / Cranbrook heat CO_2 emissions using DECC's CO_2 displaced emissions factors

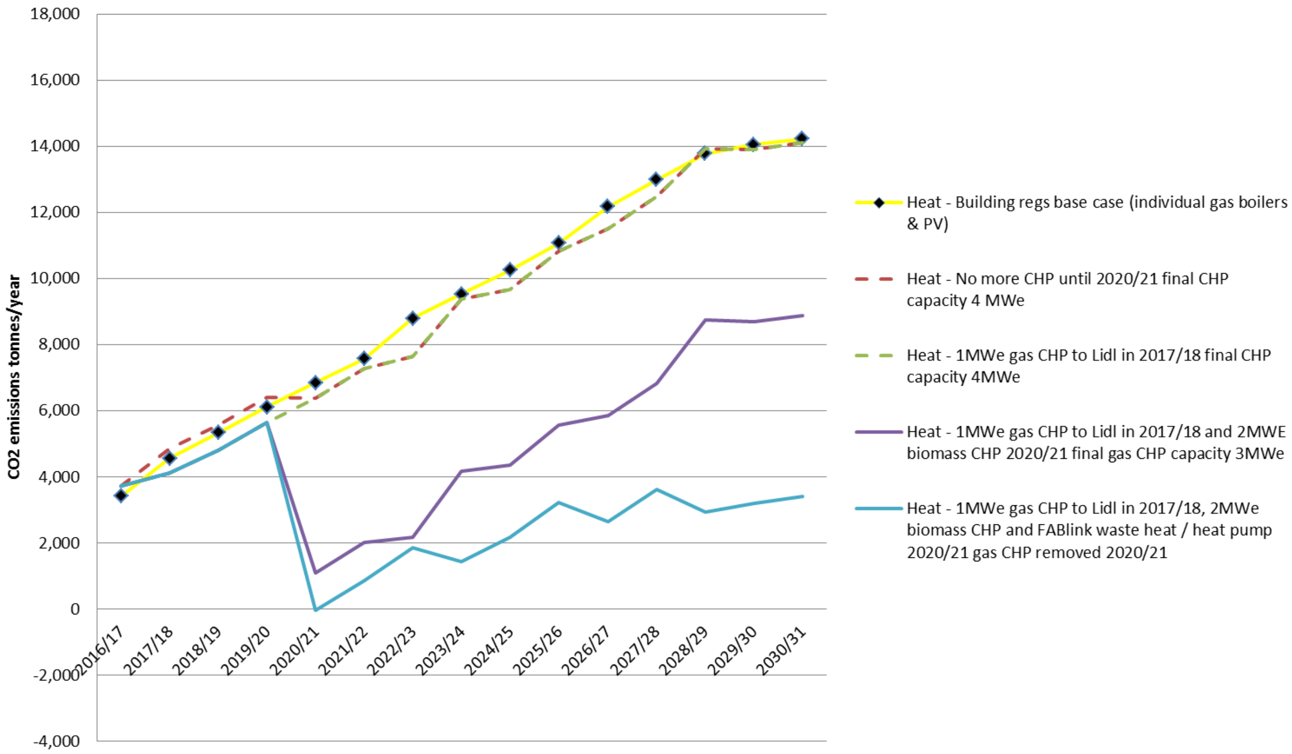

Figure 10: Cumulative annual heat CO_2 emissions from Skypark / Cranbrook using DECC's CO_2 displaced emissions factors

6.1.2 Heat Scenario Comparison

Under constant electricity emission factors each heat scenario achieves significant CO_2 savings over the period 2016 to 2030 ranging from 30% to 82%. Beyond 2030 ongoing savings from the base case (annual emissions post 2030 of 14,225 tCO2/y) range from 33% to 82%.

Gas CHP in Scenario 1 shows consistent savings to the base case which grow to 4,701tCO_2/y in 2031. Private wire to Lidl (Scenario 2) enables 5,154t CO_2 incremental savings over the period 2017/18 to 2020/21 compared to Scenario 1. Biomass CHP provides the largest incremental savings (67,922 tCO_2 compared to Scenario 2) over the plan period and Scenario 3 provides annual saving of 10,719tCO_2/y post 2031. In Scenario 4 waste heat from FABlink displaced gas CHP and provides some addition CO_2 savings over the plan period compared to Scenario 3 (154 tCO_2). Post 2013 annual savings over Scenario 3 are 977tCO_2/y with total annual savings of 11,697tCO_2/y.

The declining electricity emission factors in the DECC time series make a significant difference. Gas CHP shows only marginal improvement over the base case with saving of 1% and 2% for Scenarios 1 and 2 respectively. These savings fall to near zero percent for both Scenarios post 2031. Although reduced from the constant emission factor case, biomass CHP still makes the largest incremental difference over the plan period (58,771tCO_2 over Scenario 2). Annual savings post 2031 are halved to 5,345tCO_2/y . However, with falling electricity emission factors the role of FABlink heat is now significant and Scenario 4 provides additional savings of 33,014tCO_2 over the plan period and post 2013 annual savings of 5,484tCO_2/y over Scenario 3 and total annual savings post 2031 of 10,829 tCO2/y.

6.2 Monkerton Heat

6.2.1 Heat Model Results

Total emissions at Monkerton between 2016 and 2031 using a constant CO_2 emission factor are shown in Table 5. Figure 11 shows the evolution of CO_2 emissions.

Scenario	Description	Total emissions 2016-31 tCO_2	Total savings 2016-31 tCO_2	Annual average savings 2016-31 tCO_2/y	Annual emissions beyond 2031 tCO2/y	Annual savings beyond 2031 tCO_2/y
Base	Individual gas boilers	59,214			5,671	
1	Gas CHP but not until 2020/21	44,663	14,551	970	3,944	1,727
2	0.5MWe gas CHP to Met Office 2018/19	42,945	16,269	1,085	3,944	1,727
3	0.5MWe gas CHP to Met Office 2018/19 and 0.5MWth biomass boiler 2017/18	36,379	22,835	1,522	3,647	2,024
4	0.5MWe gas CHP to Met Office 2018/19, 0.5MWth biomass boiler 2017/18 and Met Office supercomputer heat 2020/21	31,689	27,525	1,835	3,124	2,547

Table 5: Monkerton CO_2 heat emissions using a constant emissions factor of 0.519kg CO_2/kWh

