Carbon Trust Options Appraisal for building decarbonisation: Summary of results

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Summary of current building

St. Stephens C of E Primary School, DORSET ROAD SW8 1EJ

Office with natural ventilation and cooling	1 Units
Floorspace (m2)	1429
EPC Rating	D
Occupied space heating consumption (kWh)	279,227
Cooling consumption (kWh)	0
Water heating consumption (kWh)	19,598
Occupied area electricity use (kWh)	57,160
Annual total fuel bill	£17,434
Annual fuel bill per flat (including share of communal areas)	£17,434
Occupied area Thermal Energy Demand Intensity (kWh per m2 pa)	166
Occupied area Energy Use Intensity (kWh per m2 pa)	249

Age of construction	1976 - 1982
Windows	Double glazed windows pre 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)	Very poor performing airtightness (20 n50)
Radiators / emitters	Existing radiators - single panel single convector

Description of Options for Appraisal

Thermal fabric
The current building has a relatively inefficient thermal fabric with a high heat demand, as confirmed by the high gas use on the Display Energy Certificate. In this analysis, we assumed that the cavity walls are currently un-insulated, that loft insulation is minimal and that double glazing is of a pre-2002 standard.

In scenario 2, we assume that no fabric measures are undertaken.
In scenario 3, we model the impact of cavity wall insulation and loft insulation
In scenario 4, we model the impact of a full best practice retrofit including external wall insulation and triple glazing.

Energy systems
For scenario 1 we assume that the current gas boiler is replaced like for like.
In scenarios 2 - 4 we assume that an Air Source Heat Pump is installed to meet 100% of the heat demand. In scenario 2 we assume that radiators are upgraded to triple panel convector radiators to enable flow temperatures below 55°C. In scenarios 3 & 4 the reduction in heat loss from the thermal fabric measures is sufficient to allow the existing radiators to be retained alongside the heat pump.

Summary of options appraisal measures, costs & CO_2 emissions

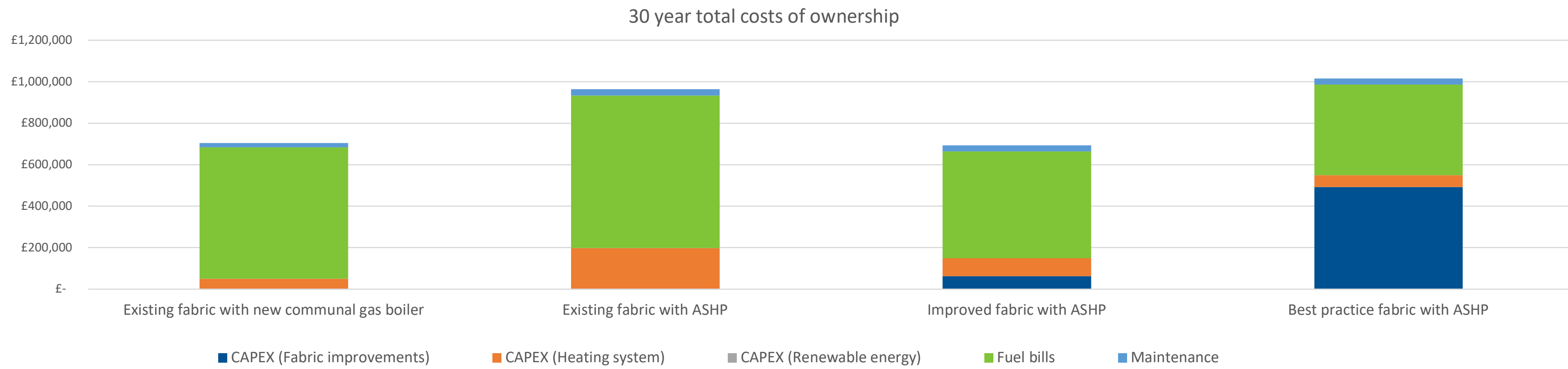
	Existing fabric with new communal gas boiler	Existing fabric with ASHP	Improved fabric with ASHP	Best practice fabric with ASHP
HVAC system	101kW New Condensing gas boiler, 0, 0, hot water from main system (gas), Communal thermal store, 0	101kW New ASHP Air to water <55°C, 0, 0, hot water from main system (electric), Communal thermal store	51kW New ASHP Air to water <55°C, 0, 0, hot water from main system (electric), Communal thermal store	34kW New ASHP Air to water <55°C, 0, 0, hot water from main system (electric), Communal thermal store
	£25,250	**£85,850**	**£43,350**	**£28,900**
Heat emitter and distribution	Existing pipework, Existing radiators - single panel single convector	Existing pipework, New - triple panel triple convector radiators	Existing pipework, Existing radiators - single panel single convector	Existing pipework, Existing radiators - single panel single convector
	£0	**£26,765**	**£0**	**£0**
Thermal fabric measures installed	, , ,	, , ,	Cavity wall insulation , Loft insulation (Joists) 0 - 270mm, ,	Cavity wall insulation , Flat roof insulation , high performance triple glazing , Insulate Suspended floor (difficult access)
	£0	**£0**	**£55,436**	**£484,269**
Air tightness	Natural ventilation , Very poor performing airtightness (20 n50)	Natural ventilation , Very poor performing airtightness (20 n50)	MEV, Average air tightness (7.5 n50)	MEV, Average air tightness (7.5 n50)
	£0	**£0**	**£7,145**	**£7,145**

