Carbon Trust Options Appraisal for building decarbonisation: Summary of results

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Summary of current building

18 HILLMEAD DRIVE SW98QE

Domestic	**10 Units**
Floorspace (m2)	**756**
EPC Rating	**C-D**
Space heating consumption (kWh)	**42,061**
Cooling consumption (kWh)	**0**
Water heating consumption (kWh)	**10,100**
Other electricity use (kWh)	**16,160**
Annual total fuel bill	**£2,086**
Thermal Energy Demand Intensity (kWh per m2 pa)	**71**
Energy Use Intensity (kWh per m2 pa)	**135**
Age of construction	1976 - 1982
Windows	Double glazed windows pre 2002
Wall	Cavity as built
Roof	Pitched roof with insulation at rafters
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 - double panel, single convector

Description of Options for Appraisal

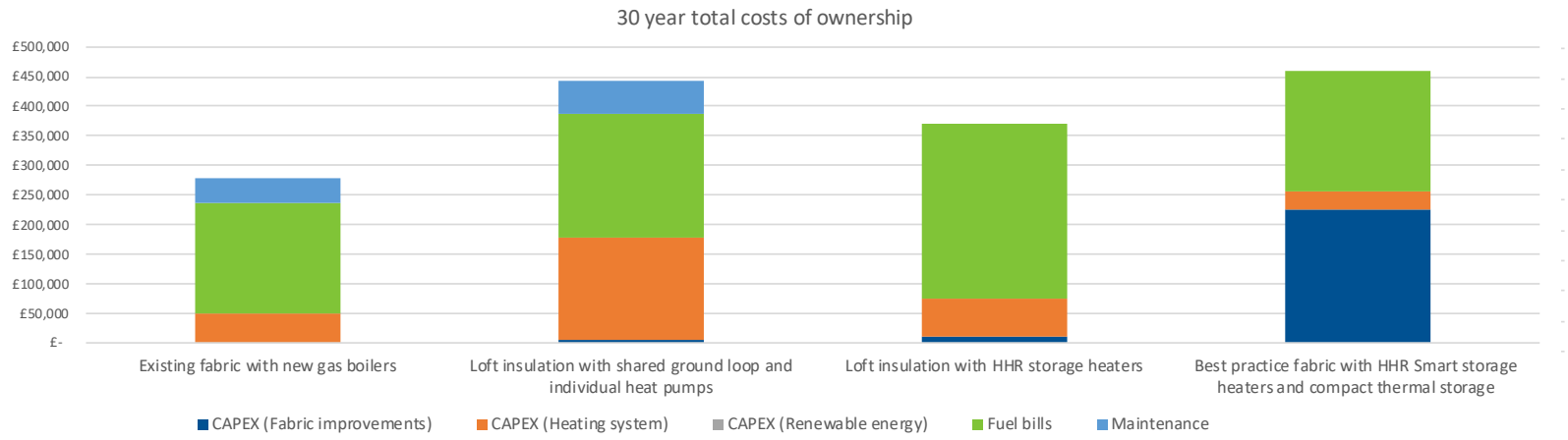
Thermal fabric measures:
1970s construction low rise flats . Fabric has reasonable but not good practice levels of fabric efficiency with partially insulated cavity walls, partially insulated loft and pre-2002 double glazing. In scenarios 2 & 3 we include full loft insulation. In scenario 4 we consider a full best practice retrofit with the addition of external wall insulation and triple glazing.

Heating systems:
The flats are currently heated by individual gas boilers. In scenario 2 we have included a shared ambient loop with individual GSHPs. In scenarios 3 & 4 we have modelled HHR smart storage heaters in combination with