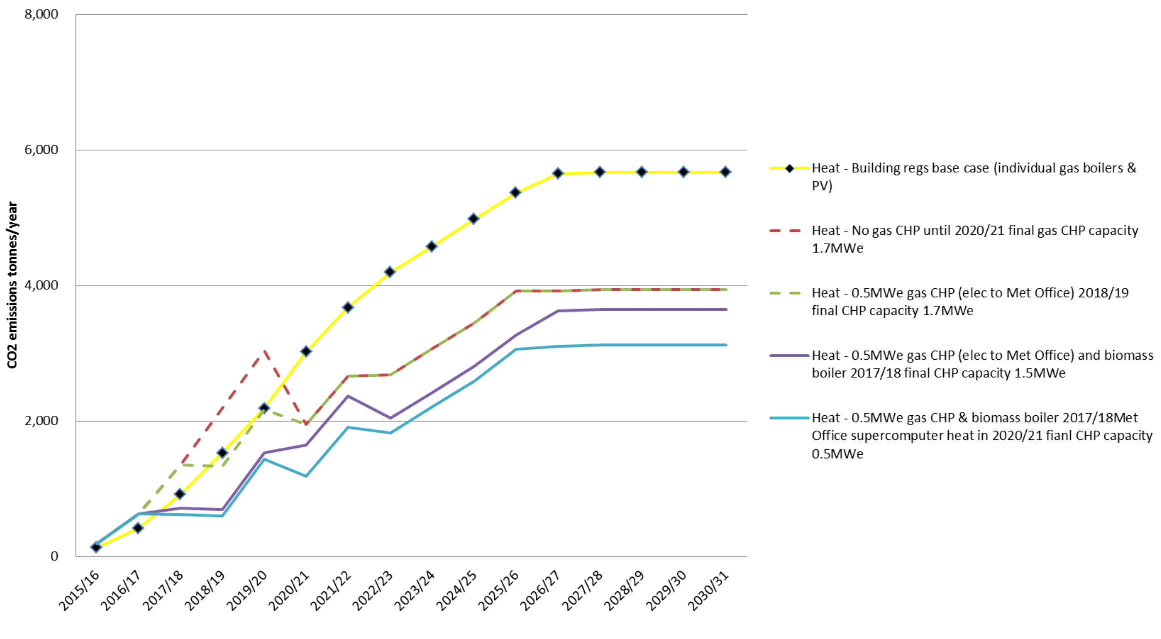

Figure 11: Cumulative annual CO_2 heat emissions from Monkerton using a constant emissions factor of 0.519kg CO_2/kWh

The effect of DECC's emissions times series is shown in Table 6 and Figure 12.

Scenario	Description	Total emissions 2016-31 tCO_2	Total savings 2016-31 tCO_2	Annual average savings 2016-31 tCO_2/y	Annual emissions beyond 2031 tCO2/y	Annual savings beyond 2031 tCO_2/y
Base	Individual gas boilers	59,214			5,671	
1	Gas CHP but not until 2020/21	62,754	-3,540	-236	5,891	-220
2	0.5MWe gas CHP to Met Office 2018/19	62,002	-2,788	-186	5,891	-220
3	0.5MWe gas CHP to Met Office 2018/19 and 0.5MWth biomass boiler 2017/18	53,897	5,317	354	5,365	306
4	0.5MWe gas CHP to Met Office 2018/19, 0.5MWth biomass boiler 2017/18 and Met Office supercomputer heat 2020/21	35,178	24,036	1,602	3,322	2,349

Table 6: Monkerton CO_2 heat emissions using DECC's CO_2 displaced emissions factors

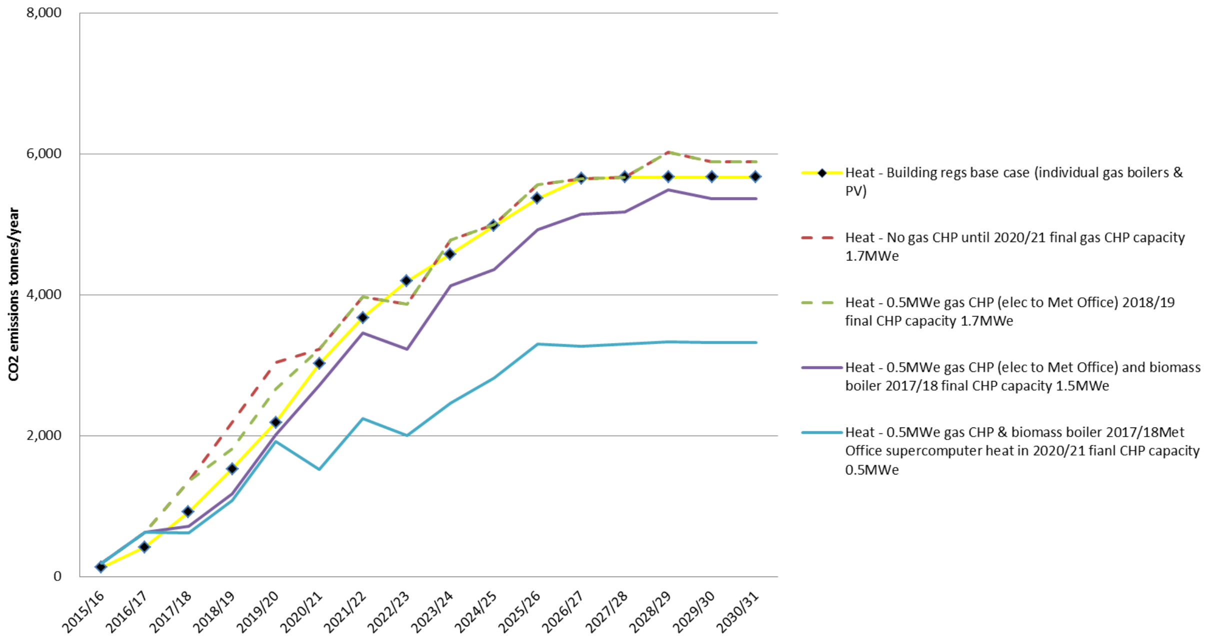

Figure 12: Cumulative annual CO_2 heat emissions from Monkerton using DECC's CO_2 displaced emissions factors

6.2.2 Heat Scenario Comparison

A 0.519kg/kWh constant CO_2 emission factor shows gas CHP providing a 25% emission reduction at Monkerton over the base case during the plan period rising to 30% beyond 2031. Accelerating the deployment of CHP from 2020 to 2018 reduces emission by 1,784tCO_2 over the plan period. Both Scenarios 1 and 2 reduce annual emissions post 2030 by 30% over the base case. Addition of a 0.5MWth biomass boiler enables further CO_2 emissions reduction. Incremental savings over Scenario 2 are 6,566tCO_2 over the plan period and long term savings are 36% from the Base Case. Heat recovery from the Met Office supercomputer reduces emission further (4,690 tCO_2 over the plan period) and cuts emissions post 2030 by 45% compared to the Base Case.

DECC's time series emission factors reduce the CO_2 savings for gas CHP and show a marginal increase in emissions compared to the Base Case. The 0.5MWth biomass boiler enables incremental savings of 5,315tCO2 over the Base Case (9%) and 5% post 2030. The use of waste heat from the next generation of Met Office supercomputer enables significant savings. Scenario 4 provides 24,036tCO_2 reduction over the Base Case during the plan period and annual savings post 2030 of 2,349tCO2/y, a 41% reduction.

6.3 Total CO_2 Emissions

While the methodology used applies all the CO_2 savings made to heat it is important to set these saving in the context of total energy forecast to be used in buildings (heat and electricity) across the study area.

6.3.1 Skypark/Cranbrook

Tables 7 and 8 and the corresponding Figures (13 and 14) take the heat scenarios and add emissions from regulated and unregulated electricity using constant and time series emission factors respectively.