Total CAPEX	**£25,250**	**£112,615**	**£105,931**	**£520,314**
Clean Heat Grant	£0	£0	£0	£0
Net CAPEX	**£25,250**	**£112,615**	**£105,931**	**£520,314**

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	**£17,434**	**£22,709**	**£15,885**	**£13,512**
Annual OPEX (maintenance)	£650	£950	£950	£950
30 year total cost of ownership (excluding grant)	**£703,753**	**£963,811**	**£693,495**	**£1,016,514**

Annual tCO_2 emissions (2021)	**71.0**	**43.2**	**30.5**	**26.0**
Predicted annual tCO_2 emissions (2030)	**62.3**	**19.8**	**14.0**	**11.9**
Predicted annual tCO_2 emissions (2050)	**55.2**	**1.1**	**0.8**	**0.6**

30 year total costs of ownership



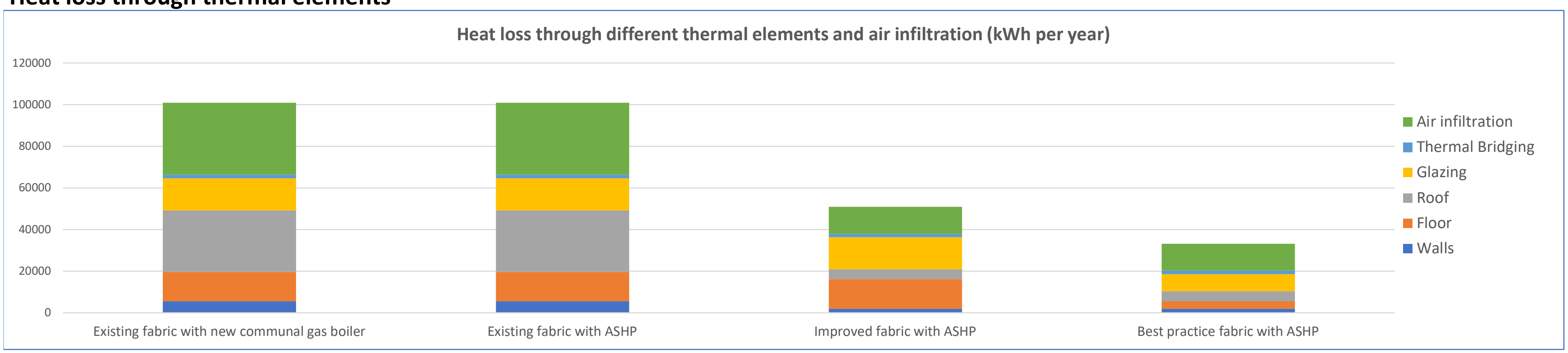
CAPEX
The CAPEX of the ASHPs is significantly more than the BAU gas boiler. However, the CAPEX of heating systems in scenarios 3 & 4 is significantly reduced as the kW capacity is lower due to the fabric improvements.
The Cavity Wall Insulation and Loft Insulation are assumed to be far lower CAPEX than the high performance triple glazing modelled in scenario 4.

