



Carbon Trust Options Appraisal for building decarbonisation: Summary of results

2nd November 2021

Author: Ruth Tewungwa

Reviewed by: Will Rivers

Summary of current building

22 ROMOLA ROAD SE24 9AZ v3

Domestic	1 Units
Floorspace (m2)	197
EPC Rating	E
Space heating consumption (kWh)	30,134
Cooling consumption (kWh)	0
Water heating consumption (kWh)	3,940
Other electricity use (kWh)	6,304
Annual total fuel bill	£2,692
Thermal Energy Demand Intensity (kWh per m2 pa)	122
Energy Use Intensity (kWh per m2 pa)	205
Age of construction	pre 1900
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)	Average air tightness (7.5 n50)
Radiators / emitters	Existing radiators - single panel single convector



Description of Options for Appraisal

Thermal fabric measures:

Victorian terrace with very high heat loss due to no insulation in walls, loft or floor. Scenarios 2-4 include loft insulation as a minimum, with scenarios 3-4 also incorporating floor insulation and triple glazing. Scenario 4 assumes a LETI / AECB standard of retrofit with all thermal elements insulated including the walls, with strategies for minimising thermal bridging and improving air tightness. Heat loss reduces substantially in scenarios 2-4, enabling lower flow temperatures electrification of heat without significant addition to fuel bills.

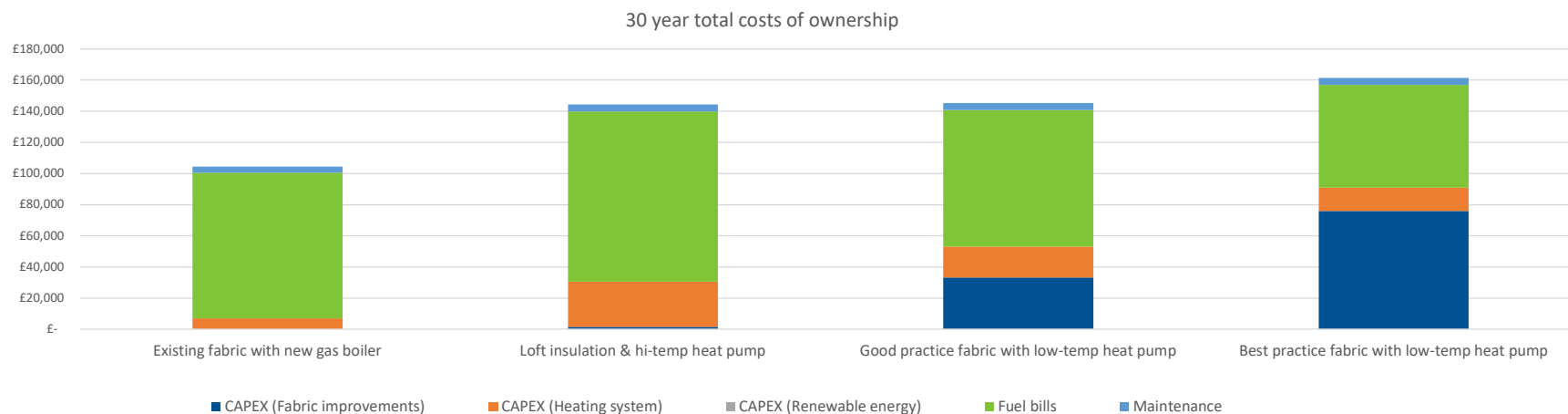
Heating system:

Current flow temperatures assumed to be high (70C). However, the reduction of heat loss and inclusion of upgraded radiators assumed in scenarios 2 - 4 enable flow temperatures compatible with heat pumps. For scenario 2, the improvements suggest a peak flow temperature of approximately 57C would be required, therefore a high temperature heat pump was specified, to ensure peak demand flow temperatures could be met. For scenario 3-4, flow temperatures are sufficiently low to enable a low temperature heat pump. Due to the proximity of neighbouring properties, a premium model low noise heat pump was assumed for scenario 2 and 3. For scenario 4, at only 4kW in size, noise is unlikely to provide cause for concern.

