Bioregional, Etude, Currie + Brown

Central Lincolnshire Local Plan: Climate Change Evidence Base

Task H - Cost Implications

January 2021

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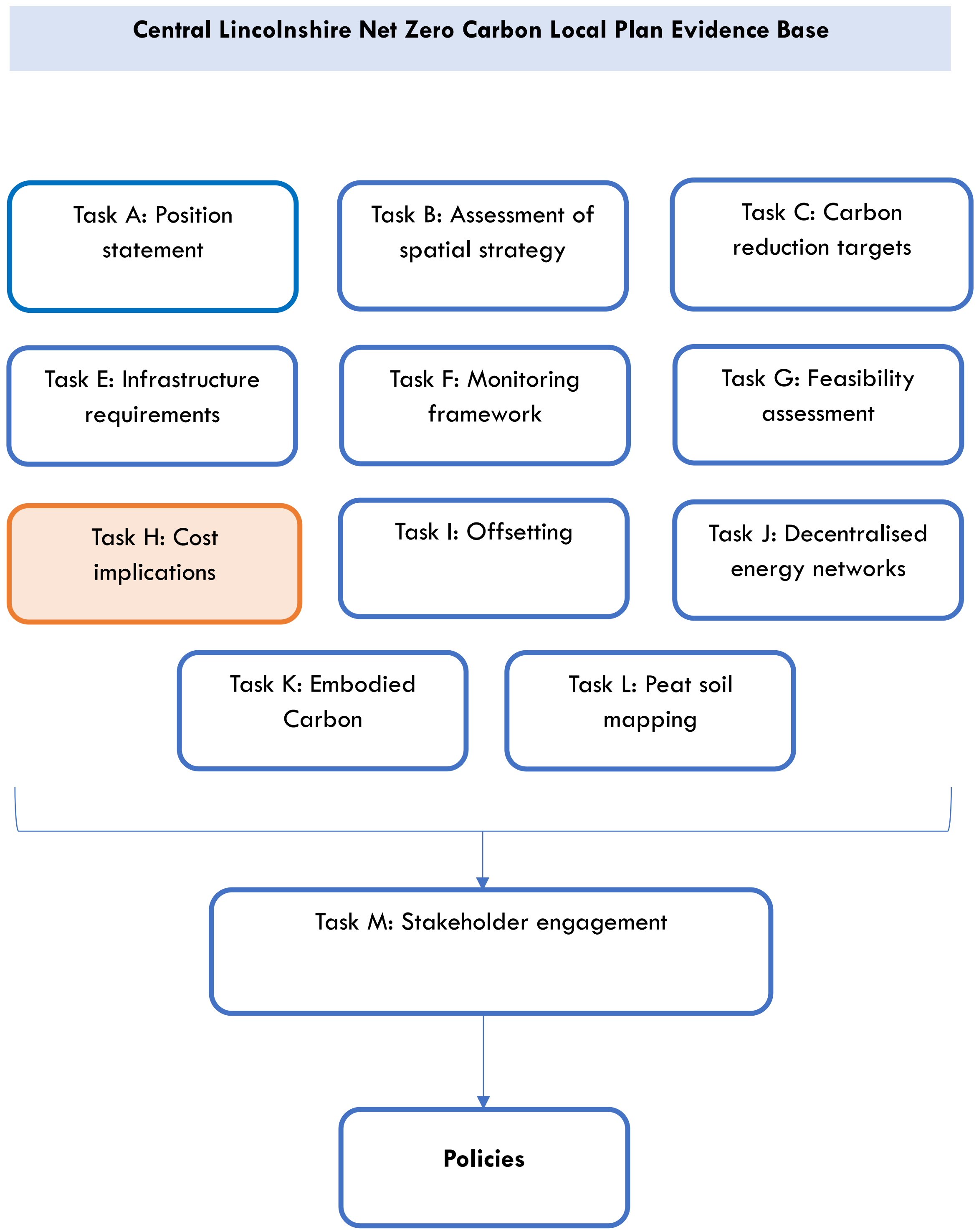
Task H: Cost Implications

This report provides costs for construction, EV infrastructure and communal systems, support each strategy option. We will have considered the costs of traditional grid reinforcement alongside options for smart grids with local storage and demand response.

The whole life cost model captures the capital, operations, replacement and revenue for each option, producing present value costs by category for any model period up to 60 years from the construction.

This is part of a wider set of analyses (shown in diagram to the right) to support the relevant local authorities in their stated commitments to combat climate emergency by transitioning their entire areas to net zero carbon by 2030 (Lincoln and North Kesteven) or no later than 2050 along with the national legislated goal (West Lindsey, and Lincolnshire County Council). It is also relevant to Lincolnshire County Council's Green Masterplan[i].



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1 Cost Report

Introduction

1.1. This report presents the costs analysis results of the domestic and non-domestic architype models developed by Etude for Central Lincolnshire. Cost is presented in the form of additional capital cost, running cost to the user (delivered energy - based on predicted energy consumption only, excluding lifecycle costs) and monetised value of carbon savings.

1.2. There were five different building architype models used during this costing exercise. These were provided by Etude and include:

- A semi-detached house (Figure 2)
- A semi-detached house, optimised to a simpler form (Figure 3)
- A bungalow (Figure 4)
- A detached house (Figure 5)
- A light industrial unit (Figure 6)

1.3. Each domestic building starts from a baseline that includes a gas boiler and systems typical for a property constructed to today's standards. The models (scenarios) that are tested against this baseline, for each one of the architypes, follow the London Energy Transformation Initiative (LETI)[1] guidance (Figure 1). They are all in all cases improved in terms of their thermal envelope compared to the baseline, and they are supported by all electric solutions for their operation (heat pumps or direct electric, and photovoltaic panels). None of the baseline models included energy generation.

[1] https://www.leti.london/

1.4. The naming conventions of the improved domestic models used by the technical team follows the LETI logic and these are mentioned as 15kwh/m2/year (15-20kWh/m2/year) and 30kWh/m2/year (as modelled by PHPP energy assessment models).
1.5. Only one fabric upgrade option was considered for the non-domestic improved building model and is simply referred to as 'improved'.
1.6. These names reflect upgrades to the thermal envelope of the buildings, with two heating system options assigned to each. For domestic buildings, heat pumps and direct electric options were considered with a photovoltaic (PV) array of varying size. For the non-domestic building (light industrial unit) both electric fan heaters and electric radiant heaters were considered together with varying amounts of PV.

Please refer to

Table 1 to Table 5 for more information.

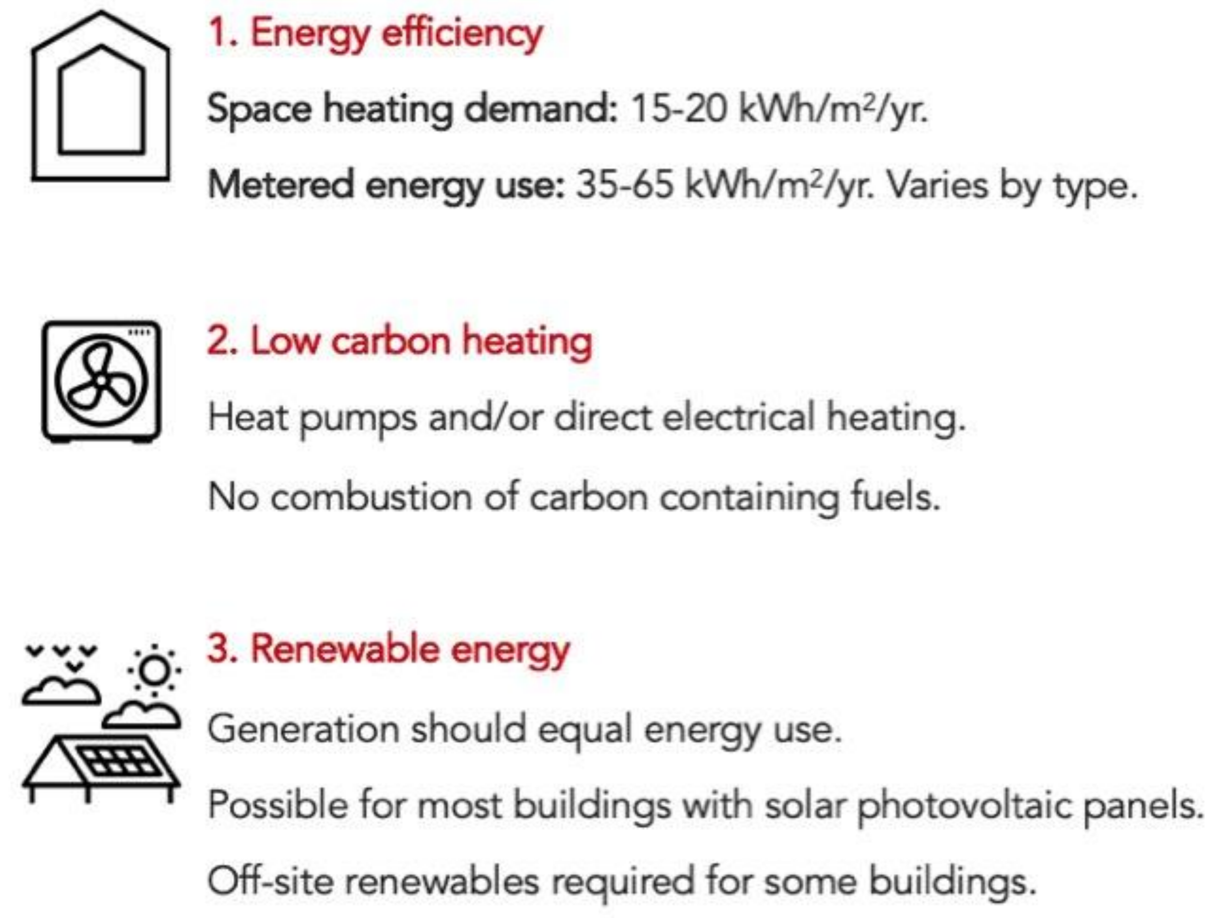

Figure 1 - The LETI principles of a zero-carbon building, metered energy use refers to delivered energy. The space heating demand metric is used in this report as the name of the improved building models examined

2 Cost assumptions

This section includes cost assumptions used in the production of all models.

Assumptions

Capital costs

2.1. The construction capital costs presented in this report are for a medium-sized developer, building several hundred homes per year. The costs used in the case of the industrial unit are indicative of a small-scale development

2.2. It is important to remember that the costs of developing a new building can vary widely for a range of factors, not least: location, ground conditions, site constraints, access, topography, quality of finishes, design complexity, supply chain and management.

2.3. Construction costs can also be subject to sudden and significant change because of market or economic factors, for example varying exchange rates, skills or materials shortages and interest rates.

2.4. These extensive factors mean that a benchmark cost analysis is only indicative of overall cost implications of different energy and carbon performance improvement options and their relative significance.

2.5. There are three cost factors that can vary average costs produced when compared with previous Currie & Brown cost reports of a similar nature, these include:

- The time that the costs were assessed
- The exact technical details requested to be costed
- Variations in the buildings' models used as a proxy in terms of architecture, geometry, size and other factors.

2.6. All capital costs shown in this report reflect the detailed technical specifications received for the models. Please note that in the case of capital costs, the additional costs produced refer to the additional costs of technologies and materials assigned to the baseline models, with redundant elements added as a 'saving' where applicable.

2.7. Costs associated with additional design fees (initial RIBA stages), the effect of certain modifications to structural elements of the buildings (structural upgrades and modifications), consultant fees and any potential architectural special features were not noted and are not included in the cost outputs.

2.8. There are two main capital cost drivers in the models evaluated:

- Upgrades in terms of the thermal envelope of each building, costed based on approximate built-up modifications (fabric / thermal envelope additional costs/savings)
- Upgrades in terms of technologies assigned to each building (like in the case of heat pumps and direct electric systems), costed based on the technical specifications provided by Etude

2.9. The new build costs are based on Currie & Brown's professional experience of project costs and are developed for typical average cost of the building typologies requested. These reflect an average construction capital cost per m^2 of Gross Internal Floor area (GIA) for each building typology.

2.10. As explained, the additional capital costs for fabric improvements are based on the new built-up of these construction elements (walls, roofs) while the costs of airtightness and thermal bridging are approximated based on the 'course-of-action' to address those noted by the technical team. In the case of airtightness, as the same technical measures were noted between the 1m3/m2h and 0.6m3/m2h targets, an allowance of 50% labour cost on top was used to indicate the additional potential effort required to achieve the lower target. Please note airtightness and thermal bridging additional costs heavily rely on the architectural design complexity, materials and construction methods selected.