Fuel bills
Fuel bills are higher than BAU in scenario 2. However, fuel bills in scenarios 3 & 4 are lower than the BAU scenario.

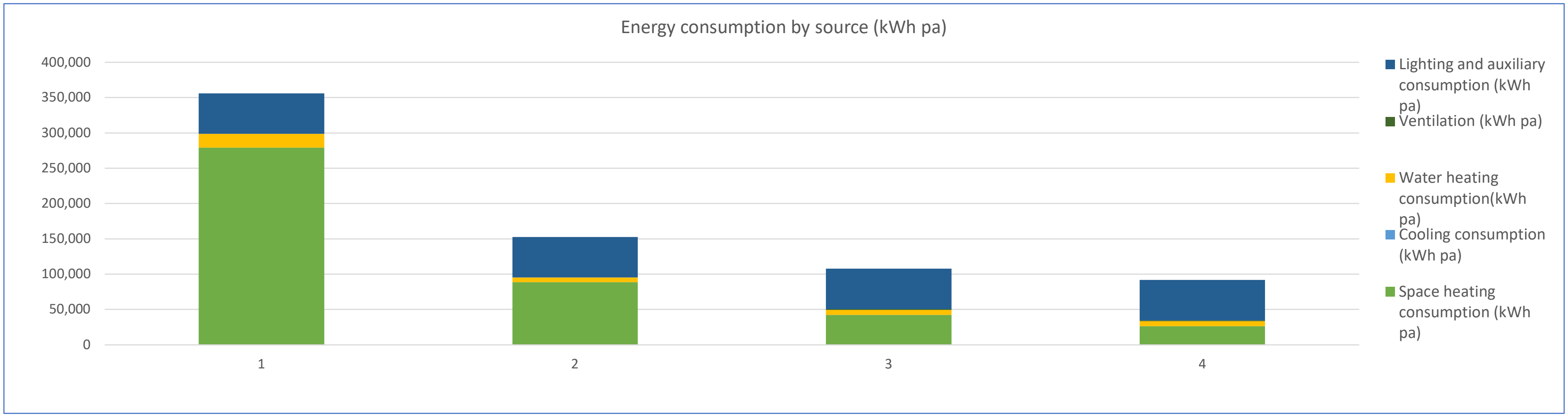
30 year costs of ownership
Whilst the BAU scenario has the lowest cost of ownership, scenario 3 costs are only marginally higher. This suggests that the investment in Cavity Wall Insulation has a very good payback, whereas the additional investment to best practice fabric does not have a positive payback within 30 years.

Note that costs do not include consideration of grants or planned investment and maintenance.

Heat loss through thermal elements



Energy Consumption kWh pa



Heat demand and heating system efficiency

	Existing fabric with new communal gas boiler	Existing fabric with ASHP	Improved fabric with ASHP	Best practice fabric with ASHP
Space heating demand (kWh pa)	237,343	237,343	119,600	78,025
Space heating peak demand (kW)	101.0	101.0	50.9	33.2
Peak electricity load @ 6:00pm	0.0	13.8	48.0	30.2
Required flow temperatures °C	60	46	39	32
Space heating consumption (kWh pa)	279,227	88,561	42,411	26,360
Cooling consumption (kWh pa)	0	0	0	0
Water heating consumption(kWh pa)	19598	6859	6859	6859
Lighting and auxiliary consumption (kWh pa)	57160	57160	57160	57160
Assumed heating system Seasonal Performance Factor (SPF)	**85%**	**268%**	**282%**	**296%**
Assumed distribution losses	**0%**	**0%**	**0%**	**0%**
Space heating Thermal Energy Demand Intensity (kwh per m2 pa)	**166**	**166**	**84**	**55**
Energy Use Intensity - all energy use (kWh per m2 pa)	**249**	**107**	**75**	**64**