Summary of options appraisal measures, costs & CO₂ emissions

	Existing fabric with new gas boiler	Loft insulation & hi-temp heat pump	Good practice fabric with low-temp heat pump	Best practice fabric with low-temp heat pump
HVAC system	2kW New Condensing gas boiler, 0, 0, hot water from main system (gas), 0, 0	7kW 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 ASHP (premium, low noise) <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
	£3,500	£13,850	£9,650	£7,750
Heat emitter and distribution	0, Existing radiators - single panel single convector	0, New - Double panel double convector radiators	0, New - Double panel double convector radiators	0, New - Double panel double convector radiators
	£0	£0	£0	£0
Thermal fabric measures installed	...	, Loft insulation (Joists) 0 - 270mm, ,	, Loft insulation (Joists) 0 - 270mm, high performance triple glazing , Insulate Suspended floor (difficult access)	External wall insulation (High price - complex façade), Loft insulation (Joists) 0 - 270mm, high performance triple glazing , Insulate Suspended floor (difficult access)
	£0	£1,576	£32,288	£73,565
Air tightness	Natural ventilation , Average air tightness (7.5 n50)	Natural ventilation , Average air tightness (7.5 n50)	MEV, Building regs airtightness (5 n50)	MVHR (de-centralised) , AECB airtightness (1.5 n50)
	£0	£0	£985	£2,364
Total CAPEX	£3,500	£15,426	£42,923	£83,679
Clean Heat Grant	£0	£5,000	£5,000	£5,000
Net CAPEX	£3,500	£10,426	£37,923	£78,679
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	£2,692	£3,370	£2,704	£2,030
Annual OPEX (maintenance)	£129	£148	£148	£148
30 year total cost of ownership (excluding grant)	£104,515	£144,398	£145,254	£161,421
Annual tCO₂ emissions (2021)	8.0	4.5	3.7	2.8
Predicted annual tCO₂ emissions (2030)	7.1	2.1	1.7	1.3
Predicted annual tCO₂ emissions (2050)	6.3	0.1	0.1	0.1

30 year total costs of ownership



CAPEX

The loft insulation in scenario 2 provides a highly cost effective improvement, enabling a lower CAPEX for the heat pump unit. The CAPEX for fabric measures in Scenario 3 is also cost effective, resulting in lower fuel bills and the lowest overall 30 year costs of ownership (aside from BAU). The large CAPEX for the best practice fabric scenario results in the lowest fuel bills but overall this option has the highest 30 year costs of ownership.

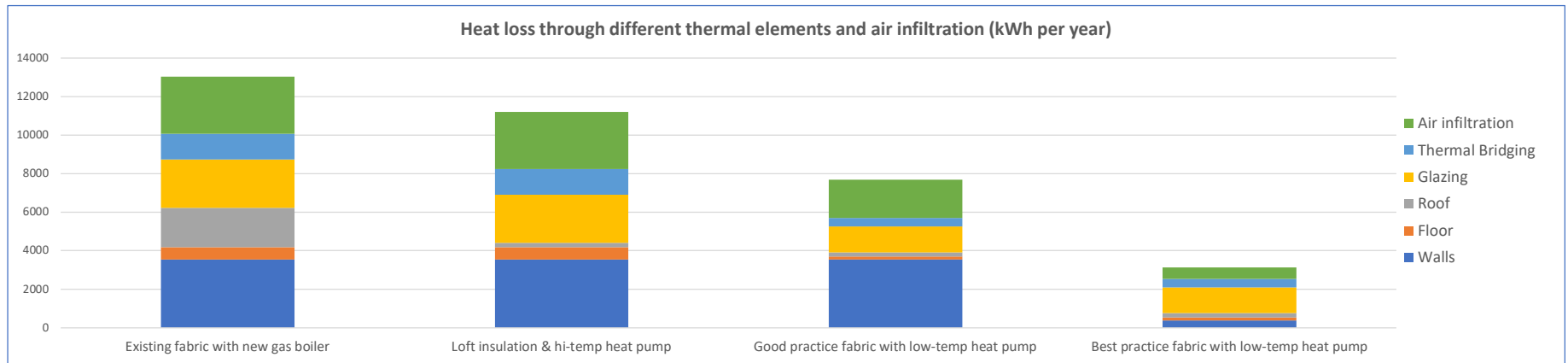
Fuel bills

Fuel bills increase marginally in scenario 2 and 3 relative to BAU, despite the lower demand for heat. However, scenarios 4 result in significantly lower fuel bills.

