Carbon Trust Options Appraisal for building decarbonisation: Summary of results

2nd November 2021

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Summary of current building

57 WORSOPP DRIVE SW4 9RD

Domestic	1 Units
Floorspace (m2)	78
EPC Rating	D

Space heating consumption (kWh)	12,021
Cooling consumption (kWh)	0
Water heating consumption (kWh)	1,560
Other electricity use (kWh)	2,496
Annual total fuel bill	£543

Thermal Energy Demand Intensity (kWh per m2 pa)	131
Energy Use Intensity (kWh per m2 pa)	206

Age of construction	1967 - 1975
Windows	double glazing, unknown install date
Wall	Cavity as built
Roof	Pitched roof with insulation at joists
Floor	Insulation unkown 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

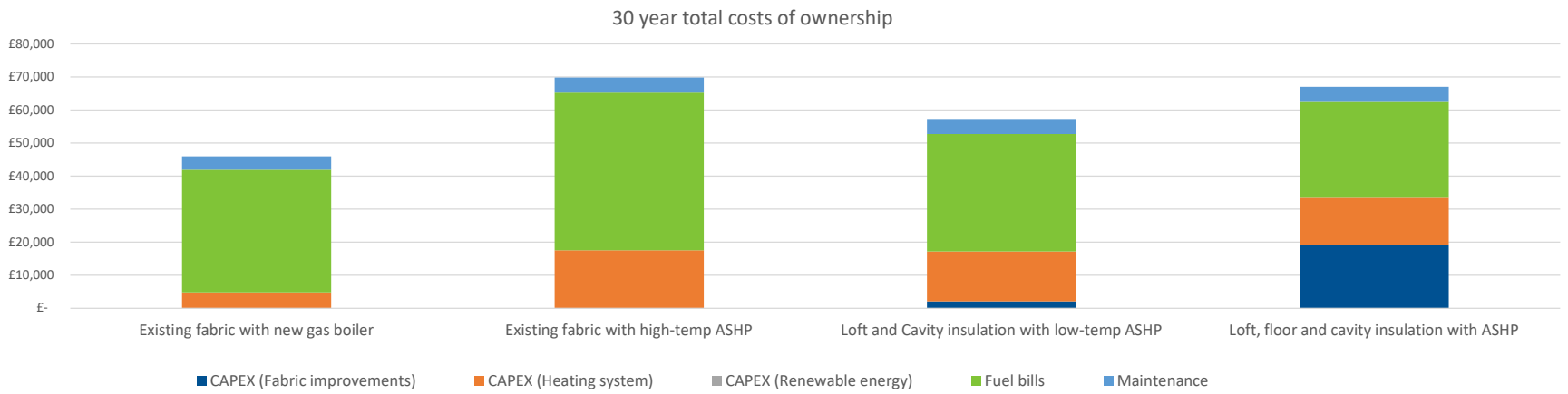
Thermal fabric measures:
This mid-terrace house has an EPC rating of D and currently has poor levels of insulation with un-insulated cavity walls, partial insulation in the loft and no floor insulation. Windows are double glazed.
In scenario 1 2 we assume that the thermal fabric remains the same.
in scenario 3 we assume that cost effective measures are undertaken including cavity wall insulation and loft insulation.
In scenario 4, we assume that a full house retrofit is undertaken also include high performance triple glazing and under-floor insulation.

Heating system:
In scenario 1, we assume that the gas boiler is replaced like for like.
In scenario 2, we assume an air-source heat pump is installed. Due to the high level of heat loss, a high temperature heat pump is specified to enable flow temperatures above 55°C.
In scenario 3, a standard air source heat pump is specified, with upgraded radiators to enable flow temperatures of around 45°C
In scenario 4, we assume an air source heat pump is installed, utilising existing radiators. The lower heat loss in this scenario means flow temperatures below 45°C could still be achieved.

