Carbon Trust Options Appraisal for building decarbonisation: Summary of results

2nd November 2021

Author: Ruth Tewungwa

Reviewed by: Will Rivers

Summary of current building

NORTH LODGE VICTORIA RISE SW4 0NX

Domestic	8 Units
Floorspace (m2)	665
EPC Rating	C,D
Occupied space heating consumption (kWh)	83,346
Communal area space heating consumption (kWh)	9,970
Cooling consumption (kWh)	0
Water heating consumption (kWh)	9,840
Occupied area electricity use (kWh)	15,744
Communal area electricity use (kWh)	1,211
Annual total fuel bill	£3,726
Annual fuel bill per flat (including share of communal areas)	£466
Occupied area Thermal Energy Demand Intensity (kWh per m2 pa)	115
Occupied area Energy Use Intensity (kWh per m2 pa)	224
Age of construction	1930 - 1949
Windows	Double glazed windows pre 2002
Wall	Solid brick, as built, no insulation (assumed)
Roof	Flat roof
Floor	Insulation unknown or as-built
Primary heating	Existing gas boilers in individual flats
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:
The existing building benefits from double glazing, however walls are solid (un-insulated) and the roof is also assumed to have no insulation. Therefore, loft insulation is included in option 2. In option 3, glazing is upgraded to high performance triple glazing. In option 3, a best practice fabric retrofit is assumed, with full external wall insulation and floor insulation.

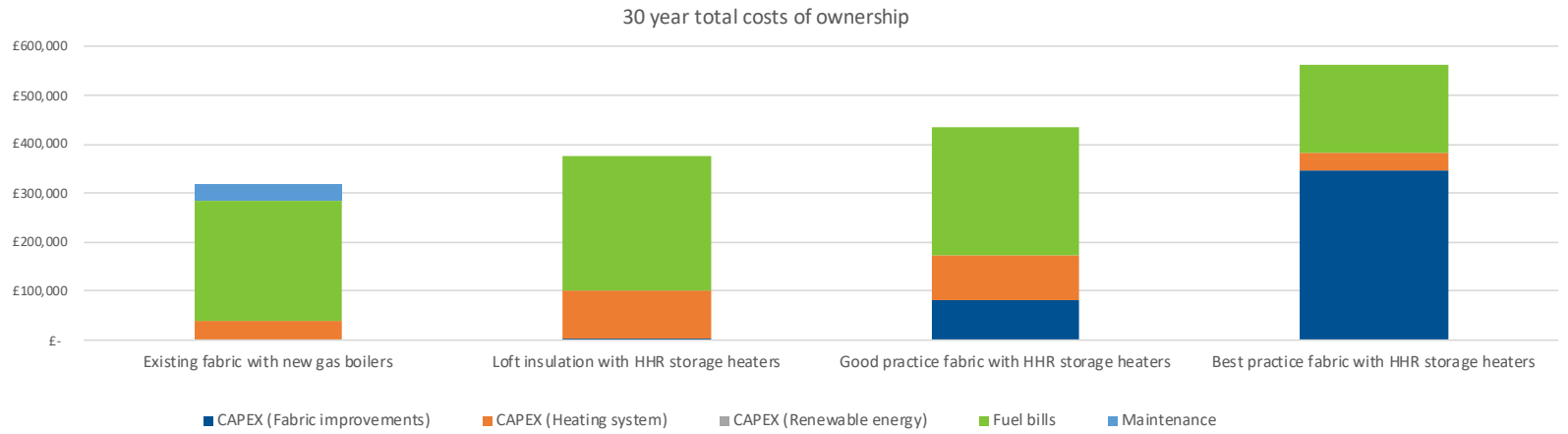
Heating systems:
The 8 flats are currently heated by individual gas boilers. Replacing them with individual heat pumps would be challenging due to the lack of suitable of locations to site them and the proximity of neighbouring bedroom windows.

