Carbon Trust Options Appraisal for building decarbonisation: Summary of results

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Summary of current building

Top Floor Flat, 20 HEYFORD AVENUE SW8 1ED

Domestic	1 Units
Floorspace (m2)	79
EPC Rating	D

Space heating consumption (kWh)	12,372
Cooling consumption (kWh)	0
Water heating consumption (kWh)	1,580
Other electricity use (kWh)	2,528
Annual total fuel bill	£558

Thermal Energy Demand Intensity (kWh per m2 pa)	125
Energy Use Intensity (kWh per m2 pa)	209

Age of construction	pre 1900
Windows	Double glazed windows pre 2002
Wall	Solid brick, as built, no insulation (assumed)
Roof	Room in roof
Floor	Another dwelling below
Primary heating	Existing - condensing gas boiler
Air tightness (ACH @ ambient pressure)	Average air tightness (7.5 n50)
Radiators / emitters	Existing radiators - single panel single convector

Description of Options for Appraisal

Thermal fabric measures:
This large top floor flat has a relatively high heat loss due to having minimal roof insulation and solid walls. This property already has double glazing (pre 2002). In scenario 2, we assume that the fabric remains the same. In scenario 3 we include room in roof insulation. In scenario we assess the impact of internal wall insulation, room in roof insulation and high performance triple glazing.

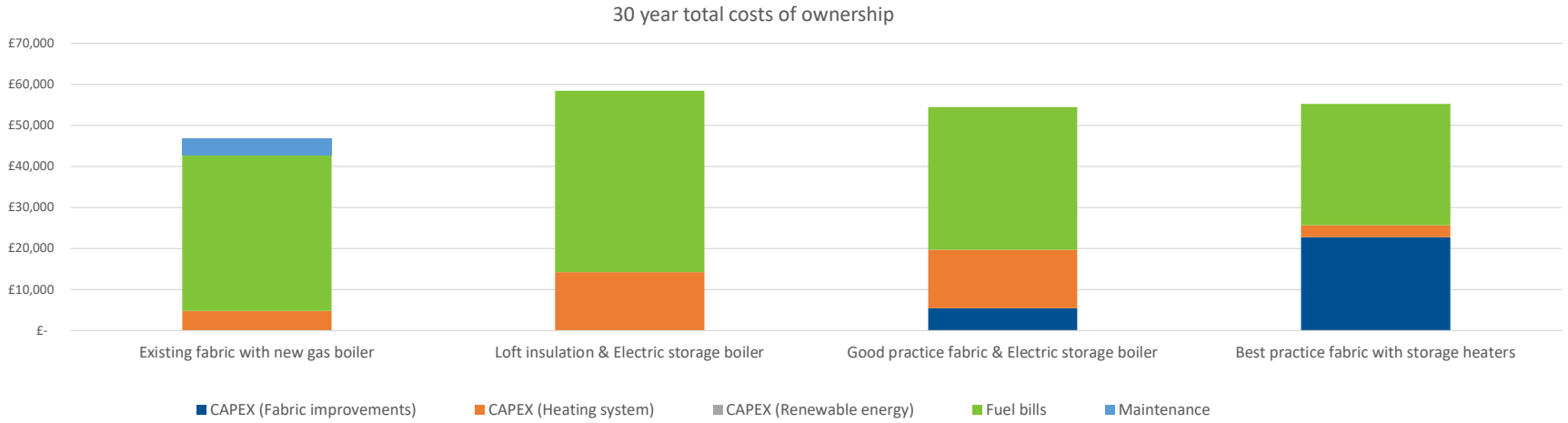
Heating system:
As a top floor flat, options for heat pump installation are limited. The level of peak heat loss at less than 6kW suggests that an electric storage boiler could be a feasible retrofit option, enabling the retention of existing heat distribution and emitters.

In scenario 4, the heat loss has reduced to such an extent that individual storage heaters are likely to be more cost effective than a centralised storage boiler.