Summary of options appraisal measures, costs & CO_2 emissions

	Existing fabric with new gas boilers	Loft insulation with shared ground loop and individual heat pumps	Loft insulation with HHR storage heaters	Best practice fabric with HHR Smart storage heaters and compact thermal storage
HVAC system	71kW Individual flat gas boiler, 0, 0, hot water from main system (gas), 0, 0	61kW Individual flat WSHP (for shared ground loops) , 0, ground loop (borehole) , hot water from main system (electric), Hot water cylinder and associated pipework	56kW New smart high heat retention storage heaters, 0, 0, New electric immersion heater, Hot water cylinder and associated pipework	19kW New smart high heat retention storage heaters, 0, 0, New electric immersion heater, Hot water cylinder and associated pipework
	£25,000	**£101,250**	**£38,260**	**£21,460**
Heat emitter and distribution	Existing pipework, Existing radiators - double panel, single convector	Existing pipework, New - triple panel triple convector radiators	0, 0	0, 0
	£0	**£6,625**	**£0**	**£0**
Thermal fabric measures installed	, , ,	, Loft insulation (Joists) 0 - 270mm, ,	, Loft insulation (Joists) 0 - 270mm, ,	External wall insulation (High price - complex façade), Loft insulation (Joists) 0 - 270mm, high performance triple glazing , Insulate solid floor
	£0	**£6,048**	**£6,048**	**£216,144**
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**	**£3,780**	**£9,072**
Total CAPEX	**£25,000**	**£113,923**	**£48,088**	**£246,676**
Clean Heat Grant	£0	£0	£0	£0
Net CAPEX	**£25,000**	**£113,923**	**£48,088**	**£246,676**
Electricity tariff	Treasury Green Book Central Domestic Tariff	Treasury Green Book Central Domestic Tariff	Domestic Economy 7 00:00 - 07:00	Domestic Economy 7 00:00 - 07:00
Annual fuel bills	**£5,494**	**£6,447**	**£9,158**	**£6,308**
Annual fuel bills (per flat)	**£549**	**£645**	**£916**	**£631**
Annual OPEX (maintenance)	£1,290	£1,800	£0	£0
30 year total cost of ownership (excluding grant)	**£277,638**	**£443,649**	**£370,613**	**£460,030**
Annual tCO_2 emissions (2021)	**14.1**	**8.7**	**15.8**	**10.2**
Predicted annual tCO_2 emissions (2030)	**11.7**	**4.0**	**7.3**	**4.7**
Predicted annual tCO_2 emissions (2050)	**9.7**	**0.2**	**0.4**	**0.3**

30 year total costs of ownership

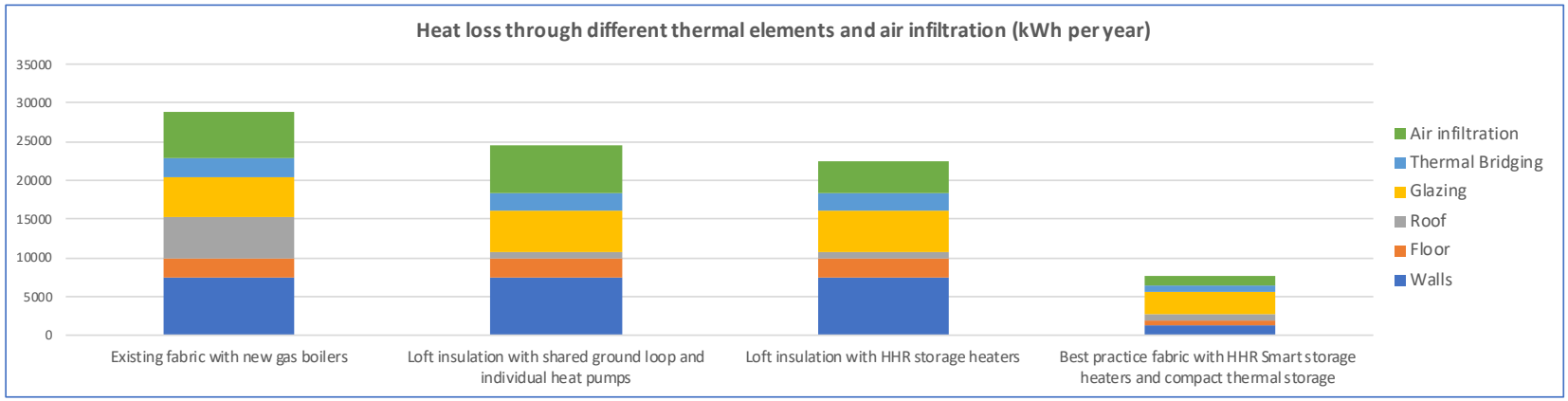


CAPEX
CAPEX for the shared ambient loop and ground source heat pumps is high relative to the costs of the HHR storage heaters and gas boilers. However, the costs of the fabric retrofit in scenario 4 would give this option the highest CAPEX.