Heat scenario	Description	Total emissions 2016-31 tCO_2	Total savings 2016-31 tCO_2	Annual average savings 2016-31 tCO_2/y	Annual emissions beyond 2031 tCO2/y	Annual savings beyond 2031 tCO_2/y
Base	Individual gas boilers	406,505			42,148	
1	No more CHP until 2020/21	364,853	41,653	2,777	37,447	4,701
2	1 MWe to Lidl in 2017/18	359,699	46,807	3,120	37,447	4,701
3	1 MWe to Lidl in 2017/18 and biomass CHP 2020/21	291,777	114,728	7,649	31,428	10,719
4	1 MWe to Lidl in 2017/18, biomass CHP and FABlink waste heat / heat pump 2020/21	291,623	114,882	7,659	30,451	11,697

Table 7: Skypark / Cranbrook total CO_2 emissions using a constant emissions factor of 0.519kg CO_2/kWh

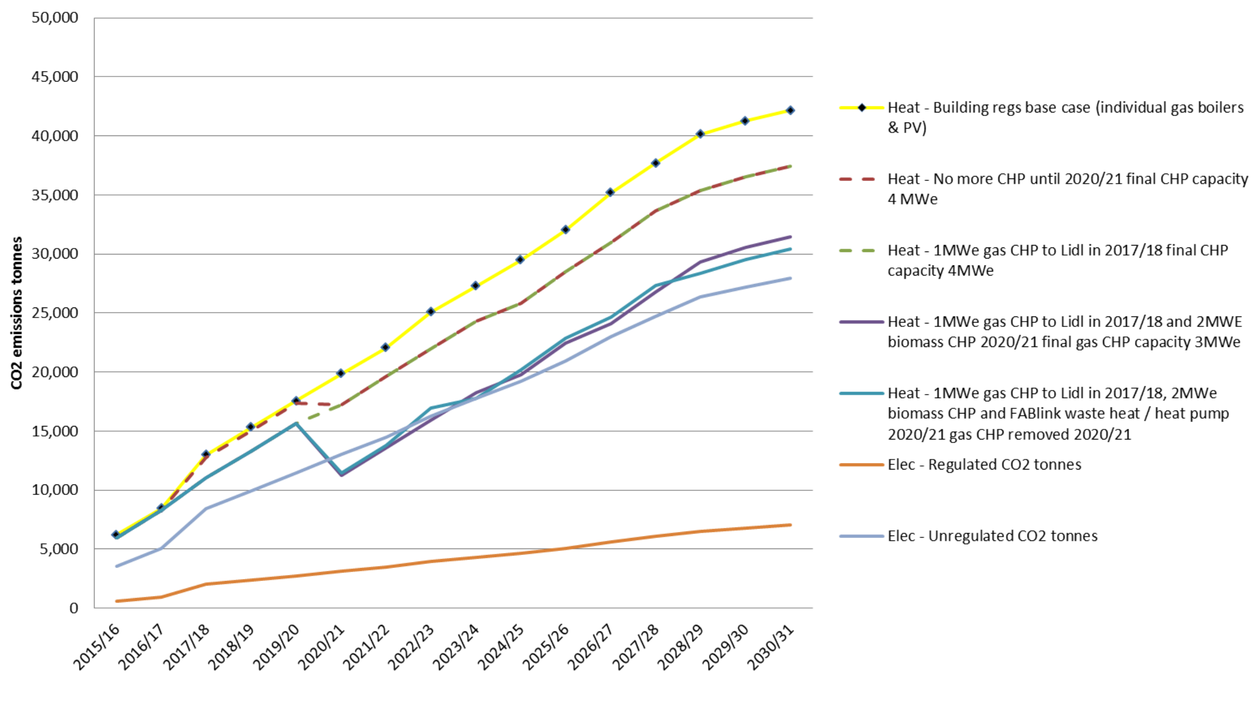

Figure 13: Cumulative annual total CO_2 emissions from Skypark/Cranbrook using a constant emissions factor of 0.519kg CO_2/kWh

Heat scenario	Description	Total emissions 2016-31 tCO_2	Total savings 2016-31 tCO_2	Annual average savings 2016-31 tCO_2/y	Annual emissions beyond 2031 tCO2/y	Annual savings beyond 2031 tCO_2/y
Base	Individual gas boilers	310,679			31,325	
1	No more CHP until 2020/21	307,643	3,036	202	31,206	119
2	1 MWe to Lidl in 2017/18	305,389	5,290	353	31,206	119
3	1 MWe to Lidl in 2017/18 and biomass CHP 2020/21	246,618	64,061	4,271	25,980	5,345
4	1 MWe to Lidl in 2017/18, biomass CHP and FABlink waste heat / heat pump 2020/21	213,605	97,074	6,472	20,496	10,829

Table 8: Skypark / Cranbrook total CO_2 emissions using DECC's CO_2 displaced emissions factors

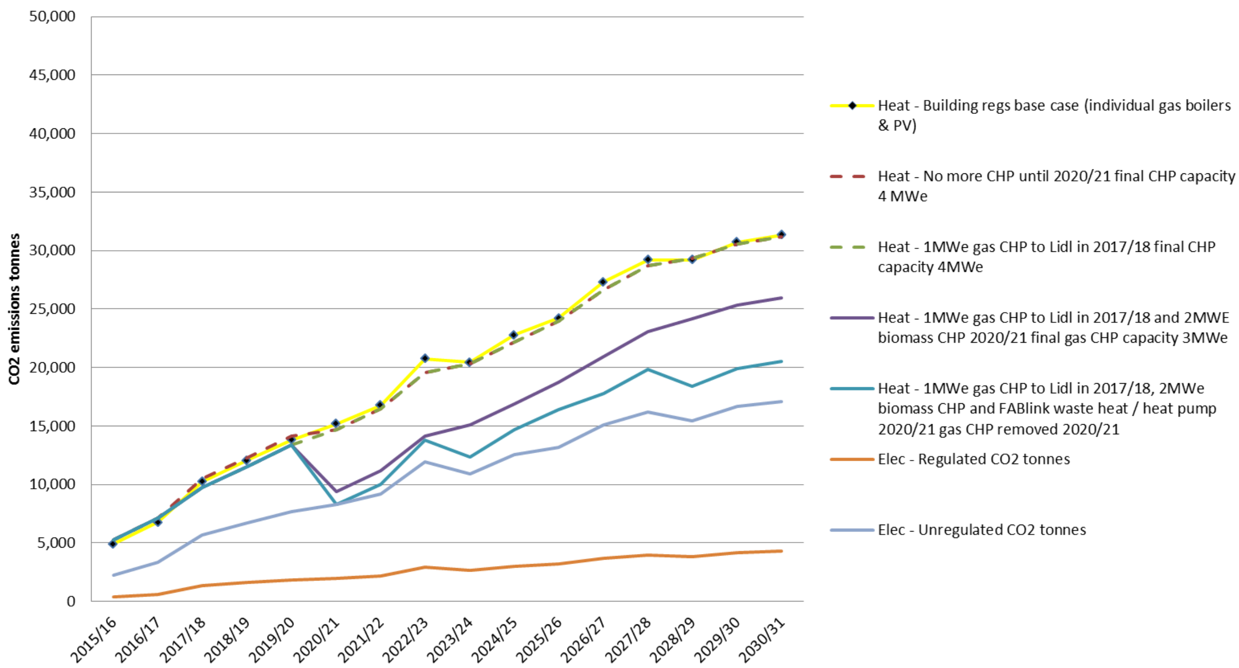

Figure 14: Cumulative annual total CO_2 emissions from Skypark/Cranbrook using DECC's CO_2 displaced emissions factors

The graphs show the impact of declining grid emission factors of overall emissions and the relative contribution of the different heat scenarios.

Table 7 summarises post 2030 percentage annual savings at Skypark/Cranbrook from each of the heat scenarios as a proportion of the Base Case heat and Base Case total emissions.

