Carbon Trust Options Appraisal for building decarbonisation: Summary of results

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Summary of current building

LAMBETH HOSPITAL 108 LANDOR ROAD SW9 9NU

Health centre / clinic	1 Units
Floorspace (m2)	14769
EPC Rating	DE
Occupied space heating consumption (kWh)	2,082,813
Cooling consumption (kWh)	664,605
Water heating consumption (kWh)	1,434,703
Occupied area electricity use (kWh)	1,624,590
Annual total fuel bill	£447,955
Annual fuel bill per flat (including share of communal areas)	£447,955
Occupied area Thermal Energy Demand Intensity (kWh per m2 pa)	118
Occupied area Energy Use Intensity (kWh per m2 pa)	393
Age of construction	1996 - 2002
Windows	Double glazed windows post 2002
Wall	Cavity as built
Roof	Flat roof
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, double convector

Description of Options for Appraisal

Thermal fabric

This hospital building is assumed to have a relatively good level of thermal fabric efficacy, with insulated cavity walls, insulated roof and modern, high performance double glazing. However, heat demand, as identified by the Display Energy Certificate, for the building is nevertheless very high compared to industry benchmarks. In scenarios 1 - 3 we assume that no fabric upgrades are made. In scenario 4 we model the impact of a full building best practice retrofit with upgrades to all external walls and the roof. Windows are already assumed to have near best practice U-values.

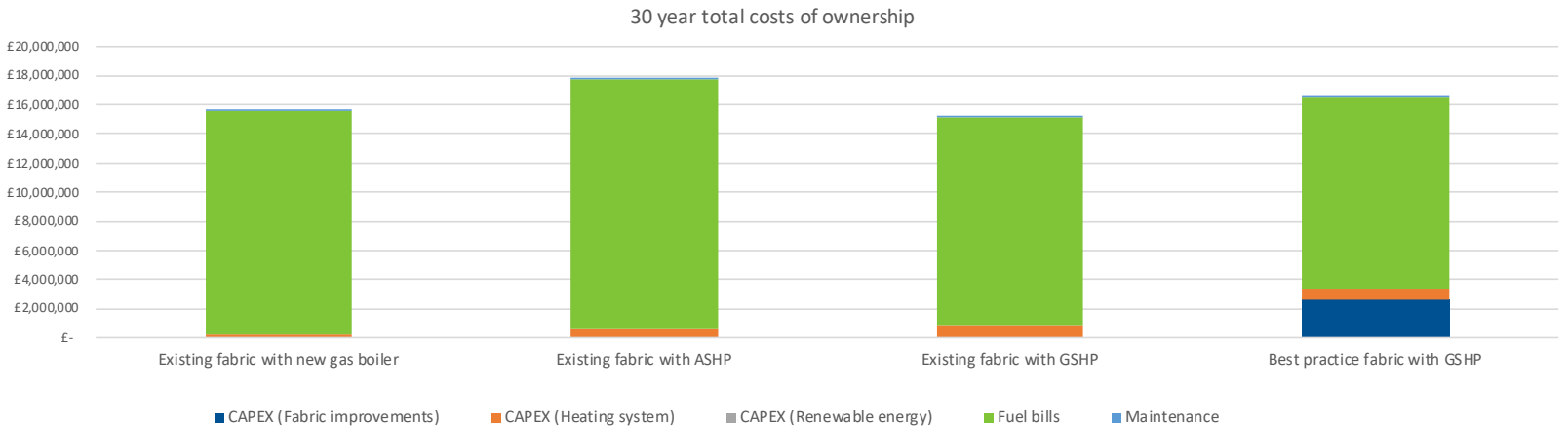
Energy systems

The building is currently heated by gas boilers. In scenario 2 we consider replacing these with Air source heat pumps. In scenario 3 we consider replacing these with Ground Source Heat Pumps. In scenario, we again consider Ground Source Heat Pumps. In scenarios 3 & 4 we assume that a level of cooling demand is met passively from the ground source heat pump loop.