2.11. In the case of the Mechanical & Electrical (M&E) heating and hot water solutions, the baseline system' s - combi gas boiler - size for each domestic model baseline was kept constant across all typologies, at 24kW, as per the technical specifications received. There is a notable change in the spec of the hot water cylinders (150L for semi-detached to 210 L in bungalows and detached properties). All transitions from a gas boiler to a heat pump led to a 5kW air-to-water heat pump in all domestic models, as per the technical specifications received.

2.12. Reasonable assumptions were made for the reduction of hot water distribution networks and radiator numbers in the more thermally efficient properties operating a heat pump.

2.13. Gas connection charges and potential electrical network upgrades (on-site) were made by the Currie & Brown M&E QSs teams based on typical projects. The only variation occurred in the case of the light industrial unit. A lump sum £30,000 (thirty thousand pounds) gas connection cost was allocated as an indicator, but this cost can hugely vary, based on location of the building and other factors.

2.14. Average cost uplifts (presented in %), derived from the additional cost uplift calculated combined with an 'average construction capital cost' for a baseline new-build building of each category (£/m2).

Running costs

2.15. In terms of running / operational costs, these refer to the cost of using each building. In effect this is a direct translation of total energy consumption per year to cost, using the Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal[2] for the years 2020 to 2080. Central retail prices were selected for domestic and non-domestic (commercial) models.

2.16. The total predicted energy consumption of each model was estimated by the technical team using the Passive House Planning Package (PHPP), both terms of gas and electricity. Total energy includes predicted 'regulated' and 'unregulated' energy use. Technical team outputs were used for this costing exercise.

2.17. The cost of renewable energy generation export (income) and gas and electricity standing charges were based on the SAP version 10.1 (September 2019) [3]. The export cost of renewable energy generation was maintained constant for the duration of the evaluation period.

2.18. As the models do not contain any direct energy storage facilities, 30% of the PV energy generation was assumed to be used directly on site and 70% was exported. Please note that all cost-benefits from the electricity export (and direct use) were allocated directly to the expected occupants /users and owners of the building as a cast saving in their energy bills.

Monetised future cost of carbon

2.19. The monetised future cost of carbon refers to the cost associated with carbon emissions (CO_2e) predicted to be emitted each year during the life of each building model for the predicted energy consumption and only. These do not include embodied carbon or lifecycle cost elements but include PV generation.

2.20. They derive from the translation of the predicted total energy consumption, and energy mix used, per building per year for all scenarios to carbon emissions (CO_2e). The conversion of energy use to CO_2e is based on government approved carbon factors for 2020 to 2080 (Green Book supplementary guidance, Table 1 of the guidance document) for electricity, while for gas the carbon factor 0.216 kg/ kWh, as per the Standard Assessment Procedure SAP 2012 version 9.92 (October 2013, Table 12, page 225, is used and was retained constant during the whole period of evaluation (2020-2080) [4].

2.21. The Net Present Value calculations use a standard discount factor of 3.5%.

2.22. Predicted total energy use per year as explains includes all energy uses (and the occupant's lifestyle). For additional information on prediction methods used, please refer to the technical report.

2.23. According to the technical modelling team, models allow for a 'reasonable baseline level of consumption, while it is openly acknowledged that actual consumption may be higher than the assumed due to user behaviour or voluntary selection of inefficient appliances. The baseline selected represents a sensible level of consumption that can reasonably be achieved if the occupant desires.'

Evaluated scenarios

2.24. Sketches of the architypes used are shown in Figure 2 to Figure 6. All scenarios reviewed and costed are shown in summary below:
Table *1* to Table 5.
These include:

- The semi-detached standard (SDS). It contains two thermal performance upgrades in terms of heating requirements (15[5] kWh/m2/yr and 30 kWh/m2/yr).

  It also includes the upgrade of the gas boiler to a heat pump solution for each heating requirement, and an alternative upgrade of the gas boiler to direct electric.

  The capacity of the photovoltaic panels (PV) in all models remain the same while the baseline does not contain any PV.

- The semi-detached optimised (SDO). It contains two thermal performance upgrades in terms of heating requirement (15-20 kWh/m2/yr and 30 kWh/m2/yr)

[2] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal
[3] https://www.bregroup.com/wp-content/uploads/2019/11/SAP-10.1-08-11-2019_1.pdf
[4] https://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf
[5] 15-20 kWh/m2/yr, we used a naming convention of 15 kWh/m2/yr in all relevant models in the graphs. All upgrades, energy and carbon cost savings reflect the exact models as provided by the technical team.

It also includes the upgrade of the gas boiler to a heat pump solution for each heating requirement, and an alternative upgrade of the gas boiler to direct electric, for each heating requirement.
The capacity of the photovoltaic panels (PV) varies between the models, while the baseline does not contain any PV.

- The bungalow (BL). It contains two thermal performance upgrades in terms of heating requirement (15-20 kWh/m2/yr and 30 kWh/m2/yr)
  It also includes the upgrade of the gas boiler to a heat pump solution for each heating requirement, and an alternative upgrade of the gas boiler to direct electric, for each heating requirement.
  The capacity of the photovoltaic panels (PV) varies between the models, while the baseline does not contain any PV.

- The detached (DT). It contains two thermal performance upgrades in terms of heating requirement (15-20 kWh/m2/yr and 30 kWh/m2/yr)
  It also includes the upgrade of the gas boiler to a heat pump solution for each heating requirement, and an alternative upgrade of the gas boiler to direct electric, for each heating requirement.
  The capacity of the photovoltaic panels (PV) varies between the models, while the baseline does not contain any PV.

- The light industrial unit (LIU). It contains one thermal performance upgrade in terms of heating requirement (‘improved’).
  It also includes the upgrade of the gas fan heaters to a direct electric fan heater, in one scenario tested and the upgrade of the gas fan heaters to a direct radiant heater in a second scenario (both are based on one fabric upgrade).
  The capacity of the photovoltaic panels (PV) varies between the models, while the baseline does not contain any PV.

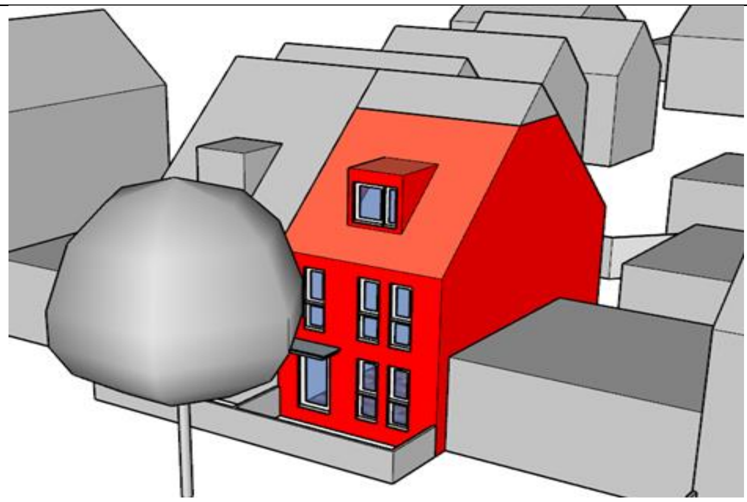

Figure 2 Semi-detached standard (SDS)

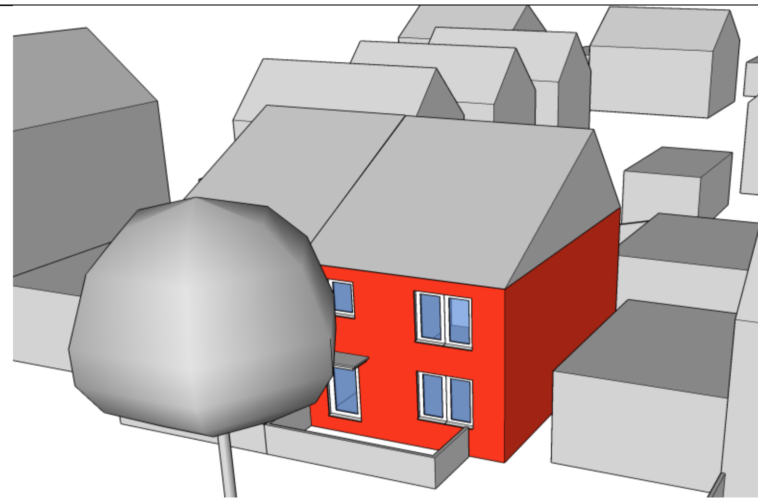

Figure 3 - Semi-detached optimised (SDO)

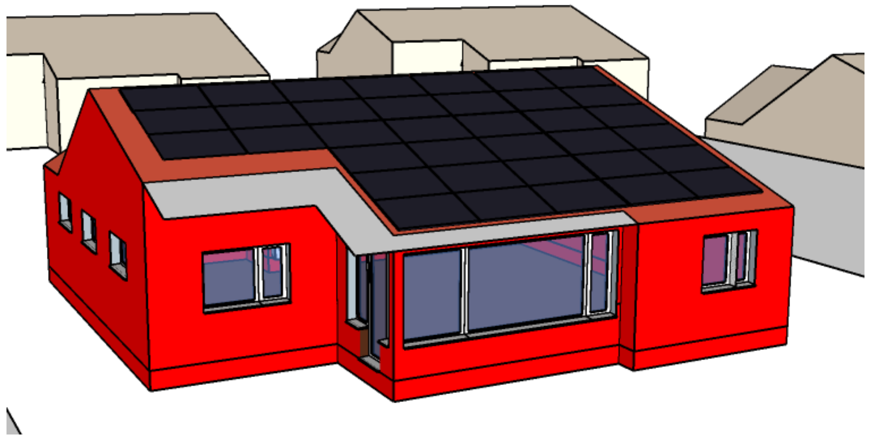

Figure 4 - Bungalow (BL)

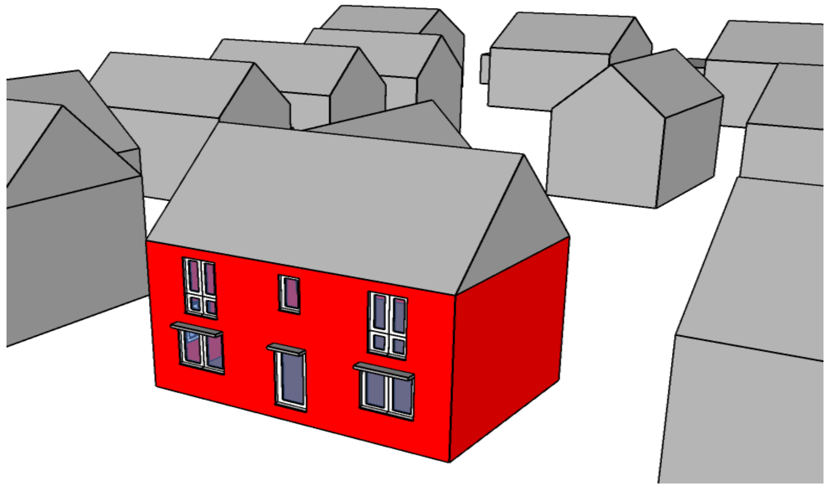

Figure 5 - Detached (DT)

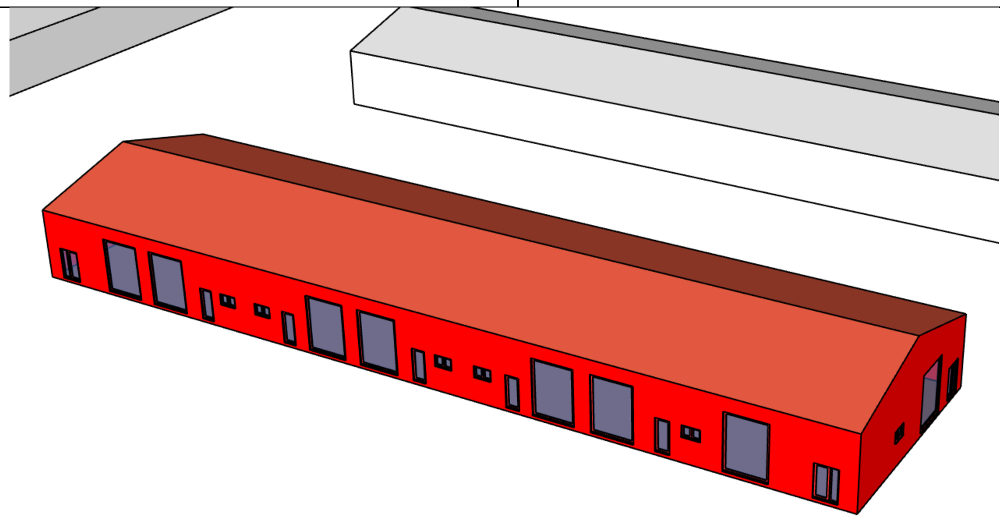

Figure 6 - Light industrial unit (LIU)

