Carbon Trust Options Appraisal for building decarbonisation: Summary of results

2nd November 2021

Author: Ruth Tewungwa

Reviewed by: Will Rivers

Summary of current building

FLAT 1, 32 MACAULAY ROAD SW4 0QX

Domestic	1 Units
Floorspace (m2)	41
EPC Rating	D
Space heating consumption (kWh)	12,384
Cooling consumption (kWh)	0
Water heating consumption (kWh)	820
Other electricity use (kWh)	1,312
Annual total fuel bill	£528
Thermal Energy Demand Intensity (kWh per m2 pa)	242
Energy Use Intensity (kWh per m2 pa)	354

Age of construction	pre 1900
Windows	Single glazed windows
Wall	Solid brick, as built, no insulation (assumed)
Roof	Another dwelling above
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:
Despite its small size, this ground floor flat has high heat loss due to having three external walls (solid, un-insulated) and single glazing. Therefore, double glazing is considered in scenario 2 and high performance triple glazing considered in scenario 4. in scenario 3, internal wall insulation and floor insulation are also included.

Heating system:
Being on the ground floor, there is potential for a premium low noise heat pump model to be located in the rear garden. This is included in scenario 2. However, this would need to be subject to a noise impact assessment with the proximity of neighbouring windows potentially providing a barrier to installation.

In scenario 3, an electric storage boiler is considered alongside existing radiators. In scenario 4, due to the low level of heat loss, HHR electric storage heaters are considered.

In scenarios 2-4, a new how water cylinder would be required. In a small flat, space may be difficult to find for this. Therefore, it may be necessary to consider a small thermal store phase change unit (e.g. Sunamp).

Summary of options appraisal measures, costs & CO_2 emissions

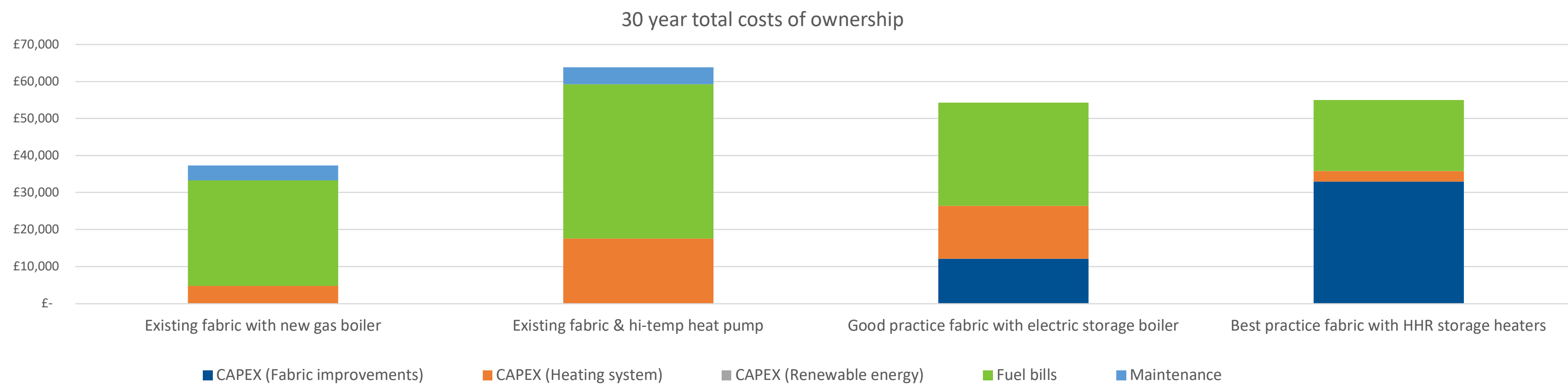
	Existing fabric with new gas boiler	Existing fabric & hi-temp heat pump	Good practice fabric with electric storage boiler	Best practice fabric with HHR storage heaters
HVAC system	6kW New Condensing gas boiler, 0, 0, hot water from main system (gas), 0, 0	6kW New Hi-temp ASHP Air to water >55°C, 0, 0, hot water from main system (electric), Hot water cylinder and associated pipework	5kW New electric storage boiler (e.g. Tepeo) , 0, 0, hot water from main system (electric), Hot water cylinder and associated pipework	2kW New electric storage heaters, 0, 0, New electric immersion heater, Hot water cylinder and associated pipework
	£2,400	**£8,750**	**£7,750**	**£2,830**
Heat emitter and distribution	0, Existing radiators - single panel single convector	0, New - Double panel double convector radiators	0, Existing radiators - single panel single convector	0, 0
	£0	**£1,290**	**£0**	**£0**
Thermal fabric measures installed	, , ,	, , ,	, , Double Glazing (Wooden sash) ,	Internal wall insulation (High price - complex interior), , high performance triple glazing , Insulate Suspended floor (difficult access)
	£0	**£0**	**£11,930**	**£32,486**
Air tightness	Natural ventilation , Average air tightness (7.5 n50)	Natural ventilation , Average air tightness (7.5 n50)	MEV, Average air tightness (7.5 n50)	MVHR (de-centralised) , Good new build performance (3 n50)
	£0	**£0**	**£205**	**£492**