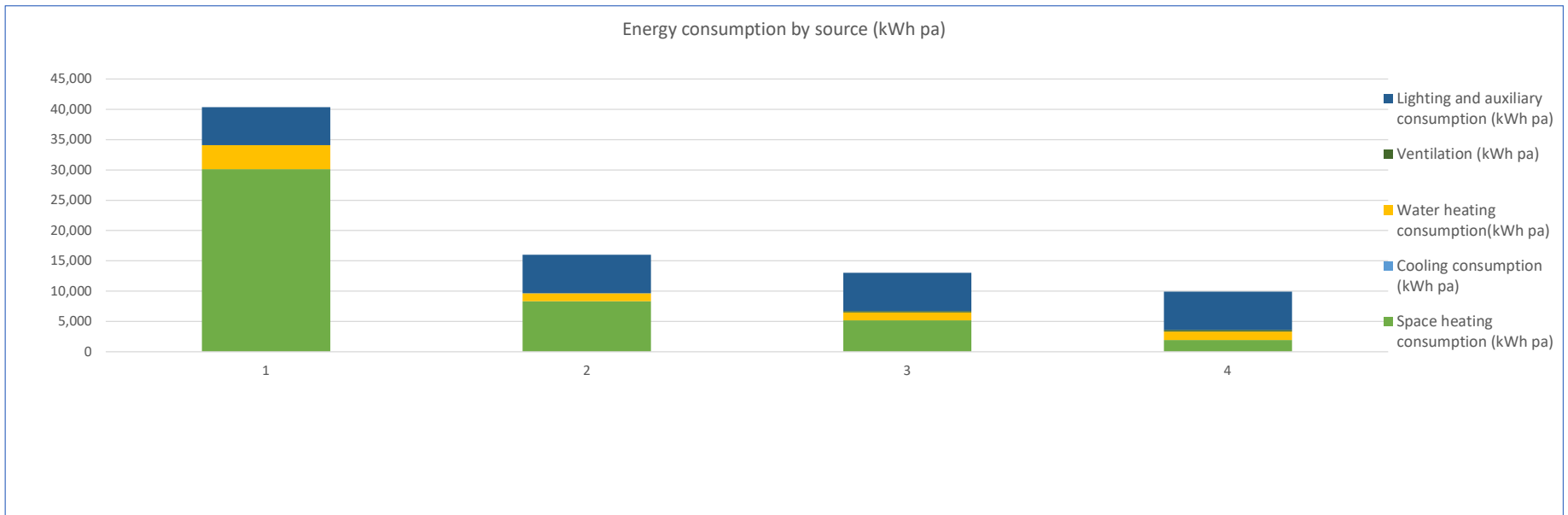
30 year cost of ownership

Option 2 has the lowest 30 year costs of ownership relative to BAU. Option 3 costs are only marginally higher suggesting that the high CAPEX of the fabric improvements pays is almost repaid within the 30 years. However, the additional CAPEX investment in Option 4 does not appear to rap financial benefit in the longer term.

Heat loss through thermal elements



Energy Consumption kWh pa



Heat demand and heating system efficiency

	Existing fabric with new gas boiler	Loft insulation & hi-temp heat pump	Good practice fabric with low-temp heat pump	Best practice fabric with low-temp heat pump
Space heating demand (kWh pa)	24,107	20,721	14,202	5,791
Space heating peak demand (kW)	13.0	11.2	7.7	3.1
Space heating peak demand per flat (kW)	13.0	11.2	7.7	3.1
Peak electricity load @ 6:00pm	1.5	6.0	4.3	2.6
Required flow temperatures °C	70	57	45	31
Space heating consumption (kWh pa)	30,134	8,322	5,164	1,943
Cooling consumption (kWh pa)	0	0	0	0
Water heating consumption(kWh pa)	3940	1352	1352	1379
Ventilation (kWh pa)	0	0	197	276
Lighting and auxiliary consumption (kWh pa)	6304	6304	6304	6304
Assumed heating system Seasonal Performance Factor (SPF)	80%	249%	275%	298%
Assumed distribution losses	0%	0%	0%	0%
Space heating Thermal Energy Demand Intensity (kwh per m2 pa)	122	105	72	29
Energy Use Intensity - all energy use (kWh per m2 pa)	205	81	66	50

The improvements to thermal fabric efficiency in scenarios 2-4, significantly reduce heat loss. In turn, this reduces progressively reduces the additional CAPEX of the heating systems and heat distribution system. The efficiencies of the heating systems also progressively improve as heat loss reduces as this enables lower flow temperatures.