Table 1 - Scenarios applied to the semi-detached standard house model

Type	Short	Baseline	Baseline Energy	Scenario 1 15 kWh/m2/yr	Scenario 2 30 kWh/m2/yr
Semi-detached Standard	**SDS**	Current practise	Gas boiler & electricity	▪ 15 kWh/m2/yr. ▪ Improved fabric ▪ Heat pump ▪ PV **2.72 kWp**	▪ 30 kWh/m2/yr. ▪ Improved fabric ▪ Heat pump ▪ PV **2.72 kWp**
				Scenario 3 15 kWh/m2/yr	**Scenario 4 30 kWh/m2/yr**
				▪ 15 kWh/m2/yr. ▪ Improved fabric ▪ Direct electric ▪ PV **2.72 kWp**	▪ 30 kWh/m2/yr. ▪ Improved fabric ▪ Direct electric ▪ PV **2.72 kWp**

Table 2 - Scenarios applied to the semi-detached optimised house model

Type	Short	Baseline	Baseline Energy	Scenario 1 15 kWh/m2/yr	Scenario 2 30 kWh/m2/yr
Semi-detached Optimised	**SDO**	Current practise	Gas boiler & electricity	▪ 15 kWh/m2/yr. ▪ Improved fabric ▪ Heat pump ▪ PV **2.72 kWp**	▪ 30 kWh/m2/yr. ▪ Improved fabric ▪ Heat pump ▪ PV **3.06 kWp**
				Scenario 3 15 kWh/m2/yr	**Scenario 4 30 kWh/m2/yr**
				▪ 15 kWh/m2/yr. ▪ Improved fabric ▪ Direct electric ▪ PV **4.08 kWp**	▪ 30 kWh/m2/yr. ▪ Improved fabric ▪ Direct electric ▪ PV **5.10 kWp**

Table 3 - Scenarios applied to the bungalow house model

Type	Short	Baseline	Baseline Energy	Scenario 1 15 kWh/m2/yr	Scenario 2 30 kWh/m2/yr
Bungalow	**BL**	Current practise	Gas boiler & electricity	▪ 15-20 kWh/m2/yr. ▪ Improved fabric ▪ Heat pump ▪ PV **3.40 kWp**	▪ 30 kWh/m2/yr. ▪ Improved fabric ▪ Heat pump ▪ PV **3.74 kWp**
				Scenario 3 15 kWh/m2/yr	**Scenario 4 30 kWh/m2/yr**
				▪ 15-20 kWh/m2/yr. ▪ Improved fabric ▪ Direct electric ▪ PV **5.44 kWp**	▪ 30 kWh/m2/yr. ▪ Improved fabric ▪ Direct electric ▪ PV **6.12 kWp**

Table 4 - Scenarios applied to the detached house model

Type	Short	Baseline	Baseline Energy	Scenario 1 15 kWh/m2/yr	Scenario 2 30 kWh/m2/yr
Detached	**DT**	Current practise	Gas boiler & electricity	▪ 15-20 kWh/m2/yr. ▪ Improved fabric ▪ Heat pump ▪ PV **3.74 kWp**	▪ 30 kWh/m2/yr. ▪ Improved fabric ▪ Heat pump ▪ PV **4.08 kWp**
				Scenario 3 15 kWh/m2/yr	**Scenario 4 30 kWh/m2/yr**
				▪ 15-20 kWh/m2/yr. ▪ Improved fabric ▪ Direct electric ▪ PV **6.12 kWp**	▪ 30 kWh/m2/yr. ▪ Improved fabric ▪ Direct electric ▪ PV **7.14 kWp**

Table 5 - Scenarios applied to the light industrial unit (non-domestic model)

Type	Short	Baseline	Baseline Energy	Scenario 1 'Improved'
Light industrial unit	**LIU**	Current practise	Gas fan heaters & Electricity	▪ 'Improved' ▪ Improved fabric - same in both scenarios ▪ Electric fan heaters ▪ PV **116 kWp**
				Scenario 2 'Improved'
				▪ 'Improved' ▪ Improved fabric - same in both scenarios ▪ Electric radiant heaters ▪ PV **112 kWp**

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3 Capital cost models results

The capital cost impact of the different models was assessed for all cases.

Chapter notes

Please refer to Cost assumptions chapter for further information on the method for the evaluation of capital costs.

3.1. In terms of high-level notes, these include:

- The baselines assume no PV, which aligns with the Central Lincolnshire Adopted Local Plan (2017). It is unclear if the new proposed Local Plan (2019) will include a minimum % of renewable energy generation using solar panels (Merton type of rule[6]) as a mandatory requirement. Within the Central Lincolnshire Local Plan Issues and Options Consultation Report (September 2019)[7], page 14 it is noted: 'Policy LP19 – Renewable Energy Projects: Renewables should always be encouraged, and this policy needs to be amended to encourage developers to provide solar panels on all new developments where feasible'. If such a requirement is added, then part of the additional capital cost attributed to the use of photovoltaic panels (PV) in the different models within this report might become redundant as developers would be required to add these elements to the new developments as a baseline.
- The fabric capital cost uplift of each model was calculated following an elemental approach. The make up of the fabric elements was provided to Currie & Brown by the technical team.
- Typical new-built costs were produced by Currie & Brown irrespective of the specifications in the models, to evaluate the impact of the different potential improvement solutions as a % over a new built cost.
- Areas of cost such as airtightness and thermal bridging can vary significant based on the design and construction strategy used. The technical team provided information to Currie & Brown as to the solutions sought for each model. These technical specifications were used to cost these elements.
- Gas connection costs will vary between locations and typologies. Average indicative costs are used in this section, as per the Currie & Brown project experience.
- Electrical upgrades in terms of cabling for the heat pump and direct electric solutions may vary, these are used as average cost in the report.
- The effect of generation and all electric solutions, associated costs to sub-stations, is not included as it is unknown (location and installation specific)

[6] The Merton Rule is a prescriptive planning policy that requires new developments to generate at least 10% of their energy needs from on-site renewable energy equipment. A number of local authorities have included such requirements within their local plans.
[7] https://www.n-kesteven.gov.uk/_resources/assets/attachment/full/0/92909.pdf

Capital cost results

Additional capital cost

3.2. The following tables show all additional costs (2020) calculated for the different buildings.

Table 6 - Semi-detached standard house (SDS) - Additional capital cost - models

Building	Model Name	Heating system
SDS	15 kWh/m2/yr	Option 1: Heat pump and PV
Additional capital cost	£ 13,820	
SDS	30 kWh/m2/yr	Option 1: Heat pump and PV
Additional capital cost	£ 9,680	
SDS	15 kWh/m2/yr	Option 2: Direct electric and PV
Additional capital cost	£8,925	
SDS	30 kWh/m2/yr	Option 2: Direct electric and PV
Additional capital cost	£ 4,580	

Table 7 - Semi-detached optimised house (SDO) - Additional capital cost - models

Building	Model Name	Heating system
SDO	15 kWh/m2/yr	Option 1: Heat pump and PV
Additional capital cost	£ 11,235	
SDO	30 kWh/m2/yr	Option 1: Heat pump and PV
Additional capital cost	£ 8,260	
SDO	15 kWh/m2/yr	Option 2: Direct electric and PV
Additional capital cost	£ 7,345	
SDO	30 kWh/m2/yr	Option 2: Direct electric and PV
Additional capital cost	£ 4,675	

Table 8 - Bungalow (BL) - Additional capital cost - models

Building	Model Name	Heating system
Bungalow	15-20 kWh/m2/yr	Option 1: Heat pump and PV
Additional capital cost	£ 18,030	
Bungalow	30 kWh/m2/yr	Option 1: Heat pump and PV
Additional capital cost	£ 13,930	
Bungalow	15-20 kWh/m2/yr	Option 2: Direct electric and PV
Additional capital cost	£ 14,375	
Bungalow	30 kWh/m2/yr	Option 2: Direct electric and PV
Additional capital cost	£ 10,260	

Table 9 - Detached house (DT) - Additional capital cost - models

Building	Model Name	Heating system
Detached	15-20 kWh/m2/yr	Option 1: Heat pump and PV
Additional capital cost	£ 16,110	
Detached	30 kWh/m2/yr	Option 1: Heat pump and PV
Additional capital cost	£ 12,445	
Detached	15-20 kWh/m2/yr	Option 2: Direct electric and PV
Additional capital cost	£ 13,145	
Detached	30 kWh/m2/yr	Option 2: Direct electric and PV
Additional capital cost	£ 9,270	

Table 10 - Light industrial unit (LIU) - Additional capital cost - models

Building	Model Name	Heating system
Light industrial unit	Improved	Option 1: Electric fan heaters
Additional capital cost	£ 67,620	
Detached	Improved	Option 2: Electric radiant heaters
Additional capital cost	£ 77,310	

Capital cost increase

3.3. The following rates were calculated based on the following new building rates, Table 11:

Table 11 - New building rates used in this report.

New Building type	£/m2 of GIA
Semi-detached house	£ 1,260 / m^2
Bungalow	£ 1,430 / m^2
Detached house	£ 1,680 / m^2
Light industrial unit	£ 890 / m^2

SDS and SDO Additional capital cost and breakdown

3.4. The cost uplift for the different scenarios developed was calculated and is shown in Figure 7 to Figure 13 in detail.

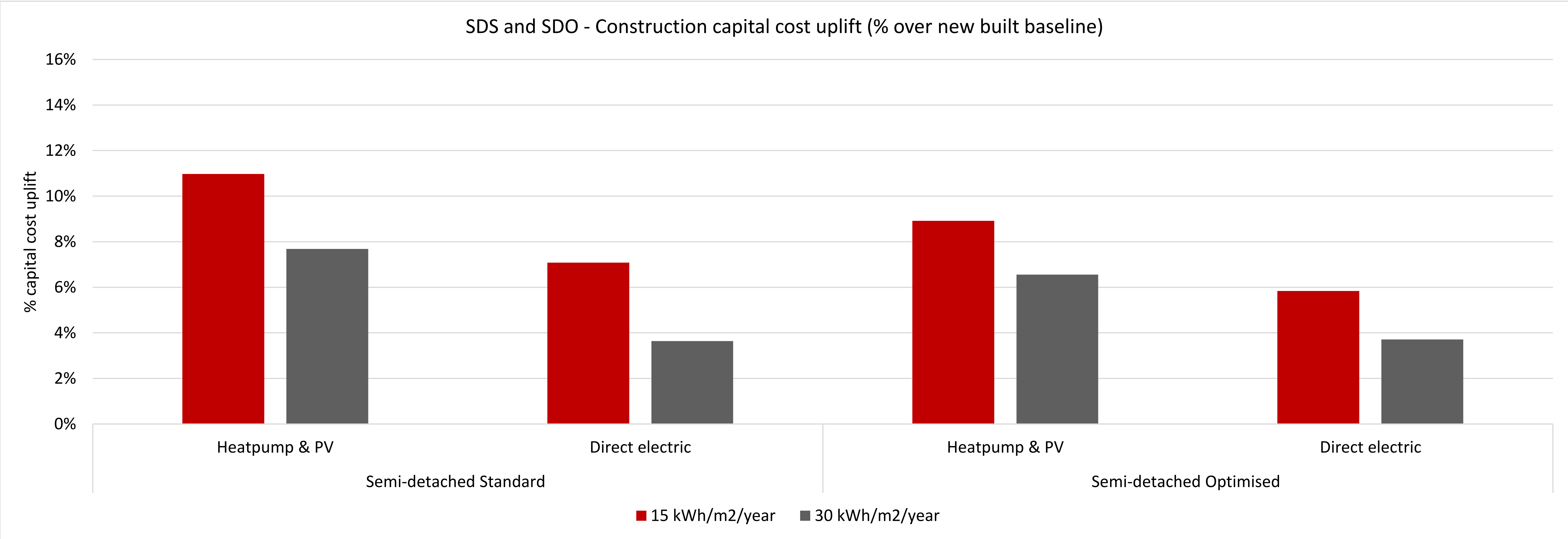

Figure 7 - SDS and SDO capital cost uplifts based on average new built cost and modifications as per the technical specifications received