Summary of options appraisal measures, costs & CO_2 emissions

	Existing fabric with new gas boiler	Existing fabric with ASHP	Existing fabric with GSHP	Best practice fabric with GSHP
HVAC system	302kW New Condensing gas boiler, 0, 0, hot water from main system (gas), Communal thermal store, Existing - AHUs with chillers	302kW New ASHP Air to water <55°C, 0, 0, hot water from main system (electric), Communal thermal store	302kW New GSHP/ WSHP <55°C, 0, ground loop (borehole) , hot water from main system (electric), Communal thermal store	221kW New GSHP/ WSHP <55°C, 0, ground loop (borehole) , hot water from main system (electric), Communal thermal store
	£158,576	£339,776	£596,476	£535,726
Heat emitter and distribution	Existing pipework, Existing radiators - double panel, single convector	Existing pipework, New - triple panel triple convector radiators	Existing pipework, New - triple panel triple convector radiators	Existing pipework, New - triple panel triple convector radiators
	£0	£80,030	£80,030	£58,565
Thermal fabric measures installed	, , ,	, , ,	, , ,	External wall insulation (High price - complex façade), Flat roof insulation , ,
	£0	£0	£0	£2,660,301
Air tightness	Natural ventilation , Average air tightness (7.5 n50)	Natural ventilation , Average air tightness (7.5 n50)	Natural ventilation , Average air tightness (7.5 n50)	Natural ventilation , Building regs airtightness (5 n50)
	£0	£0	£0	£0
Total CAPEX	£158,576	£419,806	£676,506	£3,254,592
Clean Heat Grant	£0	£0	£0	£0
Net CAPEX	£158,576	£419,806	£676,506	£3,254,592
Electricity tariff	Treasury Green Book Central Commercial Tariff	Treasury Green Book Central Commercial Tariff	Treasury Green Book Central Commercial Tariff	Treasury Green Book Central Commercial Tariff
Annual fuel bills	£447,955	£526,228	£438,133	£404,154
Annual OPEX (maintenance)	£650	£950	£1,050	£1,050
30 year total cost of ownership (excluding grant)	£15,572,435	£17,758,360	£15,133,238	£16,549,488
Annual tCO_2 emissions (2021)	1293.4	991.7	825.6	761.6
Predicted annual tCO_2 emissions (2030)	943.1	455.5	379.3	349.9
Predicted annual tCO_2 emissions (2050)	661.6	24.5	20.4	18.8

30 year total costs of ownership

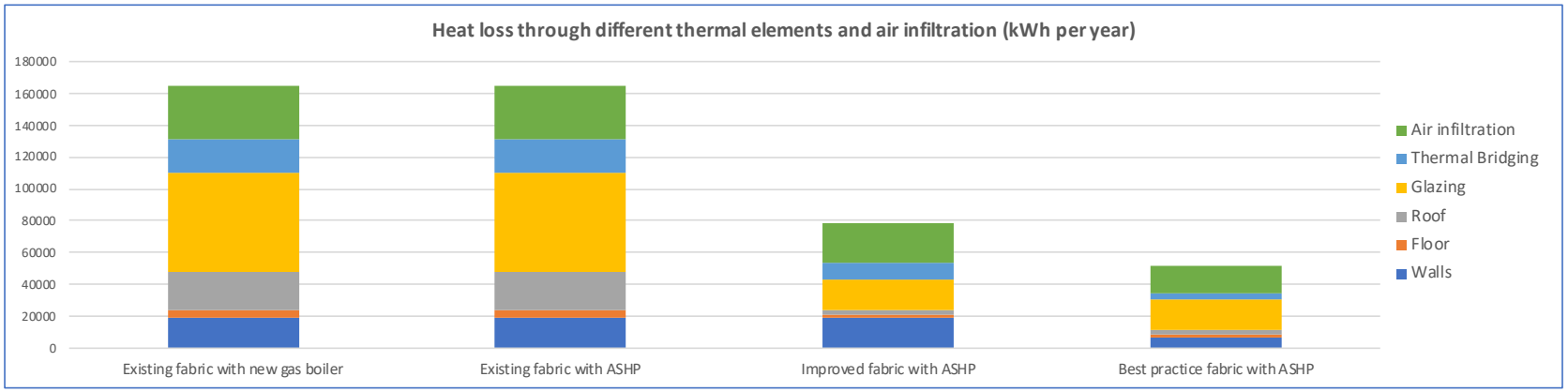


CAPEX
CAPEX increases significantly for all heat pump options relative to the BAU with the Air Source Heat Pumps in scenario 2 having the lowest CAPEX of the three electrification options.

