Carbon Trust Options Appraisal for building decarbonisation: Summary of results

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Summary of current building

SIDFORD HOUSE COSSER STREET SE1 7DD

Domestic	41 Units
Floorspace (m2)	2090
EPC Rating	D

Space heating consumption (kWh)	309,858
Cooling consumption (kWh)	0
Water heating consumption (kWh)	41,800
Other electricity use (kWh)	66,880
Annual total fuel bill	£14,061

Thermal Energy Demand Intensity (kWh per m2 pa)	119
Energy Use Intensity (kWh per m2 pa)	200

Age of construction	1900 - 1929
Windows	Double glazed windows pre 2002
Wall	Solid brick, as built, no insulation (assumed)
Roof	Pitched roof with insulation at joists
Floor	Insulation unknown or as-built
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:
A common archetype of London tenement flats with external walkways constructed between 1900 - 1929 (with some examples constructed as late as the 1950s). The flats already benefit from double glazing.

In options 2 & 3, the only fabric measures undertaken were to maximise loft insulation. In option 4, a full good practice retrofit including external wall insulation is appraised.

Heating system:
Replacing individual gas boilers in blocks of flats can be challenging. Air source heat pumps are unlikely to be suitable due to the dense nature of the blocks and potential issues with noise.

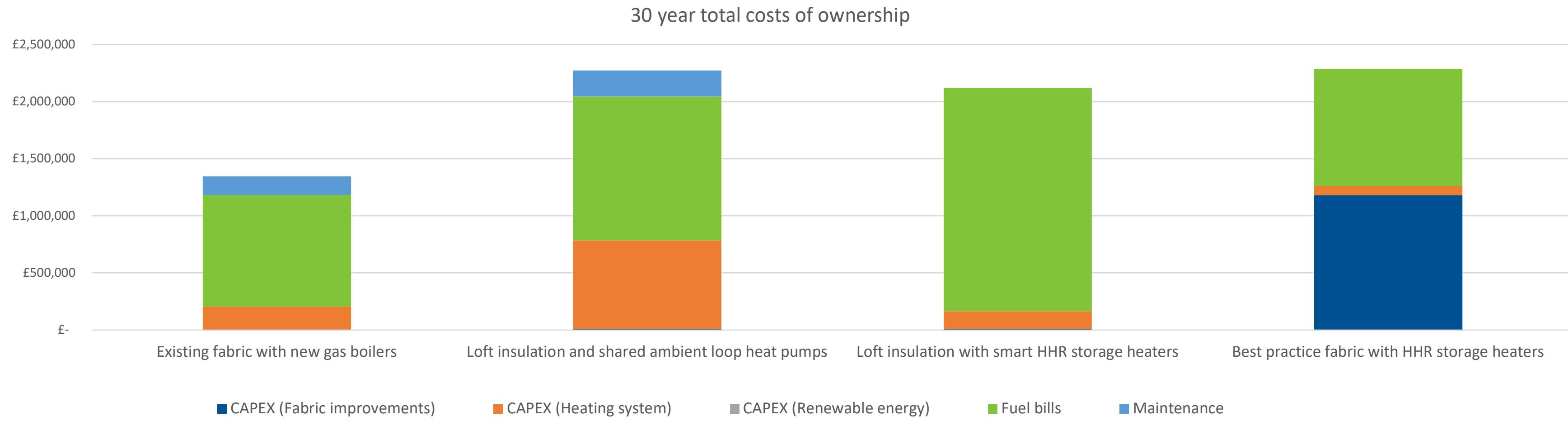
In scenario 2, we consider the installation of a new communal ambient loop with individual ground source heat pumps within each flat.

In scenarios 3 & 4 we consider installing High Heat Retention (HHR) storage heaters in each flats. Note that we assume these heaters are used in conjunction with an Economy 7 tariff, rather than a 'super off-peak' tariff. The super off-peak tariff could in theory provide lower cost storage heating. However, it was considered that there may be connection issues should every flat attempt to charge storage heaters and hot water cylinders in a short time period between

