Bioregional, Etude, Currie & Brown

Greater Cambridge Local Plan

Cost Report

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Contents

Cost report

Introduction

This report presents the costs analysis results of the domestic and non-domestic architype models developed by Etude for Greater Cambridge.

Cost is presented in the form of additional capital cost and running cost to the user (delivered energy - based on predicted energy consumption only, excluding lifecycle costs).

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

- A semi-detached house (figure 2, page 7)
- A mid-terrace house (figure 3, page 7)
- A block of flats (figure 5, page 8)
- A school (figure 6, page 8)

Each building model starts from a baseline that is typical for a building constructed to today's standards and includes a gas boiler.

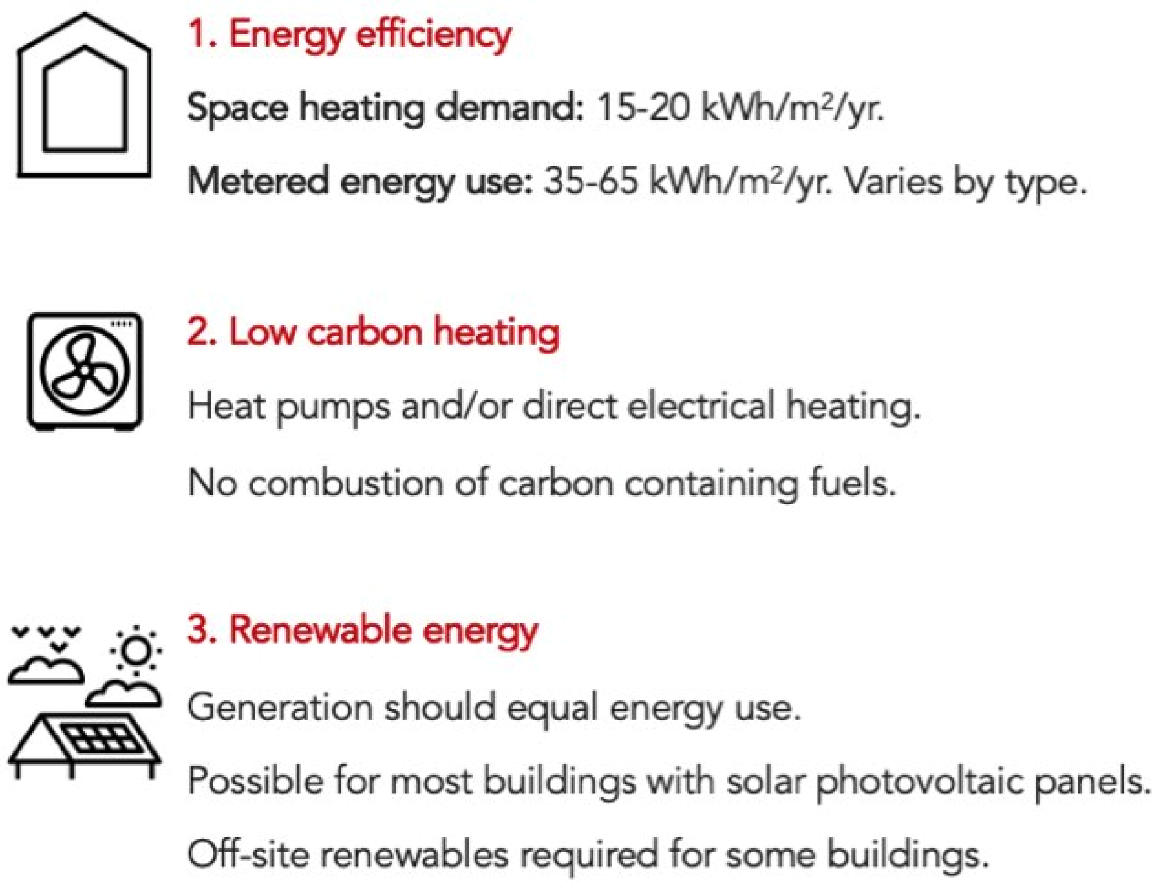
The Net Zero Carbon[1] models have an improved thermal envelope compared to the baseline and are supported by all electric solutions for their operation (heat pumps and photovoltaic panels).

They follow the London Energy Transformation Initiative (LETI) guidance (Figure 1), with the main difference being that the amount of photovoltaics allocated equals, in terms of expected annual energy generation, the predicted annual energy needs of each building.

None of the baseline models includes energy generation.

[1] Please check the main report for an exact definition of 'net zero carbon', as used within this report.

Figure 1: The LETI principles of a zero-carbon building; metered energy use refers to delivered energy



Cost assumptions

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

Assumptions

Capital costs

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.

It is important to remember that the costs of developing new buildings 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.

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.

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.

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 building used as a proxy in terms of architecture, geometry, size and other factors.

All capital costs shown in this report reflect the technical specifications received. 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 improved models as per the technical instructions.

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.

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
- Upgrades in terms of technologies assigned to each building (like in the case of heat pumps and renewable energy generation systems)

Both were costed based on the technical specifications provided by Etude.

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 m2 of gross internal floor area (GIA) for each building typology.

As explained, the additional capital costs for the fabric improvements are based on the new proposed construction elements (walls, roofs) details and an approximation of the costs of airtightness and thermal bridging details based on a course of action as noted by the technical team.

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.

