Carbon Trust Options Appraisal for building decarbonisation: Summary of results

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Summary of current building

IRBY HOUSE TULSE HILL SW2 2HJ

Domestic	37 Units
Floorspace (m2)	2117
EPC Rating	C-E

Space heating consumption (kWh)	322,983
Cooling consumption (kWh)	0
Water heating consumption (kWh)	42,340
Other electricity use (kWh)	67,744
Annual total fuel bill	£14,608

Thermal Energy Demand Intensity (kWh per m2 pa)	122
Energy Use Intensity (kWh per m2 pa)	205

Age of construction	1930 - 1949
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)	Poor performing airtightness (10 n50)
Radiators / emitters	Existing radiators - single panel single convector

Description of Options for Appraisal

Thermal fabric measures:
This block of flats has relatively high heat loss within-insulated solid wall and only partial insulation in the roof. We therefore consider upgrades to roof insulation in scenario 3. In scenario 4, we model the impact of a whole building retrofit including external wall insulation and new triple glazing.

Heating systems:
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.

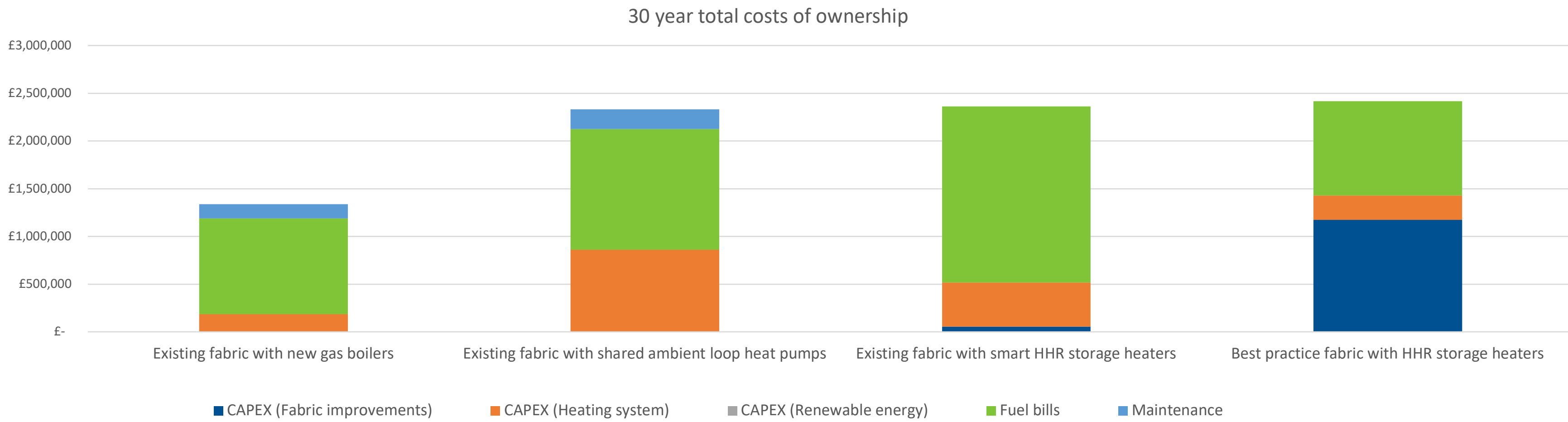
In scenario 2, we consider the installation of a new communal ambient loop with individual ground source heat pumps within each flat.

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 01:30 and 05:30.

Summary of options appraisal measures, costs & CO_2 emissions

	Existing fabric with new gas boilers	Existing fabric with shared ambient loop heat pumps	Existing fabric with smart HHR storage heaters	Best practice fabric with HHR storage heaters
HVAC system	140kW Individual flat gas boiler, 0, 0, hot water from main system (gas), combi-boiler, 0	140kW Individual flat WSHP (for shared ground loops) , 0, ground loop (communal borehole) , hot water from main system (electric), Thermal storage heat battery (e.g. Sunamp)	128kW New smart high heat retention storage heaters, 0, 0, New electric immersion heater, Thermal storage heat battery (e.g. Sunamp)	36kW New smart high heat retention storage heaters, 0, 0, New electric immersion heater, Thermal storage heat battery (e.g. Sunamp)
	£92,500	**£549,250**	**£319,110**	**£216,070**
Heat emitter and distribution	Existing pipework, Existing radiators - single panel single convector	New ambient loop installation to existing in-flat pipework , New - triple panel triple convector radiators	0, 0	0, 0
	£0	**£72,250**	**£0**	**£0**
Thermal fabric measures installed	, , ,	, , ,	, Flat roof insulation , ,	External wall insulation (Very high price - complex project) , Flat roof insulation , high performance triple glazing , Insulate solid floor
	£0	**£0**	**£54,394**	**£1,146,372**
Air tightness	Natural ventilation , Poor performing airtightness (10 n50)	Natural ventilation , Poor performing airtightness (10 n50)	Natural ventilation , Poor performing airtightness (10 n50)	MVHR (de-centralised) , AECB airtightness (1.5 n50)
	£0	**£0**	**£0**	**£25,404**
Total CAPEX	**£92,500**	**£621,500**	**£373,504**	**£1,387,846**
Clean Heat Grant	£0	£0	£0	£0
Net CAPEX	**£92,500**	**£621,500**	**£373,504**	**£1,387,846**
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	**£28,896**	**£38,979**	**£56,923**	**£30,486**
Annual fuel bills (per flat)	**£781**	**£1,053**	**£1,538**	**£824**
Annual OPEX (maintenance)	£4,773	£6,660	£0	£0
30 year total cost of ownership (excluding grant)	**£1,336,658**	**£2,331,572**	**£2,361,437**	**£2,416,066**
Annual tCO_2 emissions (2021)	**86.2**	**52.3**	**102.0**	**50.5**
Predicted annual tCO_2 emissions (2030)	**75.9**	**24.0**	**46.9**	**23.2**
Predicted annual tCO_2 emissions (2050)	**67.5**	**1.3**	**2.5**	**1.2**