Heat scenario	Description	Constant emissions factor		DECC time series emissions factor	
		As % of heat	As % of total	As % of heat	As % of total
1	No more CHP until 2020/21	33%	11%	1%	0%
2	1 MWe to Lidl in 2017/18	33%	11%	1%	0%
3	1 MWe to Lidl in 2017/18 and biomass CHP 2020/21	75%	25%	38%	17%
4	1 MWe to Lidl in 2017/18, biomass CHP and FABlink waste heat / heat pump 2020/21	82%	28%	76%	35%

Table 9: Skypark/Cranbrook percentage reduction in annual CO_2 emissions compared to the Base Case post 2030

6.3.2 Monkerton

Tables 10 and 11 and the corresponding Figures (15 and 16) take the heat scenarios for Monkerton and add emissions from regulated and unregulated electricity using constant and time series emission factors respectively.

Heat scenario	Description	Total emissions 2016-31 tCO_2	Total savings 2016-31 tCO_2	Annual average savings 2016-31 tCO_2/y	Annual emissions beyond 2031 tCO2/y	Annual savings beyond 2031 tCO_2/y
Base	Individual gas boilers	150,309			14,468	
1	Gas CHP but not until 2020/21	135,758	14,551	970	12,741	1,727
2	0.5MWe gas CHP to Met Office 2018/19	134,040	16,269	1,085	12,741	1,727
3	0.5MWe gas CHP to Met Office 2018/19 and 0.5MWth biomass boiler 2017/18	127,474	22,835	1,522	12,444	2,024
4	0.5MWe gas CHP to Met Office 2018/19, 0.5MWth biomass boiler 2017/18 and Met Office supercomputer heat 2020/21	122,783	27,525	1,835	11,921	2,547

Table 10: Monkerton CO_2 total emissions using a constant emissions factor of 0.519kg CO_2/kWh

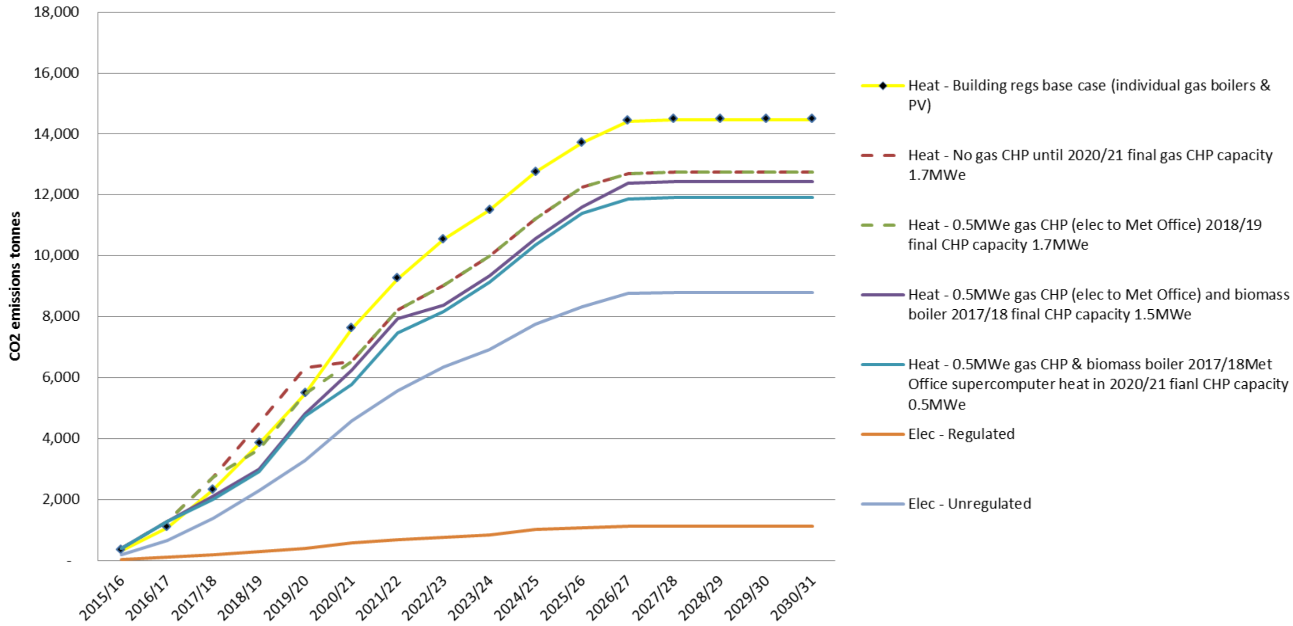

Figure 15: Cumulative annual total CO_2 emissions from Monkerton using a constant emissions factor of 0.519kg CO_2/kWh

Heat scenario	Description	Total emissions 2016-31 tCO_2	Total savings 2016-31 tCO_2	Annual average savings 2016-31 tCO_2/y	Annual emissions beyond 2031 tCO2/y	Annual savings beyond 2031 tCO_2/y
Base	Individual gas boilers	117,452			11,058	
1	Gas CHP but not until 2020/21	120,992	-3,540	-236	11,279	-220
2	0.5MWe gas CHP to Met Office 2018/19	120,240	-2,788	-186	11,279	-220
3	0.5MWe gas CHP to Met Office 2018/19 and 0.5MWth biomass boiler 2017/18	112,135	5,317	354	10,752	306
4	0.5MWe gas CHP to Met Office 2018/19, 0.5MWth biomass boiler 2017/18 and Met Office supercomputer heat 2020/21	93,415	24,036	1,602	8,709	2,349

Table 11: Monkerton CO_2 total emissions using DECC's CO_2 displaced emissions factors

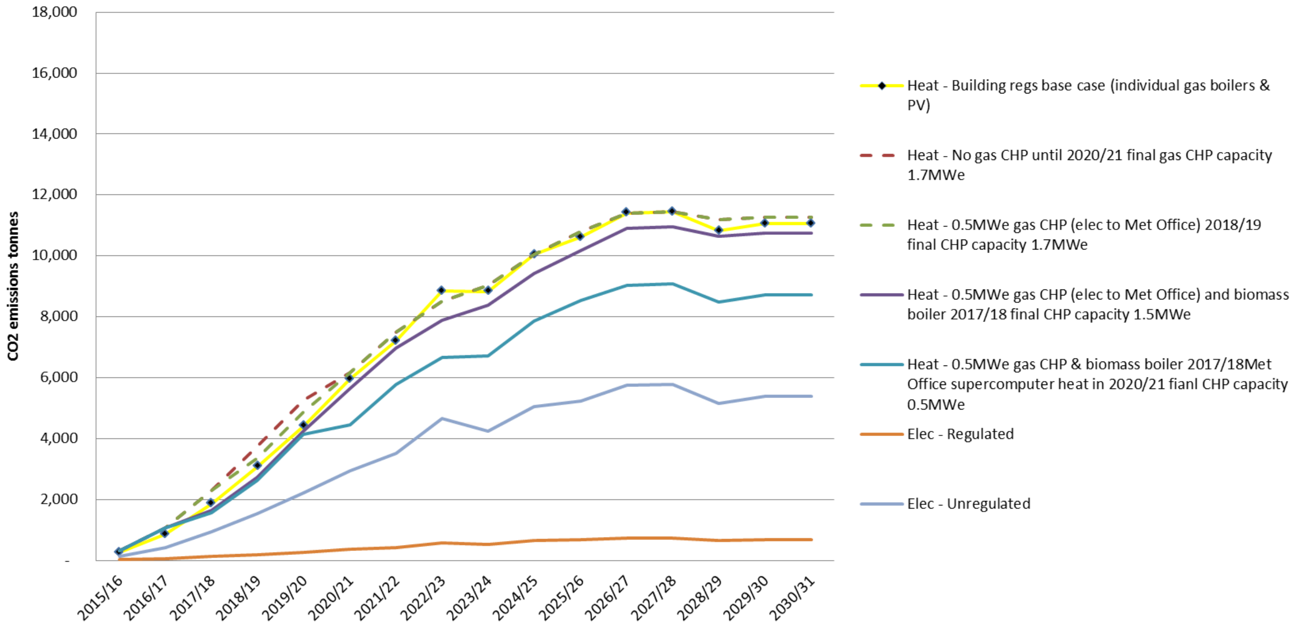

Figure 16: Cumulative annual total CO_2 emissions from Monkerton using DECC's CO_2 displaced emissions factors