Any on-peak direct electric heating options would lead to a significant increase in fuel bills and so these options were disregarded despite having the lowest CAPEX. Therefore, only electric storage options were considered. For this building, we considered electric storage heaters in options 2, 3 & 4. Whilst electric storage boilers could be a further option, it was deemed that the additional benefit of retaining the existing pipework and radiators was

Summary of options appraisal measures, costs & CO_2 emissions

	Existing fabric with new gas boilers	Loft insulation with HHR storage heaters	Good practice fabric with HHR storage heaters	Best practice fabric with HHR storage heaters
HVAC system	42kW Individual flat gas boiler, 0, 0, hot water from main system (gas), 0, 0	39kW New smart high heat retention storage heaters, 0, 0, New electric immersion heater, Hot water cylinder and associated pipework	36kW New smart high heat retention storage heaters, 0, 0, New electric immersion heater, Hot water cylinder and associated pipework	11kW New smart high heat retention storage heaters, 0, 0, New electric immersion heater, Hot water cylinder and associated pipework
	£20,000	**£53,680**	**£50,320**	**£22,320**
Heat emitter and distribution	0, Existing radiators - single panel single convector	0, 0	0, 0	0, 0
	£0	**£0**	**£0**	**£0**
Thermal fabric measures installed	, , ,	, Loft insulation (Joists) 0 - 270mm, ,	, Loft insulation (Joists) 0 - 270mm, high performance triple glazing ,	External wall insulation (Very high price - complex project) , Loft insulation (Joists) 0 - 270mm, high performance triple glazing , Insulate Suspended floor (difficult access)
	£0	**£3,990**	**£79,417**	**£339,639**
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) , AECB airtightness (1.5 n50)
	£0	**£0**	**£3,325**	**£7,980**
Total CAPEX	**£20,000**	**£57,670**	**£133,062**	**£369,939**
Clean Heat Grant	£0	£0	£0	£0
Net CAPEX	**£20,000**	**£57,670**	**£133,062**	**£369,939**
Electricity tariff	Treasury Green Book Central Domestic Tariff	Domestic low overnight Tariff 01:30 - 06:30	Domestic low overnight Tariff 01:30 - 06:30	Domestic low overnight Tariff 01:30 - 06:30
Annual fuel bills	**£7,047**	**£8,440**	**£8,081**	**£5,533**
Annual fuel bills (per flat)	**£881**	**£1,055**	**£1,010**	**£692**
Annual OPEX (maintenance)	£1,032	£0	£0	£0
30 year total cost of ownership (excluding grant)	**£317,515**	**£374,847**	**£435,261**	**£561,569**
Annual tCO_2 emissions (2021)	**21.9**	**26.2**	**24.7**	**12.5**
Predicted annual tCO_2 emissions (2030)	**19.3**	**12.0**	**11.3**	**5.7**
Predicted annual tCO_2 emissions (2050)	**17.2**	**0.6**	**0.6**	**0.3**

30 year total costs of ownership

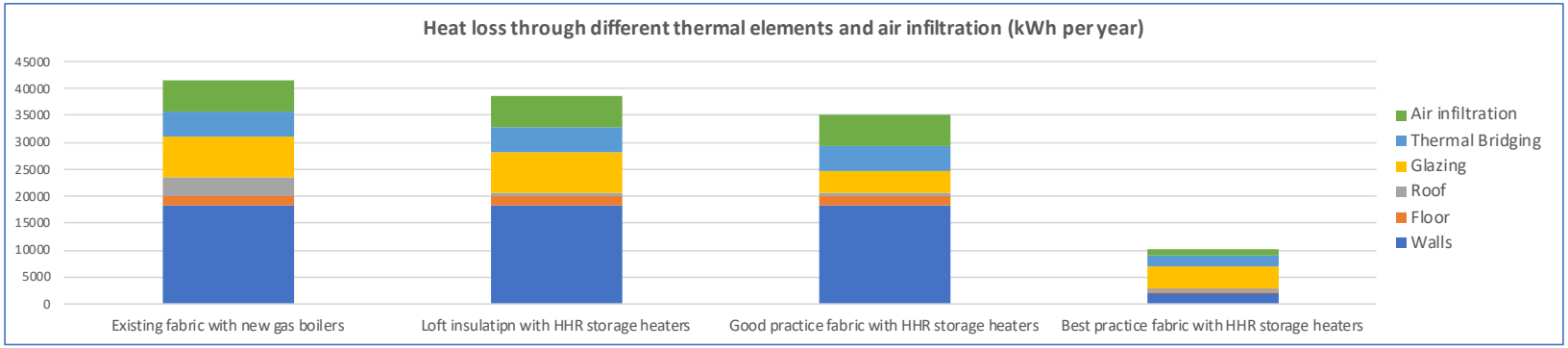


CAPEX
Scenarios 2 shows a relatively small increase in CAPEX for the HHR storage heaters s the gas boilers in scenario 1. However, scenarios 3 &4 both show significant increases in CAPEX with the high performance triple glazing and external wall insulation have very high upfront costs.