Indicative gas connection charges are included within the housing models (based on Currie & Brown experience). In the case of the block of flats and the school models, a fixed lump sum of £15,000 for the gas connection cost is used. Please note that this cost can hugely vary, based on location and other factors.

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

Running costs

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 for the years 2020 to 2080.

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

The cost of energy was estimated based on the Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal for the years 2020 to 2080. Central retail energy prices were selected for domestic and non-domestic (commercial) models. Please note that the energy price markets continuously change. Options such as economy 7, dynamic and off-peak tariffs are also available to consumers. Energy provider and tariff options, the actual (non-modelled) performance of the buildings and user behaviour can lead to variations in predicted annual, total operational energy, costs.

The cost of renewable energy generation export and standing charges were based on the SAP version 10.1 (September 2019). The export cost of renewable energy generation was maintained for the duration of the evaluation period.

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 to each building model occupant/user.

Evaluated models

Sketches of the architypes used are shown in figures 2 to figure 5.

The semi-detached house (SD)

Table 1 - Fabric specifications and systems installed - Baseline to Net Zero Carbon (operational energy only)

-	-	Baseline	Zero Carbon
U-values, W/m2K	Floor (unadjusted U-value)	0.15	0.12
-	Walls	0.18	0.1
-	Roof	0.13	0.1
-	Dormer walls & roof	0.2	0.12
-	Windows	1.4	0.9
-	Glazed doors	1.4	0.9
-	Opaque doors	1.0	1.0
Thermal bridging	kWh/m2/yr	5	2
Air tightness	Air tightness, m3/m2/hr.	5	0.65
Heating system	-	-	-
-	Type	Gas boiler	Air source heat pump
-	Nominal heating capacity	24kW	5kW
-	Efficiency	90%	280%
-	Mode of heat delivery	6 x 450mm x 750mm twin skin radiators	4 x 450mm x 700mm twin skin radiators
Ventilation system	Type	Continuous extract vent	MVHR, 88% heat recovery
Solar photovoltaics	Type	n/a	Monocrystalline Silicon
-	Number of panels	n/a	8
-	Installed capacity	n/a	2.9kW

The mid-terrace house (SD)

Table 2 - Fabric specifications and systems installed - Baseline to Net Zero Carbon (operational energy only)

-	-	Baseline	Zero Carbon
U-values, W/m2K	Floor (unadjusted U-value)	0.15	0.12
-	Walls	0.18	0.1
-	Roof	0.13	0.1
-	Windows	1.4	0.9
-	Glazed doors	1.4	0.9
-	Opaque doors	1.0	1.0
Thermal bridging	kWh/m2/yr	5	2
Air tightness	Air tightness, m3/m2/hr.	5	0.65
Heating system	-	-	-
-	Type	Gas boiler	air source heat pump
-	Nominal heating capacity	24kW	5kW
-	Efficiency	90%	280%
-	Mode of heat delivery	6 x 450mm x 750mm twin skin radiators	4 x 450mm x 700mm twin skin radiators
Ventilation system	Type	Continuous extract vent	MVHR, 88% heat recovery
Solar photovoltaics	Type	n/a	Monocrystalline Silicon

-	-	Baseline	Zero Carbon
-	Number of panels	n/a	10
-	Installed capacity	n/a	3.4kW

The block of flats

Table 3 - Fabric specifications and systems installed - Baseline to Net Zero Carbon (operational energy only)

-	-	Baseline	Zero Carbon
U-values, W/m2K	Floor (unadjusted U-value)	0.25	0.16
-	Soffit	0.2	0.18
-	Walls	0.25	0.16
-	Walls to unheated space	0.25	0.2
-	Roof	0.2	0.15
-	Windows	1.4	0.9
-	Glazed doors	1.4	0.9
-	Opaque doors	1.0	1.0
Thermal bridging	kWh/m2/yr	8	4
Air tightness	Air tightness, m3/m2/hr.	5	0.65
Heating system	-	-	-
-	Type	Gas boiler	Air source heat pump
-	Nominal heating capacity	100kW	27.7kW
-	Efficiency	90%	280%
-	Mode of heat delivery	5 x 450mm x 750mm twin skin radiators	3 x 450mm x 700mm twin skin radiators
Ventilation system	Type	Continuous extract vent	MVHR, 88% heat recovery
Solar photovoltaics	Type	n/a	Monocrystalline Silicon
-	Number of panels	n/a	328
-	Installed capacity	n/a	112kW

The school (SC)

Table 4 - Fabric specifications and systems installed - Baseline to Net Zero Carbon (operational energy only)

-	-	Baseline	Zero Carbon
U-values, W/m2K	Floor (unadjusted U-value)	0.6	0.15
-	Walls	0.18	0.13
-	Walls to unheated space	0.18	0.13
-	Roof	0.15	0.12
-	Windows	1.55	0.95
-	Glazed doors	1.55	0.95
-	Opaque doors	1.0	1.0
Thermal bridging	kWh/m2/yr	5	3
Air tightness	Air tightness, m3/m2/hr.	5	0.65
Heating system	-	-	-
-	Type	Gas boiler	air source heat pump
-	Nominal heating capacity	80kW	24kW

-	-	Baseline	Zero Carbon
-	Efficiency	90%	280%
-	Mode of heat delivery	60 x 450mm x 750mm twin skin radiators	40 x 450mm x 700mm twin skin radiators
Ventilation system	Type	Continuous extract vent	MVHR, 88% heat recovery
Solar photovoltaics	Type	n/a	Monocrystalline Silicon
-	Number of panels	n/a	328
-	Installed capacity	n/a	112kW