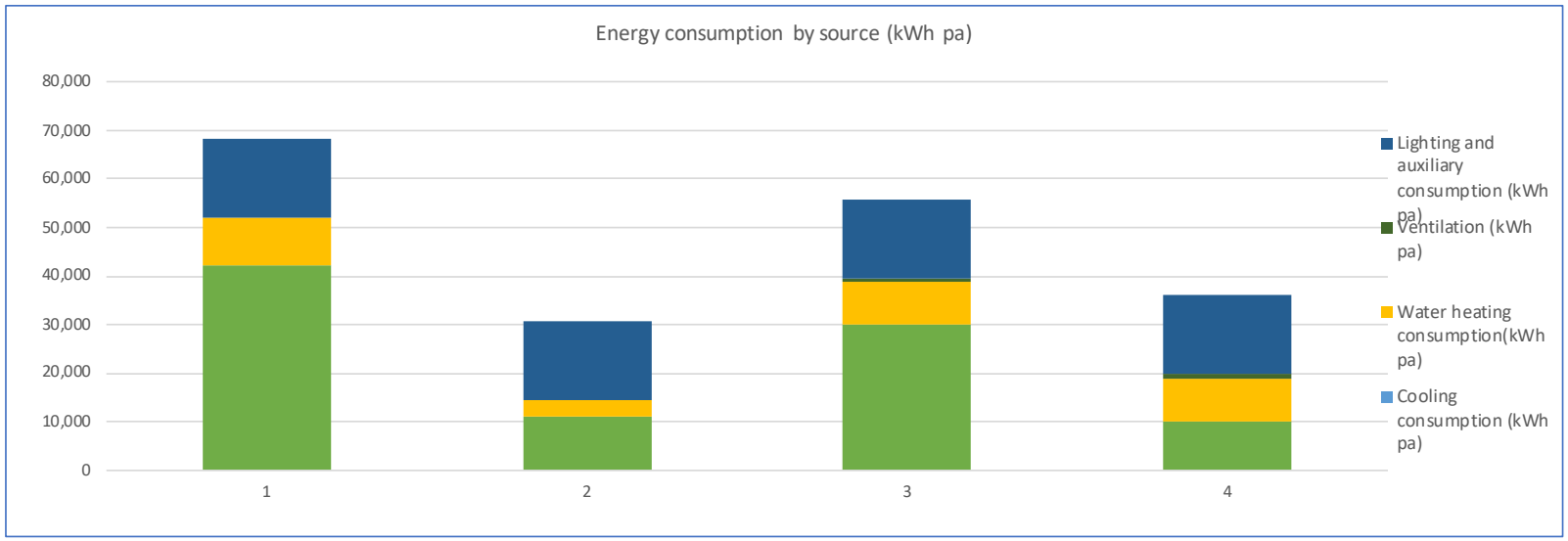
Fuel bills
All the options modelled here would increase fuel bills relative to the BAU scenario. However, in scenarios 2 & 4 this increase is relatively small. Scenarios 3 & 4 are modelled using a standard Economy 7 tariff. It may be possible to reduce fuel bills by utilising a 'super off-peak' tariff that would give very low rates between 01:30 and 05:30 , however, we considered that there may be grid connection issues should all flats in the area attempt to change storage heaters and hot water cylinders in a short period of time.

30 year cost of ownership
Of the electrification options, scenario 3 has the lowest overall costs of ownership. However, scenario 3 also has the highest fuel bills and so other options may be preferable from the point of view of not increasing