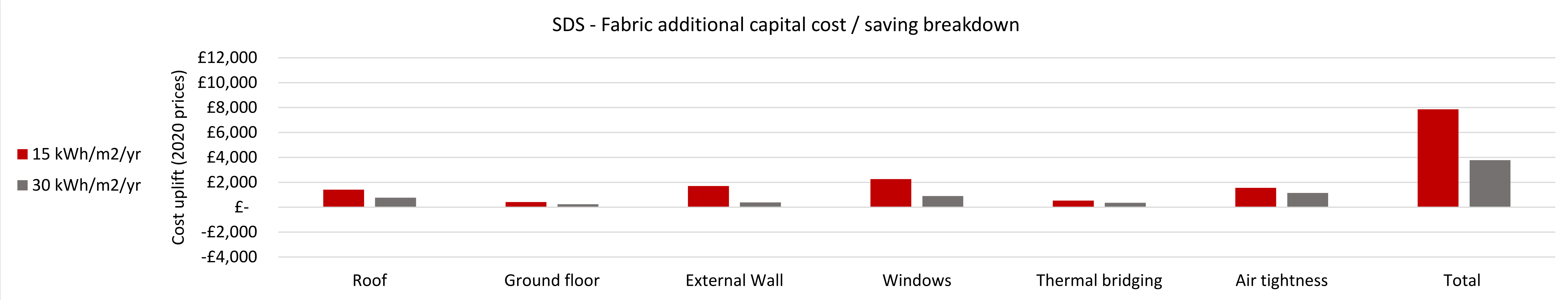

Figure 8 - SDS - Additional capital cost / savings - fabric (thermal envelope) improvements - total fabric upgrade cost ~15kWh/m2/year: £7,866 ~ 30kWh/m2/year: £3,775

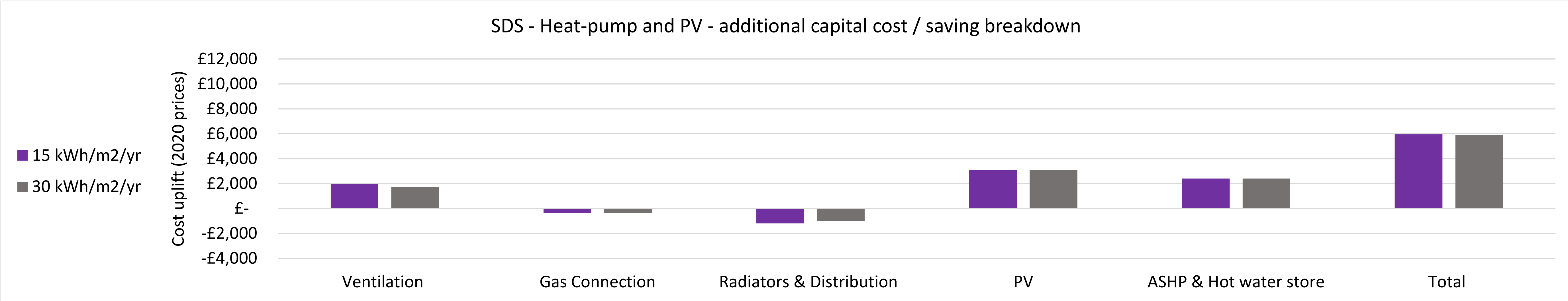

Figure 9 - SDS - Additional capital cost / savings - Heat pump and PV improvements - total M&E upgrade cost ~15kWh/m2/year: £5,954 ~ 30kWh/m2/year: £5,904

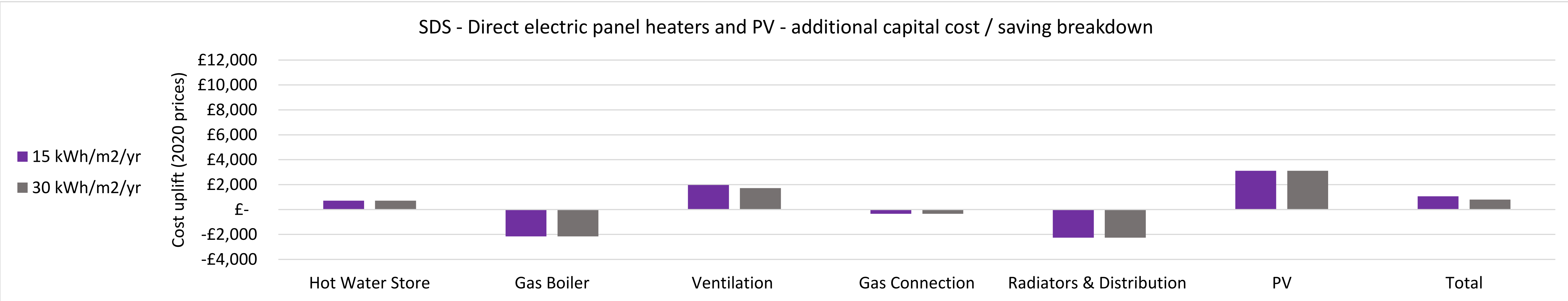

Figure 10 - SDS - Additional capital cost / savings - Direct electric panel heaters and PV improvements - total M&E upgrade cost ~15kWh/m2/year: £1,058 ~ 30kWh/m2/year: £808

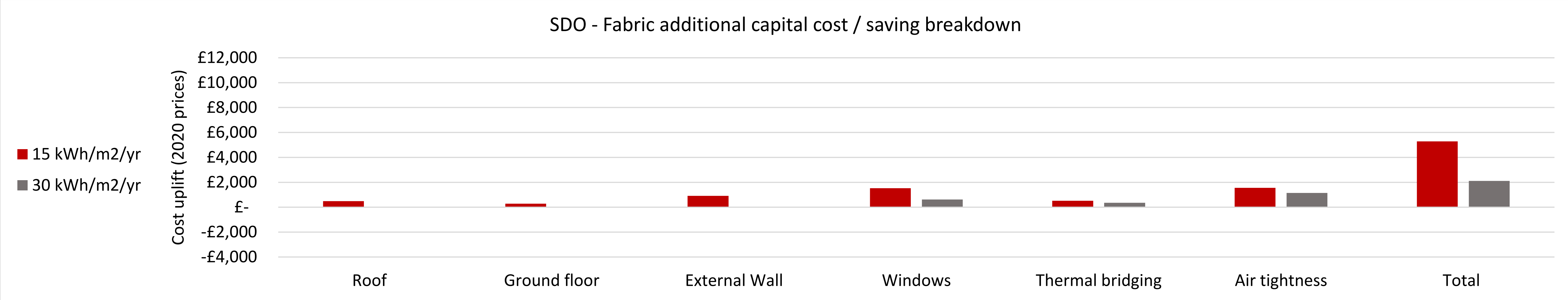

Figure 11 - SDO - Additional capital cost / savings - fabric (thermal envelope) improvements - total fabric upgrade cost ~15kWh/m2/year: £5,283 ~ 30kWh/m2/year: £2,106

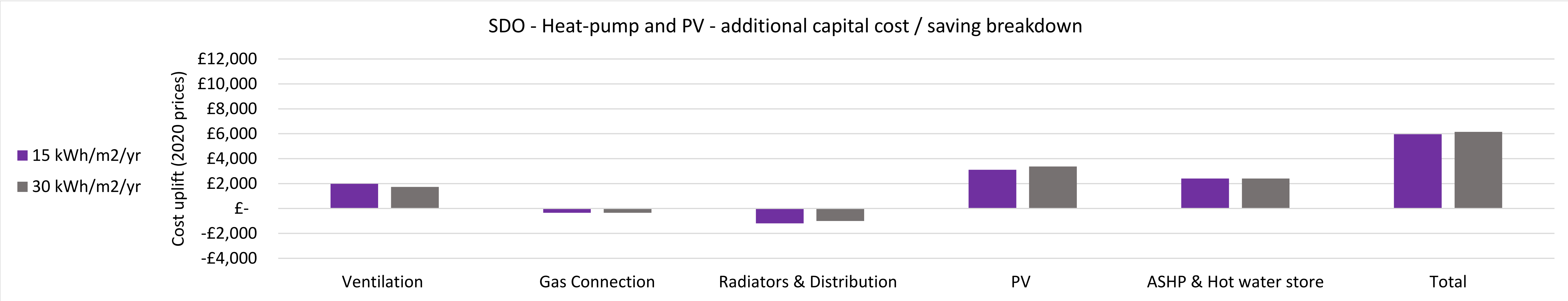

Figure 12 - SDO - Additional capital cost / savings - Heat pump and PV improvements - total M&E upgrade cost ~15kWh/m2/year: £5,954 ~ 30kWh/m2/year: £6,155

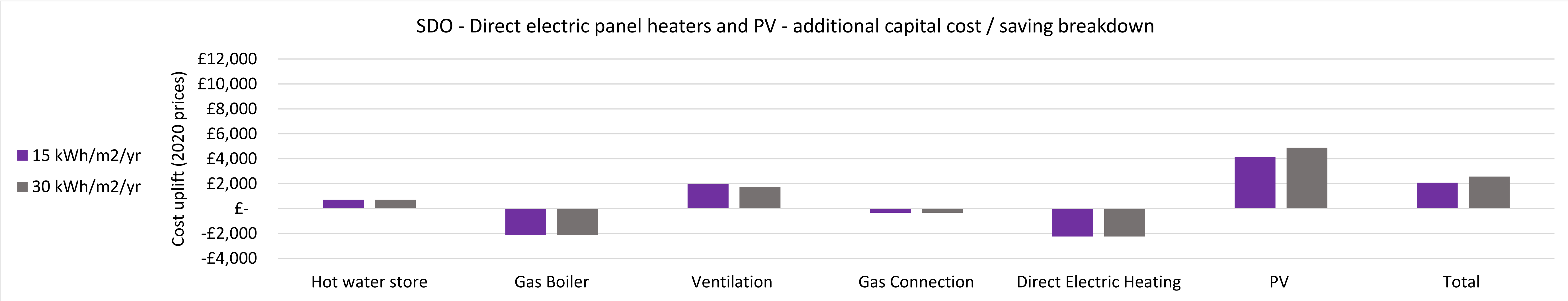

Figure 13 - SDO - Additional capital cost / savings - Direct electric panel heaters and PV improvements - total M&E upgrade cost ~15kWh/m2/year: £2,064 ~ 30kWh/m2/year: £2,569

BL and DT Additional capital cost and breakdown

3.5. The cost uplift for the different scenarios developed was calculated and is shown in Figure 14 to Figure 20 in detail.

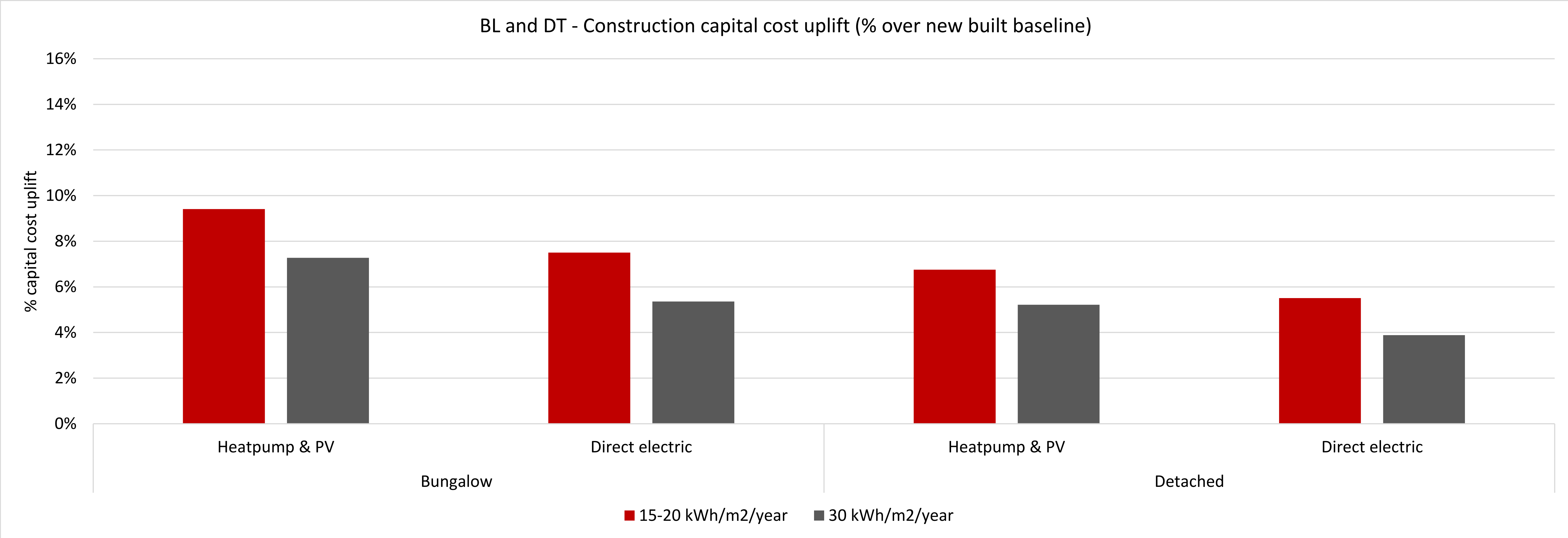

Figure 14 - BL and DT capital cost uplifts based on average new built cost and modifications as per the technical specifications received