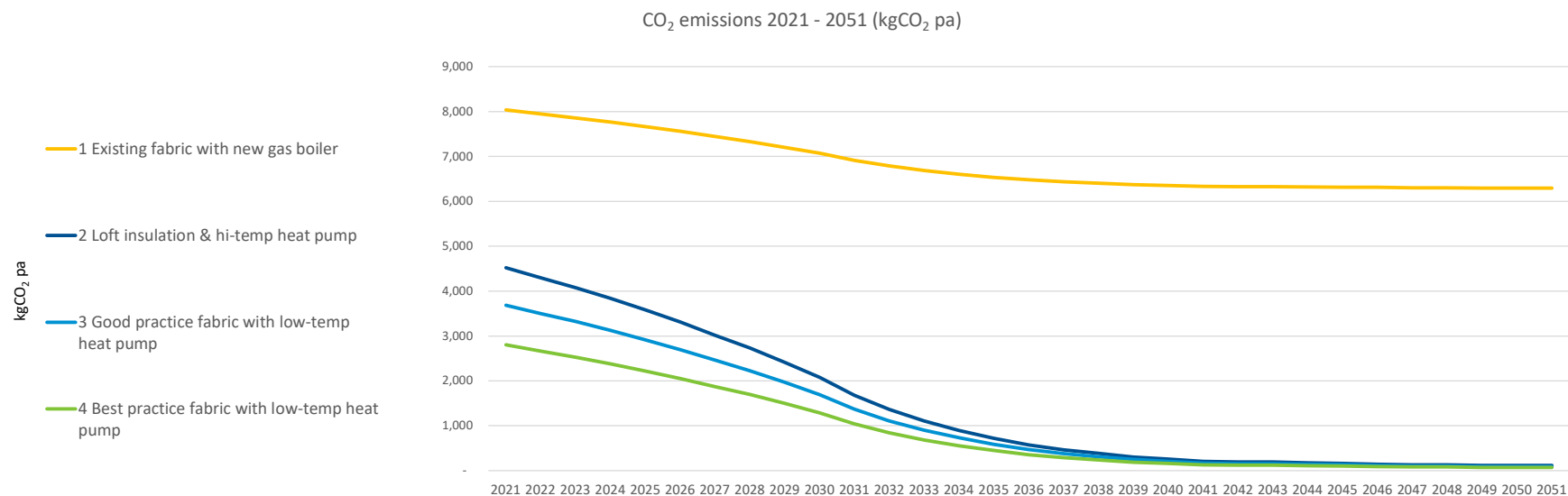
Of the fabric measures installed in options 2-4, loft insulation is the only measure to provide a positive return on investment within 30 years. The high cost of External Wall Insulation and Triple Glazing mean that the initial outlay is not recouped through reduced fuel bills.

Retrofit package CO₂ emissions

tCO ₂ in 2021	8	5	4	3
Predicted annual tCO ₂ emissions (2030)	7.1	2.1	1.7	1.3
tCO ₂ in 2050	6.3	0.1	0.1	0.1
tCO ₂ cumulative 2021 - 2050	205	43	35	27
tCO ₂ saved relative to BAU (30 year cumulative)	0	-161	-169	-178
CO ₂ saving relative to baseline (30 year cumulative)	0%	79%	83%	87%
Additional cost over BAU scenario (30 years)	£0	£39,883	£40,739	£56,906
£ per tonne of CO ₂ reduction (30 year cumulative)	NA	£247	£240	£320

* 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 CO₂ emissions



CO₂ emissions

Scenarios 2-4 all deliver significant reductions in CO₂ emissions over a 30 year time frame of between 79% and 87% with emissions reducing to near zero by 2050.

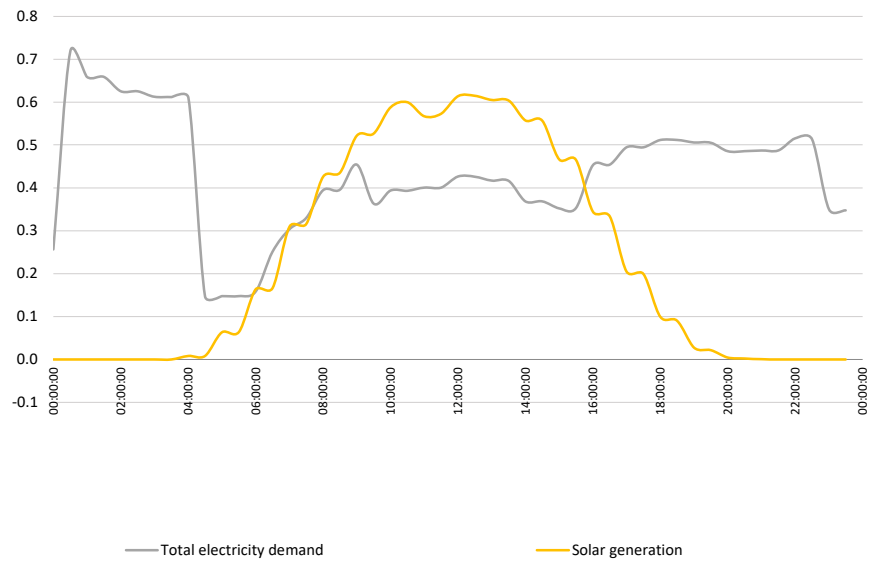
Carbon cost effectiveness: Scenario 3 offers the lowest cost of carbon reduction per tCO₂ at £240 per tonne.

Potential impact of Solar PV on all scenarios

	Existing fabric with new gas boiler	Loft insulation & hi-temp heat pump	Good practice fabric with low-temp heat pump	Best practice fabric with low-temp heat pump
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	1956	2109	2089	2042
Utilisation on site kWh pa	81%	88%	87%	85%
Exported to grid kWh pa	453	300	320	367
Assumed system cost £	3750	3750	3750	3750
Net impact on fuel bills £ pa	-£ 431	-£ 457	-£ 453	-£ 445
Renewable energy:				

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

Average July day half hourly generation & consumption profile (option 2)



Average January day half hourly consumption & demand profiles (option 2)