Summary of options appraisal measures, costs & CO_2 emissions

	Existing fabric with new gas boiler	Loft insulation & Electric storage boiler	Good practice fabric & Electric storage boiler	Best practice fabric with storage heaters
HVAC system	6kW New Condensing gas boiler, 0, 0, hot water from main system (gas), 0, 0	6kW New electric storage boiler (e.g. Tepeo) , 0, 0, hot water from main system (electric), Hot water cylinder and associated pipework	3kW New electric storage boiler (e.g. Tepeo) , 0, 0, hot water from main system (electric), Hot water cylinder and associated pipework	2kW New electric storage heaters, 0, 0, New electric immersion heater, Hot water cylinder and associated pipework
	£2,400	**£7,750**	**£7,750**	**£2,830**
Heat emitter and distribution	0, Existing radiators - single panel single convector	0, Existing radiators - single panel single convector	0, Existing radiators - single panel single convector	0, 0
	£0	**£0**	**£0**	**£0**
Thermal fabric measures installed	, , ,	, , ,	, Loft insulation (Rafters) (room in roof), ,	Internal wall insulation (High price - complex interior), Loft insulation (Rafters) (room in roof), high performance triple glazing ,
	£0	**£0**	**£5,075**	**£21,850**
Air tightness	Natural ventilation , Average air tightness (7.5 n50)	Natural ventilation , Average air tightness (7.5 n50)	MEV, Building regs airtightness (5 n50)	MVHR (de-centralised) , AECB airtightness (1.5 n50)
	£0	**£0**	**£395**	**£948**
Total CAPEX	**£2,400**	**£7,750**	**£13,220**	**£25,628**
Clean Heat Grant	£0	£0	£0	£0
Net CAPEX	**£2,400**	**£7,750**	**£13,220**	**£25,628**
Electricity tariff	Treasury Green Book Central Domestic Tariff	Domestic low overnight Tariff 01:30 - 06:30	Domestic low overnight Tariff 01:30 - 06:30	Domestic low overnight Tariff 01:30 - 06:30
Annual fuel bills	**£1,091**	**£1,363**	**£1,072**	**£914**
Annual OPEX (maintenance)	£129	£0	£0	£0
30 year total cost of ownership (excluding grant)	**£46,727**	**£58,430**	**£54,473**	**£55,244**
Annual tCO_2 emissions (2021)	**3.3**	**4.2**	**2.8**	**2.1**
Predicted annual tCO_2 emissions (2030)	**2.9**	**1.9**	**1.3**	**0.9**
Predicted annual tCO_2 emissions (2050)	**2.6**	**0.1**	**0.1**	**0.1**

30 year total costs of ownership

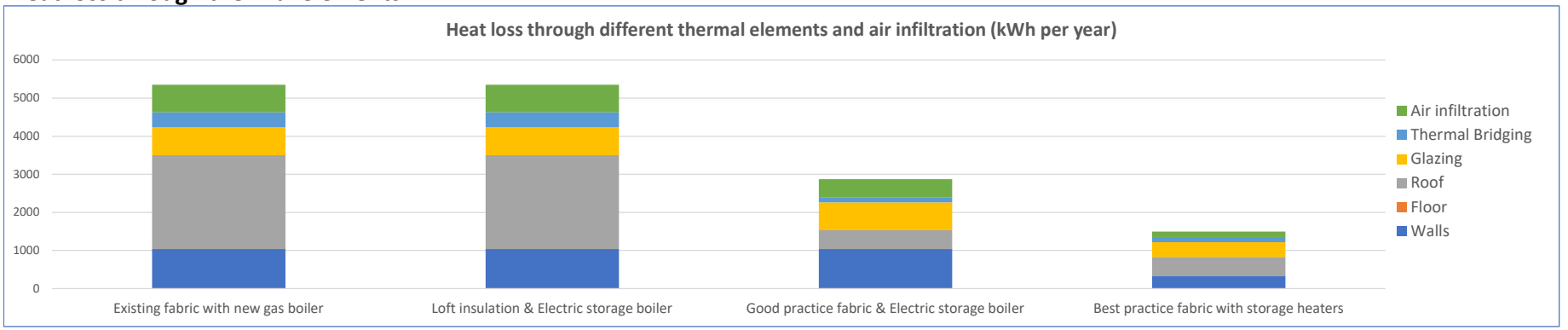


CAPEX
CAPEX is significantly higher for all 3 retrofit options, especially because there are currently no grants available for off-peak electric storage heating. However, of the electrification options, option 3 has the lowest lifetime costs, suggesting that additional investment in fabric retrofit does not have a positive financial payback.