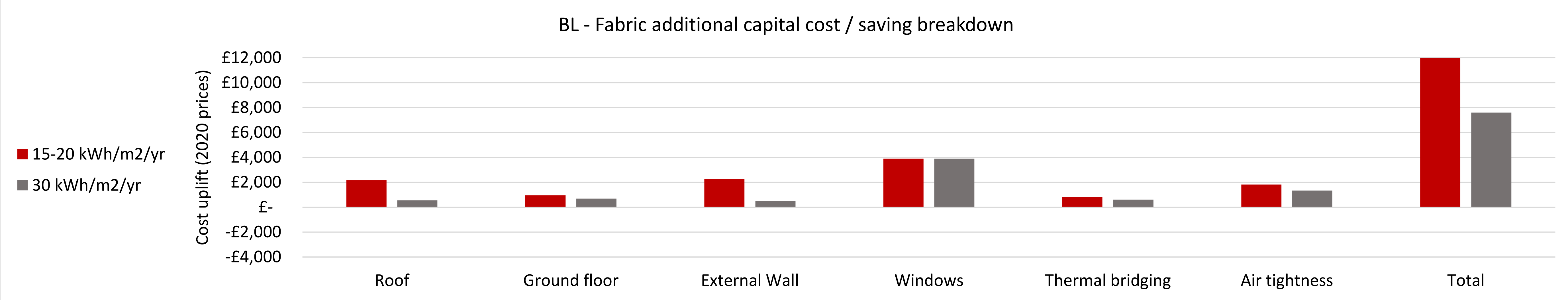

Figure 15 - BL - Additional capital cost / savings - fabric (thermal envelope) improvements - total fabric upgrade cost ~15kWh/m2/year: £11,963 ~ 30kWh/m2/year: £7,595

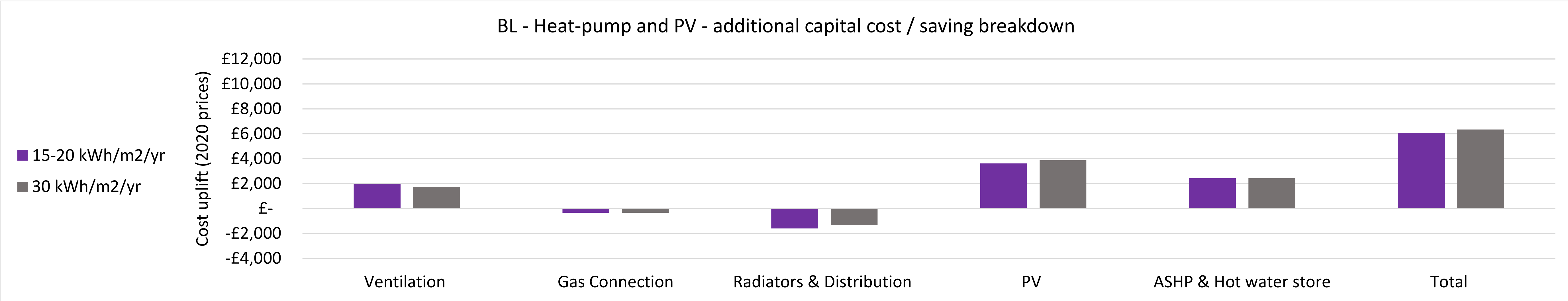

Figure 16 - BL - Additional capital cost / savings - Heat pump and PV improvements - total M&E upgrade cost ~15kWh/m2/year: £6,067 ~ 30kWh/m2/year: £6,337

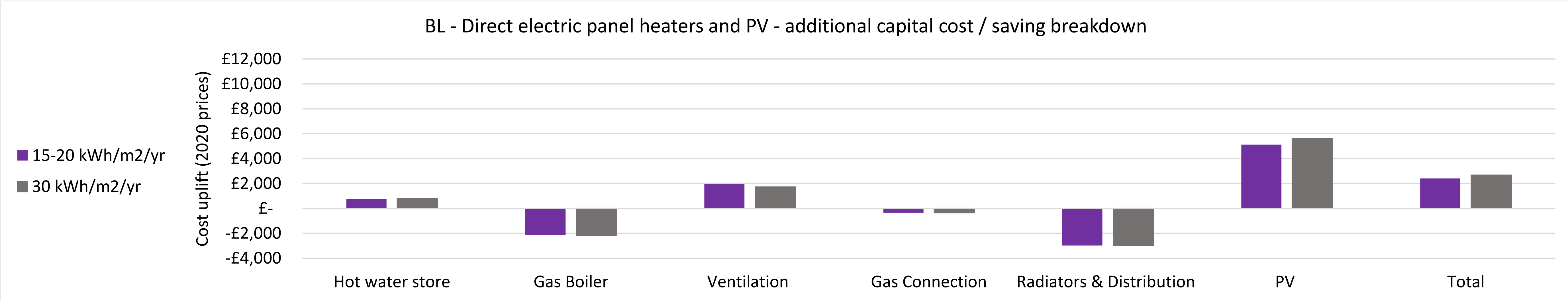

Figure 17 - BL - Additional capital cost / savings - Direct electric panel heaters and PV improvements - total M&E upgrade cost ~15kWh/m2/year: £2,414 ~ 30kWh/m2/year: £2,667

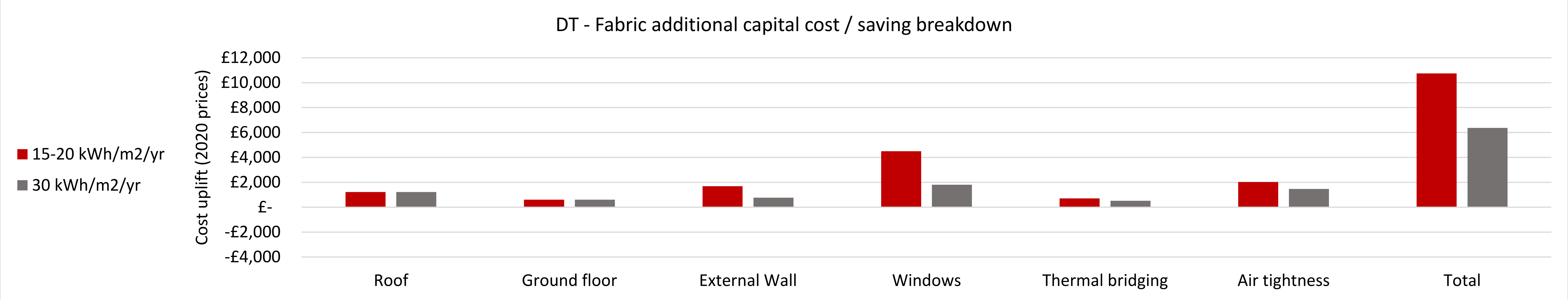

Figure 18 - DT - Additional capital cost / savings - fabric (thermal envelope) improvements - total fabric upgrade cost ~15kWh/m2/year: £10,744 ~ 30kWh/m2/year: £6,362

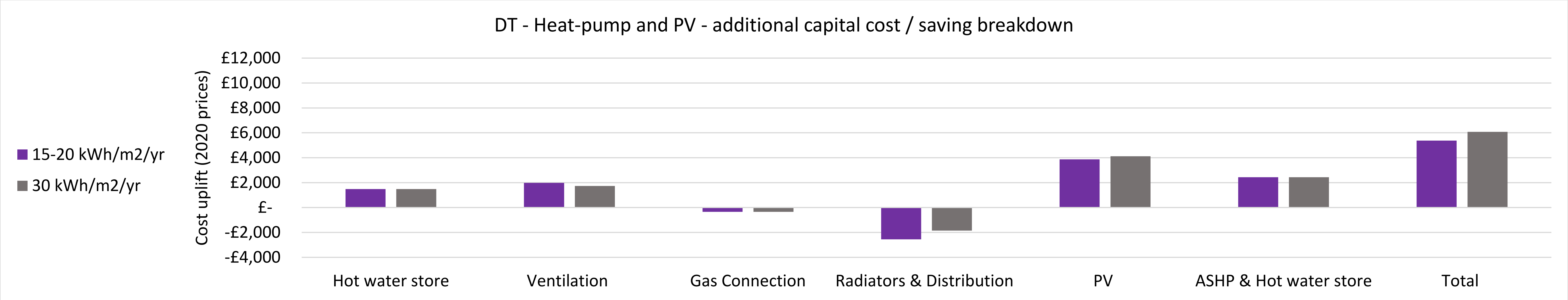

Figure 19 - DT - Additional capital cost / savings - Heat pump and PV improvements - total M&E upgrade cost ~15kWh/m2/year: £5,371 ~ 30kWh/m2/year: £6,082

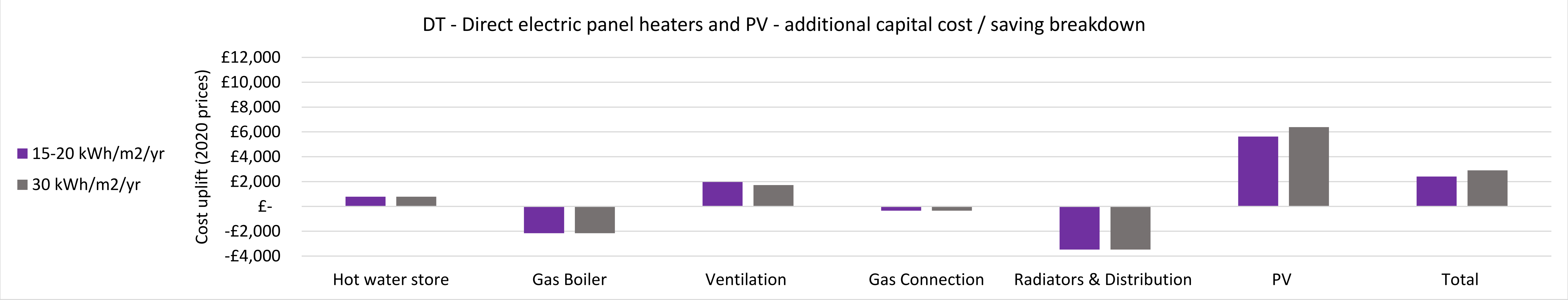

Figure 20 - DT - Additional capital cost / savings - Direct electric panel heaters and PV improvements - total M&E upgrade cost ~15kWh/m2/year: £2,402 ~ 30kWh/m2/year: £2,907

LIU Additional capital cost and breakdown

3.6. The cost uplift for the different scenarios developed was calculated and is shown in Figure 21 to Figure 24 in detail.