Summary of options appraisal measures, costs & CO_2 emissions

	Existing fabric with new gas boilers	Loft insulation and shared ambient loop heat pumps	Loft insulation with smart HHR storage heaters	Best practice fabric with HHR storage heaters
HVAC system	134kW Individual flat gas boiler, 0, 0, hot water from main system (gas), 0, 0	130kW Individual flat WSHP (for shared ground loops) , 0, ground loop (communal borehole) , hot water from main system (electric), Hot water cylinder and associated pipework	130kW New electric storage heaters, 0, 0, New electric immersion heater, Hot water cylinder and associated pipework	38kW New electric storage heaters, 0, 0, New electric immersion heater, Hot water cylinder and associated pipework
	£102,500	**£441,250**	**£153,950**	**£81,270**
Heat emitter and distribution	0, Existing radiators - single panel single convector	New ambient loop installation to existing in-flat pipework , New - Double panel double convector radiators	0, 0	0, 0
	£0	**£66,900**	**£0**	**£0**
Thermal fabric measures installed	, , ,	, Loft insulation (Joists) 0 - 270mm, ,	, Loft insulation (Joists) 0 - 270mm, ,	External wall insulation (Very high price - complex project) , Loft insulation (Joists) 0 - 270mm, high performance triple glazing , Insulate Suspended floor (difficult access)
	£0	**£10,032**	**£10,032**	**£1,154,807**
Air tightness	Natural ventilation , Average air tightness (7.5 n50)	Natural ventilation , Average air tightness (7.5 n50)	Natural ventilation , Average air tightness (7.5 n50)	MVHR (de-centralised) , AECB airtightness (1.5 n50)
	£0	**£0**	**£0**	**£25,080**
Total CAPEX	**£102,500**	**£518,182**	**£163,982**	**£1,261,157**
Clean Heat Grant	£0	£0	£0	£0
Net CAPEX	**£102,500**	**£518,182**	**£163,982**	**£1,261,157**
Electricity tariff	Treasury Green Book Central Domestic Tariff	Treasury Green Book Central Domestic Tariff	Domestic Economy 7 00:00 - 07:00	Domestic Economy 7 00:00 - 07:00
Annual fuel bills	**£28,168**	**£38,907**	**£60,383**	**£31,708**
Annual fuel bills (per flat)	**£687**	**£949**	**£1,473**	**£773**
Annual OPEX (maintenance)	£5,289	£7,380	£0	£0
30 year total cost of ownership (excluding grant)	**£1,346,525**	**£2,274,242**	**£2,120,690**	**£2,288,647**
Annual tCO_2 emissions (2021)	**83.5**	**52.2**	**109.0**	**53.0**
Predicted annual tCO_2 emissions (2030)	**73.2**	**24.0**	**50.1**	**24.4**
Predicted annual tCO_2 emissions (2050)	**65.0**	**1.3**	**2.7**	**1.3**

30 year total costs of ownership



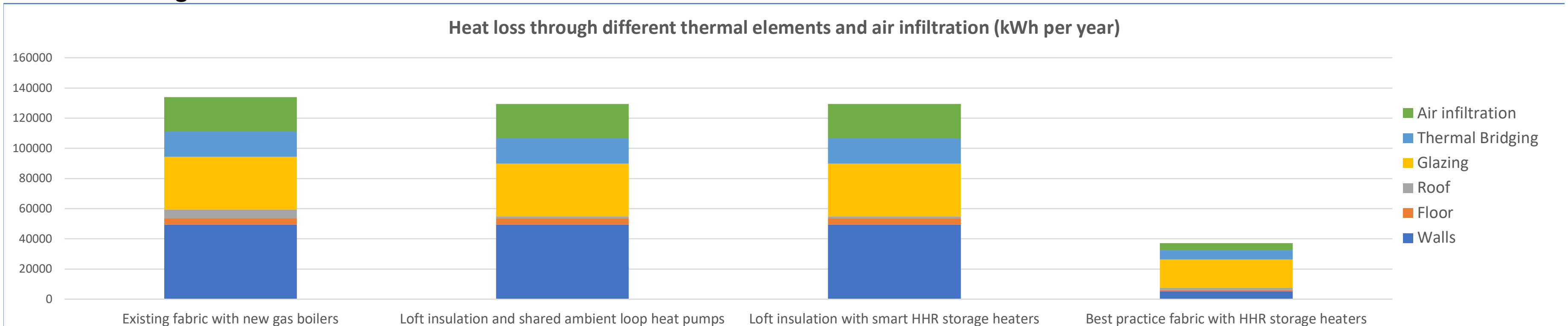
CAPEX
CAPEX is significantly higher in options 2 (due to high cost of communal ambient loop heat pumps) and 4 (due to high cost of fabric retrofit).

Fuel bills
Fuel bills increase under all scenarios 2-4. The greatest increase in fuel bills is associated with Option 3 - in this option storage heaters are combined with an Economy 7 tariff, with the lower overnight electricity rate not being low enough to compete with the gas or heat pump options. In scenario 4, the overall energy demand is low enough to ensure that electricity bills do not increase significantly relative to the BAU.