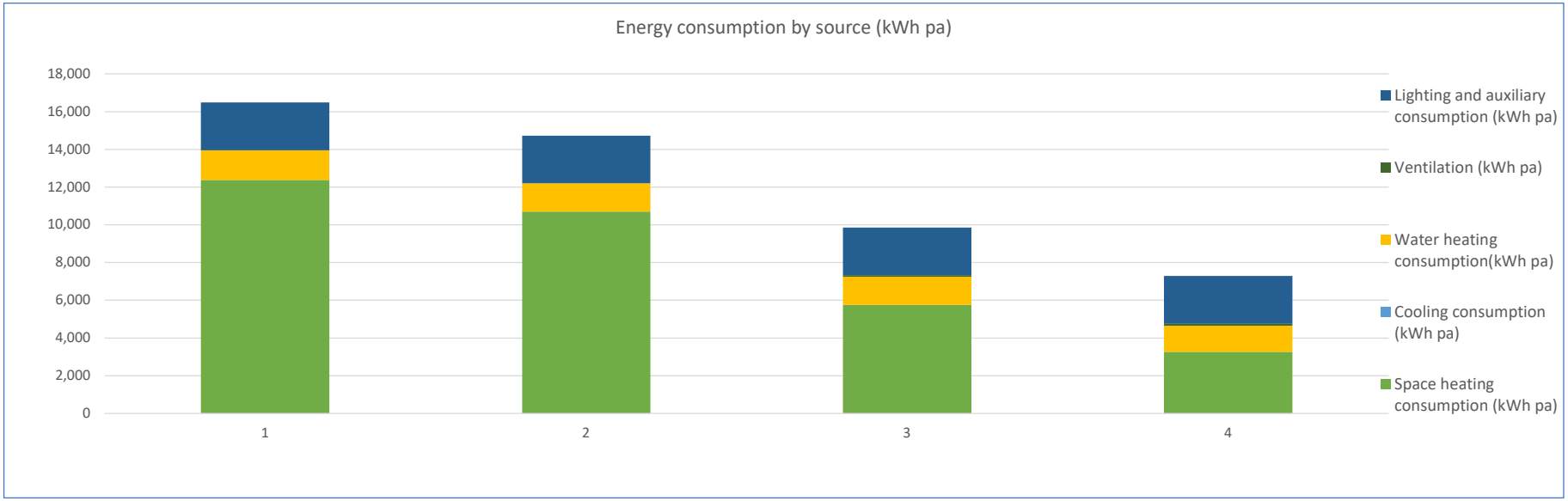
Fuel bills
Fuel bills for option 3 & 4 are marginally lower than the BAU scenario. Fuel bills in scenario 2 increase relative to BAU. The low fuel bills of the electric storage systems are due to the ability of the storage boilers and storage heaters to take advantage of very low off-peak tariffs at approx. £0.06 per kWh between 01:30 and 05:30am. With this tariff, on peak electricity prices are higher than standard tariffs, but because of the high proportion of electricity used for heat, overall fuel bills are lower.

30 year cost of ownership
Of the retrofit options, Option 3 has the lowest 30 year costs of ownership. However, Option 4 lifetime costs are only marginally higher. This is helped by the fact that the additional investment in thermal fabric efficiency enables the

Heat loss through thermal elements



Energy Consumption kWh pa



Heat demand and heating system efficiency

	Existing fabric with new gas boiler	Loft insulation & Electric storage boiler	Good practice fabric & Electric storage boiler	Best practice fabric with storage heaters
Space heating demand (kWh pa)	9,898	9,898	5,322	2,770
Space heating peak demand (kW)	5.4	5.4	2.9	1.5
Space heating peak demand per flat (kW)	5.4	5.4	2.9	1.5
Peak electricity load @ 6:00pm	0.6	0.6	0.6	0.6
Required flow temperatures °C	70	70	51	40
Space heating consumption (kWh pa)	12,372	10,700	5,753	3,259
Cooling consumption (kWh pa)	0	0	0	0
Water heating consumption(kWh pa)	1580	1495	1495	1383
Ventilation (kWh pa)	0	0	79	111
Lighting and auxiliary consumption (kWh pa)	2528	2528	2528	2528
Assumed heating system Seasonal Performance Factor (SPF)	**80%**	**93%**	**93%**	**85%**
Assumed distribution losses	**0%**	**0%**	**0%**	**0%**
Space heating Thermal Energy Demand Intensity (kwh per m2 pa)	**125**	**125**	**67**	**35**
Energy Use Intensity - all energy use (kWh per m2 pa)	**209**	**186**	**125**	**92**

