Carbon Trust Options Appraisal for building decarbonisation: Summary of results

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Summary of current building

WEST NORWOOD FIRE STATION KNIGHT'S HILL SE27 0QA

Office with natural ventilation and cooling	1 Units
Floorspace (m2)	1402
EPC Rating	A
Occupied space heating consumption (kWh)	93,513
Cooling consumption (kWh)	0
Water heating consumption (kWh)	26,918
Occupied area electricity use (kWh)	98,140
Annual total fuel bill	£18,305
Occupied area Thermal Energy Demand Intensity (kWh per m2 pa)	40
Occupied area Energy Use Intensity (kWh per m2 pa)	134

Age of construction	2012 onwards
Windows	Double glazed windows post 2002
Wall	Cavity as built
Roof	Flat roof
Floor	Insulation unknown or as-built
Primary heating	Existing gas boiler CHP
Air tightness (ACH @ ambient pressure)	Good new build performance (3 n50)
Radiators / emitters	Existing radiators - double panel, double convector

Description of Options for Appraisal

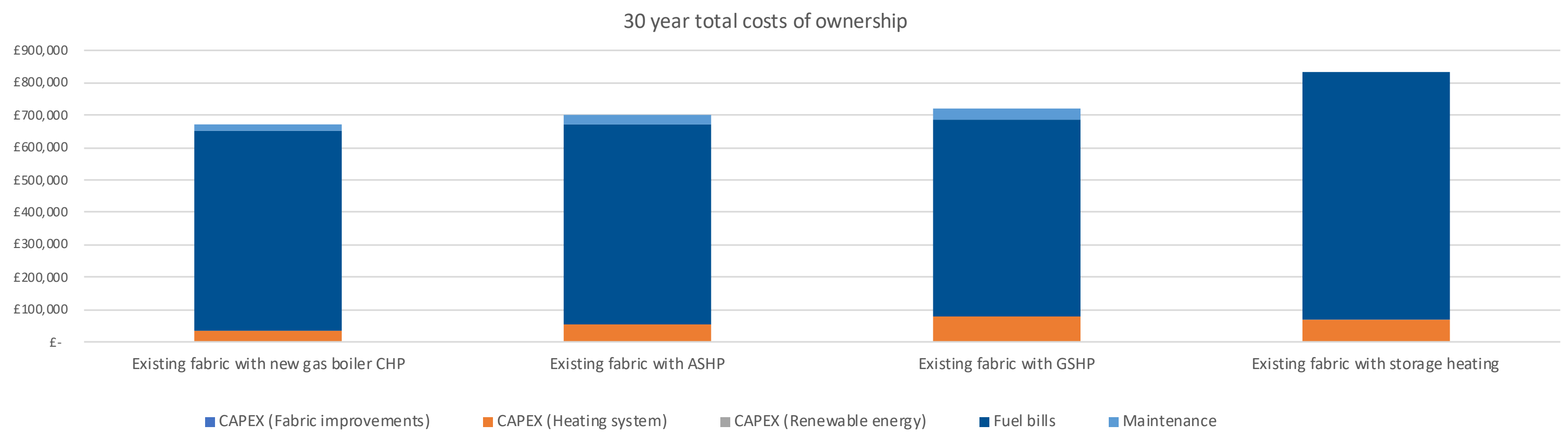
Thermal fabric measures:
This fire station is assumed to have relatively high thermal fabric efficiency, with an EPC Rating of A. Therefore, no further improvements to thermal fabric efficiency were considered in the scenarios.

Heating systems:
Currently heated by gas CHP. The benefits of gas CHP have decreased in recent years because the electricity produced by gas CHP is now has a higher carbon intensity than grid supplied electricity. Therefore, scenarios 2-4 consider the impact of installation an Air Source Heat Pump, Ground Source Heat Pump and electric storage heaters respectively.