30 year total costs of ownership



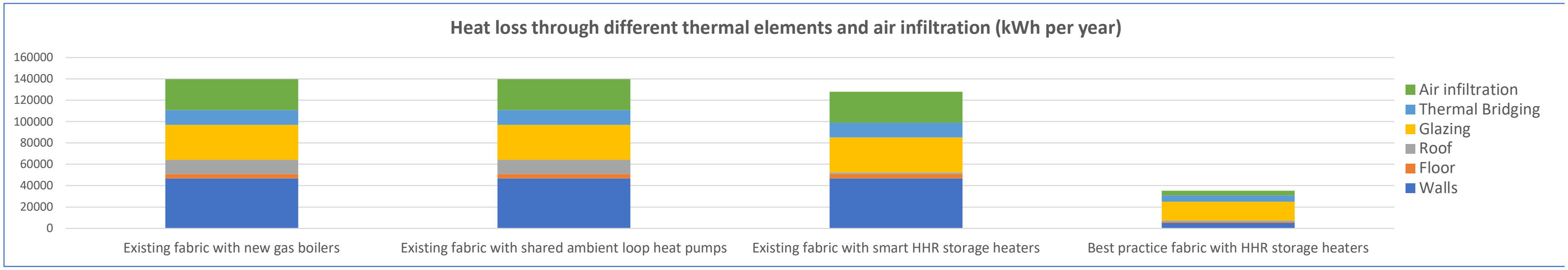
CAPEX
CAPEX is significantly higher in options 2 (due to high cost of communal ambient loop heat pumps) and 4 (due to high cost of fabric retrofit).

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.

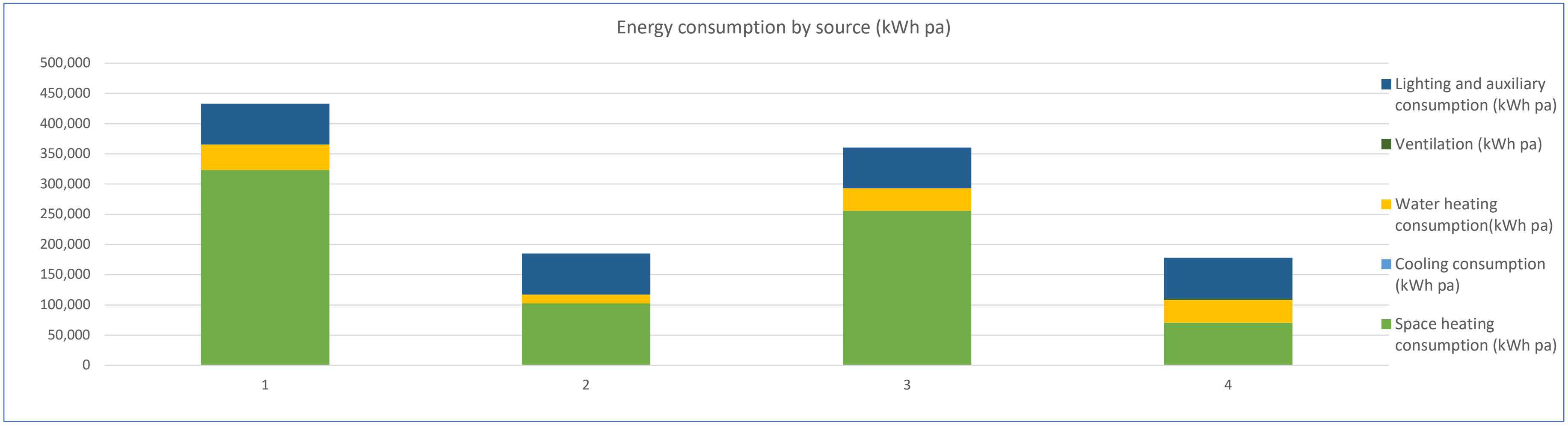
Combining heat pumps with Option 4 would have resulted in the lowest fuel bills, however with heat loss of less than 1kW per flat, the extra CAPEX for individual heat pumps in each flat would not have been worthwhile.