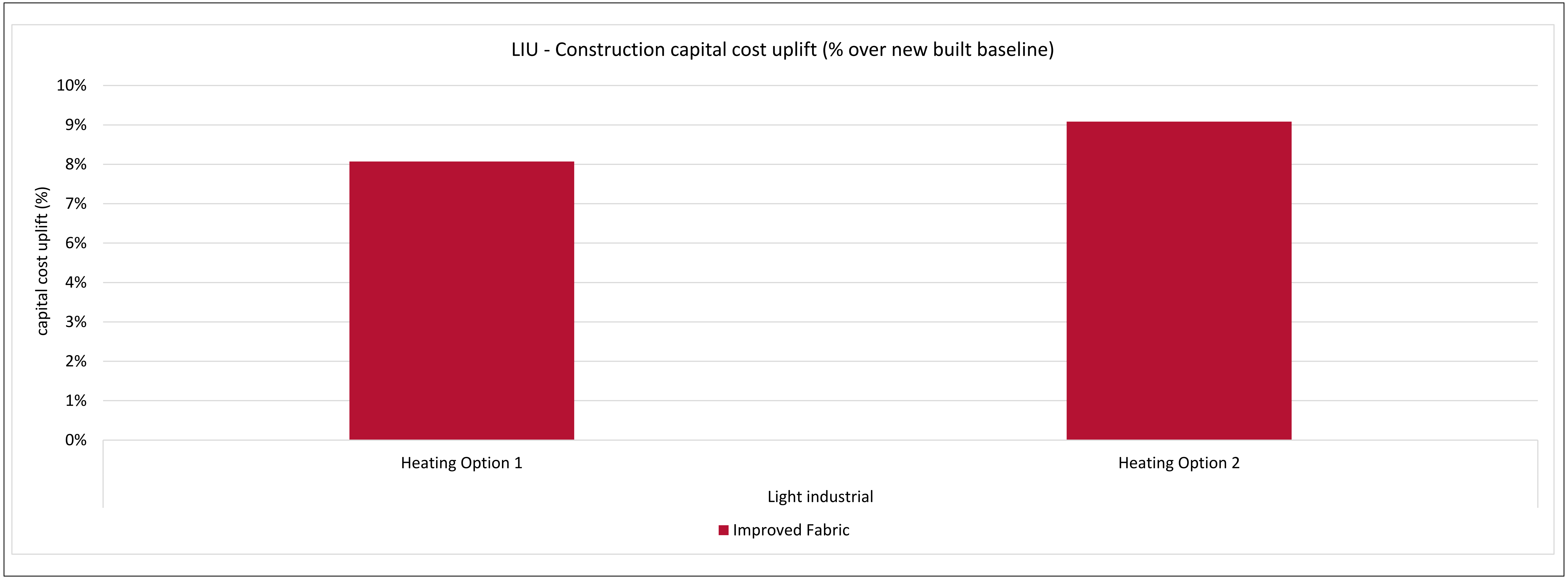

Figure 21 - BL and DT capital cost uplifts based on average new built cost and modifications as per the technical specifications received

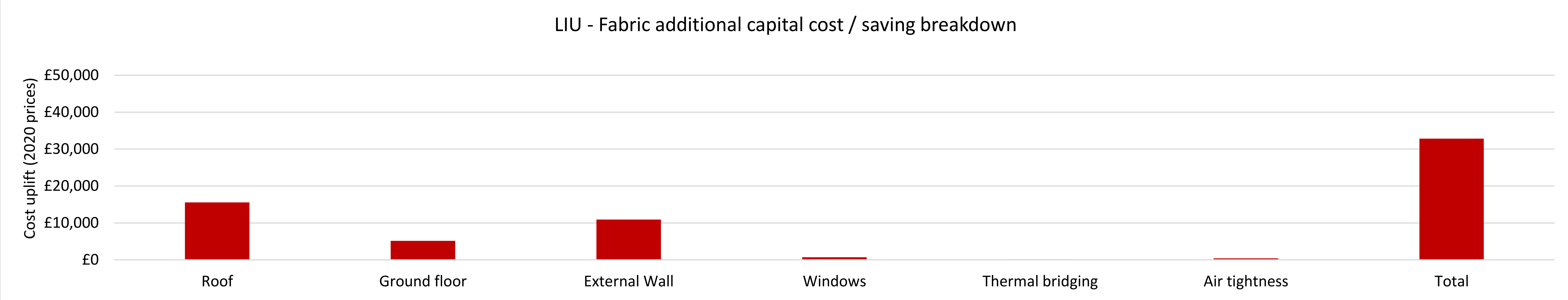

Figure 22 - LIU - Additional capital cost / savings - fabric (thermal envelope) improvements - total fabric upgrade cost ~£32,839

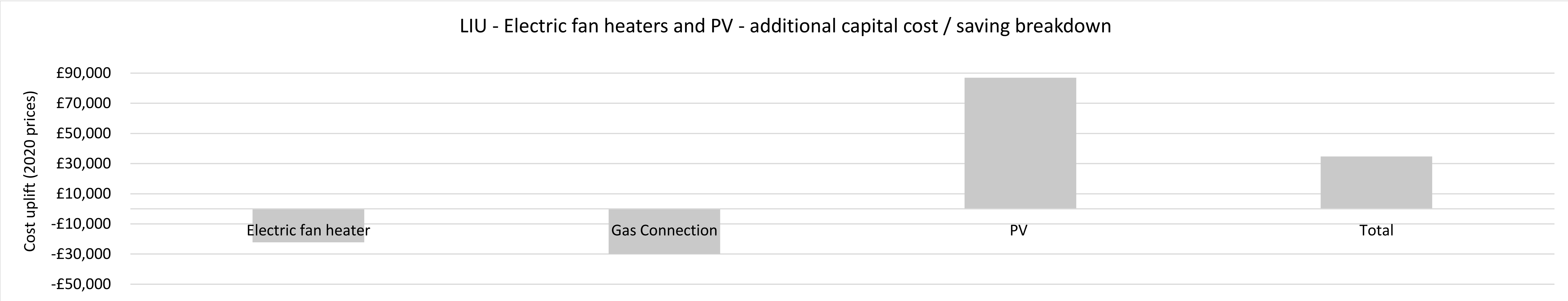

Figure 23 - LIU - Additional capital cost / savings - Direct electric fan heaters - total M&E upgrade cost ~£34,782

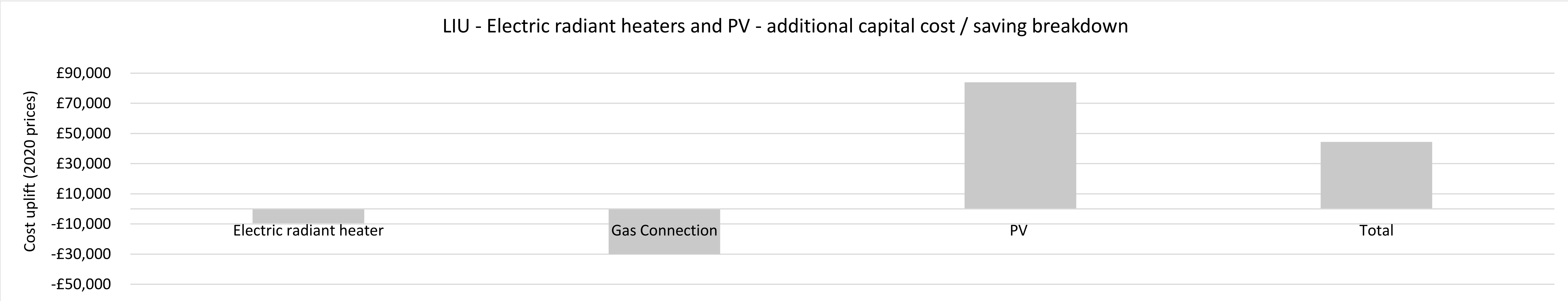

Figure 24 - LIU - Additional capital cost / savings - Direct electric radiant heaters - total M&E upgrade cost ~£44,472

4 Running / operational costs - evaluation

Chapter notes

Please refer to Cost assumptions for further information on the evaluation of costs.

4.1. In terms of high-level notes, these include:

- The baseline assumes no PV, but the local plan might include a 'Merton' type rule for renewables not accounted for in these calculations (see page 12 of this report).
- While total energy demand reduction was key to reducing annual energy costs (mainly through a reduction in the heating requirement), the move to all electric means that there is a factor of 3-4 in energy demand reduction required to make annual energy costs similar to those when using gas (due to the cost of electricity). Very energy efficient homes should be able to make use of off-peak tariffs and thereby reduce the multiplier. Also, it is worth noting that the ASHP delivers a proportion of this multiplier (not the same for direct electric).
- A significant, to running energy consumption costs, reduction contribution was allocated to PV, Annual operational energy consumption cost to the user is predicted by assuming that all PV benefits are directly attributed to the user. In the case of another entity operating the PV installations and generation, benefiting from the sale of energy, the 'without PV' annual cost scenarios in all instances of improved fabric and system options might apply.
- The operational cost to the user, has been estimated using future energy prices[8]. The per year expenditure refers to an average cost taking into consideration the predicted energy cost per year of future operational energy consumption related costs.
- SAP 10.1 values were used to assess the gas standing charge (£88 per year), the electricity standing charge (£72 per year) and the £/kWh of PV generation export (£0.053 per kWh). The same were applied to the small industrial unit.
- In terms of PV generation, it was assumed that 30% will be directly used by the property, while 70% will be exported to the grid (no energy storage provisions).
- PV electricity generation export at £0.053 /kWh is low when compared to the cost of electricity (£0.18-0.19 / kWh). This demonstrates that PV direct use on site should always be prioritised over export.

Please see **Appendix - Running costs based on annual energy consumption (2020-2080) V additional capital costs graphs** for the relationship between annual energy cost V capital cost.

[8] Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal, accessed October 2020

Running/ operational predicted energy consumption cost results

Average running cost per year

4.2. This is estimated based on years 2020-2080 average annual expenditure on energy (costs include standing charges). Costs also include energy savings and cost savings due to the use of PV (direct use and export). Results are shown below (Figure 25 - Figure 29) in detail.

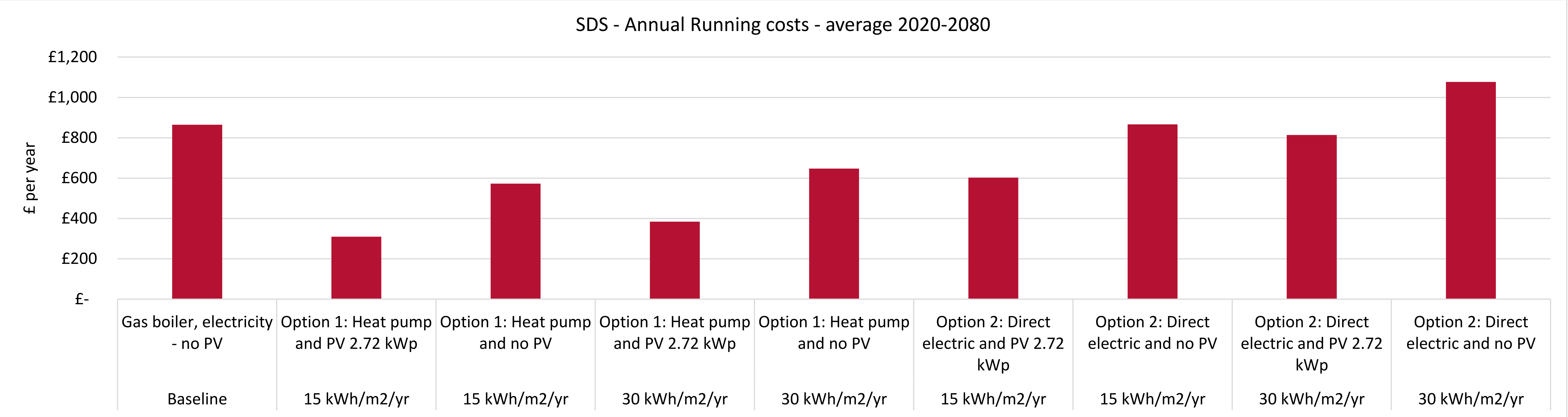

Figure 25 - Predicted annual running cost (average 2020-2080) for the energy requirements of SDS models. The operational cost model does not account for lifecycle costs as in the form of repairs, maintenance, and replacement of elements. The consumption per year is maintained constant during the period of evaluation.

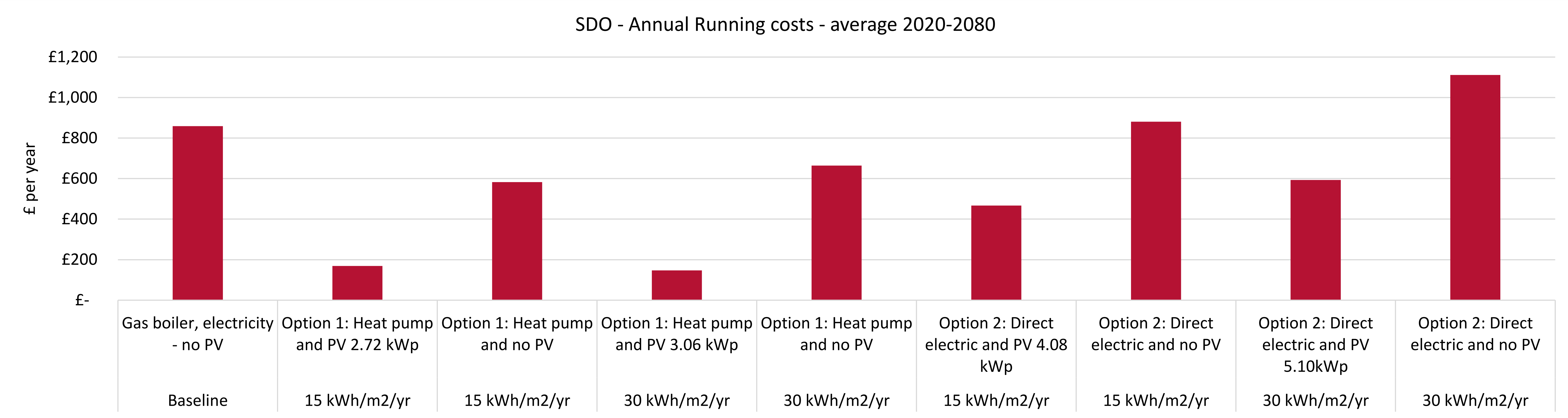

Figure 26- Predicted annual running cost (average 2020-2080) for the energy requirements of SDO models. The operational cost model does not account for lifecycle costs as in the form of repairs, maintenance, and replacement of elements. The consumption per year is maintained constant during the period of evaluation.