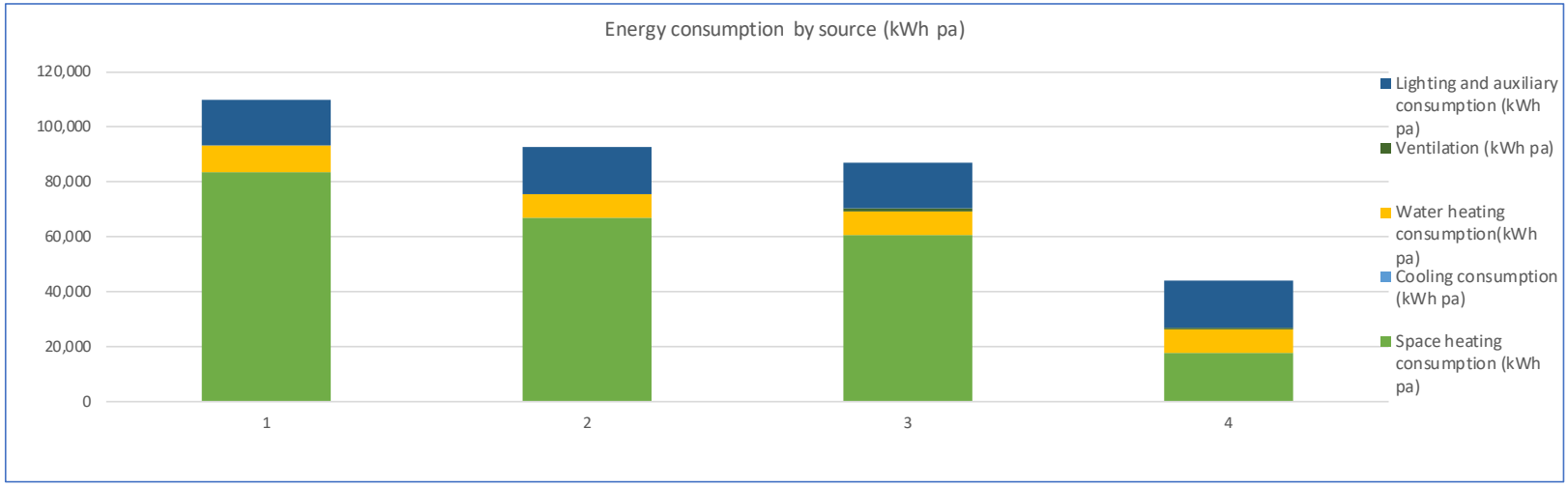
Fuel bills
Annual fuel bills are project to increase in scenarios 2 and 3 but are lowest in scenario 4. This is despite assuming that the storage heaters could take advantage of very low overnight electricity tariffs of approximately £0.06per kWh. If standard Economy 7 tariffs were assumed then these fuel bills would increase significantly.

30 year cost of ownership
Costs of ownership increase in all electrification scenarios. Scenario 2 has the lowest 30 year cost of ownership of the electrification scenarios. The addition of high performance triple glazing in Semeraro 3 does not have a positive payback within the years. Likewise the full fabric retrofit increases 30 year costs even further. However, option 4 delivers the lowest fuel bills for tenants.

Heat loss through thermal elements



Energy Consumption kWh pa



Heat demand and heating system efficiency

System efficiency: Whilst electric storage heaters are in theory 100% efficient, we have assumed a loss in efficiency to account for the fact that storage is inherently less controllable than gas heating or direct electric heating. Storage heaters have significant benefits for an overall low carbon energy system with no additional peak load at 06:00pm over BAU.