Summary of options appraisal measures, costs & CO_2 emissions

	Existing fabric with new gas boiler CHP	Existing fabric with ASHP	Existing fabric with GSHP	Existing fabric with storage heating
HVAC system	31kW New gas boiler CHP, 0, 0, hot water from main system (gas), Hot water cylinder and associated pipework , 0	31kW New ASHP Air to water <55°C, 0, 0, hot water from main system (electric), Hot water cylinder and associated pipework	31kW New GSHP/ WSHP <55°C, 0, ground loop (borehole) , hot water from main system (electric), Hot water cylinder and associated pipework	31kW New smart high heat retention storage heaters, 0, 0, hot water from main system (electric), Hot water cylinder and associated pipework
	£16,750	**£27,600**	**£53,950**	**£35,970**
Heat emitter and distribution	0, Existing radiators - double panel, double convector	0, Existing radiators - double panel, double convector	0, Existing radiators - double panel, double convector	0, Existing radiators - double panel, double convector
	£0	**£0**	**£0**	**£0**
Thermal fabric measures installed	, , ,	, , ,	, , ,	, , ,
	£0	**£0**	**£0**	**£0**
Air tightness	Natural ventilation , Good new build performance (3 n50)	Natural ventilation , Good new build performance (3 n50)	Natural ventilation , Good new build performance (3 n50)	Natural ventilation , Good new build performance (3 n50)
	£0	**£0**	**£0**	**£0**
Total CAPEX	**£16,750**	**£27,600**	**£53,950**	**£35,970**
Clean Heat Grant	£0	£0	£0	£0
Net CAPEX	**£16,750**	**£27,600**	**£53,950**	**£35,970**
Electricity tariff	Treasury Green Book Central Commercial Tariff	Treasury Green Book Central Commercial Tariff	Treasury Green Book Central Commercial Tariff	Business Economy 7 tariff
Annual fuel bills	**£18,305**	**£19,092**	**£18,846**	**£23,559**
Annual OPEX (maintenance)	£650	£950	£1,050	£0
30 year total cost of ownership (excluding grant)	**£673,035**	**£702,088**	**£720,451**	**£834,103**
Annual tCO_2 emissions (2021)	**41.4**	**36.0**	**35.5**	**50.0**
Predicted annual tCO_2 emissions (2030)	**30.9**	**16.5**	**16.3**	**22.9**
Predicted annual tCO_2 emissions (2050)	**22.6**	**0.9**	**0.9**	**1.2**

30 year total costs of ownership

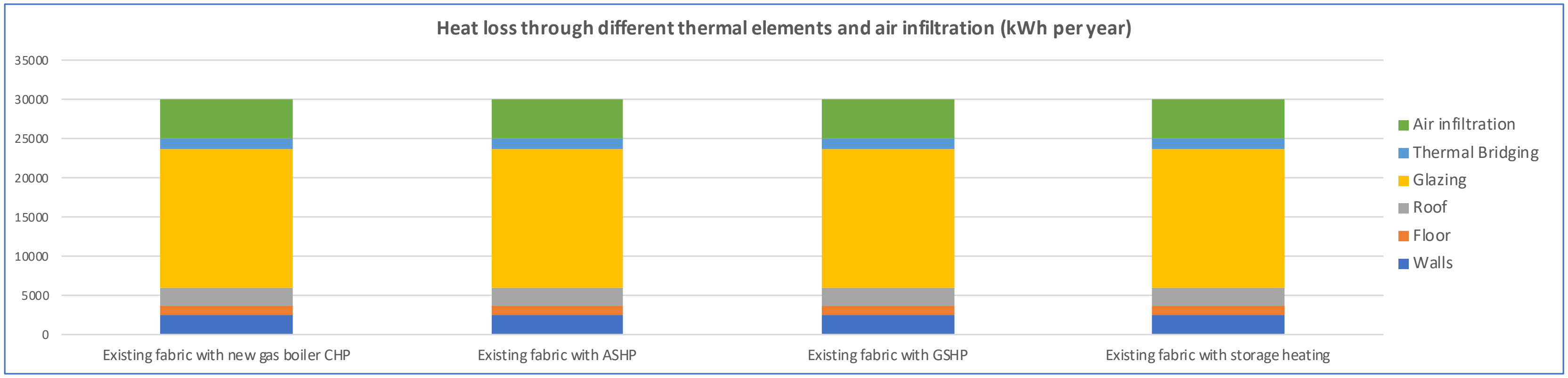


CAPEX
The CAPEX of the heat pump systems is assumed to be significantly higher than the BAU replacement with a CHP boiler. The CAPEX for electric storage heaters is presumed to be lower but still more expensive than the CHP.