Total CAPEX	**£2,400**	**£10,040**	**£19,885**	**£35,808**
Clean Heat Grant	£0	£5,000	£0	£0
Net CAPEX	**£2,400**	**£5,040**	**£19,885**	**£35,808**

Electricity tariff	Treasury Green Book Central Domestic Tariff	Treasury Green Book Central Domestic Tariff	Domestic low overnight Tariff 01:30 - 06:30	Domestic low overnight Tariff 01:30 - 06:30
Annual fuel bills	**£805**	**£1,286**	**£862**	**£594**
Annual fuel bills (per flat)	**£805**	**£1,286**	**£862**	**£594**
Annual OPEX (maintenance)	£129	£148	£0	£0
30 year total cost of ownership (excluding grant)	**£37,308**	**£63,796**	**£54,326**	**£55,048**

Annual tCO_2 emissions (2021)	**2.8**	**1.7**	**2.9**	**1.6**
Predicted annual tCO_2 emissions (2030)	**2.6**	**0.8**	**1.3**	**0.8**
Predicted annual tCO_2 emissions (2050)	**2.4**	**0.0**	**0.1**	**0.0**

30 year total costs of ownership



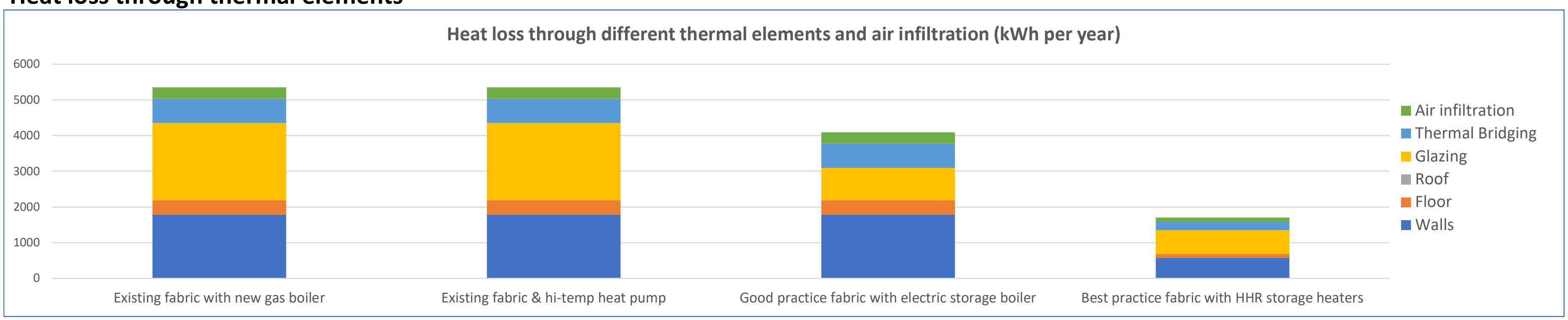
CAPEX
CAPEX for Options 3 and 4 are significantly higher than BAU due to increased heating system and fabric efficiency costs. However, CAPEX costs for the heating system decline as the heat load decreases due to the thermal fabric measures.