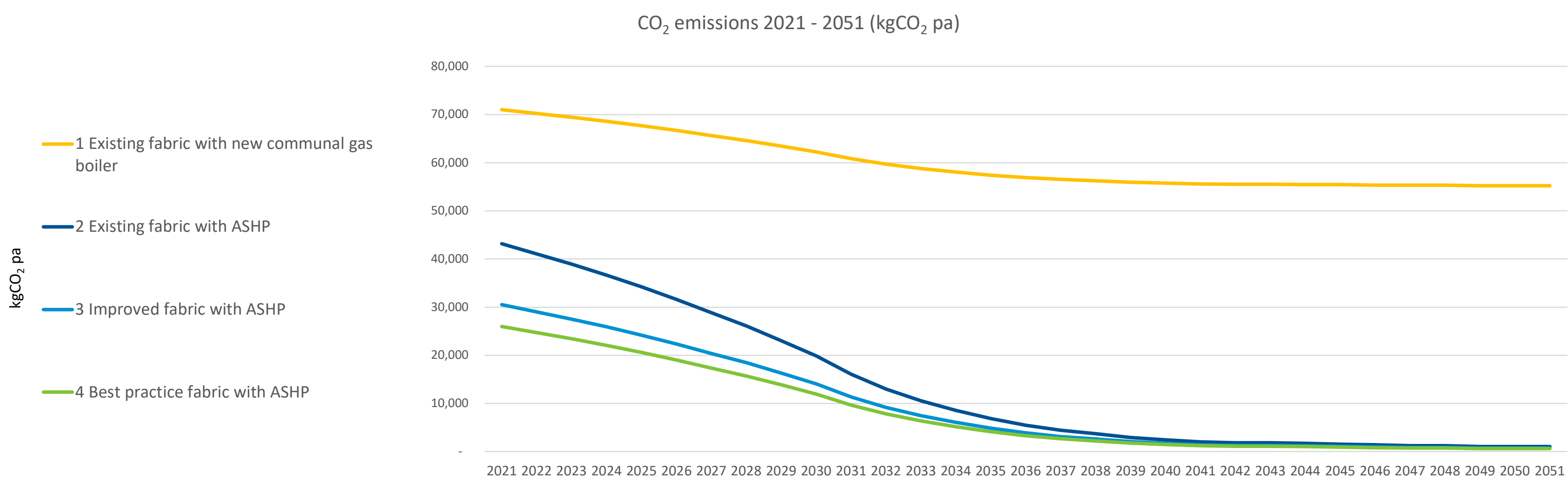
Energy use
Energy use and energy use intensity reduces significantly under all heat pump scenarios (2 - 4). Scenario 4 has the highest system efficiency, due to the heat pump operating at the lowest flow temperatures in this scenario.

Retrofit package CO_2 emissions

tCO_2 in 2021	71	43	31	26
Predicted annual tCO_2 emissions (2030)	62.3	19.8	14.0	11.9
tCO_2 in 2050	55.2	1.1	0.8	0.6
tCO_2 cumulative 2021 - 2050	1800	412	291	248
tCO_2 saved relative to BAU (30 year cumulative)	0	-1388	-1508	-1552
CO_2 saving relative to baseline (30 year cumulative)	0%	77%	84%	86%
Additional cost over BAU scenario (30 years)	£0	£260,058	-£10,259	£312,761
£ per tonne of CO_2 reduction (30 year cumulative)	NA	£187	-£7	£202

* 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 significantly under all electrification scenarios, reflecting the high efficiency of the heat pump systems and the forecast reductions in grid carbon intensity.

Potential impact of Solar PV on all scenarios

	Existing fabric with new communal gas boiler	Existing fabric with ASHP	Improved fabric with ASHP	Best practice fabric with ASHP
Included in package? (Y/N)	N	N	N	N
System size kW Peak	15.0	15.0	15.0	15.0
System generation kWh pa	14,454	14,454	14,454	14,454
Utilisation on site kWh pa	14188	14398	14398	14397
Utilisation on site kWh pa	98%	100%	100%	100%
Exported to grid kWh pa	266	56	56	57
Assumed system cost £	22500	22500	22500	22500
Net impact on fuel bills £ pa	-£ 2,141	-£ 2,164	-£ 2,164	-£ 2,164

We modelled the impact of a 15kW solar PV array separately for each of the scenarios. The results are shown above. The results show a high correlation between solar PV generation and year round demand for electricity. Our model assumed that the school building is utilised year round - in practice the summary holidays could negatively impact the on-site utilisation of solar PV.

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