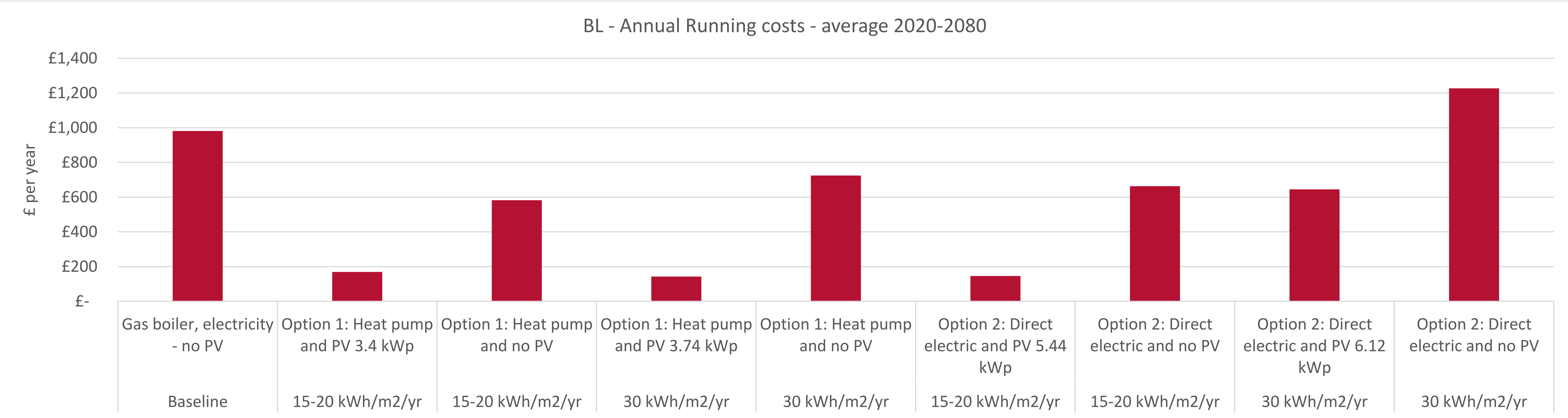

Figure 27 - Predicted annual running cost (average 2020-2080) for the energy requirements of BL models. The operational cost model does not account for lifecycle costs as in the form of repairs, maintenance, and replacement of elements. The consumption per year is maintained constant during the period of evaluation.

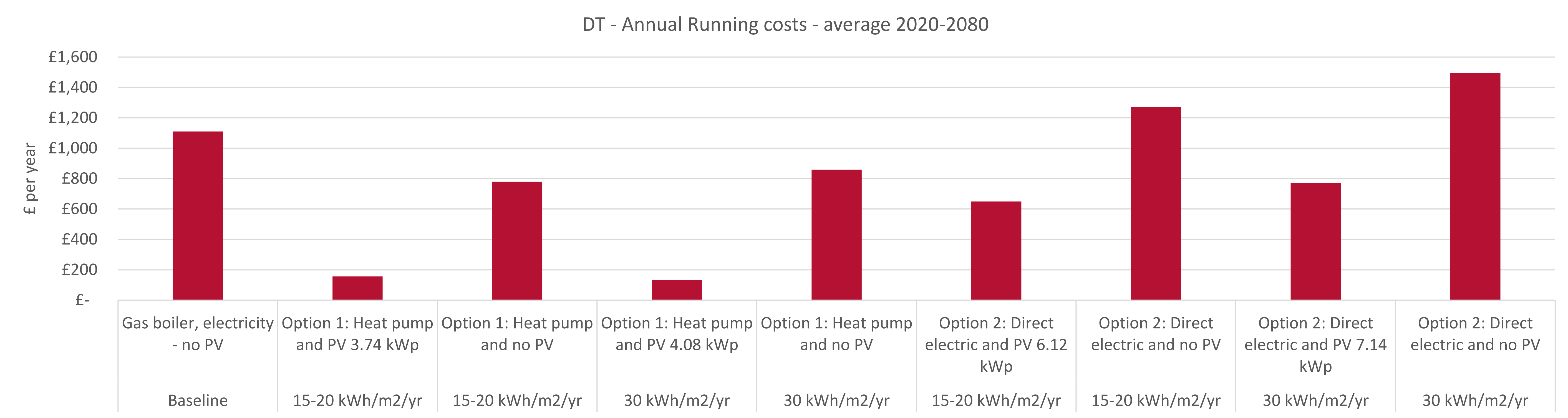

Figure 28 - Predicted annual running cost (average 2020-2080) for the energy requirements of DT models. The operational cost model does not account for lifecycle costs as in the form of repairs, maintenance, and replacement of elements. The consumption per year is maintained constant during the period of evaluation.

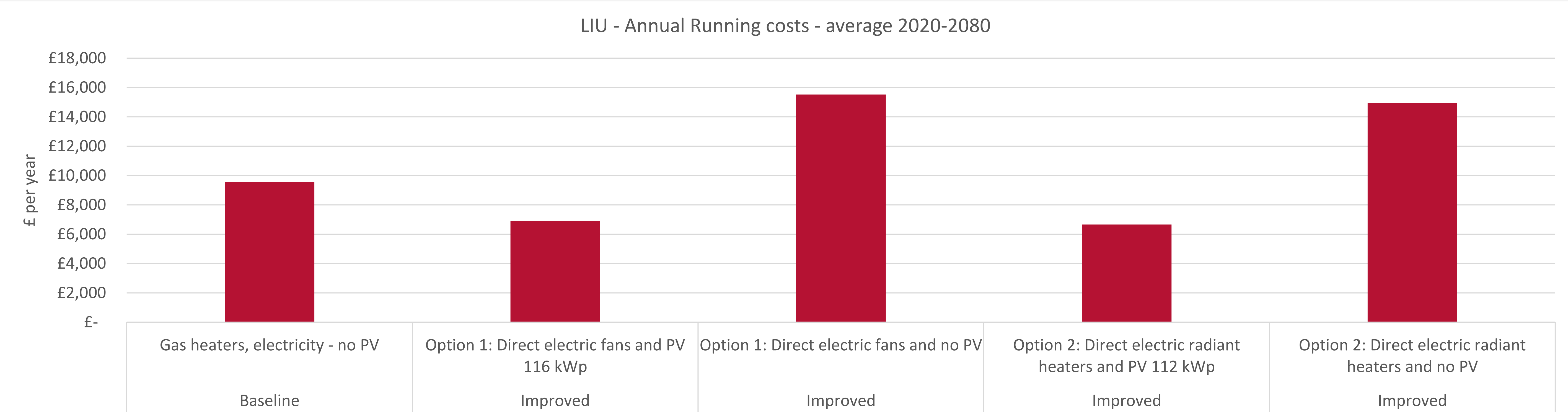

Figure 29 - Predicted annual running cost (average 2020-2080) for the energy requirements of LIU models. The operational cost model does not account for lifecycle costs as in the form of repairs, maintenance, and replacement of elements. The consumption per year is maintained constant during the period of evaluation.

5 Carbon emissions and their monetised impact

Chapter notes

Please refer to Cost assumptions for further information on the evaluation of costs.

5.1. In terms of high-level notes, these include:

- The HMRC Green Book[9] carbon factors for electricity and gas were used. In addition, the central prices of non-traded carbon were used to estimate the cost of carbon in the future
- While these costs are not associated with capital cost increases, they provide a good indicator of potential operational cost impact of carbon (if the regulations for example would require the emitter to be penalised, and therefor pay a CO_2e fee based on the non-traded CO_2e central price per year).
- Please note, for PV generation the CO_2e factors are assumed to follow the electricity grid CO_2e emissions factors. This gives an inherited advantage to all electric home solutions since the total energy demand can be balanced with generation.
- In addition, the electricity grid is expected to continue to decarbonise and therefore the associated CO_2e with electricity consumption are reducing along. This is not the case with the baseline which utilises a gas boiler (fossil fuel).

[9] Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal, accessed October 2020, https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

Carbon emissions and their monetised value

5.3. All results are provided in Table 12 to Table 16 below.

Table 12 - SDS model - Carbon emissions and their monetised impact. Carbon emissions were predicted using appropriate Green Book carbon emission factors for electricity and SAP 2012 version 9.92 (October 2013) carbon factors for gas (constant throughout the evaluation period).

Building	Model Name	Heating system	Total CO2e 2020-2080 (tCO2e)	Average per year (tCO2e)	Total accumulated[10] cost of tCO2e	Net Present Value cost[11] of tCO2e total
SDS	Baseline	Gas boiler, electricity - no PV	98.66	1.62	£ 21,729	£ 6,627
SDS	15 kWh/m2/yr	Option 1: Heat pump and PV 2.72 kWp	-0.40	-0.01	-£ 68	-£ 26
SDS	30 kWh/m2/yr	Option 1: Heat pump and PV 2.72 kWp	0.71	0.01	£ 120	£ 47
SDS	15 kWh/m2/yr	Option 2: Direct electric and PV 2.72 kWp	3.96	0.06	£ 668	£ 260
SDS	30 kWh/m2/yr	Option 2: Direct electric and PV 2.72 kWp	7.09	0.12	£ 1,196	£ 466

Table 13 - SDO model - Carbon emissions and their monetised impact. Carbon emissions were predicted using appropriate Green Book carbon emission factors for electricity and SAP 2012 version 9.92 (October 2013) carbon factors for gas (constant throughout the evaluation period).

Building	Model Name	Heating system	Total CO2e 2020-2080 (tCO2e)	Average per year (tCO2e)	Total accumulated cost of tCO2e	Net Present Value cost of tCO2e total
SDO	Baseline	Gas boiler, electricity - no PV	94.7	1.55	£ 20,845	£ 6,362
SDO	15 kWh/m2/yr	Option 1: Heat pump and PV 2.72 kWp	-4.7	-0.1	-£ 796.00	-£ 309.81
SDO	30 kWh/m2/yr	Option 1: Heat pump and PV 3.06 kWp	-6.6	-0.1	-£ 1,110.85	-£ 432.35
SDO	15 kWh/m2/yr	Option 2: Direct electric and PV 4.08 kWp	-0.3	0.0	-£ 48.91	-£ 19.03
SDO	30 kWh/m2/yr	Option 2: Direct electric and PV 5.10kWp	0.0	0.0	£ 8.38	£ 3.26

Table 14 - BL model - Carbon emissions and their monetised impact. Carbon emissions were predicted using appropriate Green Book carbon emission factors for electricity and SAP 2012 version 9.92 (October 2013) carbon factors for gas (constant throughout the evaluation period).

Building	Model Name	Heating system	Total CO2e 2020-2080 (tCO2e)	Average per year (tCO2e)	Total accumulated cost of tCO2e	Net Present Value cost of tCO2e total
BL	Baseline	Gas boiler, electricity - no PV	120.1	1.97	£ 26,468	£ 8,064
BL	15-20 kWh/m2/yr	Option 1: Heat pump and PV 3.4 kWp	-6.6	-0.1	-£ 1,115	-£ 434
BL	30 kWh/m2/yr	Option 1: Heat pump and PV 3.74 kWp	-7.6	-0.1	-£ 1,286	-£ 501
BL	15-20 kWh/m2/yr	Option 2: Direct electric and PV 5.44 kWp	-0.8	0.0	-£ 136	-£ 53
BL	30 kWh/m2/yr	Option 2: Direct electric and PV 6.12 kWp	-0.2	0.0	-£ 27	-£ 11

[10] This is the total amount - cost of carbon emissions, as a total sum of each year's fees (if a CO_2e emitter penalty applies). It is not a cost differentiation, but an absolute cost for each model.
[11] This is the net present value of the total accumulated cost sum, in effect bringing this potential future cost forward today and translating the future value of money in today's equivalent.

Table 15 - DT model - Carbon emissions and their monetised impact. Carbon emissions were predicted using appropriate Green Book carbon emission factors for electricity and SAP 2012 version 9.92 (October 2013) carbon factors for gas (constant throughout the evaluation period).