Fuel bills
Fuel bills increase significantly in scenario 2, this is due to the relatively low efficiency of the heat pump system when delivering peak flow temperatures of 63C.

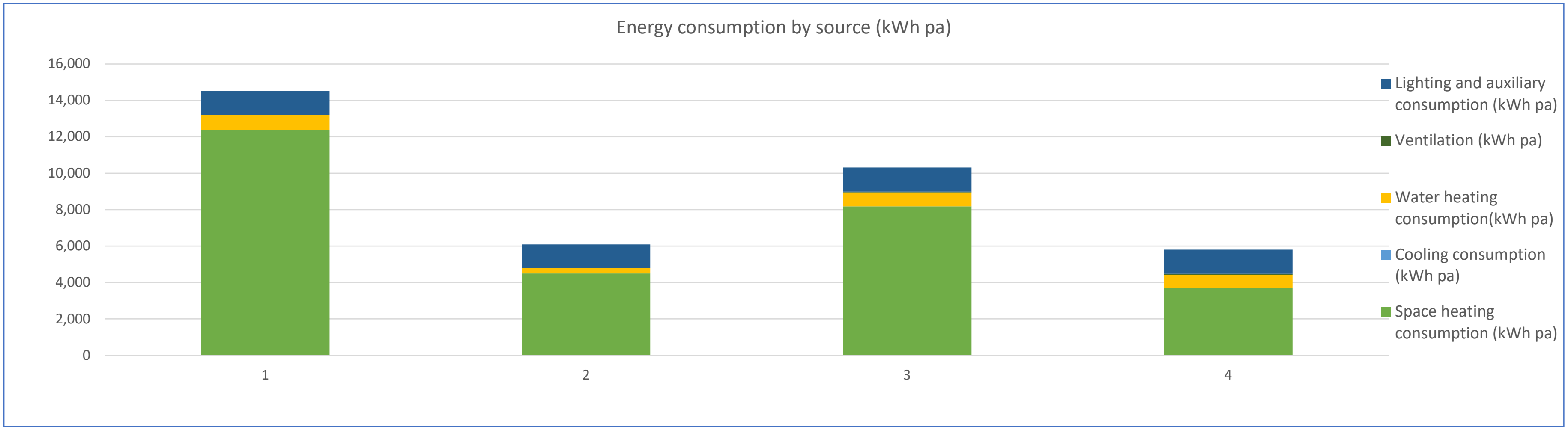
In scenario 3, fuel bills are broadly similar to BAU. In scenario 4, fuel bills are significantly lower than BAU. This is due to the storage technologies taking advantage of very low overnight rates for electricity at approx. £0.06 per kWh.

30 year cost of ownership
Of the electrification options, scenarios 3 & 4 offer the lowest costs of ownership demonstrating the that extra up-front investment in fabric efficiency provide a positive payback in terms of reduced fuel bills and reduced CAPEX for heating systems.

Heat loss through thermal elements



Energy Consumption kWh pa



Heat demand and heating system efficiency

	Existing fabric with new gas boiler	Existing fabric & hi-temp heat pump	Good practice fabric with electric storage boiler	Best practice fabric with HHR storage heaters
Space heating demand (kWh pa)	9,907	9,907	7,570	3,164
Space heating peak demand (kW)	5.4	5.4	4.1	1.7
Space heating peak demand per flat (kW)	5.4	5.4	4.1	1.7
Peak electricity load @ 6:00pm	0.3	2.7	0.3	0.3
Required flow temperatures °C	70	63	60	41
Space heating consumption (kWh pa)	12,384	4,503	8,184	3,722
Cooling consumption (kWh pa)	0	0	0	0
Water heating consumption(kWh pa)	820	281	776	718
Ventilation (kWh pa)	0	0	41	57
Lighting and auxiliary consumption (kWh pa)	1312	1312	1312	1312
Assumed heating system Seasonal Performance Factor (SPF)	**80%**	**220%**	**93%**	**85%**
Assumed distribution losses	**0%**	**0%**	**0%**	**0%**
Space heating Thermal Energy Demand Intensity (kwh per m2 pa)	**242**	**242**	**185**	**77**
Energy Use Intensity - all energy use (kWh per m2 pa)	**354**	**149**	**252**	**142**

System efficiency
The high flow temperatures required in the property in scenario mean that the high temperature heat pump is performing at a relatively low year round Seasonal Performance Factor of 2.2.