The graphs show the impact of declining grid emission factors of overall emissions and the relative contribution of the different heat technologies. Table 12 summarises the percentage post 2030 annual savings from each of the heat scenarios as a proportion of the Base Case heat and Base Case total emissions.

Scenario	Description	Constant emissions factor		DECC time series emissions factor	
		As % of heat	As % of total	As % of heat	As % of total
1	Gas CHP but not until 2020/21	30%	12%	-4%	-2%
2	0.5MWe gas CHP to Met Office 2018/19	30%	12%	-4%	-2%
3	0.5MWe gas CHP to Met Office 2018/19 and 0.5MWth biomass boiler 2017/18	36%	14%	5%	3%
4	0.5MWe gas CHP to Met Office 2018/19, 0.5MWth biomass boiler 2017/18 and Met Office supercomputer heat 2020/21	45%	18%	41%	21%

Table 12: Monkerton percentage reduction in annual CO_2 emissions compared to the Base Case post 2030

6.3.3 Cranbrook & Monkerton combined

Combined total CO_2 emissions from Cranbrook and Monkerton using a constant emissions factor and the DECC time series for the base case and all heat network measures are shown in Tables 13 and 14 and Figures 17 and 18.

Combined scenario	Description	Total emissions 2016-31 tCO_2	Total savings 2016-31 tCO_2	Annual average savings 2016-31 tCO_2/y	Annual emissions beyond 2031 tCO2/y	Annual savings beyond 2031 tCO_2/y
Base	Individual gas boilers	556,814			56,616	
All	All heat network measures at Cranbrook and Monkerton	414,406	142,408	9,494	42,372	14,244

Table 13: Cranbrook & Monkerton CO_2 total emissions using a constant emissions factor of 0.519kg CO_2/kWh

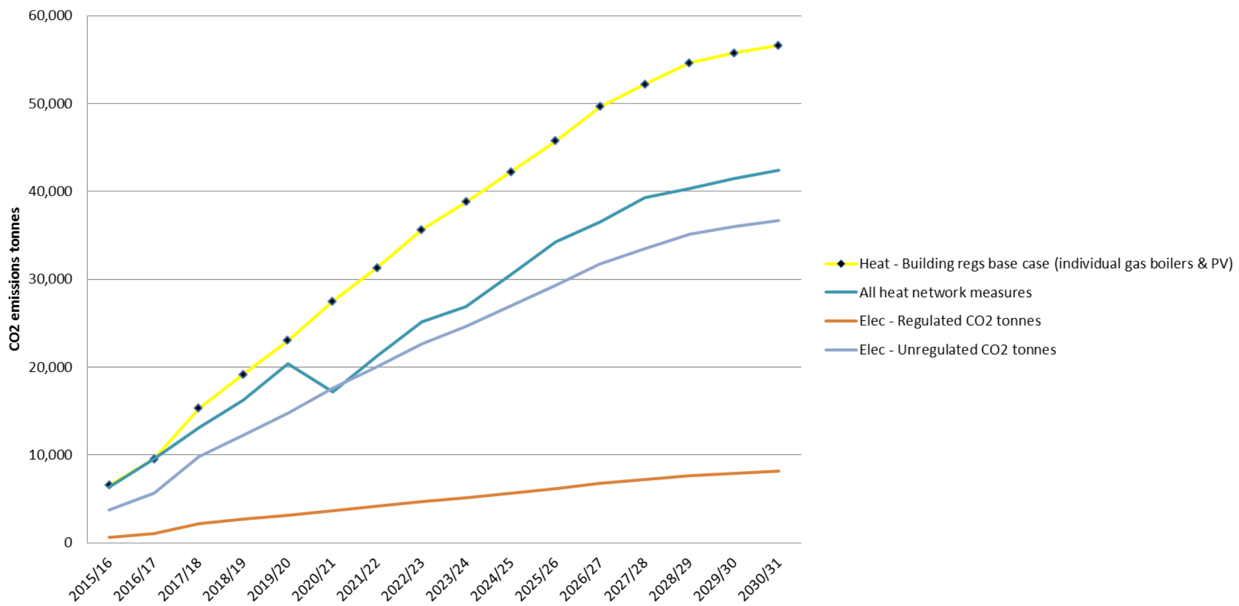

Figure 17: Cumulative annual total CO_2 emissions from Cranbrook & Monkerton using a constant emissions factor of 0.519kg CO_2/kWh

Combined scenario	Description	Total emissions 2016-31 tCO_2	Total savings 2016-31 tCO_2	Annual average savings 2016-31 tCO_2/y	Annual emissions beyond 2031 tCO2/y	Annual savings beyond 2031 tCO_2/y
Base	Individual gas boilers	428,130			42,383	
All	All heat network measures at Cranbrook and Monkerton	307,020	121,111	8,074	29,205	13,178

Table 14: Cranbrook & Monkerton CO_2 total emissions using DECC's CO_2 displaced emissions factors