Figure 2 – Semi-detached model

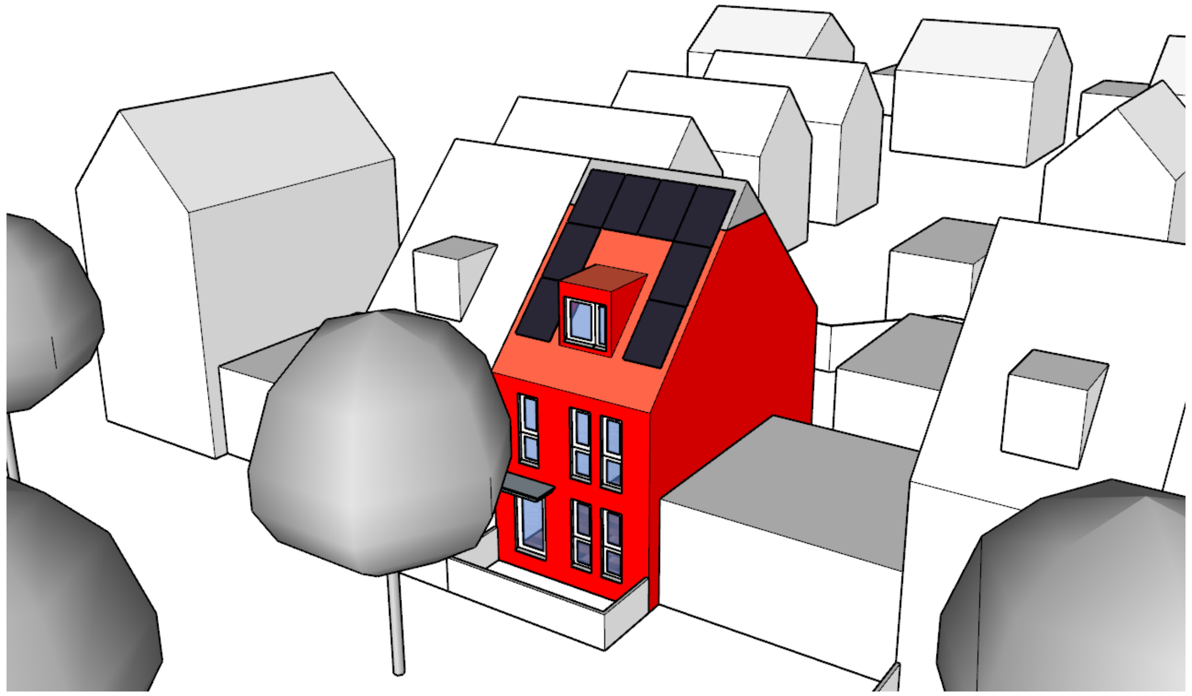


Figure 3 – Mid-Terrace model

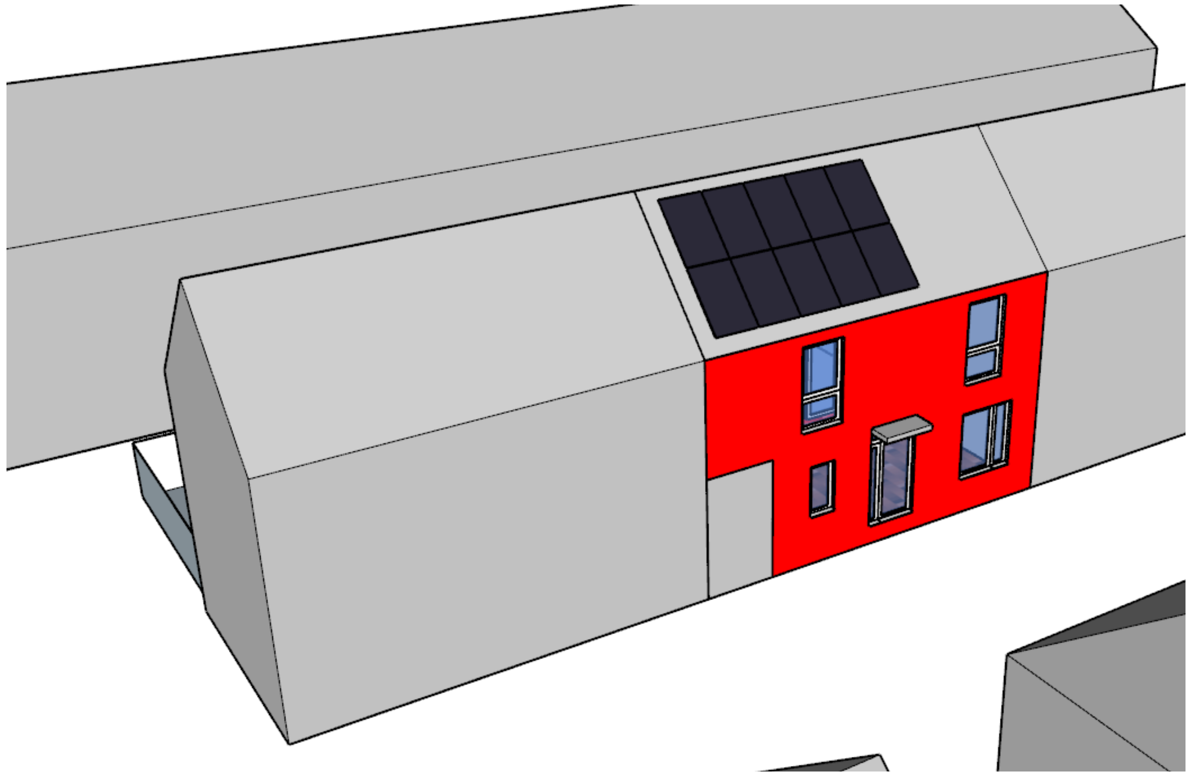


Figure 4 – Block of flats model

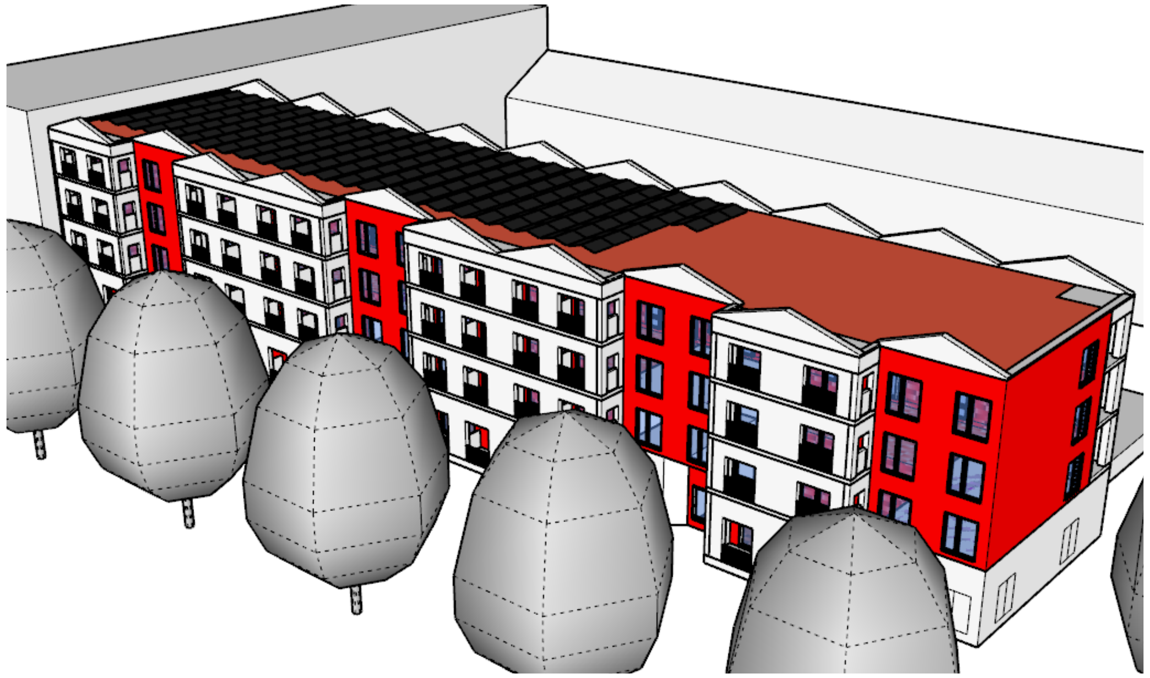
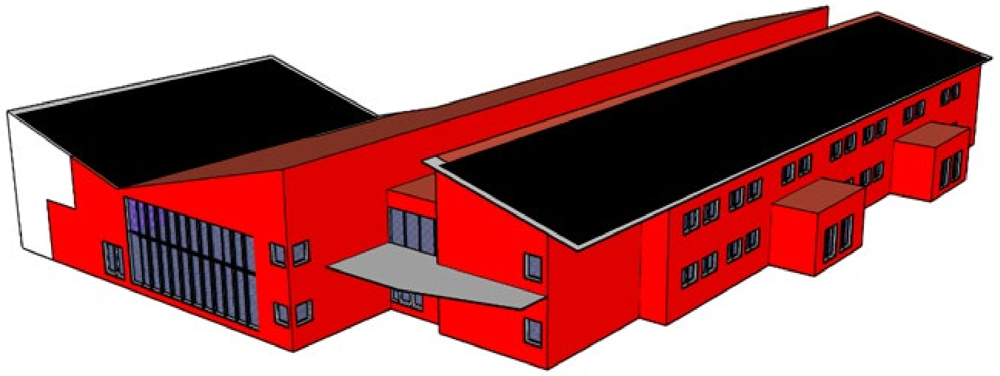


Figure 5 – School model



Capital cost models results

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

Chapter notes

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

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.
- The cost of fabric upgrades is based on average costs uplifts for specific built-ups of its components and reflects the actual design / form and size of the model building.
- Typical new-built costs were produced by Currie & Brown irrespective of the specifications in the models, in order to evaluate potential solutions, cost uplift compared to the baseline models.
- Areas of cost such as airtightness and thermal bridging can vary significantly 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.
- The effect of generation and all electric solutions / associated costs to sub-stations and the grid is not included as it is unknown (location, time, and installation-specific)

Capital cost results

Additional capital cost

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

Table 5 - Additional capital cost - all models

Building	Model name	Building services	Additional Cost
Semi-detached house	Net Zero Carbon	Heat pump, MVHR and PV	£ 12,880
Mid-terrace house	Net Zero Carbon	Heat pump, MVHR and PV	£ 13,985
Block of flats	Net Zero Carbon	Heat pump, MVHR and PV	£ 302,735
School	Net Zero Carbon	Heat pump, MVHR and PV	£ 208,865