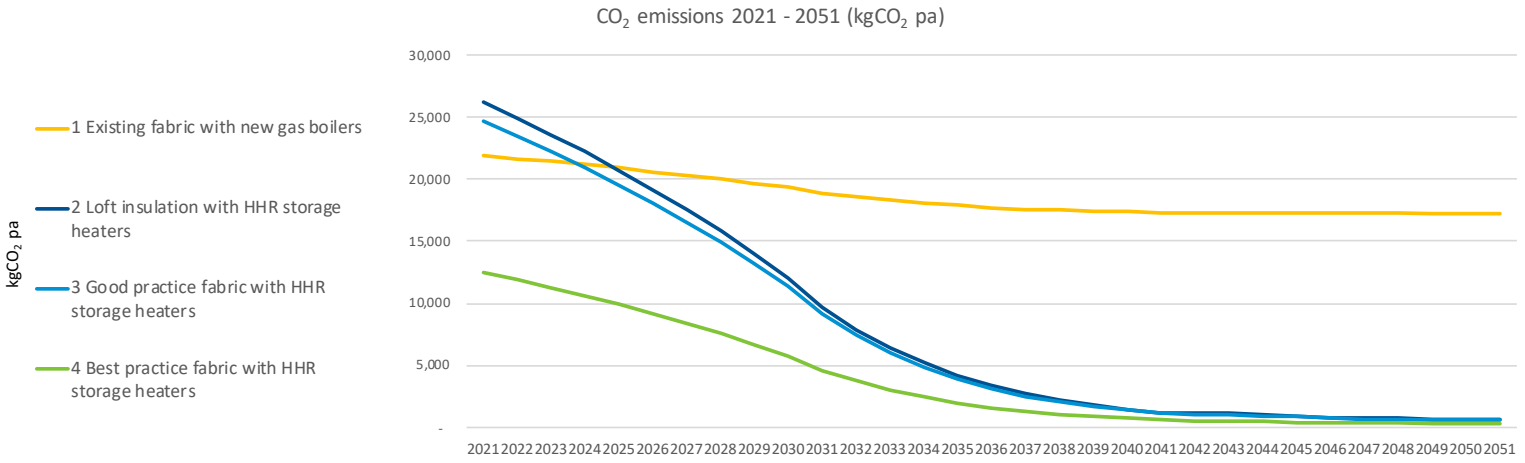
	Existing fabric with new gas boilers	Loft insulation with HHR storage heaters	Good practice fabric with HHR storage heaters	Best practice fabric with HHR storage heaters
Space heating demand (kWh pa)	56,707	52,731	47,935	13,847
Space heating peak demand (kW)	41.4	38.5	35.0	10.1
Space heating peak demand per flat (kW)	5.2	4.8	4.4	1.3
Peak electricity load @ 6:00pm	3.8	3.8	3.8	3.8
Required flow temperatures °C	70	67	64	38
Space heating consumption (kWh pa)	83,346	67,029	60,932	17,601
Cooling consumption (kWh pa)	0	0	0	0
Water heating consumption(kWh pa)	9840	8610	8610	8610
Ventilation (kWh pa)	0	0	665	931
Lighting and auxiliary consumption (kWh pa)	16955	16955	16955	16955
Assumed heating system Seasonal Performance Factor (SPF)	**80%**	**93%**	**93%**	**93%**
Assumed distribution losses	**0%**	**0%**	**0%**	**0%**
Space heating Thermal Energy Demand Intensity (kwh per m2 pa)	**85**	**79**	**72**	**21**
Energy Use Intensity - all energy use (kWh per m2 pa)	**224**	**188**	**177**	**90**

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	22	26	25	12
Predicted annual tCO_2 emissions (2030)	19.3	12.0	11.3	5.7
tCO^2 in 2050	17.2	0.6	0.6	0.3
tCO^2 cumulative 2021 - 2050	559	250	235	119
tCO_2 saved relative to BAU (30 year cumulative)	0	-309	-323	-440
CO_2 saving relative to baseline (30 year cumulative)	0%	55%	58%	79%
Additional cost over BAU scenario (30 years)	£0	£57,332	£117,746	£244,054
£ per tonne of CO_2 reduction (30 year cumulative)	NA	£186	£364	£555

30 year predicted CO_2 emissions



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 scenarios 2 & 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 boilers	Loft insulation with HHR storage heaters	Good practice fabric with HHR storage heaters	Best practice fabric with HHR storage heaters
Included in package? (Y/N)	N	N	N	N
System size kW Peak	6.0	6.0	6.0	6.0
System generation kWh pa	5,782	5,782	5,782	5,782
Utilisation on site kWh pa	4802	4802	4802	4802
Utilisation on site kWh pa	83%	83%	83%	83%
Exported to grid kWh pa	979	979	979	979
Assumed system cost £	9000	9000	9000	9000
Net impact on fuel bills £ pa	-£ 1,052	-£ 1,205	-£ 1,205	-£ 1,205

Renewable energy:
For all scenarios, the impact of a PV system was modelled separately. The table above shows the indicative savings on energy consumption and fuel bills that would occur.

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