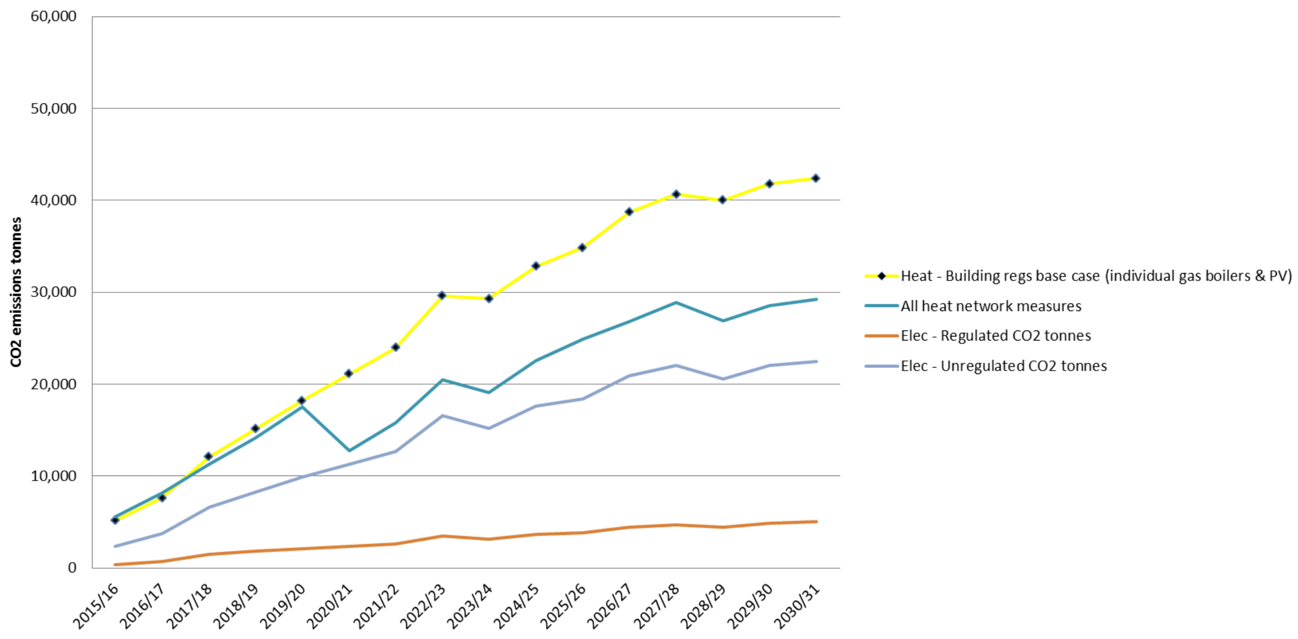

Figure 18: Cumulative annual total CO_2 emissions from Cranbrook & Monkerton using DECC's CO_2 displaced emissions factors

Table 15 summarises the percentage post 2030 annual savings from combined "all measures" total emissions scenario as a proportion of the Base Case total emissions.

Case	Description	Constant emissions factor As % of total	DECC time series emissions factor As % of total
All	All heat network measures at Cranbrook and Monkerton	25%	31%

Table 15: Cranbrook & Monkerton percentage reduction in annual CO_2 emissions compared to the Base Case post 2030

6.4 Summary of Results

The results show that CO_2 savings achieved are dependent not only on the technologies adopted at the energy centres which supply the heat networks but also on the carbon intensity of electricity available from the national grid. As more renewable electricity is fed into the grid its CO_2 content falls. When this happens the CO_2 benefit of producing electricity from CHP falls correspondingly. Because CO_2 savings are allocated to co-produced heat this results in the CO_2 content of heat rising.

Using a constant electricity emission factor gas CHP (only) provides a 33% CO_2 savings on heat at Skypark/Cranbrook and a 30% saving on heat at Monkerton. When compared with total base case emissions (heat and electricity) the savings are more modest (11% and 12% respectively). However, when DECC's declining grid emissions intensity factors are used little or no reduction is achieved. This highlights the importance for heat networks to plan strategies for further decarbonisation beyond gas CHP. Fortunately both the Skypark and Monkerton Energy Centres have existing carbon reduction strategies and the potential for further measures.

Grid constrains in the South West are have essentially halted the deployment of new decentralised electricity generation schemes in the region until 2020. The use of private wire connection to local electricity loads could bring forward the commissioning of gas CHP at both energy centres. However, the emission reductions achieved are relatively small with the benefit being more marked at Skypark than at Monkerton (total savings of 5,200 tCO_2 versus 1,718 tCO_2at a constant grid emission factor).

The impact of the s106 commitment to employ 2MWe wood based biomass CHP at the Skypark Energy Centre is significant. Long term reductions compared to the gas CHP only case are 6,000tCO_2/y in the constant emissions factor case and 5,200tCO_2/y using the DECC time series. Total emission reductions compared to the Base Case are 10,700 tCO_2/y (a 75% reduction on the heat Base Case and 25% of total Base Case) and 5,345/year (38% of heat Base Case and 17% of total Base Case) respectively. The relatively small impact of biomass CHP on overall emissions at the Skypark Energy Centre highlights that the 2MWe capacity was sized to achieve true zero carbon in the first 2,900 homes and not the non-domestic buildings or the subsequent phases of housing at Cranbrook which are now being planned.

Use of recovered heat from FABlink increases the decarbonisation of heat at Cranbrook from 75% to 82% under the constant grid emission factor. The increase is more marked under the time series emissions factors where emissions savings rise from 38% to 76%. Given the assumptions about the need for gas boiler peaking and back-up these percentages are as close as it is practical to get to heat decarbonisation. However, the reduction on total emission are much lower; 28% and 35%. Achieving zero carbon across a fully extended Cranbrook would need a significant increase in the production of renewable electricity production, for example increasing biomass CHP from 2MWe to 9MWe.

At Monkerton, the addition of a 0.5MWth biomass boiler to gas CHP and the consequent 0.2MWe reduction in gas CHP capacity enables a 14% and 3% reduction on total CO_2 emissions over the Base Case using the consent and time series gird emissions factors respectively. Limiting gas CHP to 0.5 MWe and using recovered heat from the Met Office supercomputer form 2020 increases these percentages to 18% and 21%. As at Cranbrook, the impact of using recovered heat is particularly significant under the times series emissions factors.

Combining total emissions projections from both Cranbrook and Monkerton for all heat network measures shows total annual CO_2 savings of 14,244tCO_2/y for constant grid emissions and 13,178 for the DECC time series representing 25% and 31% of total emission respectively. This shows that even if all the heat opportunities are taken, collectively the West End will mitigate only a third of its total emissions.

7. A Zero Carbon West End of East Devon

By adopting all measures from current plans and opportunities in the West End only achieves 25% to 31% of total CO_2 emission mitigation. To fully mitigate emissions requires further significant demand reduction and/or renewable energy generation (with the emphasis on renewable electricity).

The scale of additional renewable electricity generation needed is large; equivalent to 10 large (3MWe) wind turbines or 15 large (5MWe) PV farms which would each cover 10 ha. Neither of these options is practical. Element Energy's 2008 analysis proposed the mitigation of Cranbrook's total emissions with biomass CHP. Biomass CHP technology has a relatively modest land take and visual impact and benefits from larger scale. While fuel transport impacts are a key concern the development of enhanced rail freight access to the West End has the potential to reduce the need road transport.

An alternative case for mitigating the West End's CO_2 emissions has therefore been developed using biomass CHP only. This assumes that 20MWe of biomass CHP is installed to serve both the Cranbrook and Monkerton heat networks in four 5MWe steps (to track the growth in emissions). The 5MWe installations occur in 2017/18, 2021/22, 2025/26 and last in 2030/31.

The results are shown in Figure 19 for the constant grid emission factor and Figure 20 for the DECC time series.