Capital cost increase (% over)

Additional capital cost estimates were converted into % of new-build cost uplift for ease of reference and are shown in Figure 1. New built rates used are provided within

Table 6:

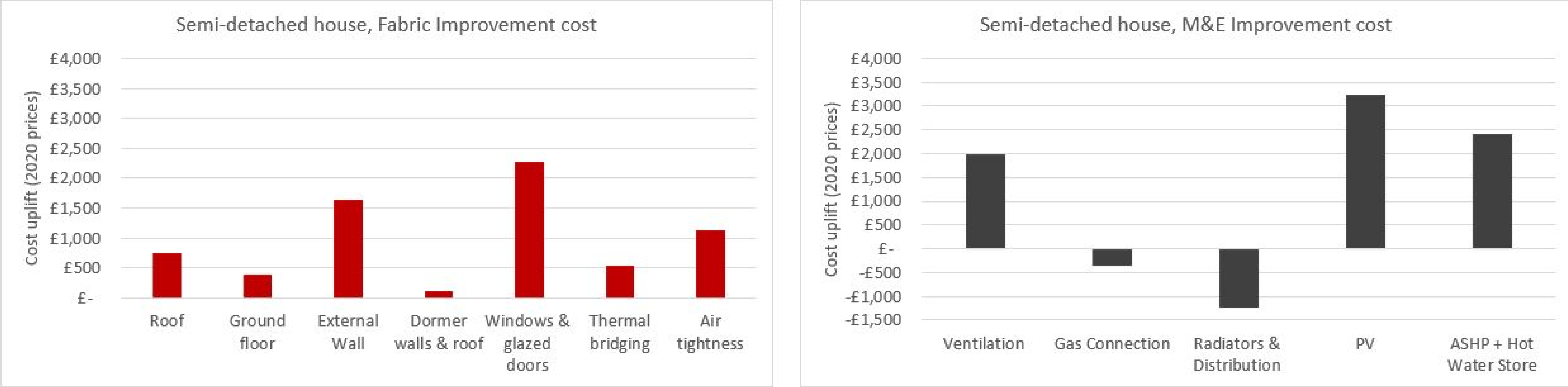
Figure 1 - Capital cost uplift to 'Net Zero Carbon' - all models

Table 6 - New building rates used in this report

New building rates	£/m2 of GIA
Semi-detached house	£ 1,260 / m^2
Mid-terrace house	£ 1,290 / m^2
Block of flats	£ 1,840 / m^2
School	£ 2,320 / m^2

The breakdown of the capital cost differentials for fabric and M&E elements is provided below (Figure 7 to Figure 10)

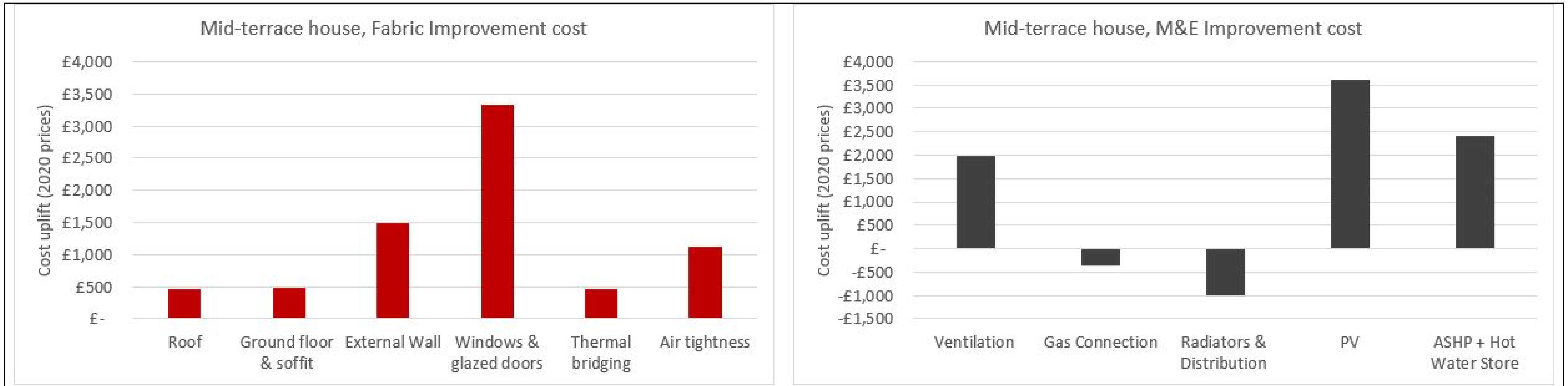
Figure 7 - Semi-detached house - capital cost differentials (Baseline to Net Zero Carbon)



