Carbon Trust Options Appraisal for building decarbonisation: Summary of results

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Summary of current building

BRIXTON TATE LIBRARY BRIXTON OVAL SW2 1JQ

Office with natural ventilation and cooling	1 Units
Floorspace (m2)	1718
EPC Rating	E
Occupied space heating consumption (kWh)	257,067
Cooling consumption (kWh)	0
Water heating consumption (kWh)	23,561
Occupied area electricity use (kWh)	111,670
Annual total fuel bill	£3,307
Occupied area Thermal Energy Demand Intensity (kWh per m2 pa)	120
Occupied area Energy Use Intensity (kWh per m2 pa)	228
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 rafters
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

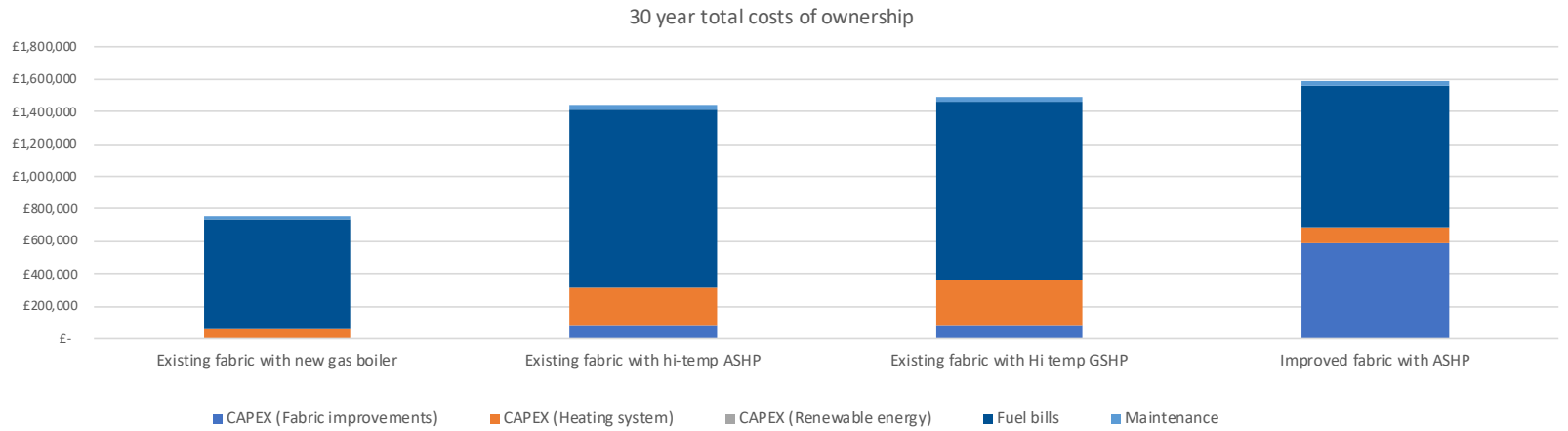
Thermal fabric measures:
This library building has relatively poor thermal fabric efficiency with an extensive area of solid external wall. However, the building is already fully double glazed and the rafters are assumed to have a level of insulation. In this options appraisal we assume that the fabric remains untouched in scenarios 1 - 3. In scenario 4, we model the impact of a full building retrofit with internal wall insulation, roof insulation, high performance triple glazing and insulated floor.

Heating systems:
The building is currently heated by a gas boiler.
In scenario 2, we assess the impact of installing a high temperature air source heat pump alongside upgraded radiators and distribution pipework.
In scenarios 3, we assess the impact of installing a high temperature ground source heat pump alongside upgraded radiators and distribution pipework.
In scenario 4, we assess the impact of an air source heat pump within the heavily upgraded building fabric.

