Carbon Trust Options Appraisal for building decarbonisation: Summary of results

2nd November 2021

Author: Ruth Tewungwa

Reviewed by: Will Rivers

Summary of current building

Halfords 51-27 Effra Road Unit B SW2 1BZ

Retail (Shop)	1 Units
Floorspace (m2)	1070
EPC Rating	C

Occupied space heating consumption (kWh)	62,620
Cooling consumption (kWh)	29,960
Water heating consumption (kWh)	11,006
Occupied area electricity use (kWh)	74,900
Annual total fuel bill	£2,181
Annual fuel bill per flat (including share of communal areas)	£2,181

Occupied area Thermal Energy Demand Intensity (kWh per m2 pa)	54
Occupied area Energy Use Intensity (kWh per m2 pa)	167

Age of construction	1996 - 2002
Windows	Double glazed windows pre 2002
Wall	Cavity as built
Roof	Flat roof
Floor	Insulation unknown or as-built
Primary heating	Existing - condensing gas boiler
Air tightness (ACH @ ambient pressure)	Building regs airtightness (5 n50)
Radiators / emitters	Existing - Air handling units (heating and cooling)

Description of Options for Appraisal

Thermal fabric measures:
Constructed between 1996 and 2002, and with minimal glazed area, this building already has relatively good performance from a fabric point of view. Therefore, in scenarios 1 - 3 we assume that the building fabric remains unchanged. In scenario 4 we assume that all areas of fabric are improved to best practice standards.

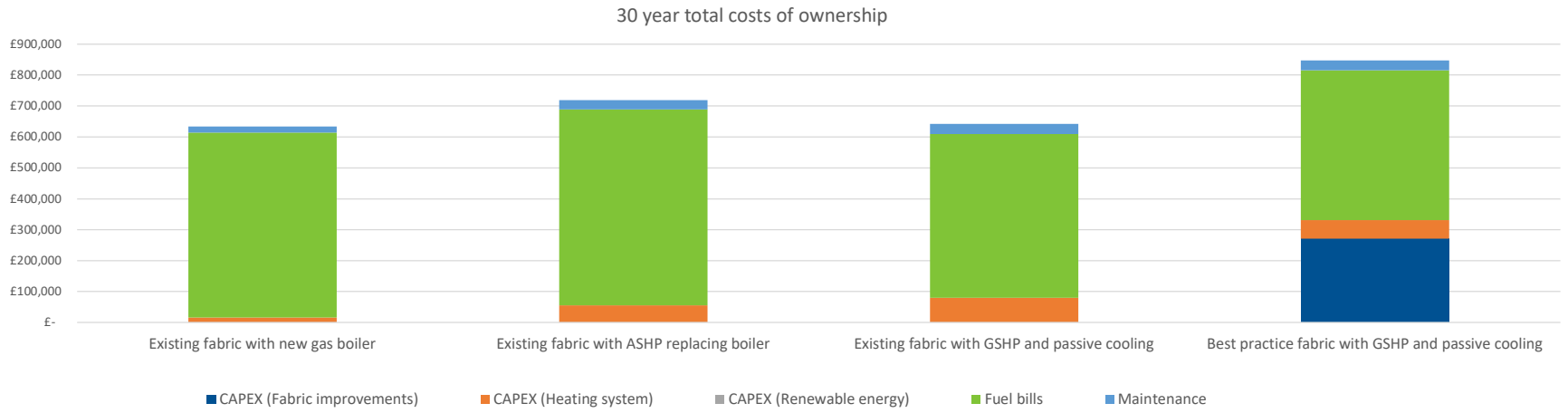
Heating systems:
The existing heating systems include a gas boiler feeding in to air handling units, that are also fed by existing chillers to provide cooling demand. in Scenario 1, we assume that the gas boiler is replaced like for like. In scenario 2, as assume that the gas boiler is replaced by an Air Source Heat Pumps for heating purposes only. In scenario 3, we assume that a ground source heat pump is used for both space heating and also passive cooling, replacing the existing gas boiler and supplementing the existing chillers. In scenario 4, we look again at an Air Source Heat Pump when partnered with best practice fabric.

In all scenarios we assume that the existing air handling units and ventilation systems are retained.