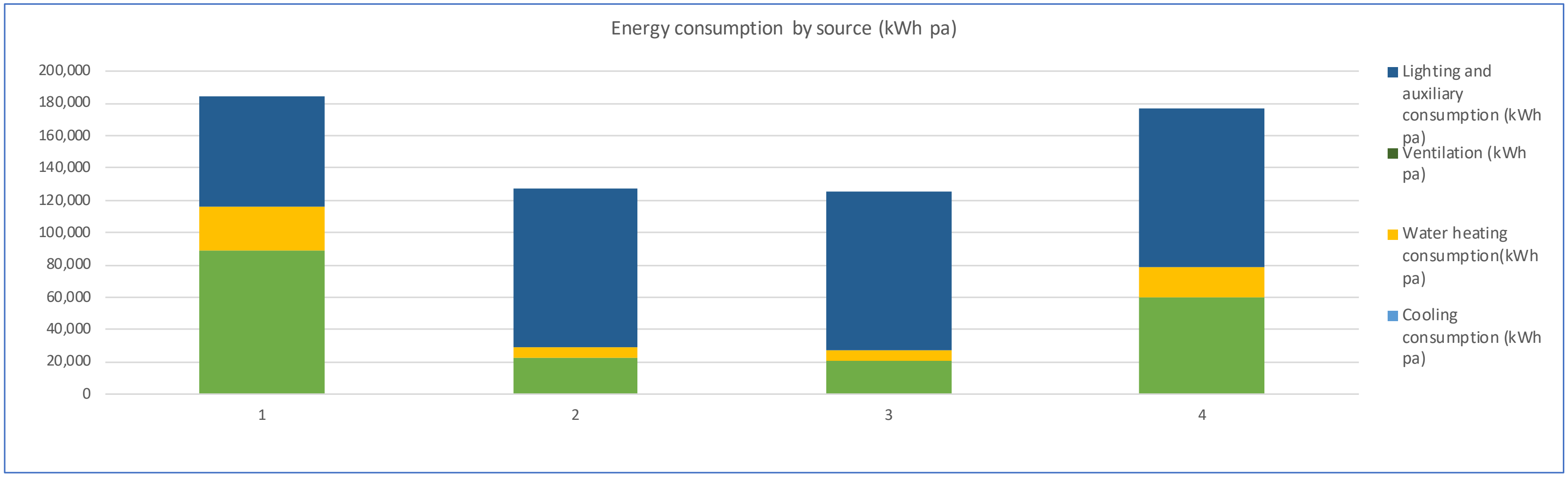
Fuel bills
The largest proportion of fuel bills is associated with lighting and there auxiliary power, therefore changes to the heating system to do not make large differences to the overall fuel bill. Fuel bills in scenarios 3 & 4 (ASHP and GSHP respectively) are modelled as being marginally higher than in the BAU. However, fuel bills are modelled as being significantly more expensive in the electric storage heater scenario (scenario 4). Scenario 4 was modelled using a Business Economy 7 tariff. It is possible that using the storage heaters in conjunction with a time of use tariff could result in lower fuel bills for scenario 4.

30 year cost of ownership
The BAU scenario has the lowest cost of ownership. Scenarios 2 & 3 (ASHP and GSHP respectively) have marginally higher costs of ownership. Scenario 4 has the highest costs of ownership.

Heat loss through thermal elements



Energy Consumption kWh pa



Heat demand and heating system efficiency

System efficiency for the CHP system in scenario 1 does not take in to account the on-site production of electricity. Overall, the CHP system is assumed to be 88% efficient. System efficiency is significantly higher in scenarios 3 & 4 (ASHP and GSHP respectively). Whilst electric storage heaters are 100% efficient at turning electricity in to heat, they have inherent limitations on controllability which means that consumption is often higher than demand- this is reflected here in a reduced efficiency.