Building	Model Name	Heating system	Total CO2e 2020-2080 (tCO2e)	Average per year (tCO2e)	Total accumulated cost of tCO2e	Net Present Value cost of tCO2e total
DT	Baseline	Gas boiler, electricity - no PV	139.4	2.29	£ 30,746	£ 9,366
DT	15-20 kWh/m2/yr	Option 1: Heat pump and PV 3.74 kWp	-8.0	-0.1	-£ 1,351	-£ 526
DT	30 kWh/m2/yr	Option 1: Heat pump and PV 4.08 kWp	-9.9	-0.2	-£ 1,672	-£ 651
DT	15-20 kWh/m2/yr	Option 2: Direct electric and PV 6.12 kWp	-0.7	0.0	-£ 117	-£ 46
DT	30 kWh/m2/yr	Option 2: Direct electric and PV 7.14 kWp	-0.4	0.0	-£ 75	-£ 29

Table 16 -LIU model - Carbon emissions and their monetised impact. Carbon emissions were predicted using appropriate Green Book carbon emission factors for electricity and SAP 2012 version 9.92 (October 2013) carbon factors for gas (constant throughout the evaluation period).

Building	Model Name	Heating system	Total CO2e 2020-2080 (tCO2e)	Average per year (tCO2e)	Total accumulated cost of tCO2e	Net Present Value cost of tCO2e total
LIU	Baseline	Gas heaters, electricity - no PV	1625.0	26.64	£ 357,559	£ 5,862
LIU	Improved	Option 1: Direct electric fans and PV 116 kWp	0	0	0	0
LIU	Improved	Option 2: Direct electric radiant heaters and PV 112 kWp	0	0	0	0

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6 Recommendations

6.1. A high fabric performance is critical to heating demand reduction. It will not affect domestic hot water energy demand. It is recommended that more efficient forms such as flats or mid-terrace properties are carefully examined in terms of cost/ fabric improvement against benefit. In the case of semi-detached and detached properties a highly insulated envelope is advised. Nevertheless, cost optimal levels of insulation should always be sought, as marginal performance increased can lead to disproportionate cost increased - which might be the case to an extend in the models used in this report.

6.2. Additional research might be required to be undertaken in terms of embodied carbon of installed services, and life cycle costs.

6.3. All PV benefits should be allocated to the user in terms of all electric home solutions. This should include energy storage (electricity or hot water) solutions to optimise energy use on-site rather than exports.

Appendix - Running costs based on annual energy consumption (2020-2080) V additional capital costs graphs

The following graphs note additional capital cost calculated for the different model upgrades, against the predicted average annual energy consumption cost (2020-2080), in support of the evaluation process.

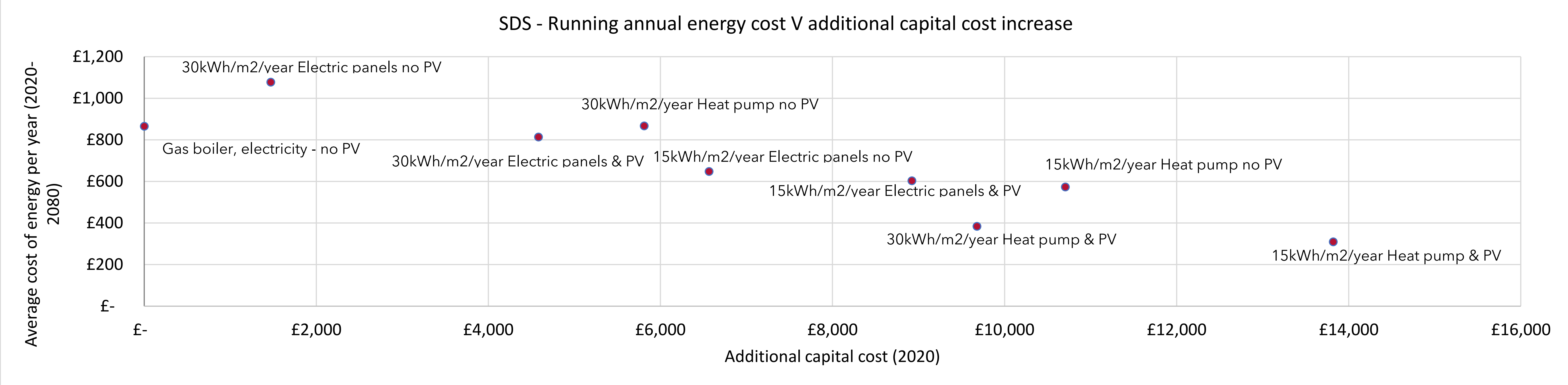

Figure 30 - SDS - Annual energy cost V capital cost

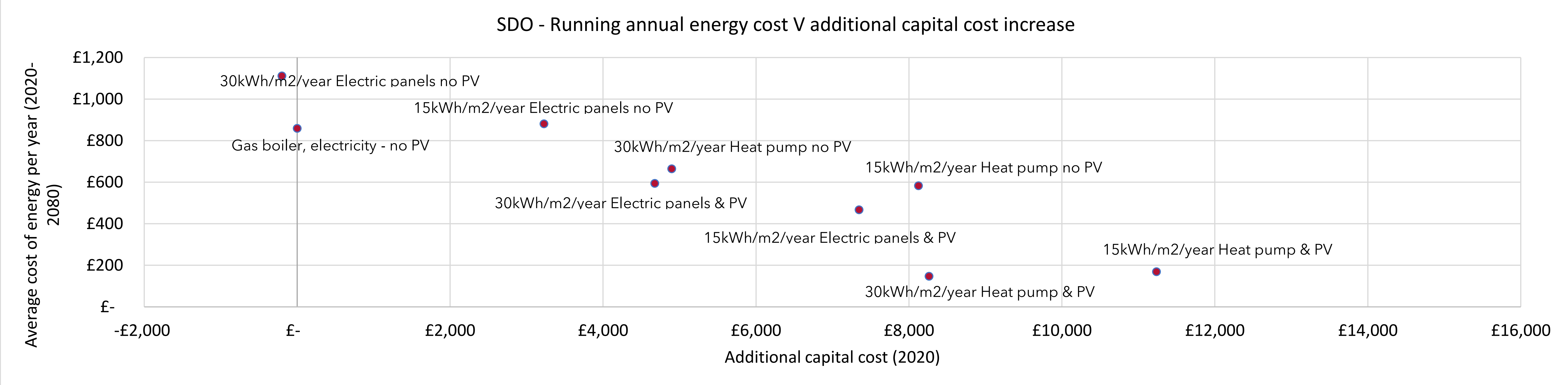

Figure 31 - SDO - Annual energy cost V capital cost

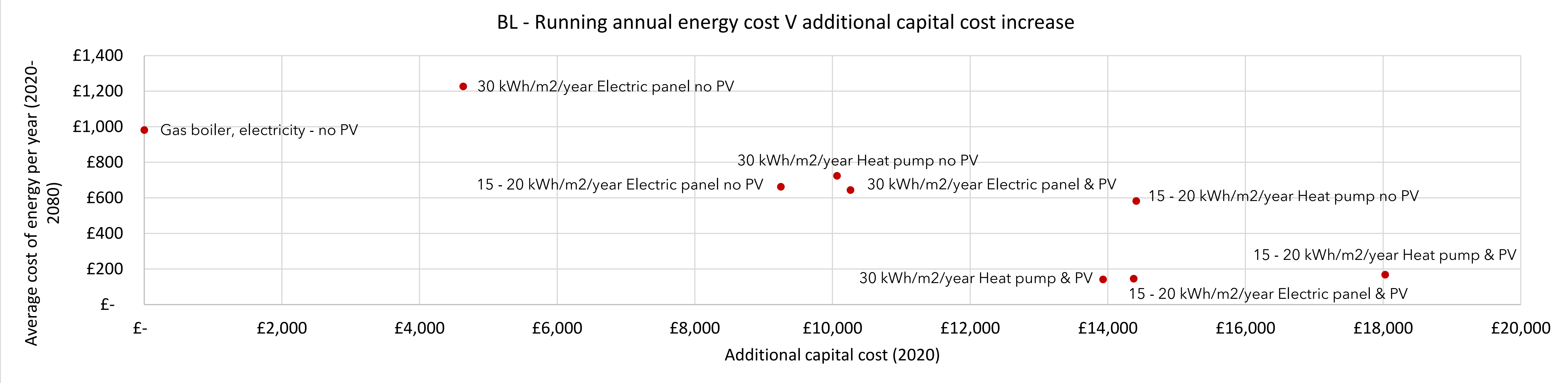

Figure 32 - BL - Annual energy cost V capital cost

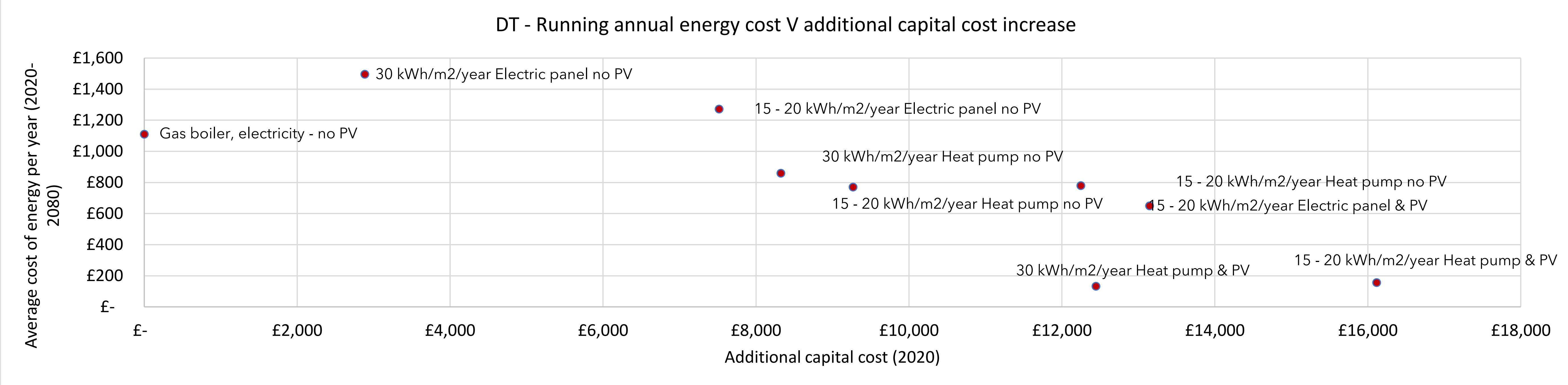

Figure 33 - DT - Annual energy cost V capital cost

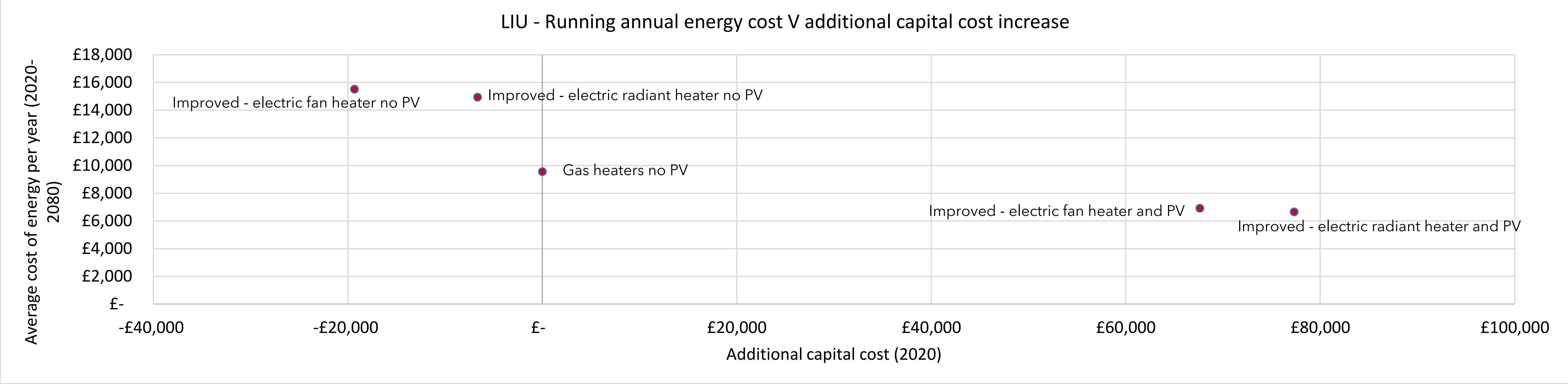

Figure 34 - LIU - Annual energy cost V capital cost

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[i] Lincolnshire County Council (2020), *Environment and Planning: Green Masterplan.* https://www.lincolnshire.gov.uk/green-masterplan