Summary of options appraisal measures, costs & CO_2 emissions

	Existing fabric with new gas boiler	Existing fabric with ASHP replacing boiler	Existing fabric with GSHP and passive cooling	Best practice fabric with GSHP and passive cooling
HVAC system	32kW New Condensing gas boiler, 0, 0, hot water from main system (gas), 0, Existing - AHUs with chillers	32kW New ASHP Air to water <55°C, 0, 0, hot water from main system (electric), Hot water cylinder and associated pipework	32kW New GSHP/ WSHP <55°C, 0, ground loop (borehole) , hot water from main system (electric), Hot water cylinder and associated pipework	19kW New GSHP/ WSHP <55°C, 0, ground loop (borehole) , hot water from main system (electric), Hot water cylinder and associated pipework
	£8,000	**£28,450**	**£55,650**	**£45,900**
Heat emitter and distribution	0, Existing - Air handling units (heating and cooling)	0, Existing - Air handling units (heating and cooling)	0, Existing - Air handling units (heating and cooling)	0, Existing - Air handling units (heating and cooling)
	£0	**£0**	**£0**	**£0**
Thermal fabric measures installed	, , ,	, , ,	, , ,	External wall insulation (very high price - complex project), Flat roof insulation , high performance triple glazing , Insulate Suspended floor (difficult access)
	£0	**£0**	**£0**	**£271,082**
Air tightness	Existing AHUs (energy use accounted for in emitters), Building regs airtightness (5 n50)	Existing AHUs (energy use accounted for in emitters), Building regs airtightness (5 n50)	Existing AHUs (energy use accounted for in emitters), Building regs airtightness (5 n50)	Existing AHUs (energy use accounted for in emitters), AECB airtightness (1.5 n50)
	£0	**£0**	**£0**	**£0**
Total CAPEX	**£8,000**	**£28,450**	**£55,650**	**£316,982**
Clean Heat Grant	£0	£0	£0	£0
Net CAPEX	**£8,000**	**£28,450**	**£55,650**	**£316,982**
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	**£17,928**	**£19,548**	**£16,346**	**£14,941**
Annual OPEX (maintenance)	£650	£950	£1,050	£1,050
30 year total cost of ownership (excluding grant)	**£633,893**	**£718,537**	**£641,883**	**£847,948**
Annual tCO_2 emissions (2021)	**43.2**	**36.8**	**30.8**	**28.2**
Predicted annual tCO_2 emissions (2030)	**27.1**	**16.9**	**14.1**	**12.9**
Predicted annual tCO_2 emissions (2050)	**14.2**	**0.9**	**0.8**	**0.7**

30 year total costs of ownership

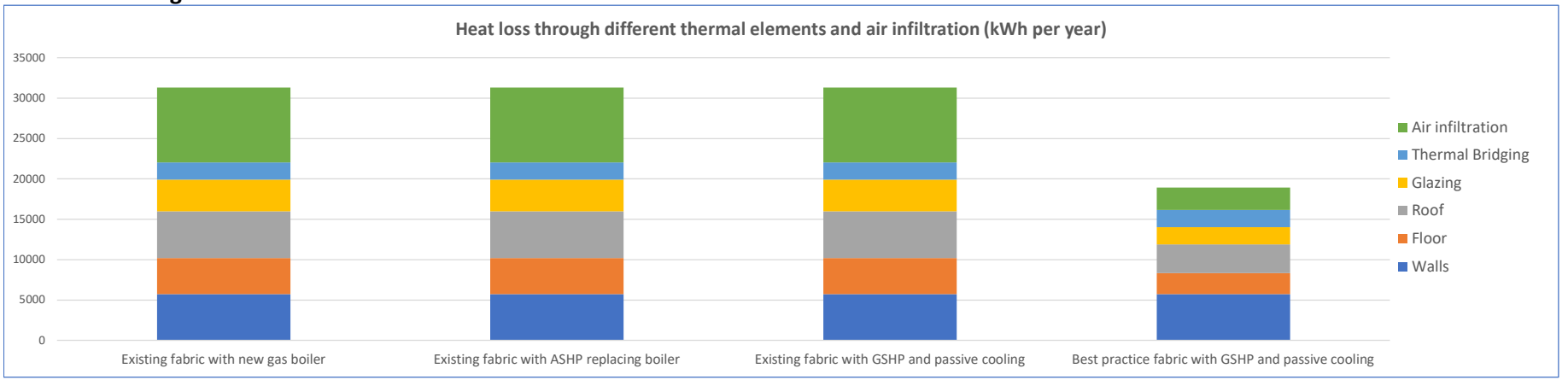


CAPEX
All electrification scenarios involve a significant uplift in CAPEX over the BAU scenario. The GSHP in scenario 3 is assumed to cost approximately double that of the ASHP in scenario 2. The highest CAPEX is in scenario 4 due to the high level of fabric retrofit.