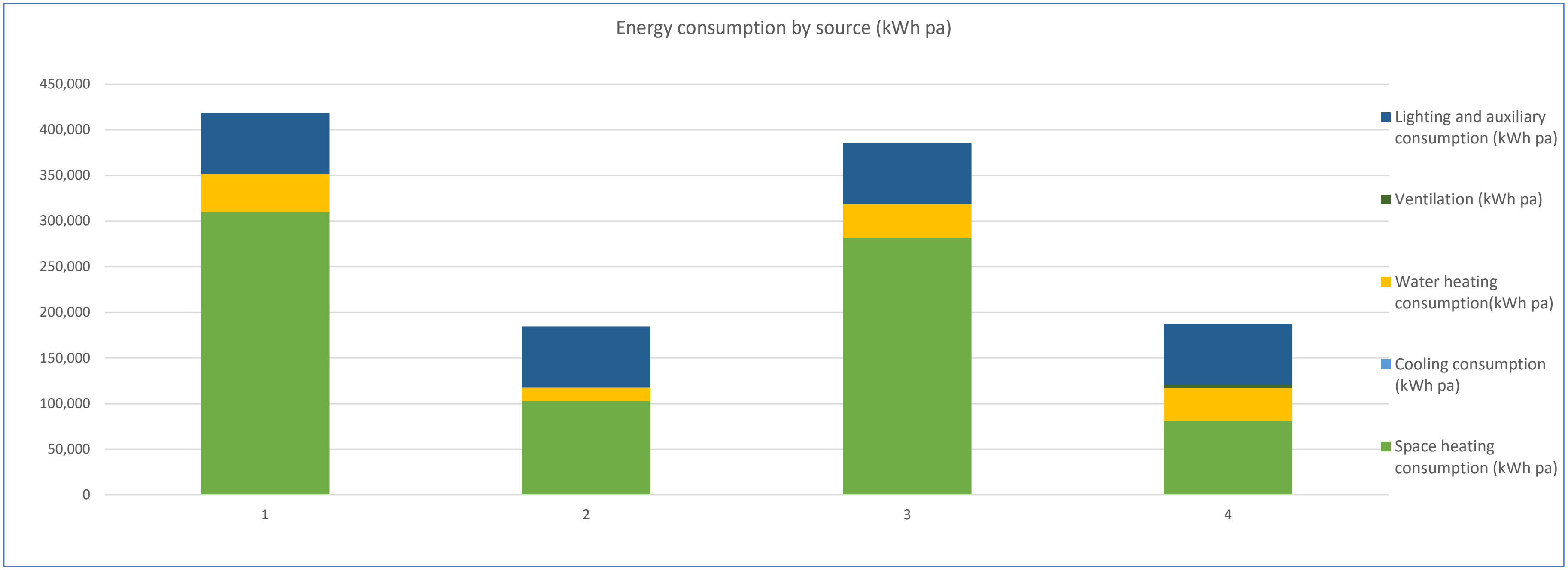
Combining heat pumps with Option 4 would have resulted in the lowest fuel bills, however with heat loss of less than 1kW per flat, the extra CAPEX for individual heat pumps in each flat would not have been worthwhile.

30 year cost of ownership
Other than the BAU, Scenario 3 has the lowest costs of ownership, suggesting that the extra investment in communal ground source heat pumps does not have an overall positive payback. However, scenario 3 has the highest tenant

Heat loss through thermal elements



Energy Consumption kWh pa



Heat demand and heating system efficiency

	Existing fabric with new gas boilers	Loft insulation and shared ambient loop heat pumps	Loft insulation with smart HHR storage heaters	Best practice fabric with HHR storage heaters
Space heating demand (kWh pa)	247,887	239,523	239,523	68,827
Space heating peak demand (kW)	134.0	129.5	129.5	37.2
Space heating peak demand per flat (kW)	3.3	3.2	3.2	0.9
Peak electricity load @ 6:00pm	16.2	71.9	16.2	16.2
Required flow temperatures °C	70	61	69	40
Space heating consumption (kWh pa)	309,858	103,242	281,791	80,973
Cooling consumption (kWh pa)	0	0	0	0
Water heating consumption(kWh pa)	41800	14343	36575	36575
Ventilation (kWh pa)	0	0	0	2926
Lighting and auxiliary consumption (kWh pa)	66880	66880	66880	66880
Assumed heating system Seasonal Performance Factor (SPF)	**80%**	**232%**	**85%**	**85%**
Assumed distribution losses	**0%**	**0%**	**0%**	**0%**
Space heating Thermal Energy Demand Intensity (kwh per m2 pa)	**119**	**115**	**115**	**33**
Energy Use Intensity - all energy use (kWh per m2 pa)	**200**	**88**	**184**	**90**