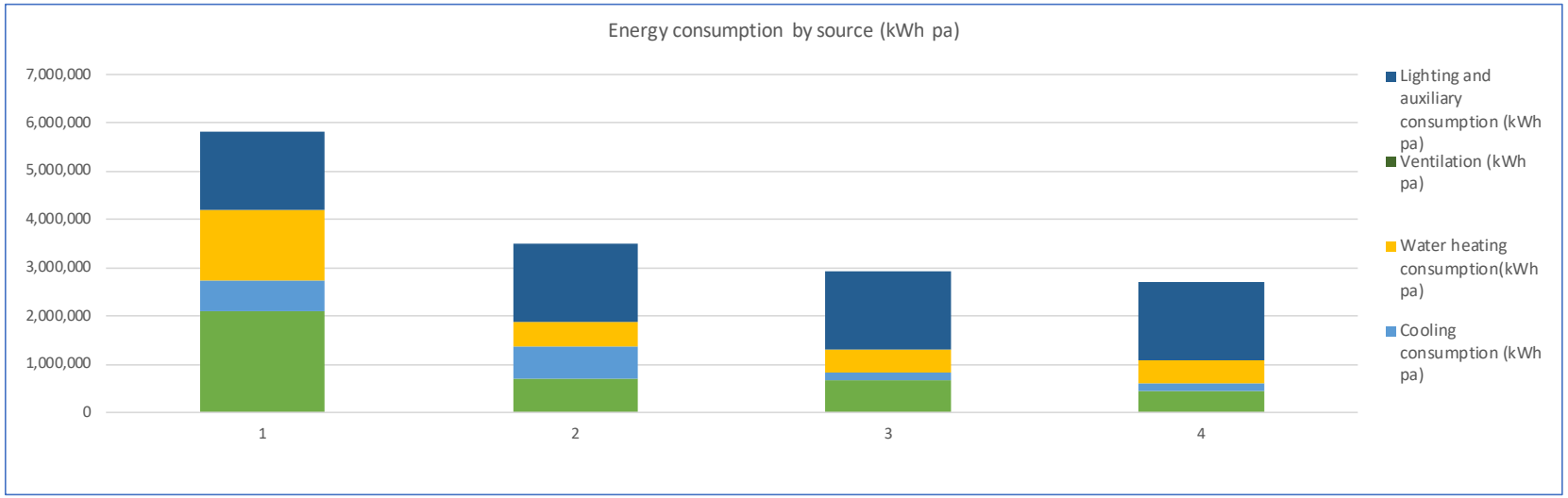
Fuel bills
Fuel bills increase significantly in scenarios 2. However, fuel bills marginally reduce in scenarios 3 & 4 reflecting the reduced energy consumption for cooling that arises from the use of the ground source heat pump loop to provide passive cooling.

30 year costs of ownership
Scenario 3 provides the lowest cost of ownership, marginally lower than the BAU scenario. This is because the Ground Source Heat Pump benefits from a marginally higher assumed efficiency and also it reduces energy consumption for the large cooling requirement of the building by providing a level of passive cooling. On this analysis, the additional investment in fabric efficiency does not yield a positive return on investment.

Heat loss through thermal elements



Energy Consumption kWh pa



Heat demand and heating system efficiency

System efficiency is highest in scenarios 3 & 4 which assume ground source heat pumps. This rated heating efficiency does not reflect the additional efficiency gained from providing passive cooling.