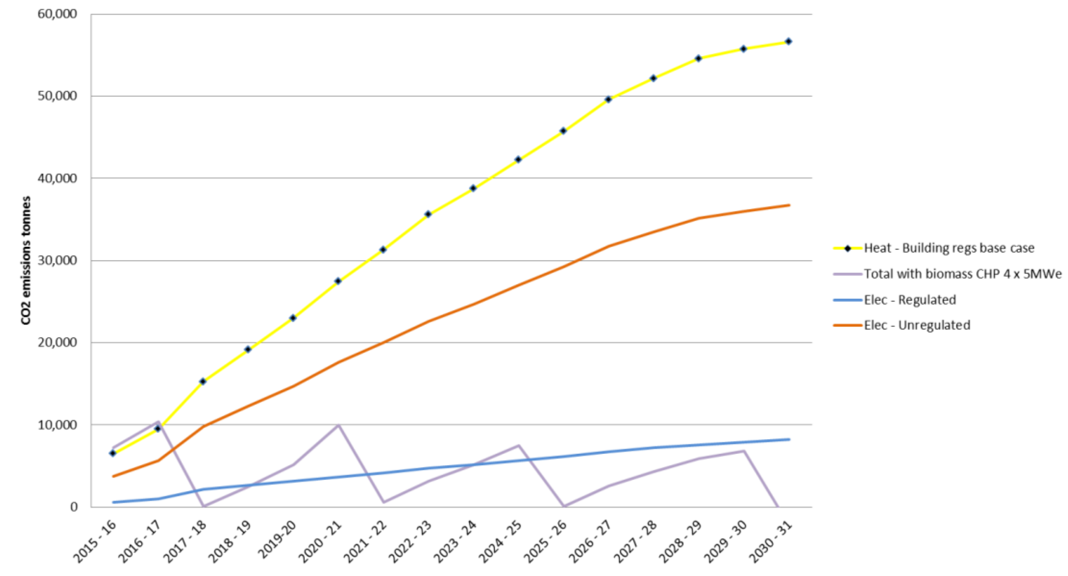

Figure 19: Cumulative annual total CO_2 emissions from Cranbrook & Monkerton using a constant emissions factor of 0.519kg CO_2/kWh

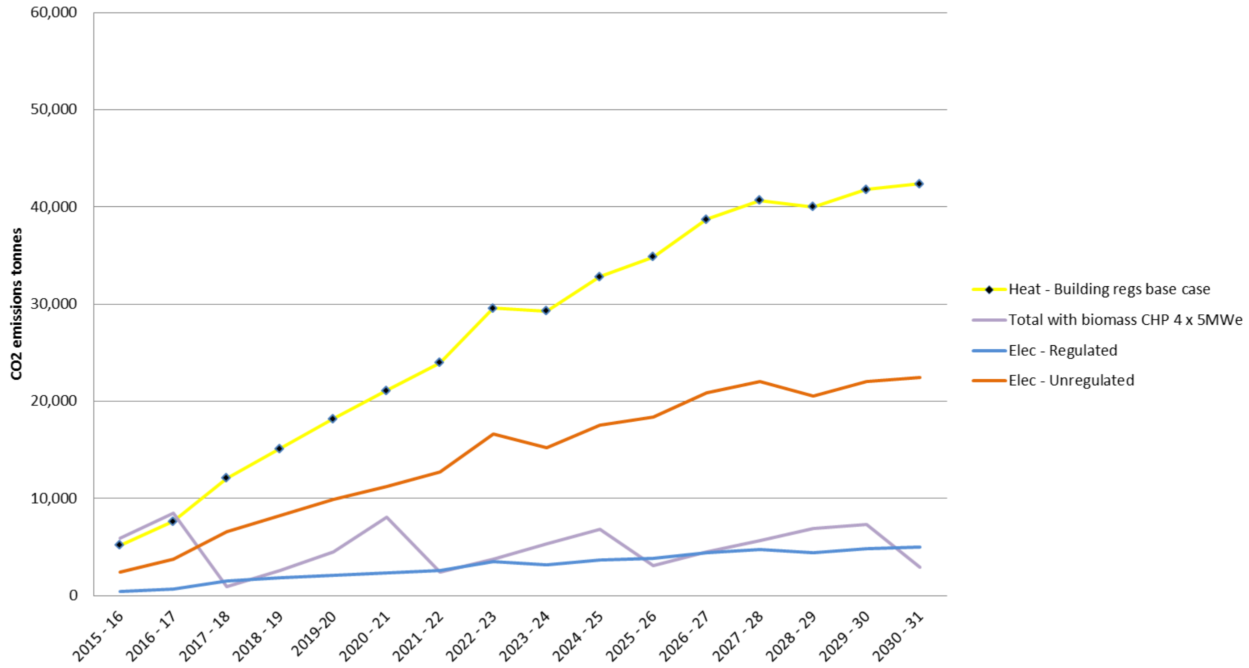

Figure 20: Cumulative annual total CO_2 emissions from Cranbrook & Monkerton using DECC's CO_2 displaced emissions factors

The need for renewable electricity means that especially beyond 2025/26 biomass CHP plant would generate more heat than would be needed in the West End. Figure 21 shows combined heat use at Cranbrook and Monkerton and the amount of the generated by 4 x 5MWe biomass CHP. In the early years gas boilers are needed to make up shortfalls. However, as 15 and 20 MWe biomass CHP is installed additional heat is generated; ultimately some 63GWh. With network links in place a portion of this zero carbon heat could potentially be used in an expanded Exeter city network (the current anticipated heat demand of the proposed City Centre scheme is 24GWh).

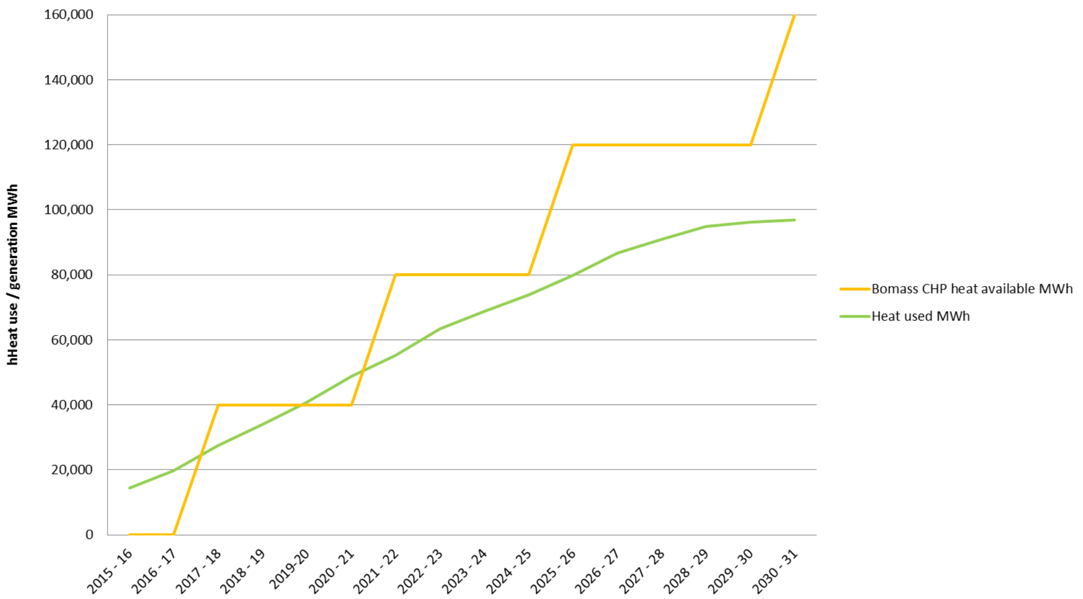

Figure 21: Projected heat use and heat generation from a 4 x 5MWe biomass CHP scheme serving Cranbrook & Monkerton

8. Conclusions and implications for planning

The 2008 energy strategy concluded that heat networks and wood based biomass combined heat and power offered the most cost effective way of achieving true zero carbon new development in the larger developments in the Exeter and East Devon area. In 2010 a £3.7m Low Carbon Infrastructure grant from the Homes and Communities Agency together with a further £0.4m from local authority partners was provided to enable EON to deliver true zero carbon for 2,900 homes at Cranbrook. Expansion of Cranbrook to some 7,600 homes means that significant additional renewable energy is needed if the true zero carbon ambition is to be extended across the entire development.