Heat loss through thermal elements



Energy Consumption kWh pa



Heat demand and heating system efficiency

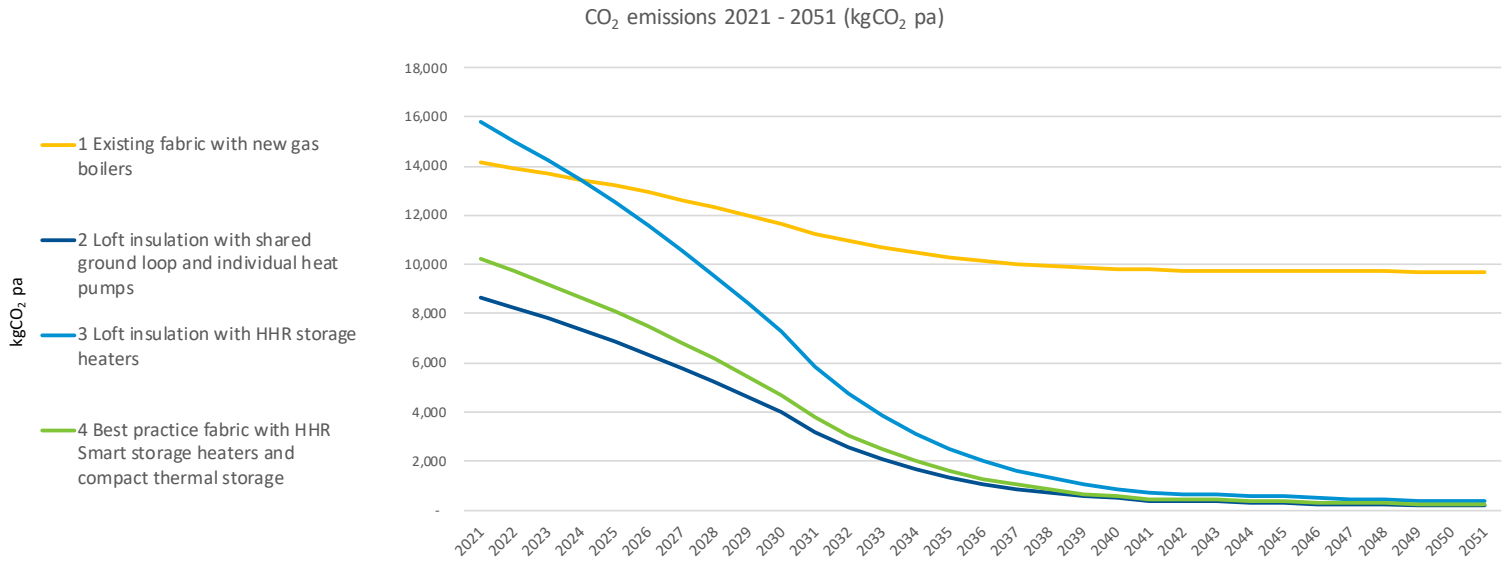
System efficiency: Whilst off-peak electric systems are less efficient than heat pump options, they offer significant advantages in adding no additional electricity load at peak times of day.

	Existing fabric with new gas boilers	Loft insulation with shared ground loop and individual heat pumps	Loft insulation with HHR storage heaters	Best practice fabric with HHR Smart storage heaters and compact thermal storage
Space heating demand (kWh pa)	35,752	30,311	27,793	9,327
Space heating peak demand (kW)	70.8	60.0	55.0	18.5
Space heating peak demand per flat (kW)	7.1	6.0	5.5	1.8
Peak electricity load @ 6:00pm	3.9	9.8	3.9	3.9
Required flow temperatures °C	60	44	51	29
Space heating consumption (kWh pa)	42,061	10,942	30,046	10,083
Cooling consumption (kWh pa)	0	0	0	0
Water heating consumption(kWh pa)	10100	3466	8838	8838
Ventilation (kWh pa)	0	0	756	1058
Lighting and auxiliary consumption (kWh pa)	16160	16160	16160	16160
Assumed heating system Seasonal Performance Factor (SPF)	**85%**	**277%**	**93%**	**93%**
Assumed distribution losses	**0%**	**0%**	**0%**	**0%**
Space heating Thermal Energy Demand Intensity (kwh per m2 pa)	**47**	**40**	**37**	**12**
Energy Use Intensity - all energy use (kWh per m2 pa)	**135**	**61**	**110**	**72**

Retrofit package CO_2 emissions

tCO_2 in 2021	14	9	16	10
Predicted annual tCO_2 emissions (2030)	11.7	4.0	7.3	4.7
tCO^2 in 2050	9.7	0.2	0.4	0.3
tCO^2 cumulative 2021 - 2050	331	83	151	98
tCO_2 saved relative to BAU (30 year cumulative)	0	-248	-180	-233
CO_2 saving relative to baseline (30 year cumulative)	0%	75%	54%	71%
Additional cost over BAU scenario (30 years)	£0	£166,011	£92,975	£182,392
£ per tonne of CO_2 reduction (30 year cumulative)	NA	£669	£516	£782

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

Potential impact of Solar PV on all scenarios

	Existing fabric with new gas boilers	Loft insulation with shared ground loop and individual heat pumps	Loft insulation with HHR storage heaters	Best practice fabric with HHR Smart storage heaters and compact thermal storage
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	4872	5133	4874	4874
Utilisation on site kWh pa	84%	89%	84%	84%
Exported to grid kWh pa	909	649	907	907
Assumed system cost £	9000	9000	9000	9000
Net impact on fuel bills £ pa	-£ 1,064	-£ 1,109	-£ 1,181	-£ 1,181

Renewable energy:
We modelled the impact of a 10kWp Solar PV array for the building under each of the scenarios. The impact of this on energy consumption and fuel bills is provided above.

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