Summary of options appraisal measures, costs & CO_2 emissions

	Existing fabric with new gas boiler	Existing fabric with hi-temp ASHP	Existing fabric with Hi temp GSHP	Improved fabric with ASHP
HVAC system	112kW New Condensing gas boiler, 0, 0, hot water from main system (gas), Communal thermal store, 0	90kW New Hi-temp ASHP Air to water >55°C, 0, 0, hot water from main system (electric), Communal thermal store	90kW New Hi-temp GSHP / WSHP >55°C, 0, ground loop (borehole) , hot water from main system (electric), Communal thermal store	39kW New ASHP Air to water <55°C, 0, 0, hot water from main system (electric), Communal thermal store
	£28,000	**£94,500**	**£162,000**	**£33,150**
Heat emitter and distribution	0, Existing radiators - single panel single convector	New in-home distribution pipework to radiators, New - triple panel triple convector radiators	New in-home distribution pipework to radiators, New - triple panel triple convector radiators	New in-home distribution pipework to radiators, New - triple panel triple convector radiators
	£0	**£49,620**	**£49,620**	**£36,105**
Thermal fabric measures installed	, , ,	, New roof with insulation (complex), ,	, New roof with insulation (complex), ,	Internal wall insulation (High price - complex interior), New roof with insulation (complex), high performance triple glazing , Insulate Suspended floor (difficult access)
	£0	**£77,310**	**£77,310**	**£576,289**
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)	MEV, Good new build performance (3 n50)
	£0	**£0**	**£0**	**£8,590**
Total CAPEX	**£28,000**	**£221,430**	**£288,930**	**£654,134**
Clean Heat Grant	£0	£0	£0	£0
Net CAPEX	**£28,000**	**£221,430**	**£288,930**	**£654,134**
Electricity tariff	Treasury Green Book Central Commercial Tariff	Treasury Green Book Central Commercial Tariff	Treasury Green Book Central Commercial Tariff	Treasury Green Book Central Commercial Tariff
Annual fuel bills	**£20,077**	**£32,625**	**£32,395**	**£25,810**
Annual OPEX (maintenance)	£650	£950	£1,050	£950
30 year total cost of ownership (excluding grant)	**£752,222**	**£1,443,976**	**£1,488,818**	**£1,586,163**
Annual tCO_2 emissions (2021)	**83.1**	**51.4**	**51.0**	**41.0**
Predicted annual tCO_2 emissions (2030)	**66.0**	**23.6**	**23.4**	**18.8**
Predicted annual tCO_2 emissions (2050)	**52.3**	**1.3**	**1.3**	**1.0**

30 year total costs of ownership

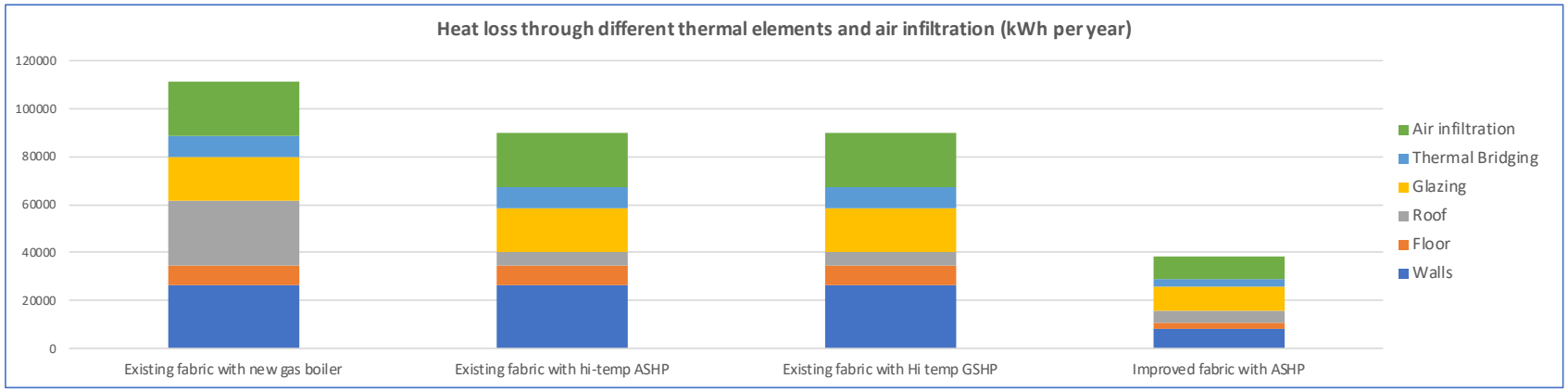


CAPEX
The highest CAPEX is associated with the thermal fabric upgrades in scenario 4. In terms of energy systems, the CAPEX for the heat pump systems is far greater than a BAU gas boiler replacement.