Although the current Government has reduced national policy aspirations for new homes, strong local policy in Exeter has enabled the 4,260 home developments straddling the M5 around Monkerton to recently become the largest low density housing development in the UK to have site wide district heating and CHP without subsidy.

The use of gas boilers and gas CHP was anticipated during the early phases of development. However, while gas CHP provides CO_2 savings while the grid is fed with electricity predominantly generated from fossil fuels the increasing penetration of renewables and the resulting fall in the emission factor for grid electricity limits its effect in reducing CO_2 emissions in the longer term.

Cranbrook and Monkerton have access to other potential sources of low carbon heat.

Cranbrook is committed to 2MWe of biomass CHP which will reduce total emissions 25% / 17%[23]. Beyond this, a Scenario which postulates the removal of gas CHP and the addition of recovered heat from FABlink has the potential to enhance emissions reduction to 38% / 35%.

At Monkerton a biomass boiler provide some savings (14% / 3%) but the recovery of heat from the next generation Met Office supercomputer provides significant additional befits and the scenario which includes this may have the potential to reduce emissions by 18% / 21%.

These reductions demonstrate the ability of heat networks to collect heat from a variety of technologies and illustrates the potential for the migration from fossil fuel gas fired CHP towards renewable and waste heat resources. The FABlink and Met Office examples show practical cases of how using heat pumps to exploit waste heat can not only reduce CO_2 emissions also provide key linkages between future heat and electricity network infrastructure allowing the virtual storage of electricity in heat networks.

However, there is also a need for overarching strategic planning of adjoining heat networks to make provision for interconnection to enable the scaling up of renewable energy technologies to deliver increased CO_2 emissions reduction.

This is illustrated in the West End because, while the combined total emission reduction from the heat opportunities achieves 25% / 31%, this reduction falls well short of the 2010 zero carbon commitment at Cranbrook. Further emissions reduction at both developments requires the generation of more renewable electricity on site.

Such a reduction could be achieved using a larger biomass CHP installation. An alternative single solution case could involve 20MWe biomass CHP installed in 5MWe stages which served both

[23] Figures for 0.519 kg CO_2/kWh constant electricity grid emission factor and DECC time series respectively

Cranbrook and Monkerton. This scheme would generate additional heat which would be available from 2025 for further new development in the vicinity and/or for an expanded Exeter city network.

As the West End is planned it is important that these potential carbon and energy solutions are developed alongside the growth in the area. In particular it is critical that land is reserved a variety of possible eventualities including:

- large scale biomass CHP at a site able to serve Cranbrook and Monkerton
- heat network interconnection between Cranbrook, Monkerton and Exeter city networks
- private wire electricity routes to Lidl and the Met Office supercomputer sites
- heat network routes from/to the FABlink interconnector site and provision for heat recovery and heat pump equipment at the FEBlink site
- heat network routes to the Met Office supercomputer site and provision for heat recovery and heat pump equipment at the Met Office site
- solar thermal ground arrays sites adjacent to energy centres

APPENDIX A: THE MET OFFICE SUPERCOMPUTER

The Met Office is constructing two buildings at the Science Park. The first a single-storey computer centre housing a supercomputer and the second a smaller two-storey "collaboration building", that will be used as a working and meeting space for Met Office and collaboration partner's staff. Construction of both buildings is due to commence on April 2015 with the construction phase lasting 12 months. Occupation of both buildings will follow thereafter. There is a planning condition in place that the buildings should demonstrate reasonable endeavours to connect to a district heating scheme. While the planning of a distinct heating scheme is well underway a definite proposal yet to come forward so provision has been made in the current design by identifying a route from the site boundary to the plant room for network pipes, and allowing sufficient space and heating header valves in the plant room to enable easy installation of for a heat exchanger and the trouble free connection of the building to the district heating network.

Aside from heat supply, the siting of the supercomputer also presents an opportunity to potentially supply heat to a heat network and also for the facility to be supplied by electricity from the energy centre via a private wire.

The Met Office was consulted to establish the potential for the buildings to be both a potential provider of heat, and customer for electricity generated from a district wide scheme. The connected load for the site is approximately 5 MVA/4MW with the majority of this required to provide power to the supercomputer, which was stated as having a broadly constant load in the region of 3 to 3.6 MW. The design team has been tasked with achieving a power usage effectiveness (PUE) of 1.2 which would imply a load of 3.6 to 4.3 MW from the supercomputer and related services. The supercomputer that has been specified is manufactured by Cray and will be cooled via turbo-chillers providing free cooling up to 18oC. A chilled water circuit will supply cooling to the supercomputer with a supply temperature of 18oC and a return temperature of 25 to 27oC. It may be possible to utilise the waste heat from the supercomputer – which would otherwise be lost to the atmosphere – by increasing the return temperature of the chilled water using a heat pump. A similar project funded through DECC's Heat Network Demonstration competition is underway that is looking at utilising heat generated from solar hot water panels with heat pumps at the E.ON Energy Centre at Skypark. The outputs of this very local initiative may prove to be informative for the Met Office site. However, as there is currently no district heating scheme at the site and that construction is due to begin imminently, there is no immediate opportunity to utilise waste heat from the supercomputer to supply surrounding buildings.

The Met Office replaces supercomputers on a five-year cycle. Therefore the Cray machine that will be installed shortly will be due for replacement in 2020. The specification of the replacement machine will not be known until a full appraisal has been undertaken closer to the time, though the technology is almost certain to have evolved over this period. However, past experienced dictates that at each replacement, the power demand approximately doubles i.e. a load of 6 to 7.2 MW for the supercomputer only. In addition, the cooling arrangements may well be different, with current best estimates based on discussions with supercomputer manufacturers indicating that return temperatures from the cooling circuits are likely to be higher. Both of these factors would improve the viability of utilising the supercomputer as a supplier of heat to a district heating network, which may well come forward in the locality prior to the first replacement of the supercomputer. The infrastructure for the facility will be revisited in 2018 to enable a two-year lead-in for the planned replacement of the supercomputer in 2020. The Met Office has indicated that in principle they would be willing to explore this option.

A district heating network serving the Science Park would also serve the housing schemes at Tithebarn Green and Mosshayne adjacent to the Science Park, as well as Monkerton in Exeter and housing developments to the north of Pinhoe. The energy centre/CHP serving all these developments would be located on land owned by DCC immediately to the west of the Tithebarn Bridge. This is a short distance for a private wire to potentially connect the energy centre to the supercomputer facility raising the possibility that the Met Office could purchase electricity directly from the energy centre. Such an arrangement would enable electricity to be purchased at a lower unit rate for the Met Office then they would otherwise pay, and would enable the operator to charge a higher rate than would be achieved if selling to the national grid, due to avoided costs. Whilst the potential power output from the energy centre is not known at this stage, it is likely to be lower than the power requirements of the supercomputer. This would make it feasible for the energy centre to export all generated electricity by the CHP to the supercomputer, with the national grid used to provide the balance of the required electricity to the supercomputer, as well as necessary contingency should the energy centre or CHP engine need to shut down e.g. for planned maintenance. The Met Office again has indicated that in principle they would be willing to explore this option. Currently, due to Government procurement rules, the Met Office is only able to purchase electricity from Crown Commercial Services. This potential barrier will need to be overcome to enable the purchasing of electricity via a private wire. More generally it is understood that DECC is working inside Government to resolve the interaction of the Government estate purchasing with distributed energy.