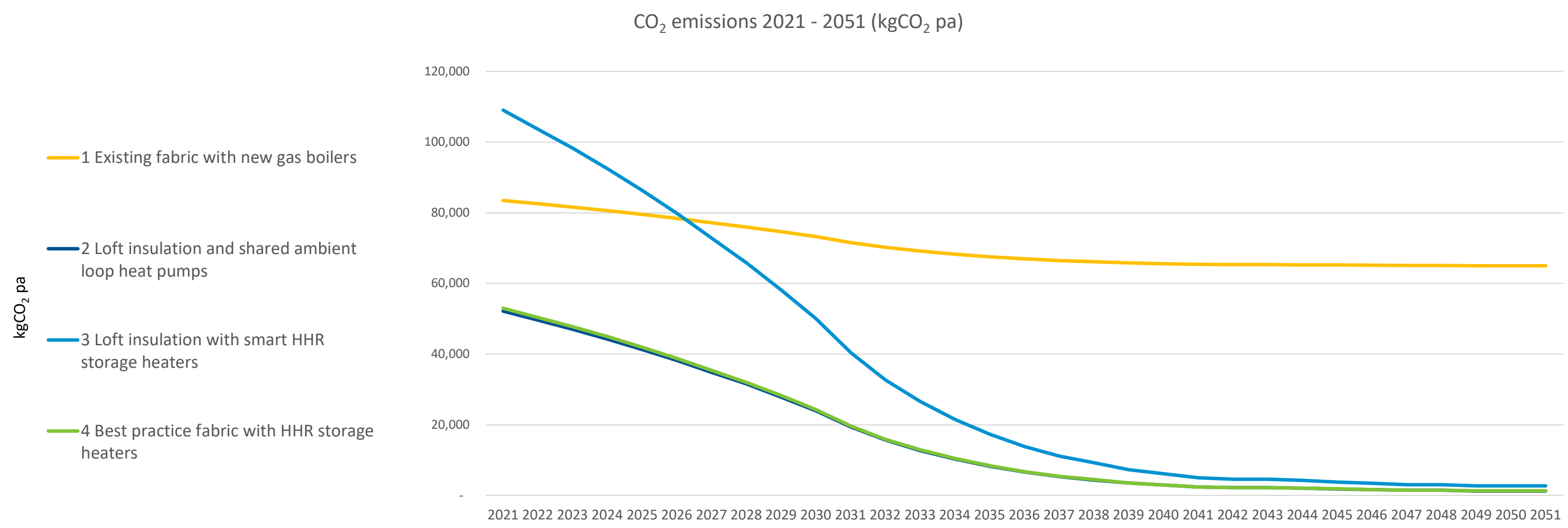
System efficiency
Whilst off-peak electric systems are less efficient than heat pump options, they offer significant advantages in adding no additional electricity load at peak times of day.

Retrofit package CO_2 emissions

tCO_2 in 2021	**83**	**52**	**109**	**53**
Predicted annual tCO_2 emissions (2030)	**73.2**	**24.0**	**50.1**	**24.4**
tCO^2 in 2050	**65.0**	**1.3**	**2.7**	**1.3**
tCO^2 cumulative 2021 - 2050	**2117**	**498**	**1040**	**506**
tCO_2 saved relative to BAU (30 year cumulative)	**0**	**-1619**	**-1077**	**-1611**
CO_2 saving relative to baseline (30 year cumulative)	**0%**	**76%**	**51%**	**76%**
Additional cost over BAU scenario (30 years)	**£0**	**£927,717**	**£774,165**	**£942,121**
£ per tonne of CO_2 reduction (30 year cumulative)	**NA**	**£573**	**£719**	**£585**

* 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

The heat pump based scenario (Option 2) and best practice fabric scenario (Option 4) offer similar savings in terms of CO_2 emissions.

Electric storage system offer smaller savings of CO_2 emissions in the near term (CO_2 emissions would rise in the immediate term under Option 3). However, these savings increase substantially in the medium - long term due to predicted decreases in grid carbon intensity. 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 boilers	Loft insulation and shared ambient loop heat pumps	Loft insulation with smart HHR storage heaters	Best practice fabric with HHR storage heaters
Included in package? (Y/N)	N	N	N	N
System size kW Peak	12.0	12.0	12.0	12.0
System generation kWh pa	11,563	11,563	11,563	11,563
Utilisation on site kWh pa	11563	11563	11563	11563
Utilisation on site kWh pa	100%	100%	100%	100%
Exported to grid kWh pa	0	0	0	0
Assumed system cost £	15600	15600	15600	15600
Net impact on fuel bills £ pa	-£ 2,439	-£ 2,439	-£ 2,721	-£ 2,721

Renewable 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. The relatively high year round use of electricity means that all scenarios could benefit from 100% on-site utilisation of solar. However, in practice, it would be difficult to split the solar PV generation between tenants.

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