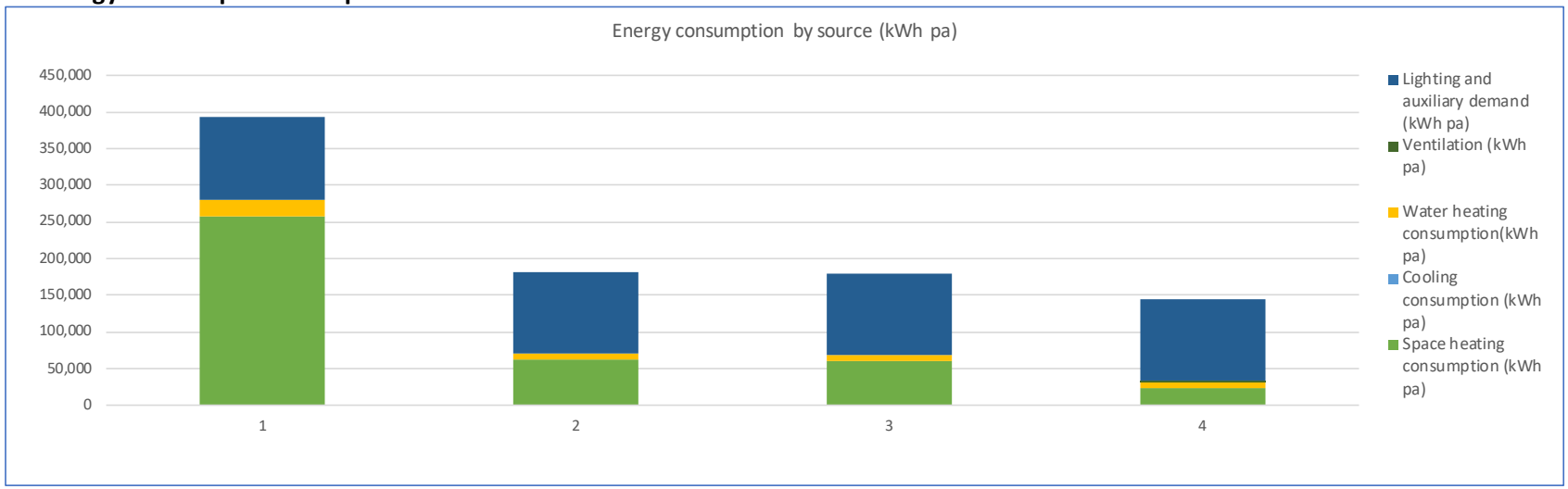
Fuel bills
Fuel bills increase significantly in all electrification scenario (2 - 4). This is due to the additional cost of electricity compared to gas, coupled with the relatively poor heat pump efficiency operating at relatively high flow temperatures. The large percentage increase in fuel bills also reflects the extent to which heat demand is the predominant source of energy use in this building.

30 year cost of ownership

Heat loss through thermal elements



Energy Consumption kWh pa



Heat demand and heating system efficiency

System efficiency

System efficiency is highest in scenario 4 reflecting the combination of reduced heat loss and increase radiator capacity.