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 fuel bills. Therefore, scenarios 2 and 4 would be preferable from the point of view of reducing fuel poverty.

Heat loss through thermal elements



Energy Consumption kWh pa



Heat demand and heating system efficiency

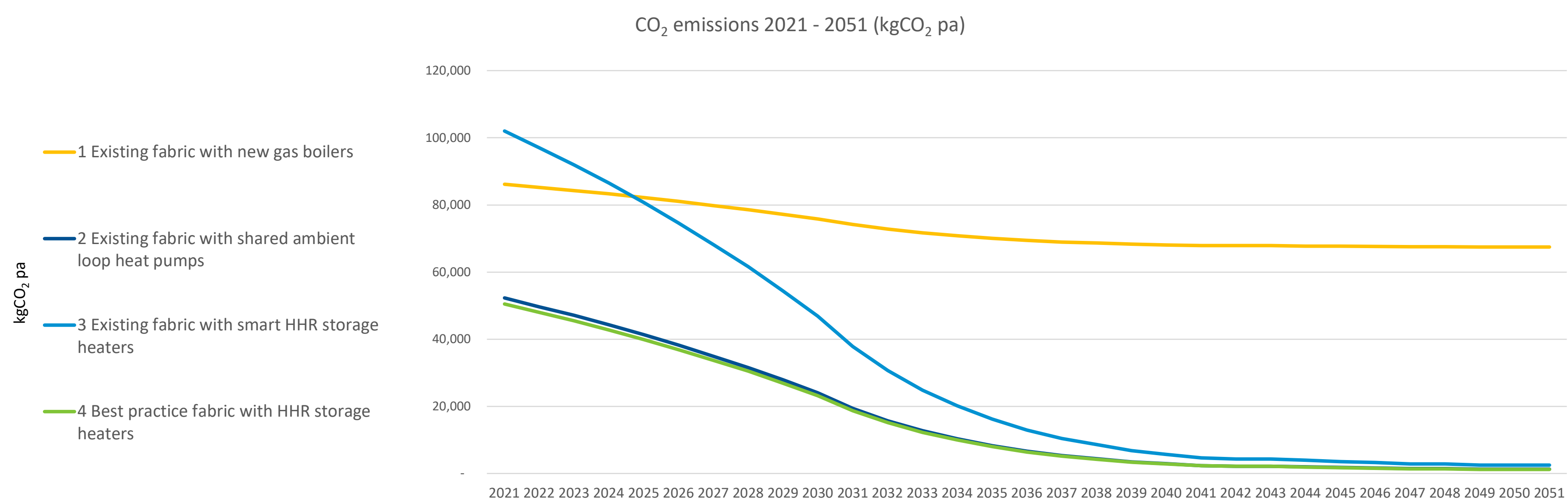
	Existing fabric with new gas boilers	Existing fabric with shared ambient loop heat pumps	Existing fabric with smart HHR storage heaters	Best practice fabric with HHR storage heaters
Space heating demand (kWh pa)	258,386	258,386	236,554	65,300
Space heating peak demand (kW)	139.7	139.7	127.9	35.3
Space heating peak demand per flat (kW)	3.8	3.8	3.5	1.0
Peak electricity load @ 6:00pm	16.4	71.8	16.4	16.4
Required flow temperatures °C	70	56	66	39
Space heating consumption (kWh pa)	322,983	102,534	255,735	70,595
Cooling consumption (kWh pa)	0	0	0	0
Water heating consumption(kWh pa)	42340	14528	37048	37048
Ventilation (kWh pa)	0	0	0	2964
Lighting and auxiliary consumption (kWh pa)	67744	67744	67744	67744
Assumed heating system Seasonal Performance Factor (SPF)	**80%**	**252%**	**93%**	**93%**
Assumed distribution losses	**0%**	**0%**	**0%**	**0%**
Space heating Thermal Energy Demand Intensity (kwh per m2 pa)	**122**	**122**	**112**	**31**
Energy Use Intensity - all energy use (kWh per m2 pa)	**205**	**87**	**170**	**84**

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	86	52	102	50
Predicted annual tCO_2 emissions (2030)	75.9	24.0	46.9	23.2
tCO^2 in 2050	67.5	1.3	2.5	1.2
tCO^2 cumulative 2021 - 2050	2194	499	973	482
tCO_2 saved relative to BAU (30 year cumulative)	0	-1695	-1221	-1713
CO_2 saving relative to baseline (30 year cumulative)	0%	77%	56%	78%
Additional cost over BAU scenario (30 years)	£0	£994,913	£1,024,779	£1,079,408
£ per tonne of CO_2 reduction (30 year cumulative)	NA	£587	£839	£630

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	Existing fabric with shared ambient loop heat pumps	Existing fabric 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