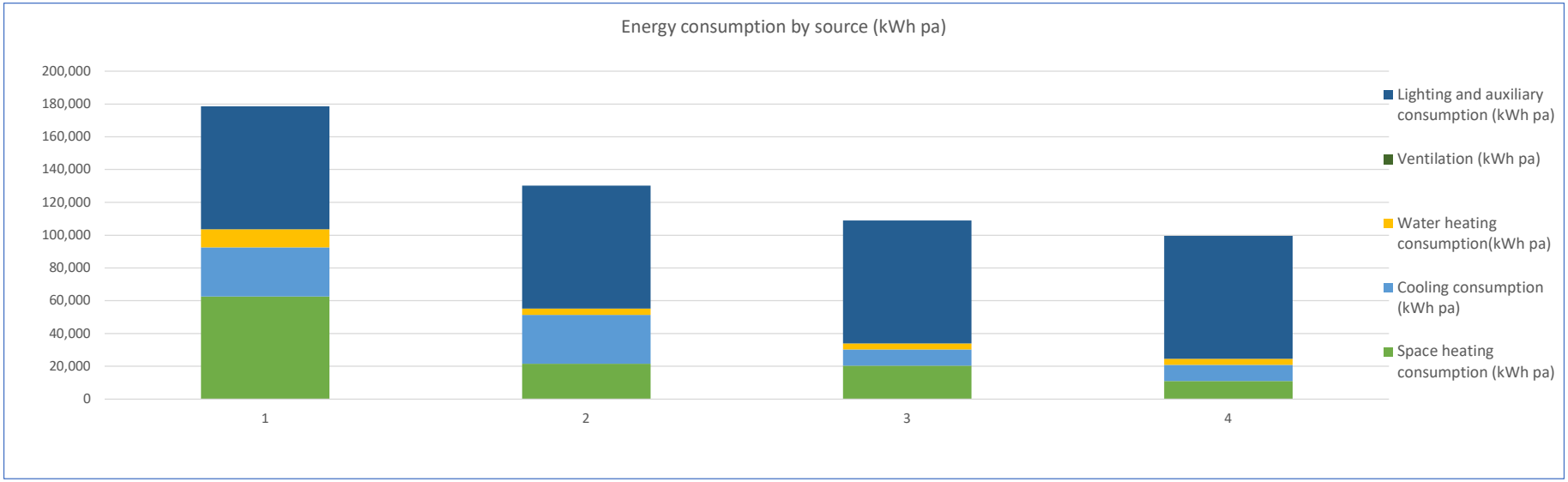
Fuel bills
Fuel bills are lowest in scenarios 3 & 4 reflecting the reduction in electricity use associated the passive cooling being provided by the ground source loop. This enables overall fuel bills that are lower than the BAU.

30 year cost of ownership
Of the electrification options, scenario 3 has the lowest overall costs of ownership, with lower lifetime costs than scenarios 2 & 4 and only marginally higher than the BAU scenario. This suggests that the additional CAPEX to invest in the ground source heat pump, used for both heating and cooling has a positive return on investment. However, the additional investment in fabric efficiency in scenario 4 does not yield a positive return on investment.

Heat loss through thermal elements



Energy Consumption kWh pa



Heat demand and heating system efficiency

	Existing fabric with new gas boiler	Existing fabric with ASHP replacing boiler	Existing fabric with GSHP and passive cooling	Best practice fabric with GSHP and passive cooling
Space heating demand (kWh pa)	57,924	57,924	57,924	34,997
Space heating peak demand (kW)	31.3	31.3	31.3	18.9
Peak electricity load @ 6:00pm	18.1	25.8	25.4	22.0
Required flow temperatures °C	45	45	45	28
Space heating consumption (kWh pa)	62,620	21,453	20,324	10,971
Cooling consumption (kWh pa)	29,960	29,960	9,987	9,987
Water heating consumption(kWh pa)	11006	3852	3634	3634
Lighting and auxiliary consumption (kWh pa)	74900	74900	74900	74900
Assumed heating system Seasonal Performance Factor (SPF)	**93%**	**270%**	**285%**	**319%**
Assumed distribution losses	**0%**	**0%**	**0%**	**0%**
Space heating Thermal Energy Demand Intensity (kwh per m2 pa)	**54**	**54**	**54**	**33**
Energy Use Intensity - all energy use (kWh per m2 pa)	**167**	**122**	**102**	**93**