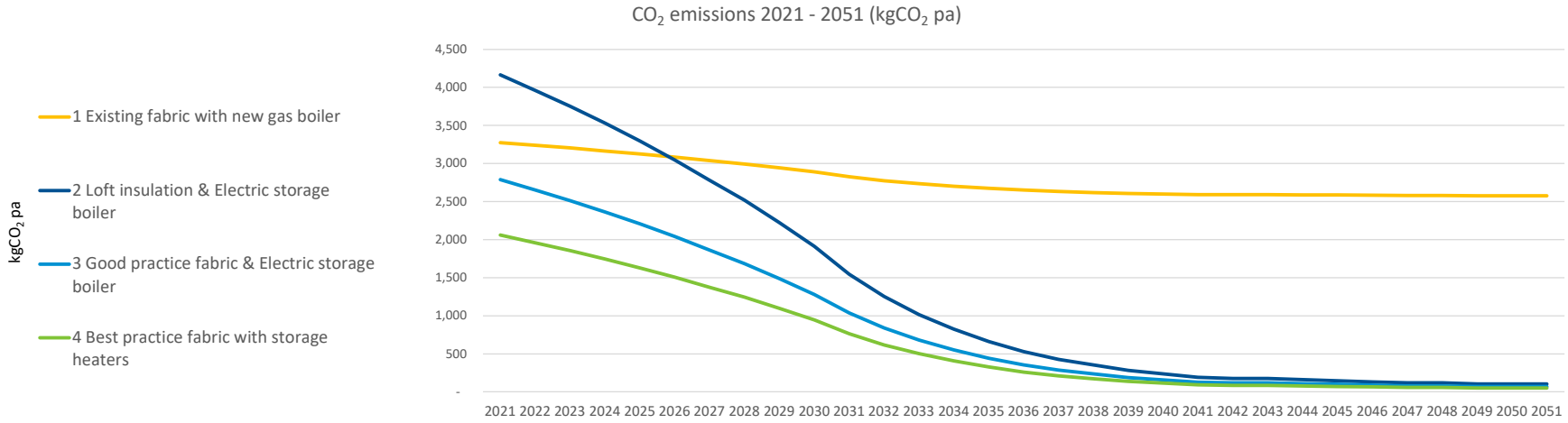
System efficiency
Whilst off-peak electric systems are less efficient than heat pump options and show as having a higher Energy Use Intensity (EUI), they offer significant advantages in adding no additional electricity load at peak times of day. Whilst electric heating systems are typically assumed to be 100% efficient, storage options are inherently less directly controllable than direct electric systems, which is reflected here in a lower overall system efficiency.

Retrofit package CO_2 emissions

tCO_2 in 2021	3	4	3	2
Predicted annual tCO_2 emissions (2030)	2.9	1.9	1.3	0.9
tCO2 in 2050	2.6	0.1	0.1	0.1
tCO2 cumulative 2021 - 2050	84	40	27	20
tCO_2 saved relative to BAU (30 year cumulative)	0	-44	-57	-64
CO_2 saving relative to baseline (30 year cumulative)	0%	52%	68%	77%
Additional cost over BAU scenario (30 years)	£0	£11,703	£7,746	£8,517
£ per tonne of CO_2 reduction (30 year cumulative)	NA	£267	£136	£133

* negative figures indicate a negative cost of carbon reduction. i.e. the packages of measures reduce 30 year costs and reduce CO2.

30 year predicted CO_2 emissions



CO_2 emissions

Electric storage system offer relatively low savings of CO_2 emissions in the near term. However, these savings increase substantially in the medium to long term due to predicted decreases in grid carbon storage options here offer CO_2 savings of 52% - 77% over the 30 year period. Furthermore, storage systems offer significant benefits in the context of an overall low carbon energy system, helping to minimise infrastructure upgrade costs and providing a valuable short term storage resource.

Potential impact of Solar PV on all scenarios

	Existing fabric with new gas boiler	Loft insulation & Electric storage boiler	Good practice fabric & Electric storage boiler	Best practice fabric with storage heaters
Included in package? (Y/N)	N	N	N	N
System size kW Peak	2.5	2.5	2.5	2.5
System generation kWh pa	2,409	2,409	2,409	2,409
Utilisation on site kWh pa	1046	1046	1046	1046
Utilisation on site kWh pa	43%	43%	43%	43%
Exported to grid kWh pa	1363	1363	1363	1363
Assumed system cost £	3750	3750	3750	3750
Net impact on fuel bills £ pa	-£ 275	-£ 307	-£ 307	-£ 307

Ren wable energy:
For all scenarios, the impact of a PV system was modelled separately. The table above shows the indicative savings on energy consumption and fuel bills that would occur. Due to the relatively low year round use of electricity, on-site utilisation of the PV was relatively low.

Impact of Solar PV on Scenario 3 - typical summer and winter days