Summary of options appraisal measures, costs & CO_2 emissions

	Existing fabric with new gas boiler	Existing fabric with high-temp ASHP	Loft and Cavity insulation with low-temp ASHP	Loft, floor and cavity insulation with ASHP
HVAC system	6kW New Condensing gas boiler, 0, 0, hot water from main system (gas), combi-boiler, 0	6kW New Hi-temp ASHP Air to water >55°C, 0, 0, hot water from main system (electric), Hot water cylinder and associated pipework	4kW New ASHP Air to water <55°C, 0, 0, hot water from main system (electric), Hot water cylinder and associated pipework	3kW New ASHP Air to water <55°C, 0, 0, hot water from main system (electric), Hot water cylinder and associated pipework
	£2,400	**£8,750**	**£7,750**	**£7,750**
Heat emitter and distribution	Existing pipework, Existing radiators - single panel single convector	Existing pipework, New - Double panel double convector radiators	Existing pipework, New - Double panel double convector radiators	Existing pipework, Existing radiators - double panel, double convector
	£0	**£0**	**£0**	**£0**
Thermal fabric measures installed	, , ,	, , ,	Cavity wall insulation , Loft insulation (Joists) 0 - 270mm, ,	Cavity wall insulation , Loft insulation (Joists) 0 - 270mm, high performance triple glazing , Insulate Suspended floor (difficult access)
	£0	**£0**	**£1,691**	**£18,812**
Air tightness	Natural ventilation , Poor performing airtightness (10 n50)	Natural ventilation , Poor performing airtightness (10 n50)	MEV, Average air tightness (7.5 n50)	MEV, Building regs airtightness (5 n50)
	£0	**£0**	**£390**	**£390**
Total CAPEX	**£2,400**	**£8,750**	**£9,831**	**£26,952**
Clean Heat Grant	£0	£5,000	£5,000	£0
Net CAPEX	**£2,400**	**£3,750**	**£4,831**	**£26,952**
Electricity tariff	Treasury Green Book Central Domestic Tariff	Treasury Green Book Central Domestic Tariff	Treasury Green Book Central Domestic Tariff	Treasury Green Book Central Domestic Tariff
Annual fuel bills	**£1,070**	**£1,471**	**£1,097**	**£896**
Annual OPEX (maintenance)	£129	£148	£148	£148
30 year total cost of ownership (excluding grant)	**£45,959**	**£69,811**	**£57,335**	**£67,063**
Annual tCO_2 emissions (2021)	**3.2**	**2.0**	**1.5**	**1.2**
Predicted annual tCO_2 emissions (2030)	**2.8**	**0.9**	**0.7**	**0.6**
Predicted annual tCO_2 emissions (2050)	**2.5**	**0.0**	**0.0**	**0.0**

30 year total costs of ownerhsip

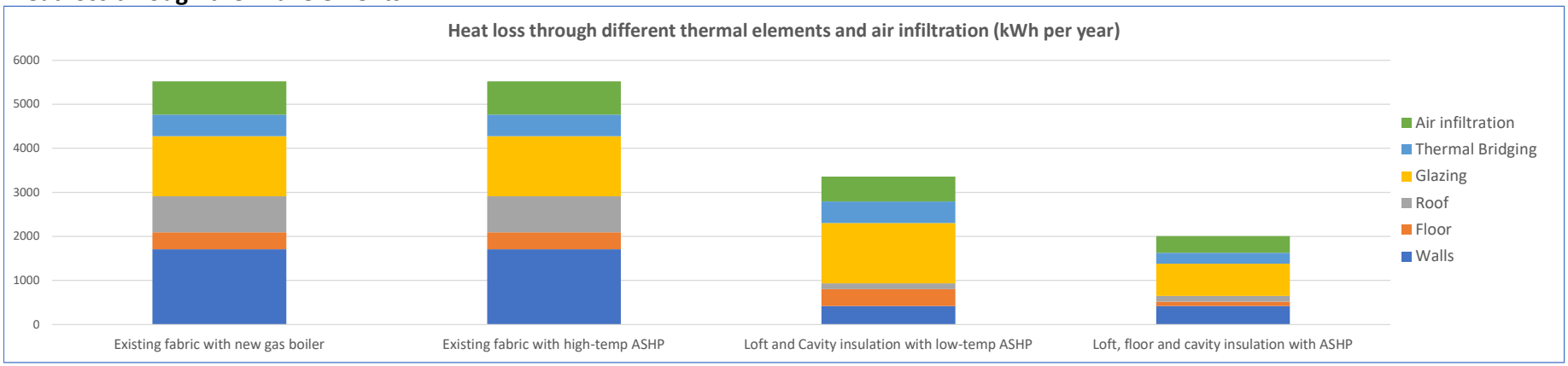


CAPEX
CAPEX increase significantly in scenarios 2 - 4. However, the thermal fabric measures in this household are relatively low cost compared to other buildings analysed in this study. The additional CAPEX for loft and cavity wall insulation is very low for a large impact on fuel bills.

