Reducing costs;
Improving comfort; and
Lowering carbon emissions

Learning from the impacts of the Wyndford Estate district heating project

Technical appendices document

Contents

The University of Edinburgh research

Many of the social impacts highlighted within the Wyndford Estate report were taken from publically available research carried out by the University of Edinburgh. All information within the Wyndford Estate report which refers to the University of Edinburgh research can be found here: http://www.heatandthecity.org.uk/resources/documents/wyndford_estate

The study was carried out by a University of Edinburgh research team as part of the Heat and the City project (http://www.heatandthecity.org.uk/) led by Professor Janette Webb and funded by the Research Councils-UK (RC-UK) Energy Programme. The Scottish Government provided additional funding. Interviews were carried out by Maddie Breeze, Mary Hanlon, David Hawkey, Alex Hensby, Dan Hope, Rhys Howell, David McCrone, Madeleine Murtagh, Katherine Ord, Tristan Partridge, Mike Slaven, Margaret Tingey and Janette Webb.

The survey was carried out using face-to-face interviews in residents' homes at two points in order to track changes over time. The first interviews were in late 2012 (and in early 2013 for owners) as the district heating was being installed, and the second were a year later, in late 2013 and early 2014. Ten per cent of the tenants on the estate were interviewed using a random sample drawn up proportional to house type. At Time 1, 154 tenants were interviewed, and at Time 2, 80 were re-interviewed, reflecting availability and access. The two samples were broadly comparable in demographic terms, with a slight tendency for those tenants re-interviewed to have lived longer on the estate. In terms of owners, we interviewed 50 at Time 1, with 39 re-interviewed at Time 2. Analysis in this document refers mainly to those residents we interviewed at both Time 1 and Time 2. Readers are referred to the Time 1 reports for tenants and owners for full analysis of the Time 1 cohorts (Heat and the City, 2013; 2012).

Cost comparison analysis

The cost comparison seeks to model the equivalent annual cost of providing heat from electric storage heaters compared to the district heating system at Wyndford. Electric storage heaters were deployed for heating prior to the installation of district heating.

The equivalent annual cost includes all of the costs involved, including for example the cost of purchasing and maintaining the counterfactual heating system (storage heaters). This is because the ESCo supplying heat from district heating is responsible for all maintenance and replacement of plant, so this method describes an equivalent level of service provision. Note that the equivalent annual cost of storage heaters is not the same as the electricity bill that would have been received by residents for electricity used for heating purposes.

The modelling further compares costs assuming the same amount of heat supplied through either storage heaters or district heating. In practice residents may take a different amount of heat from the new system.

The average heat demand at Wyndford has been measured at 4758 kWh per dwelling per year (A). The chart in the report plots the equivalent annual costs, calculated as described below, for a range of assumed heat demand values.

Costs of district heating

The heat tariffs at Wyndford at the time of reporting are shown in the table below.

Tariff	**Standing charge (£/month) (B)**	**Capital replacement fund charge (£/month) (C)**	**Variable charge (£/kWh) (D)**
Wyndford heat (tenants)	£13.23	£0	£0.0506
Wyndford heat (owners)	£13.23	£7.68	£0.0506
Low user heat tariff	£0	£0	£0.082

The equivalent annual cost of heat from district heating for a given heat demand (A) is then given by:

$$(A \times D) + \big(12 \times (B + C)\big)$$

Costs of storage heaters

The key assumptions underpinning the calculation of the equivalent annual cost of storage heaters are as follows:

Item	**Assumption**	**Note**
Heater capex	£2000 (E)	Equivalent to 4 heaters per dwelling at £500 per heater. A report by AEA Technology to Government in relation to RHI

		technologies suggested £2-4k for domestic electric heaters, see Appendix at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66165/RHI_Phase_II_-_technology_assumptions.pdf
Heater maintenance cost	£0	No maintenance assumed for storage heaters.
Heater lifetime	20 years (F)	Note reference above suggests 15 years; however in practice many storage heaters last longer and it is believed that many of those at Wyndford date to when the buildings were first constructed.
Primary heating fraction	0.85 (G)	This is the proportion of heat demand met by the storage heaters. The remainder is assumed to come from a secondary heating system, in this case heaters using peak rate electricity. This is the fraction assumed in the Standard Assessment Procedure for non-fan-assisted storage heaters, see Table 11 at https://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf
Offpeak unit rate	0.0799 (£/kWh) (H)	Standard Economy 7 tariffs (direct debit with paperless billing) from Scottish Hydro Electric website accessed 17th June 2016
Peak unit rate	0.1588 (£/kWh) (J)	As above
E7 standing charge	0.1479 (£/day) (K)	As above
Single rate tariff	0.1347 (£/kWh) (L)	Standard single-rate electricity tariff (direct debit with paperless billing) from Scottish Hydro Electric website accessed 17th June 2016
Single rate standing charge	0.1479 (£/day) (M)	As above
Average non-heating electricity demand	3200 kWh per year (N)	This is used because Economy 7 tariffs have a higher daytime unit rate than standard single rate electricity tariffs. This means that residents using storage heaters pay a higher amount for their non-heating electricity, which is a cost attributable to providing heat from storage heaters. From Ofgem: https://www.ofgem.gov.uk/sites/default/files/docs/decisions/tdcv_decision_letter_final_2.pdf