Total capital cost increase - fabric: £ 6,830

Total capital cost increase - services: £ 2,805 & PV: £3,245

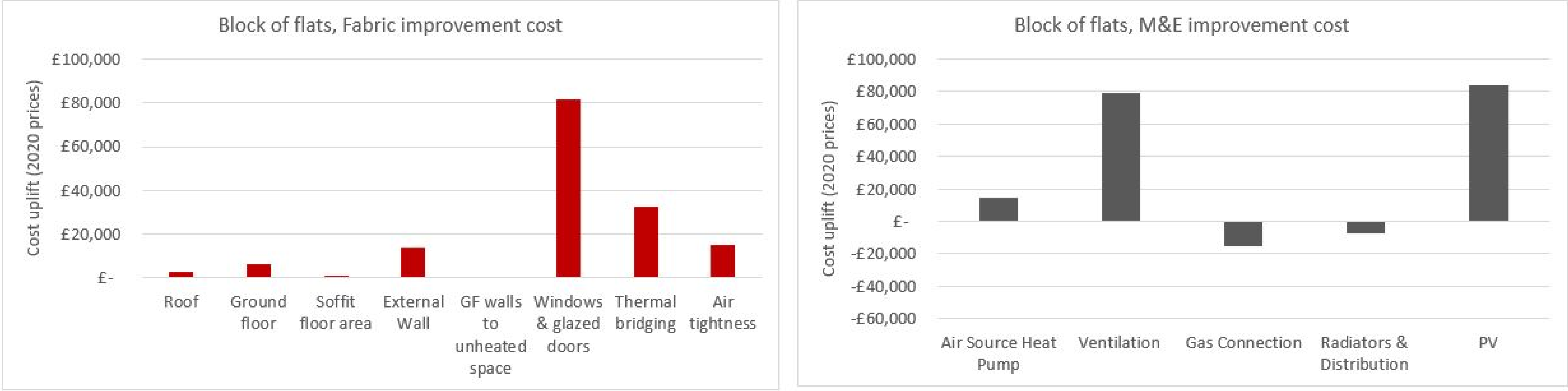
Figure 8 - Mid-terrace house - capital cost differentials (Baseline to Net Zero Carbon)



Total capital cost increase - fabric: £ 7,335

Total capital cost increase - services: £ 3,035 & PV: £3,615

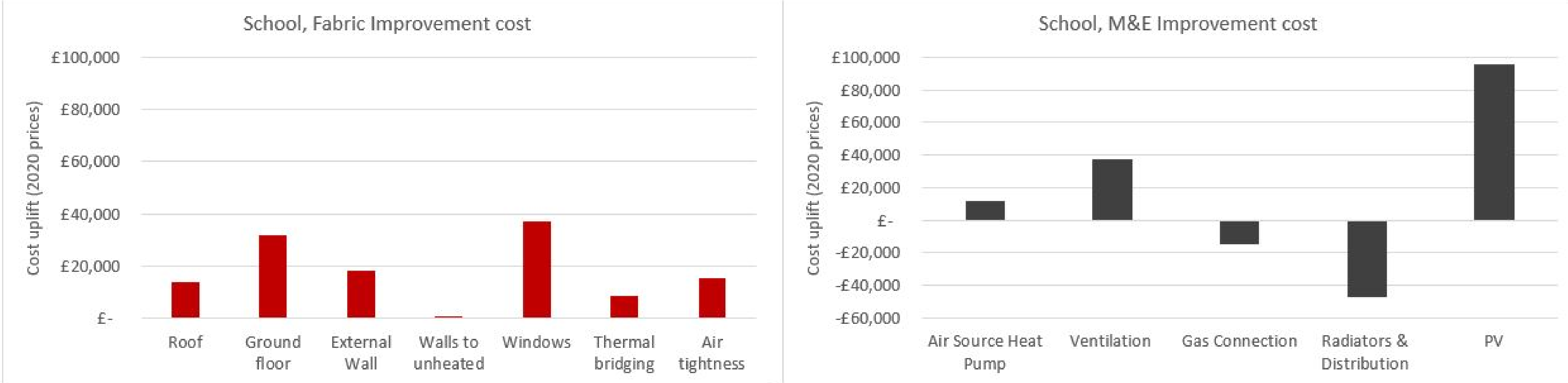
Figure 9 - Block of flats - capital cost differentials (Baseline to Net Zero Carbon)



Total capital cost increase - fabric: £ 154,032

Total capital cost increase - services: £ 64,723 & PV: £ 83,980

Figure 10 - School - capital cost differentials (Baseline to Net Zero Carbon)



Total capital cost increase - fabric: £ 126,330

Total capital cost increase - services: - £ 13,135 & PV: £ 95,670

Running / operational costs - evaluation

Chapter notes

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

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.
- While total energy demand reduction is key to reducing annual energy costs (mainly through a reduction in the heating requirement), the move to all electric means that energy that would have been delivered through gas consumption is shifted to mainly using electricity from the electricity grid. Current gas prices are 3-4 times lower than electricity (per kWh). This means that careful consideration should be given to the effect of energy cost to the user. Carbon emission reductions can be achieved by moving to all electric solutions in new buildings, due to the decarbonisation of the grid, but the overall strategy will need to align with 'Net Zero Carbon' to ensure that properties remain affordable to run.
- Please note the cost of electricity will vary based on time of use, tariffs used, allocation of PV energy generation for direct use and controls in place. The avoidance of annual gas standing charges, the efficiency of the 'Net Zero Carbon' homes proposed, and the significantly increased ability to utilise off-peak electricity for space and water heating of the proposed 'Net Zero Carbon' specifications will lead to additional running cost reduction benefits. It is advised that 'Net Zero Carbon' is applied as a complete strategy. Where this is not possible, the energy cost impact to the user should be carefully reviewed. Future proofing properties, and minimising their contribution to Climate Change, requires a move away from fossil fuels. The UK government intends to move away from fossil fuels in new homes upon the introduction of the Future Homes standard in 2025, 'new homes will not be built with fossil fuel heating, such as a natural gas boiler'.
- A significant contribution to running energy consumption costs reduction 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 'Upgrades to fabric and services as per Net Zero Carbon but no PV' annual cost scenarios might apply.
- The operational cost to the user, has been estimated using future energy prices[2]. The per year expenditure refers to an average cost taking into consideration the predicted energy cost per year of these 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 school unit.
- In terms of PV operation, it was assumed that 30% will be directly used by the property, while 70% will be exported to the grid.
- PV electricity generation export at £0.053 /kWh is low when compared to the cost of electricity (£0.18-0.19 / kWh excluding standing charge). This demonstrates that PV direct use on site should be always prioritised over export.