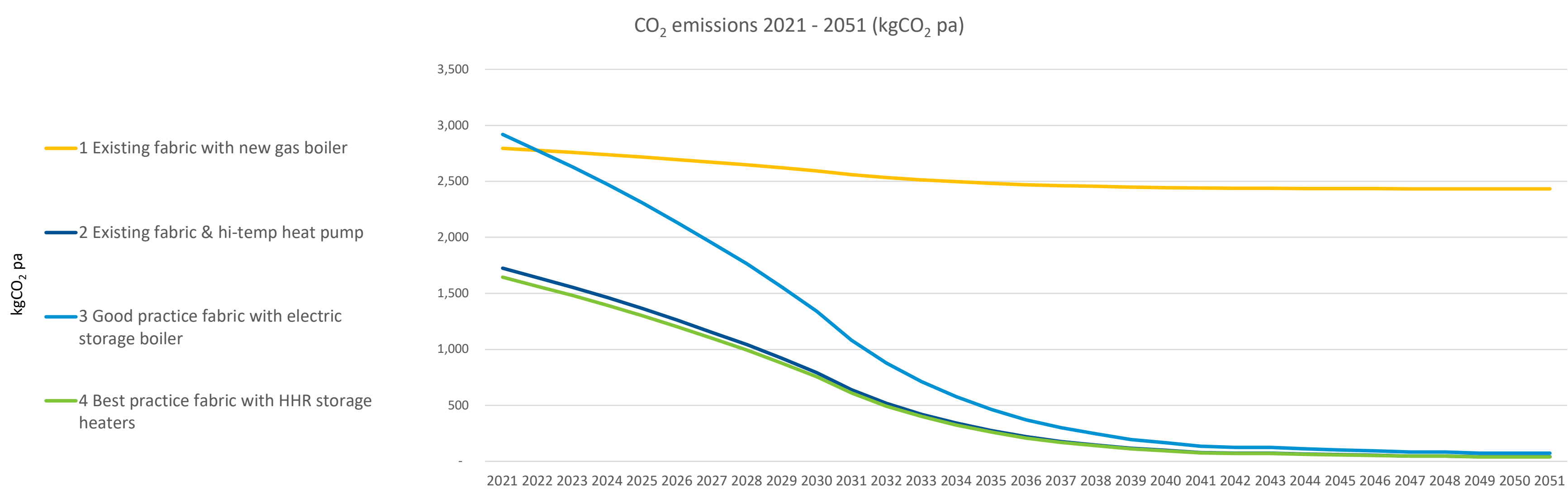
Whilst off-peak electric systems are less efficient than heat pump options, they offer significant advantages in adding no additional electricity load at peak times of day.

Retrofit package CO_2 emissions

tCO_2 in 2021	3	2	3	2
Predicted annual tCO_2 emissions (2030)	2.6	0.8	1.3	0.8
tCO^2 in 2050	2.4	0.0	0.1	0.0
tCO^2 cumulative 2021 - 2050	76	16	28	16
tCO_2 saved relative to BAU (30 year cumulative)	0	-60	-48	-61
CO_2 saving relative to baseline (30 year cumulative)	0%	78%	63%	79%
Additional cost over BAU scenario (30 years)	£0	£26,489	£17,018	£17,740
£ per tonne of CO_2 reduction (30 year cumulative)	NA	£443	£352	£293

* 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 relatively low 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 boiler	Existing fabric & hi-temp heat pump	Good practice fabric with electric storage boiler	Best practice fabric with HHR storage heaters
Included in package? (Y/N)	N	N	N	N
System size kW Peak	0.0	0.0	0.0	0.0
System generation kWh pa	0	0	0	0
Utilisation on site kWh pa	0	0	0	0
Utilisation on site kWh pa	0%	0%	0%	0%
Exported to grid kWh pa	0	0	0	0
Assumed system cost £	0	0	0	0
Net impact on fuel bills £ pa	£ -	£ -	£ -	£ -

Renewable energy:
PV was not modelled for this property.

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