The annual cost of the heaters themselves are given by:

$$\frac{E}{F}$$

(P)

The cost of electricity used to provide a given heat demand (A) is given by:

$$(A \times G \times H) + (A \times (1 - G) \times J)$$

(Q)

The additional cost of the Economy 7 tariff is given by:

$$(N \times (J - L)) + (365 \times (K - M))$$

(R)

Finally, the equivalent annual cost of heat from district heating for a given heat demand (A) is then given by:

$$P + Q + R$$

Carbon calculation

The report shows an emission saving from the district heating system compared to electric storage heaters. This assumes that the same amount of heat would have been delivered by either technology. This is considered a fair comparison, since there were other improvements made to the estate, particularly external wall insulation, at the same time as the district heating system installation.

The carbon calculation is based on metered data from December 2014 to November 2015 (inclusive) as follows:

Item	Metered quantity	Notes
Gas delivered to energy centre (A)	22000000 kWh	Gas used in CHP and boilers
Electricity exported from energy centre (B)	5678000 kWh	This is electricity generated by the CHP net of any parasitic loads in the energy centre such as distribution pumps. Note there will be some electricity demand for the district heating system that is outside the energy centre and therefore not factored into the calculation, but this is likely to be small.
Heat delivered to end customers (C)	8200000 kWh	Note metered at the customer premises, so excludes losses in the network.

The emissions factors used are from 2015 (corresponding to the metered period), published by the UK Government: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2015

As such the calculation represents a snapshot for the year in question. Emissions in future years will change as emissions factors change. The electricity factor would be expected to reduce over time as the more electricity is supplied from low-carbon sources, resulting in reduced savings attributable to gas CHP.

Fuel	Emissions factor
Gas	0.18445 kgCO2e/kWh (D)
Electricity	0.46219 kgCO2e/kWh (E)

The counterfactual emissions, that would have been associated with supplying the same amount of heat using electric heaters, is given by:

$$\frac{C \times E}{1000} = 3790\ tCO2e$$

(F)

The emissions associated with gas supplied to the energy centre are:

$$\frac{A \times D}{1000} = 4058\ tCO2e$$

(G)

The emissions avoided due to the exported electricity are:

$$\frac{B \times E}{1000} = 2624\ tCO2e$$

(H)

Net emissions from district heating are then:

$$G - H = 1433\ tCO2e$$

(J)

Finally the overall saving is:

$$F - J = 2357\ tCO2e$$

Input-Output Model Methodology

Input-Output (I-O) modelling was used to evaluate the economic impact in the UK and in Scotland from the expenditure on installing the district heating system at the Wyndford Estate[1]. This economic technique is used for calculating the direct, indirect and induced impacts of localised economic activity on the overall economy. The model generates the Gross Value Added (GVA) to the economy and the years of employment supported within the economy as economic indicators of impact. The sum of direct, indirect and induced impacts equals the total GVA and employment supported.

This section will summarise the methodology used to calculate these impacts on the UK and Scottish economies.

Direct, indirect and induced impacts

Expenditure on large projects like the Wyndford Estate impacts the wider economy at three levels:

(1) **Direct impact**: increased post-tax profit, wages and employment produced directly by project expenditure associated with 'Tier 1' expenditure.

(2) **Indirect impact**: increased post-tax profit, wages and employment created from 'Tier 1' employment of sub-contractors and demand for goods and services from suppliers down the supply-chain.

(3) **Induced impact**: increased post-tax profit, wages and employment generated from greater demand and spending on goods and services such as accommodation, food, fuel and retail by employees who are employed as a result of the direct and indirect impacts.

Using the I-O model, the GVA and years of employment supported can be calculated at each of these impact levels, as a result of Wyndford Estate district heating scheme expenditure.