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

Average running cost per year

This is estimated based on years 2020-2080 average annual expenditure on energy and includes standing charges. It also includes energy and cost savings from the PV generation (direct use and export). Results are shown below (figure 11 to figure 14)

Figure 11 -predicted energy use cost during operation for semi-detached house

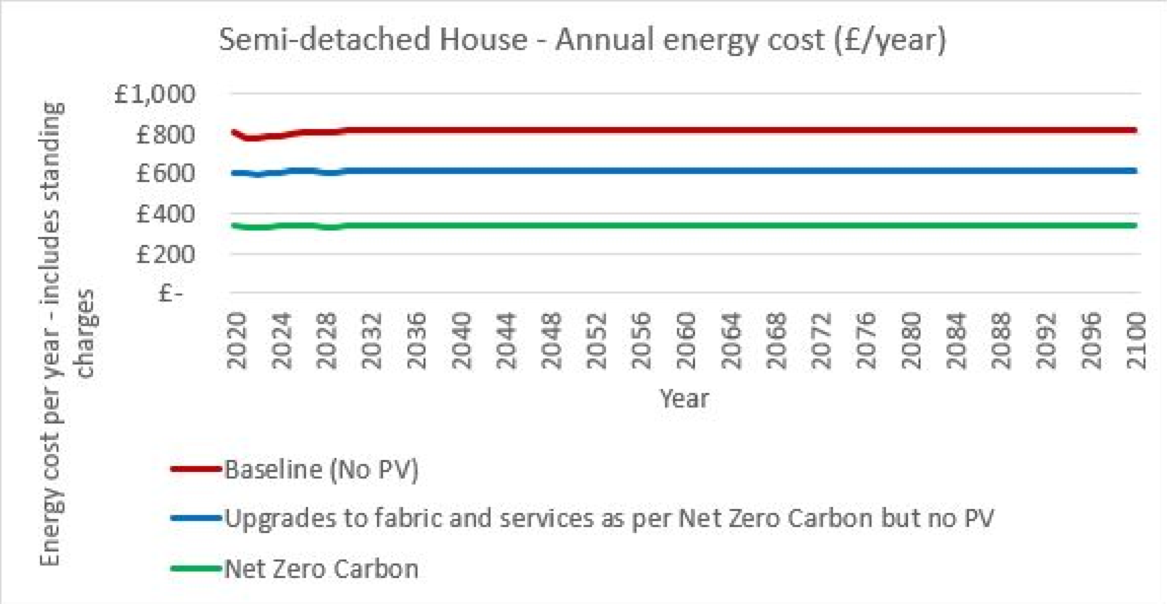


Figure 12 – predicted energy use cost during operation for a mid-terrace house

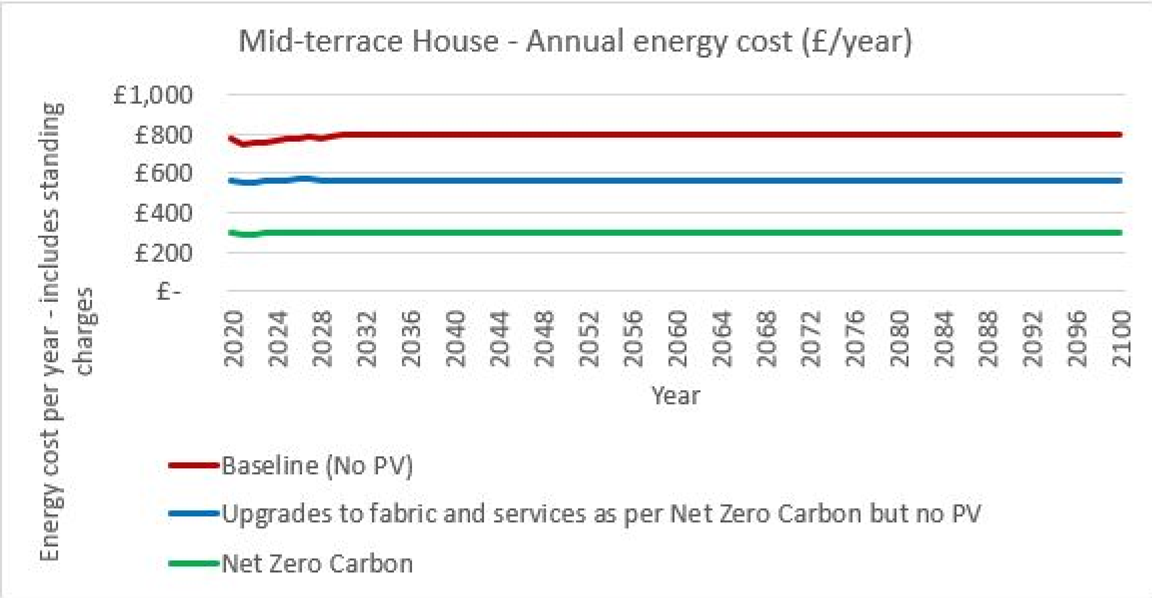


Figure 13 – predicted energy cost during operation for a block of flats