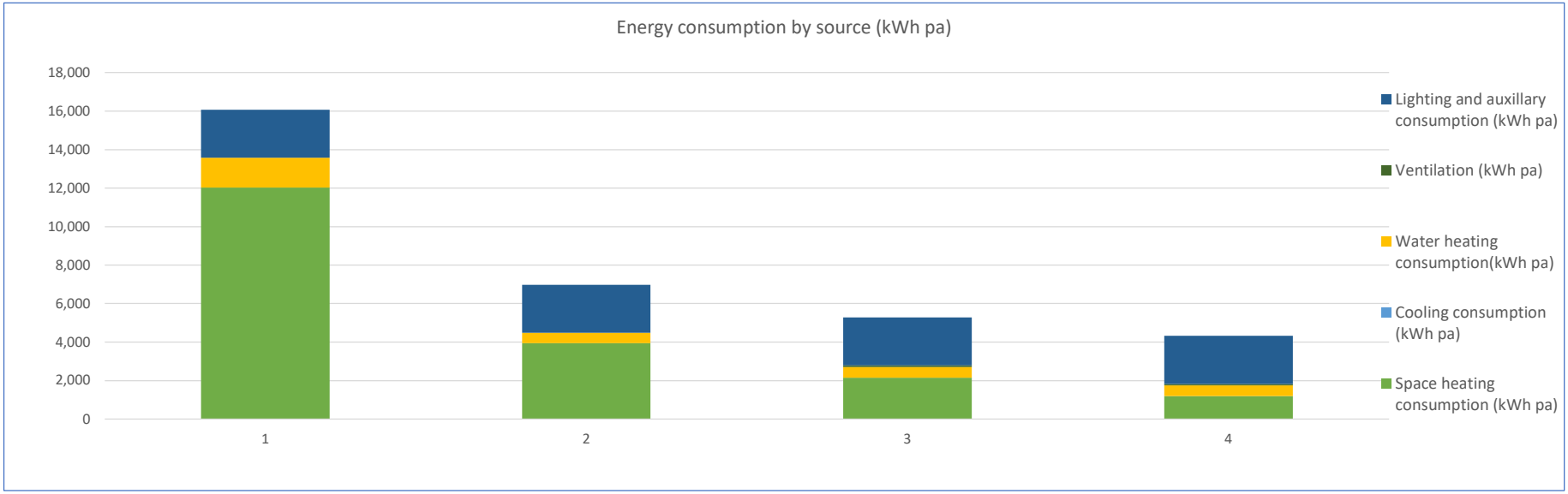
Fuel bills
Fuel bills increase significantly in scenario 2, where the relatively poor efficiency of the high temperature heat pump causes higher energy use than in scenarios 3 & 4. Energy bills in scenario 3 are broadly equivalent to BAU. Energy bills in scenario 4 are the lowest.

30 year cost of ownership
The BAU scenario has the lowest 30 year costs of ownership. Scenario 3 has the lowest costs of ownership of the electrification options, highlighting that the investment in cavity wall insulation and loft insulation if worthwhile. In contract, the additional investment in high performance glazing and floor insulation increases costs of ownership.

Heat loss through thermal elements



Energy Consumption kWh pa



Heat demand and heating system efficiency

	Existing fabric with new gas boiler	Existing fabric with high-temp ASHP	Loft and Cavity insulation with low-temp ASHP	Loft, floor and cavity insulation with ASHP
Space heating demand (kWh pa)	10,218	10,218	6,221	3,709
Space heating peak demand (kW)	5.5	5.5	3.4	2.0
Space heating peak demand per flat (kW)	5.5	5.5	3.4	2.0
Peak electricity load @ 6:00pm	0.6	2.7	1.8	1.3
Required flow temperatures °C	60	53	36	26
Space heating consumption (kWh pa)	12,021	3,945	2,160	1,204
Cooling consumption (kWh pa)	0	0	0	0
Water heating consumption(kWh pa)	1560	535	546	546
Ventilation (kWh pa)	0	0	78	78
Lighting and auxillary consumption (kWh pa)	2496	2496	2496	2496
Assumed heating system Seasonal Performance Factor (SPF)	**85%**	**259%**	**288%**	**308%**
Assumed distribution losses	**0%**	**0%**	**0%**	**0%**
Space heating Thermal Energy Demand Intensity (kwh per m2 pa)	**131**	**131**	**80**	**48**
Energy Use Intensity - all energy use (kWh per m2 pa)	**206**	**89**	**68**	**55**