Gross Value Added and years of employment supported

Gross Valued Added (GVA) measures the post-tax profit and wage contribution to the economy from an industry, business, or project in a country or region. The sum of GVA from all of these areas equates to the total economic output of a country: the country's Gross Domestic Product (GDP). In this case GVA measures the contribution of a project, the Wyndford Estate district heating scheme, to the Scottish and UK economies. Wyndford's total GVA is the sum of post-tax profits and wages generated from the direct, indirect and induced impacts.

The total number of **years of employment supported** is the sum of the employment generated at each impact level as a result of Wyndford's expenditure. The total number of years of employment

[1] The data for the total 'Tier 1' expenditure of £13.9m was provided by Vital Energi, broken down to where this money was spent geographically and by type of spend, or supplier name where possible, and is not publicly available. The total expenditure for installing the Wyndford Estate district heating scheme to all residents was provided by a number of different organisations, including Cube Housing Association, SSE and the Scottish Government.

supported relates to different numbers of people all working for different lengths of time. For example, ten years of employment supported could be ten people working for a year, four people working for two and a half years each, or any combination.

Expenditure

To compute the direct, indirect and induced GVA and employment impacts, all 'Tier 1' expenditure had to be categorised and matched to a relevant economic sector before it could be inputted into the I-O model.

The I-O modelling consisted of four key stages:

(1) Identify whether expenditure is UK or non-UK. If UK, go on to identify whether spend is Scottish or non-Scottish.

(2) Using the description of spend or supplier name to match expenditure to the relevant economic sector(s) and assign the relevant industry codes (Standard Industrialisation Classification (SIC) 07). Each type of economic activity within the economy can be matched to the relevant SIC 07 code. The industry codes are published by the UK and Scottish governments.

(3) Matching the SIC codes to the I-O sector group numbers.

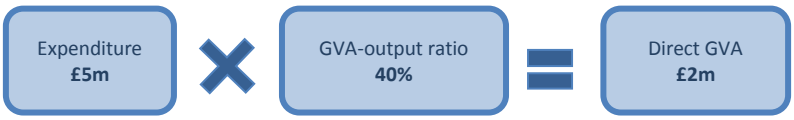
(4) Inputting the I-O sector-matched data for the relevant countries into the I-O models and generating the output.

For all categorised expenditure, the I-O model generated direct, indirect, induced and total impacts for both GVA and employment in Scotland and UK. These results were then used to produce the results shown in the GVA and jobs supported section of this report.

Direct GVA Impacts

Direct GVA impacts are calculated in the I-O model using 'GVA-output ratios'. These measure the relative GVA increase per unit increase of output, and are nationally published by the UK and Scottish governments. These nationally published ratios are equal to the national/regional average GVA increase per unit increase of output for each of these sectors. National/regional average ratios were used instead of independently derived ratios, which would be specific to SSE, so that comparisons with other companies can be made.

To compute the direct GVA impact, sector-matched expenditure (which is equal to output) is multiplied by the relevant GVA-output ratios for either the UK or Scotland. For example, if £5m is spent in Scotland in 'sector X' and 'sector X' has a GVA-output ratio in Scotland of 40%, then the direct GVA impact in Scotland is equal to £2m added to the Scottish economy.



Although the majority expenditure may be within one sector, simply multiplying the total spend by the GVA-output ratio associated with that sector would not generate an accurate estimate of direct GVA. To calculate a more granular estimate of direct GVA, expenditure which does not fall within this sector and which will have different GVA-output ratios must be taken into account as these ratios can vary significantly. A more robust approach, such as the one taken for the Wyndford Estate, sector-matches all expenditure to the relevant economic sector, computes the direct GVA for each, then sums the individual GVAs to calculate the total direct GVA estimate.

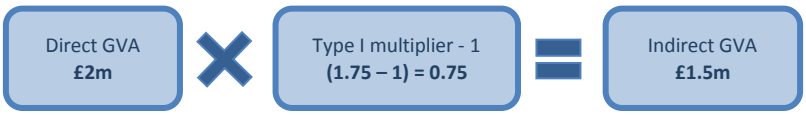
An even more granular approach would be to collect primary data on the exact increase in post-tax profit, wages and employment that each stakeholder experienced as a result of the installation of the Wyndford Estate district heating scheme and then sum these findings. In reality however there are many hundreds of stakeholders which would have been economically impacted by the project. Consequently, due to the huge complexity, the value added to this study would not outweigh the financial costs of performing such a task. As noted, economic indicators such as sector-specific GVA-output ratios generate results that are acceptably accurate given the confines of this report.