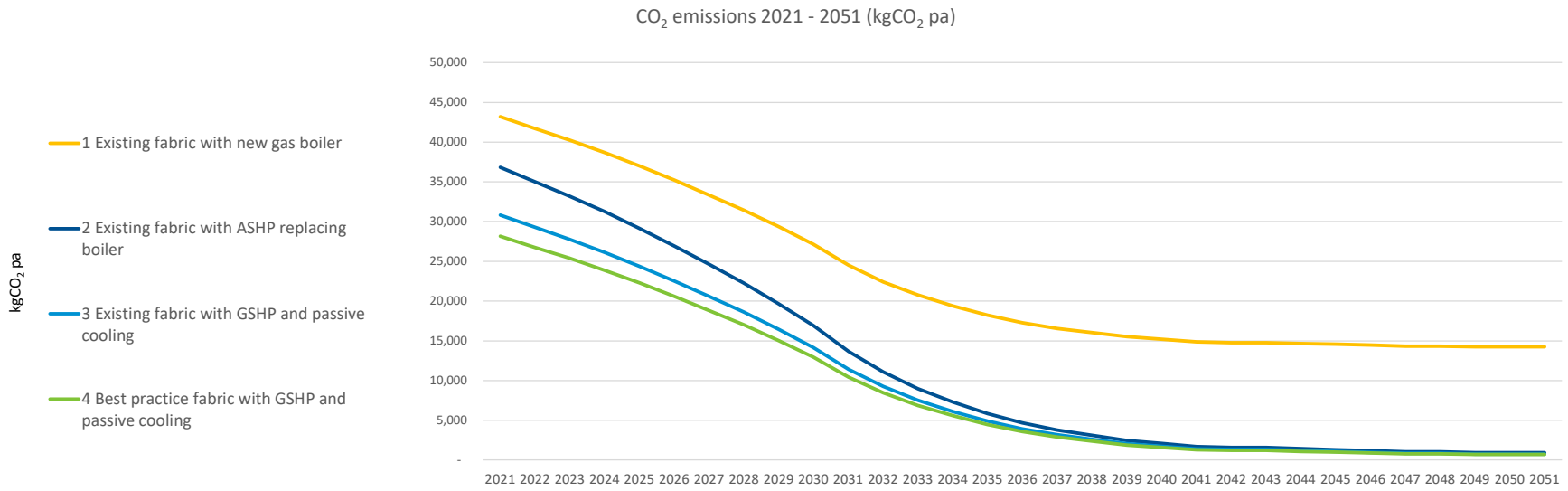
System efficiency
Energy Use Intensity declines significantly in scenarios 2-4 relative to BAU, thanks to the high efficiency of the heat pump options. Energy Use Intensity is lowest in Scenarios 3 & 4 due to the high efficiency of the passive cooling from the ground loop.

Retrofit package CO_2 emissions

tCO_2 in 2021	43	37	31	28
Predicted annual tCO_2 emissions (2030)	27.1	16.9	14.1	12.9
Predicted annual tCO_2 emissions (2035)	14.2	0.9	0.8	0.7
tCO2 cumulative 2021 - 2050	688	351	294	269
tCO_2 saved relative to BAU (30 year cumulative)	0	-337	-395	-420
CO_2 saving relative to baseline (30 year cumulative)	0%	49%	57%	61%
Additional cost over BAU scenario (30 years)	£0	£84,644	£7,989	£214,055
£ per tonne of CO_2 reduction (30 year cumulative)	NA	£251	£20	£510

* 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 decline significantly in all scenarios. This is due to the high proportion of energy use that is already electricity and the relatively low proportion of energy use from gas.

Potential impact of Solar PV on all scenarios

	Existing fabric with new gas boiler	Existing fabric with ASHP replacing boiler	Existing fabric with GSHP and passive cooling	Best practice fabric with GSHP and passive cooling
Included in package? (Y/N)	N	N	N	N
System size kW Peak	20.0	20.0	20.0	20.0
System generation kWh pa	19,272	19,272	19,272	19,272
Utilisation on site kWh pa	19265	19271	19262	19262
Utilisation on site kWh pa	100%	100%	100%	100%
Exported to grid kWh pa	7	1	10	10
Assumed system cost £	30000	30000	30000	30000
Net impact on fuel bills £ pa	-£ 2,893	-£ 2,894	-£ 2,893	-£ 2,893

Renewable energy:
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