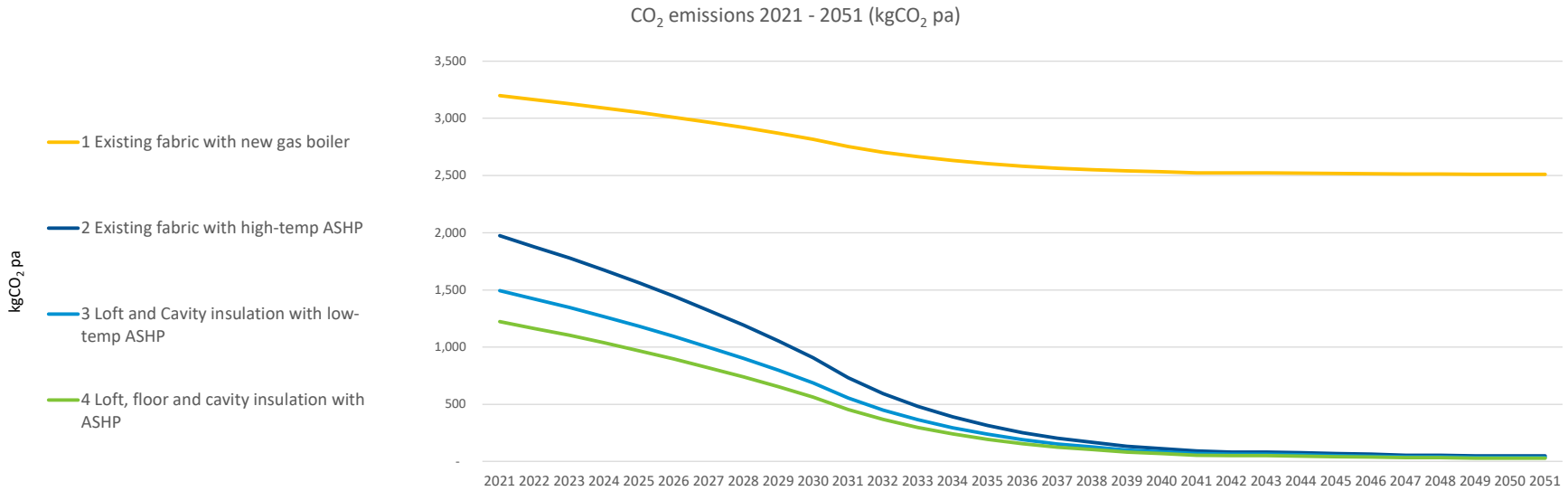
Scenario 4 offers the best system efficiency, with very low peak flow temperatures below 40°C. Scenarios 3 & 4 also significantly reduce peak time consumption compared to scenario 2 (high temperature heat pump) demonstrating the potential benefits of thermal fabric efficiency to the electricity network.

Retrofit package CO_2 emissions

tCO_2 in 2021	3	2	1	1
Predicted annual tCO_2 emissions (2030)	2.8	0.9	0.7	0.6
tCO^2 in 2050	2.5	0.0	0.0	0.0
tCO^2 cumulative 2021 - 2050	82	19	14	12
tCO_2 saved realtive to BAU (30 year cumulative)	0	-63	-67	-70
CO_2 saving relative to baseline (30 year cumulative)	0%	77%	83%	86%
Additional cost over BAU scenario (30 years)	£0	£23,852	£11,375	£21,104
£ per tonne of CO_2 reduction (30 year cumulative)	NA	£381	£169	£302

* 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
CO_2 emissions reduce substantially under all electrification scenarios, reducing CO2 emissions by 77 - 86% between 2021 and 2051.

Potential impact of Solar PV on all scenarios

	Existing fabric with new gas boiler	Existing fabric with high-temp ASHP	Loft and Cavity insulation with low-temp ASHP	Loft, floor and cavity insulation with ASHP
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	1036	1373	1279	1198
Utilisation on site kWh pa	43%	57%	53%	50%
Exported to grid kWh pa	1373	1036	1130	1211
Assumed system cost £	3750	3750	3750	3750
Net impact on fuel bills £ pa	-£ 273	-£ 331	-£ 315	-£ 301

Renewable energy:
We separately modelled the impact of a 2.5kW solar PV system for each of the scenarios. Due to the relatively low year round demand for electricity in this property, on-site utilisation is modelled as being relatively low.

Impact of Solar PV on Scenario 2 - typical summer and winter days