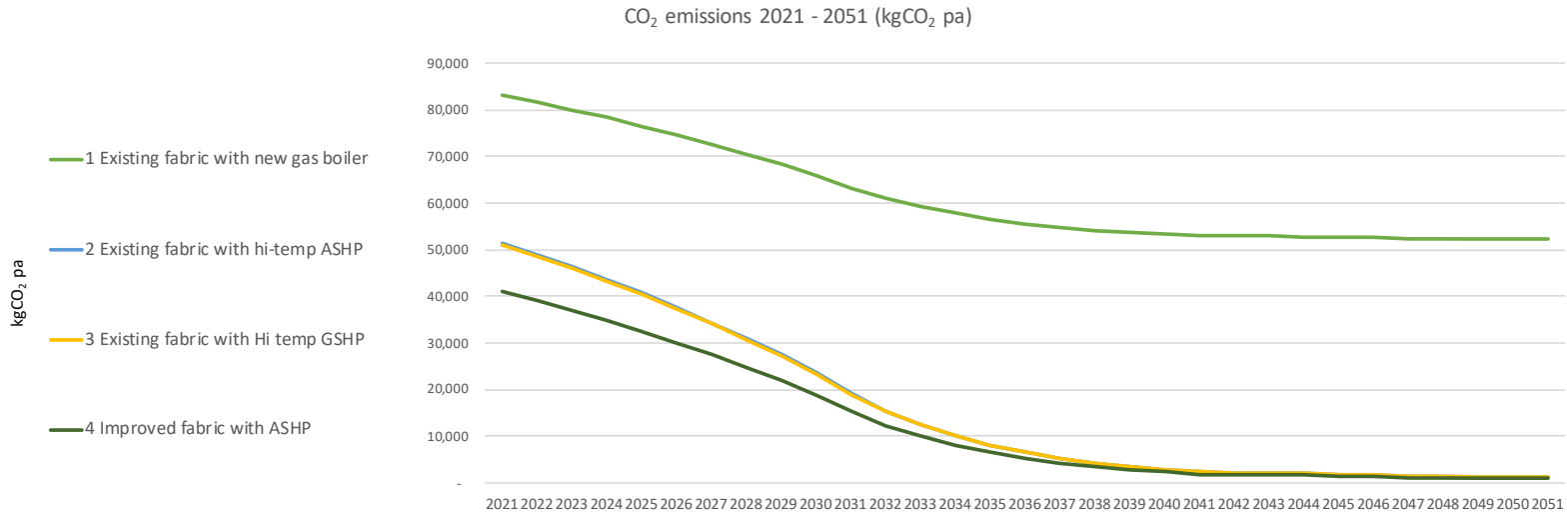
	Existing fabric with new gas boiler	Existing fabric with hi-temp ASHP	Existing fabric with Hi temp GSHP	Improved fabric with ASHP
Space heating demand (kWh pa)	205,653	165,988	165,988	70,530
Water heating demand (kW)	20616	20616	20616	20616
Required flow temperatures °C	70	48	48	29
Space heating consumption (kWh pa)	257,067	61,706	60,580	23,354
Cooling consumption (kWh pa)	0	0	0	0
Water heating consumption(kWh pa)	23561	8085	7929	8246
Lighting and auxiliary demand (kWh pa)	111670	111670	111670	111670
Space heating peak demand (kW)	111.2	89.7	89.7	38.1
Water heating peak demand (kW)	14	14	14	14
Required heating system size (kWtherm)	111	90	90	38
Peak electricity load kW @ 6:00pm	27.0	49.2	48.8	35.4
Assumed primary heating system SPF	**80%**	**269%**	**274%**	**302%**
Assumed distribution losses	**0%**	**0%**	**0%**	**0%**
Space heating Thermal Energy Demand Intensity (kwh per m2 pa)	**120**	**97**	**97**	**41**
Energy Use Intensity - all energy use (kWh per m2 pa)	**228**	**106**	**105**	**84**

Retrofit package CO_2 emissions

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

tCO_2 in 2021	83.1	51.4	51.0	41.0
Predicted annual tCO_2 emissions (2030)	66.0	23.6	23.4	18.8
Predicted annual tCO_2 emissions (2050)	52.3	1.3	1.3	1.0
tCO2 cumulative 2021 - 2050	1847	490	486	391
tCO_2 saved relative to BAU (30 year cumulative)	0	-1357	-1360	-1455
CO_2 saving relative to baseline (30 year cumulative)	0%	73%	74%	79%
Additional cost over BAU scenario (30 years)	£0	£691,754	£736,596	£833,941
£ per tonne of CO_2 reduction (30 year cumulative)	NA	£510	£542	£573

30 year predicted CO_2 emissions



CO_2 emissions

The electrification scenarios (2 - 4) show a far greater decrease in CO_2 emissions over time than the BAU, reflecting the fact that heating accounts for the majority of this buildings energy use. Scenarios 2 & 3 show a very similar level of carbon reduction of 73 - 74% over 30 years. Scenario 4 shows the largest CO_2 emissions reduction with a 79% reduction relative to BAU over 30 years.

Scenario 2 has the lows cost of carbon reduction per tCO_2.

Potential impact of Solar PV on all scenarios

	Existing fabric with new gas boiler	Existing fabric with hi-temp ASHP	Existing fabric with Hi temp GSHP	Improved fabric with ASHP
Included in package? (Y/N)	N	N	N	N
System size kW Peak	10.0	10.0	10.0	10.0
System generation kWh pa	9,636	9,636	9,636	9,636
Utilisation on site kWh pa	9636	9636	9636	9636
Utilisation on site kWh pa	100%	100%	100%	100%
Exported to grid kWh pa	0	0	0	0
Assumed system cost £	15000	15000	15000	15000
Net impact on fuel bills £ pa	-£ 1,447	-£ 1,447	-£ 1,447	-£ 1,447

Renewable energy:
We modelled the potential impact of a 10kW solar PV array on this building. Due to the high year round requirement for electricity (primarily for lighting and cooling) solar PV utilisation on-site would be high under all scenarios with assumed 100% utilisation. This would lead to significant reductions in fuel bills.

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