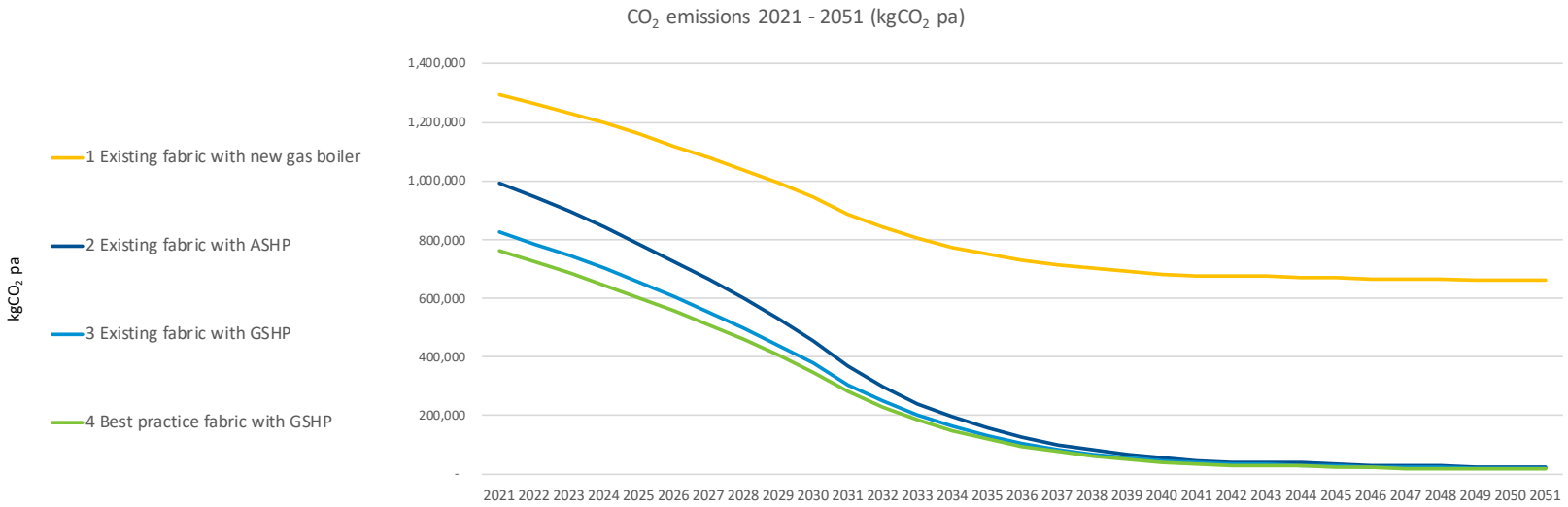
	Existing fabric with new gas boiler	Existing fabric with ASHP	Existing fabric with GSHP	Best practice fabric with GSHP
Space heating demand (kWh pa)	1,739,149	1,739,149	1,739,149	1,268,886
Space heating peak demand (kW)	301.9	301.9	301.9	220.3
Peak electricity load @ 6:00pm	0.0	392.5	552.9	543.6
Required flow temperatures °C	60	57	57	45
Space heating consumption (kWh pa)	2,082,813	712,766	671,486	445,223
Cooling consumption (kWh pa)	664,605	664,605	147,690	147,690
Water heating consumption(kWh pa)	1434703	502146	473723	473723
Ventilation (kWh pa)	0	0	0	0
Lighting and auxiliary consumption (kWh pa)	1624590	1624590	1624590	1624590
Assumed heating system Seasonal Performance Factor (SPF)	**84%**	**244%**	**259%**	**285%**
Assumed distribution losses	**0%**	**0%**	**0%**	**0%**
Space heating Thermal Energy Demand Intensity (kwh per m2 pa)	**118**	**118**	**118**	**86**
Energy Use Intensity - all energy use (kWh per m2 pa)	**393**	**237**	**198**	**182**

Retrofit package CO_2 emissions

tCO_2 in 2021	1293	992	826	762
Predicted annual tCO_2 emissions (2030)	943.1	455.5	379.3	349.9
Predicted annual tCO_2 emissions (2050)	661.6	24.5	20.4	18.8
tCO2 cumulative 2021 - 2050	25547	9461	7877	7266
tCO_2 saved relative to BAU (30 year cumulative)	0	-16086	-17670	-18281
CO_2 saving relative to baseline (30 year cumulative)	0%	63%	69%	72%
Additional cost over BAU scenario (30 years)	£0	£2,185,925	-£439,197	£977,053
£ per tonne of CO_2 reduction (30 year cumulative)	NA	£136	-£25	£53

* 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

CO_2 emissions reduce significant in all electrification scenarios (2 - 4). The greatest emissions reductions are achieved in scenarios 3 (due to the higher efficiency of the GSHP and the reduction in cooling demand from passive cooling) and scenario 4 (due to the same reasons as 3 but also the reduction in space heating demand from fabric retrofit).

Potential impact of Solar PV on all scenarios

	Existing fabric with new gas boiler	Existing fabric with ASHP	Existing fabric with GSHP	Best practice fabric with GSHP
Included in package? (Y/N)	N	N	N	N
System size kW Peak	150.0	150.0	150.0	150.0
System generation kWh pa	144,540	144,540	144,540	144,540
Utilisation on site kWh pa	144540	144540	144540	144540
Utilisation on site kWh pa	100%	100%	100%	100%
Exported to grid kWh pa	0	0	0	0
Assumed system cost £	225000	225000	225000	225000
Net impact on fuel bills £ pa	-£ 21,706	-£ 21,706	-£ 21,706	-£ 21,706

We modelled the impact of a 150kW PV array for each of the scenarios. Due to the high year round demand for electricity in all scenarios, on-site utilisation of electricity was modelled as being high, leading to significant fuel bill reductions.

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