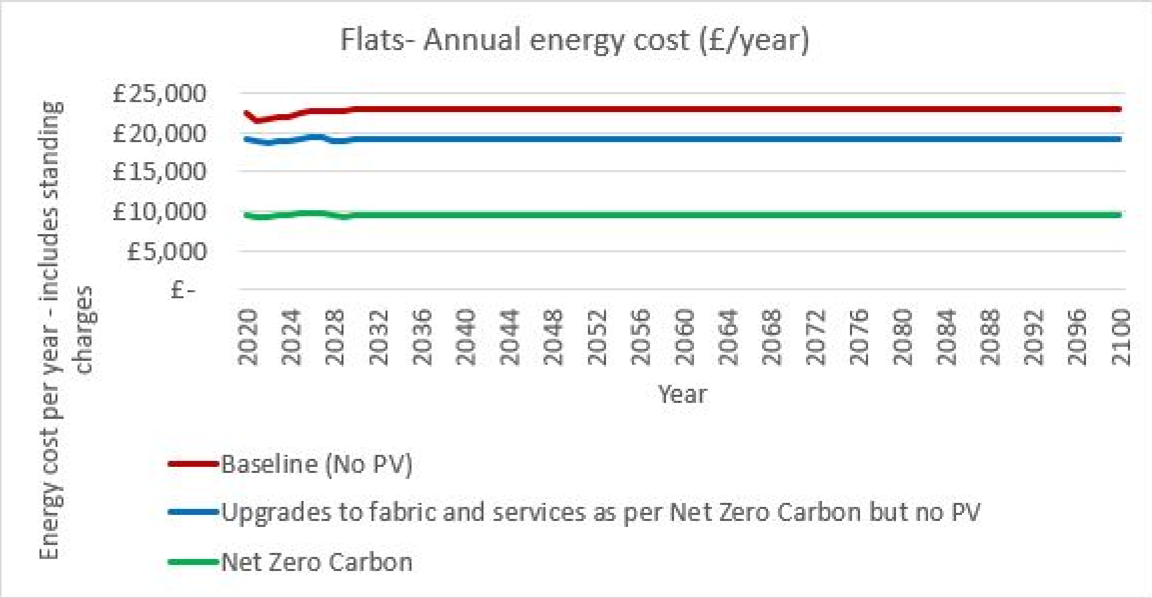
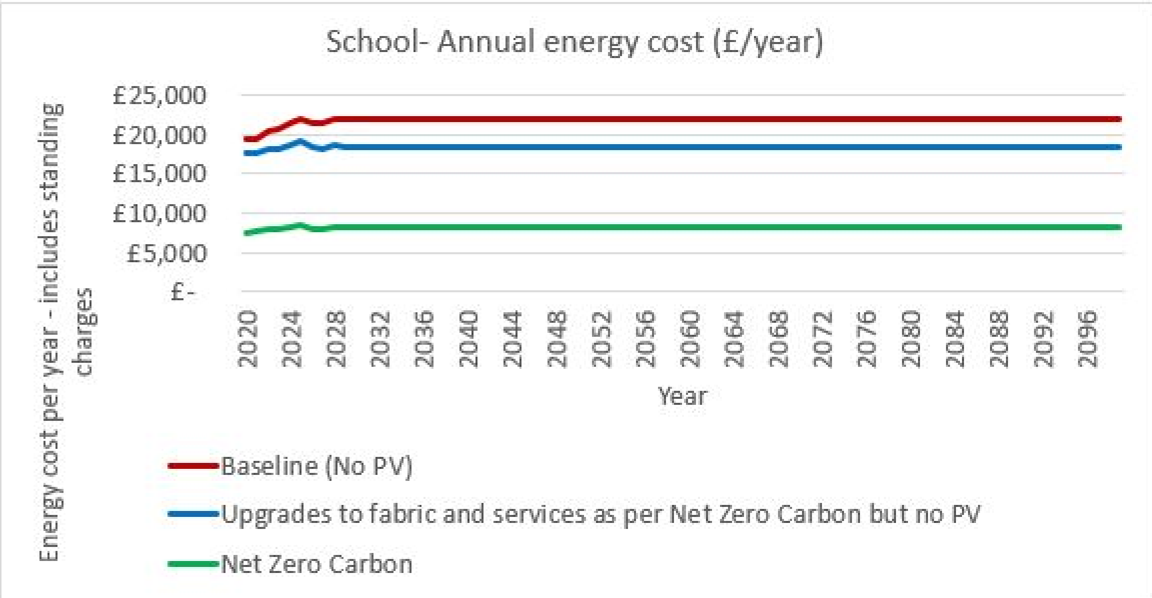


Figure 14 – predicted energy cost during operation for a school



Recommendations

- 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.
- Additional research might be required to be undertaken in terms of embodied carbon of installed services, and lifecycle costs.
- Direct energy use from PV generation on site must be prioritised over exports. This can be achieved with the right services design strategy that can include the use of energy stores (thermal mass, hot water, smart EV, batteries and other).