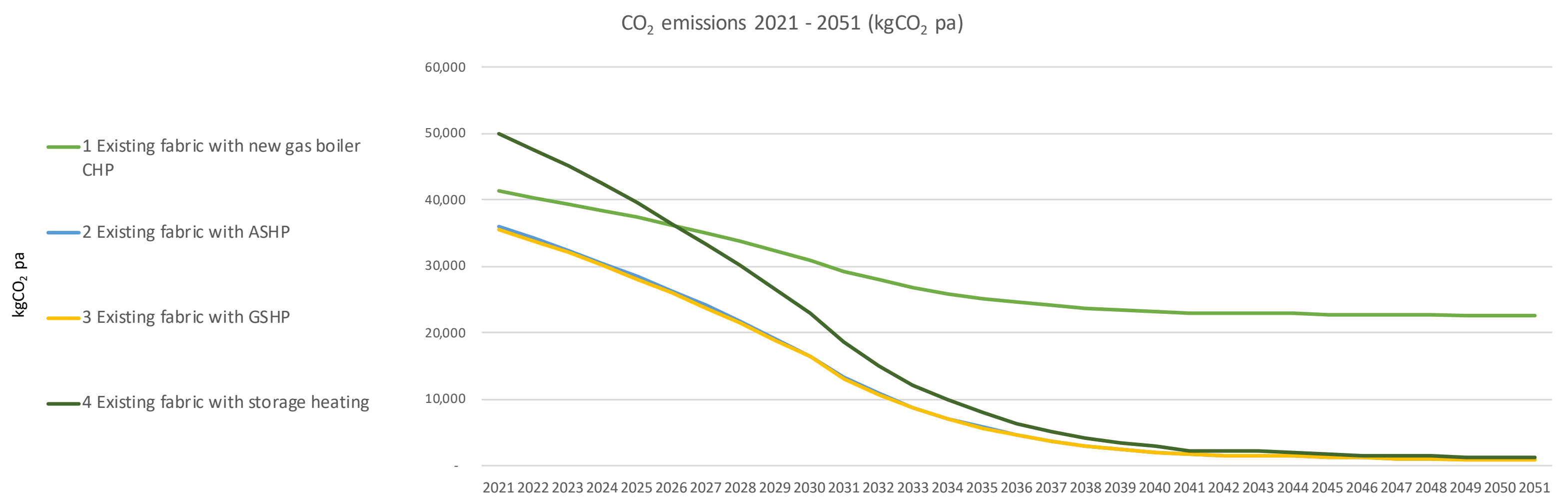
	Existing fabric with new gas boiler CHP	Existing fabric with ASHP	Existing fabric with GSHP	Existing fabric with storage heating
Space heating demand (kWh pa)	55,662	55,662	55,662	55,662
Water heating demand (kW)	16824	16824	16824	16824
Required flow temperatures °C	55	55	55	55
Space heating consumption (kWh pa)	89,060	22,265	21,005	60,175
Cooling consumption (kWh pa)	0	0	0	0
Water heating consumption(kWh pa)	26918	6730	6349	18188
Lighting and auxiliary consumption (kWh pa)	68032	98140	98140	98140
Space heating peak demand (kW)	30.1	30.1	30.1	30.1
Water heating peak demand (kW)	12	12	12	12
Required heating system size (kWtherm)	30	30	30	30
Peak electricity load kW @ 6:00pm	23.7	32.3	31.8	23.7
Assumed primary heating system SPF	**63%**	**250%**	**265%**	**93%**
Assumed distribution losses	**5%**	**0%**	**0%**	**0%**
Space heating Thermal Energy Demand Intensity (kwh per m2 pa)	**40**	**40**	**40**	**40**
Energy Use Intensity - all energy use (kWh per m2 pa)	**134**	**91**	**90**	**126**

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	41	36	36	50
Predicted annual tCO_2 emissions (2030)	30.9	16.5	16.3	22.9
tCO2 in 2050	22.6	0.9	0.9	1.2
tCO2 cumulative 2021 - 2050	847	343	339	477
tCO_2 saved relative to BAU (30 year cumulative)	0	-503	-508	-370
CO_2 saving relative to baseline (30 year cumulative)	0%	59%	60%	44%
Additional cost over BAU scenario (30 years)	£0	£29,053	£47,416	£161,068
£ per tonne of CO_2 reduction (30 year cumulative)	NA	£58	£93	£435

30 year predicted CO_2 emissions



CO_2 emissions

CO_2 emissions decline significantly in scenarios 2 - 4 with the forecast reduction in grid carbon intensity. The largest reductions in CO_2 emissions come from scenarios 2 & 3 where heat pumps are utilised. Scenario 4 has higher CO2 emissions compared to 2 & 3. However, the use of storage heaters could bring significant benefits to a low carbon energy system and has the lowest 06:00pm peak emissions.

Potential impact of Solar PV on all scenarios

	Existing fabric with new gas boiler CHP	Existing fabric with ASHP	Existing fabric with GSHP	Existing fabric with storage heating
Included in package? (Y/N)	N	N	N	N
System size kW Peak	10.0	10.0	10.0	10.0
System generation kWh pa	9,636	9,636	9,636	9,636
Utilisation on site kWh pa	9636	9636	9636	9636
Utilisation on site kWh pa	100%	100%	100%	100%
Exported to grid kWh pa	0	0	0	0
Assumed system cost £	15000	15000	15000	15000
Net impact on fuel bills £ pa	-£ 1,447	-£ 1,447	-£ 1,447	#N/A

Renewable energy:
We modelled the impact of a 10kW PV system under all scenarios. 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