Indirect GVA Impacts

Indirect GVA impacts are calculated in the I-O model using 'Type I multipliers'. These measure the relative GVA increase of indirect impacts per unit increase in direct GVA. Scottish Type I multipliers are publicly available and derived by the Scottish Government; however UK Type I multipliers must be derived[2]. As Type I multipliers take all supply-chain links between all sectors of the economy into account, Scottish Type I multipliers will generally be smaller than UK Type I multipliers. This is because trade between Scotland and the rest of the UK is considered as exporting and will be excluded within the Scottish I-O model, whereas all UK trade is internal and counted within the UK I-O model.

[2] This was undertaken as part of SSE's wider sustainability agenda and followed government recognised methodology.

To compute the indirect GVA impact, direct GVA is multiplied by the relevant Type I multiplier for either the UK or Scotland. The Type I multiplier includes both direct and indirect impacts, and therefore to isolate just the indirect GVA impact, the unit increase of direct GVA is subtracted from the Type I multiplier. For example, the direct GVA for 'sector X' was calculated to equal £2m. If the Scottish Type I multiplier for 'sector X' is equal to 1.75, then the combined direct and indirect GVA impact is equal to £3.5m and the indirect GVA impact alone is equal to £1.5m.

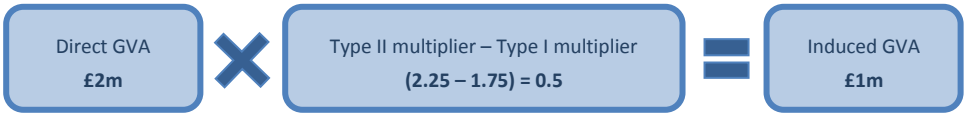


As with direct GVA, a granular approach is taken in order to achieve an acceptably accurate estimate of indirect GVA. This means that the sector-specific direct GVA which has been calculated from the sector-matched expenditure must be used, and each must be multiplied by the relevant sector-specific Type I multiplier.

Induced GVA Impacts

Induced GVA impacts are calculated in the I-O model using 'Type II multipliers'. These measure the relative GVA increase of both the indirect and induced impacts per unit increase in direct GVA. Again, Scottish Type II multipliers are publicly available and derived by the Scottish Government, however UK Type II multipliers must be derived[3]. Scottish Type II multipliers will also generally be smaller than UK Type II multipliers for the same reason that Scottish Type I multipliers are smaller than UK Type I multipliers. Type II multipliers take all household expenditure on all economic sectors into account and therefore measure how an increase in wages adds value into the economy. Consequently, even if direct and indirect employees in Scotland purchase only goods and services in Scotland, the supply-chain for these goods and services will generally not be exclusively Scottish. As noted previously, trade between Scotland and the rest of the UK is considered as exporting and is excluded within the Scottish I-O model, whereas all UK trade is internal and counted within the UK I-O model.

To compute the induced GVA impact, direct GVA is multiplied by the relevant Type II multiplier for either the UK or Scotland. The Type II multiplier includes direct, indirect and induced impacts and therefore to isolate just the indirect GVA impact, the Type I multiplier is subtracted from the Type II multiplier. For example, the direct GVA for 'sector X' was calculated to equal £2m. If the Scottish Type II multiplier for 'sector X' is equal to 2.25, and we know that the 'sector X' Scottish Type I multiplier is equal to 1.75, then the indirect GVA impact is equal to £1m.



As with direct and indirect GVA, a granular approach is taken in order to achieve an acceptably accurate estimate of induced GVA. This means that the sector-specific direct GVA which has been

[3] This was undertaken as part of SSE's wider sustainability agenda and followed government recognised methodology.

calculated from the sector-matched expenditure must be used, and each must be multiplied by the relevant sector-specific Type II multiplier.

Total GVA Impacts

In the example above, from an initial 'Tier 1' spend of £5m in Scotland in 'sector X', the contribution to Scottish GDP is equal to:

£2m (direct GVA) + £1.5m (indirect GVA) + £1m (induced GVA)
= £4.5m (total GVA)

Total GVA and jobs supported for the Scottish economy are therefore equal to the sum of direct, indirect and induced GVA and employment generated by Scottish expenditure in different economic sectors. Likewise, total GVA and jobs supported for the UK economy are equal to the sum of direct, indirect and induced GVA and employment generated from UK 'Tier 1' expenditure in many economic sectors.

Direct, Indirect and Induced Employment Impacts

Direct, indirect and induced jobs supported can be calculated following the same method used for calculating the direct, indirect and induced GVA.

To calculate the number of direct jobs supported, GVA-output ratios should be replaced with employment-output ratios. To calculate the number of indirect jobs supported, Type I GVA multipliers should be replaced with Type I employment multipliers. To calculate the number of indirect jobs supported, Type II GVA multipliers should be replaced with Type II employment multipliers.