



Royal Borough of Greenwich Elliston House Low carbon technology feasibility

Dr Gabriel Gallagher
Omied Khakshour
June 2020



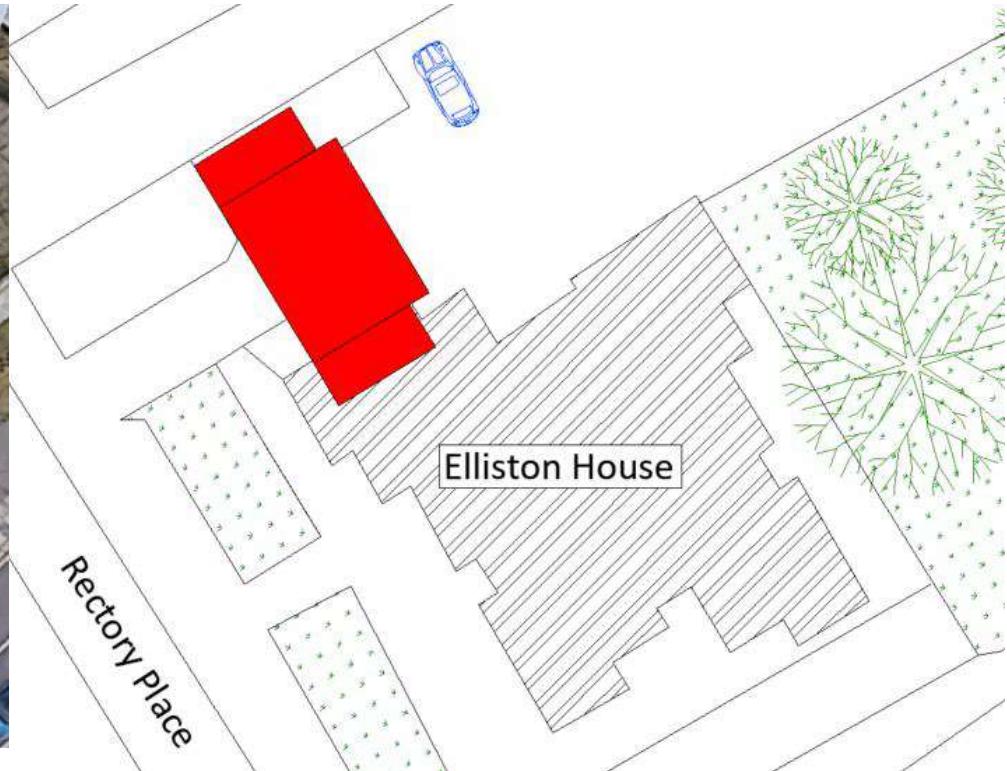
Scope of work

- To assess low carbon / renewable heating options for social housing
- Model heat and hot water demands for different levels of fabric improvements to inform sizing of new system
- Review and propose solutions for secondary heating and hot water systems
- Develop concept designs for refurbishment of energy centre with low carbon heating



Summary of Elliston House

- 90 dwellings in high rise accommodation
- Central heating system plant located in external energy centre (red)
 - Main plant is in lower ground level of energy centre, which runs under the car parking area
- Existing LTHW (82°C flow / 71°C return) communal heating system supplies radiators and individual hot water cylinders



Design considerations



- To ensure correct specification of low carbon heating systems – flow and return temperatures must be reduced we must:
 - Reduce radiator temperatures*
 - Increase temperature differential to reduce pipe sizes
 - Ensure peak loads are correctly estimated to prevent oversizing
 - Install heat interface units in dwellings to replace hot water cylinders
 - Maintain existing network and supply of heat to continue to provide service whilst new system is installed

* This does not mean a reduction in the potential energy supplied to each space; although, the operating temperatures are lower than existing, the new emitters will be compatible with the operating conditions and the required set points will be achieved

Heat demand profiling



Current heat demand



- Existing gas consumption data – 1,337,838kWh per annum
- Existing heat demand modelled based on following assumptions:
 - Fabric to ~30 year old building regs
 - Unmetered heating controls with 21°C setpoint and 15°C set back
 - Communal DHW hot water storage tank
 - 1.5 occupants per apartment
- Heat losses from existing DHW cylinders

Current heat demand

- Fabric and ventilation loss inputs:

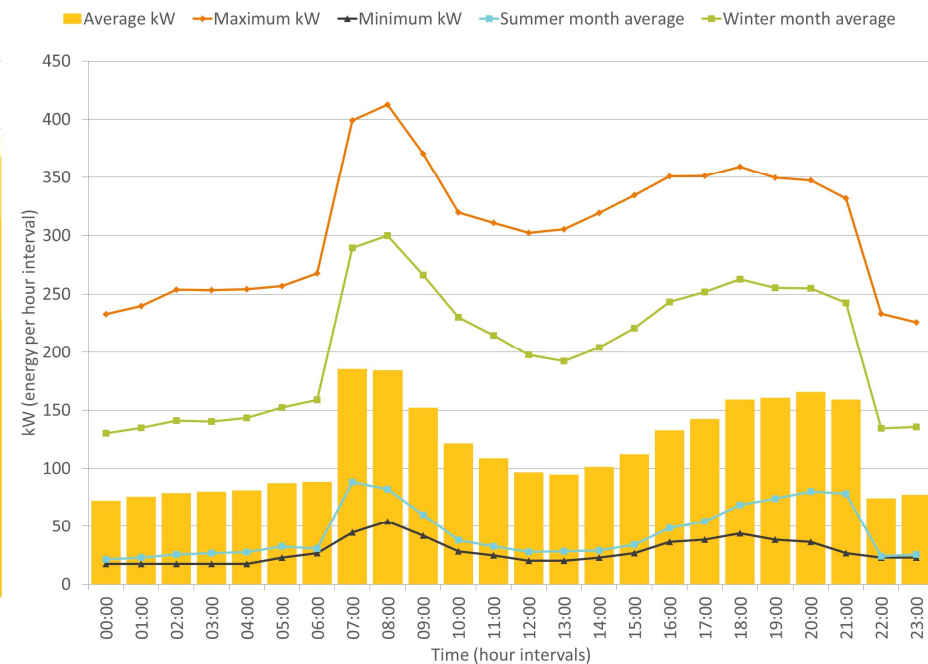
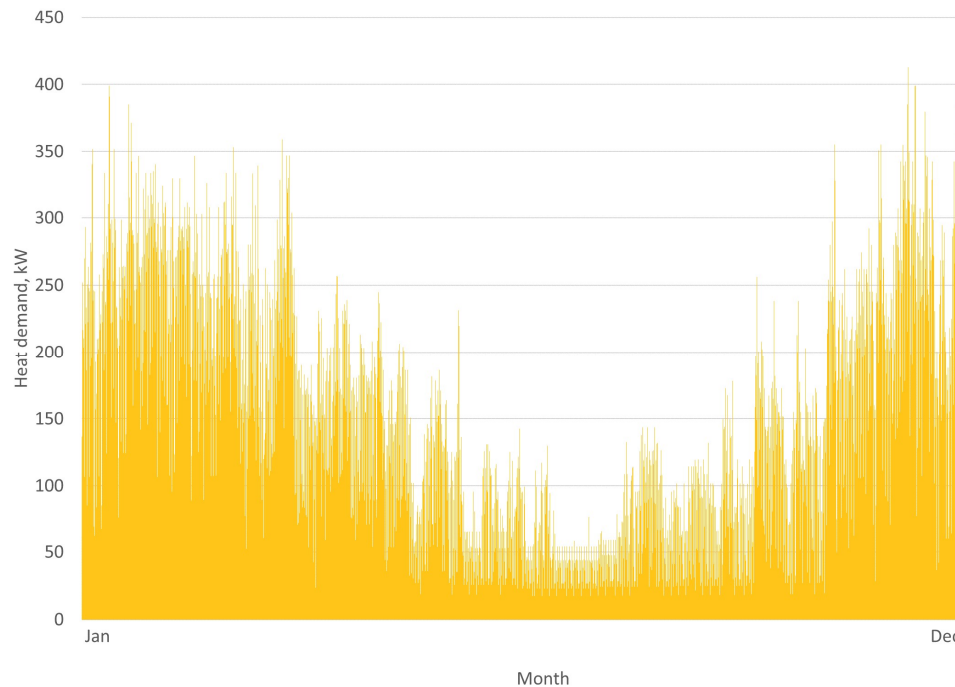
Fabric type - U-Values		
Floor	W/m ² K	0.45
Walls	W/m ² K	0.45
Glazing	W/m ² K	2.00
Roof	W/m ² K	0.25
Ventilation		
Air permeability	m ³ /h.m ²	8.5

Current heat demand

- Summary of existing heat demand

Scenario	Annual Modelled Demand kWh	Peak heat kW	kWh per flat	Total kW per flat
Existing	1,018,721	413	11,319	4.6

- Modelled boiler efficiency of existing system – 76%



Scenario 1

Upgraded heating system demand



- Scenario 1 assumes:
 - No fabric changes
 - Flat fit outs for low temperature network conditions
 - Heat interface units for local heating control, metering and instantaneous hot water
 - Upgraded pipe work for the risers and laterals in each building
- The model also considers the impact of the following factors on the heat demand for the new system:
 - Assumed change in heat setting behaviour and energy usage due to the introduction of individual metering of each apartment
 - Ambient temperature controls in energy centre
 - Heating controls with 21°C setpoint and 14°C set back
 - Reduction in heat losses due to the replacement of individual DHW hot water storage tanks with instantaneous plates in HIUs

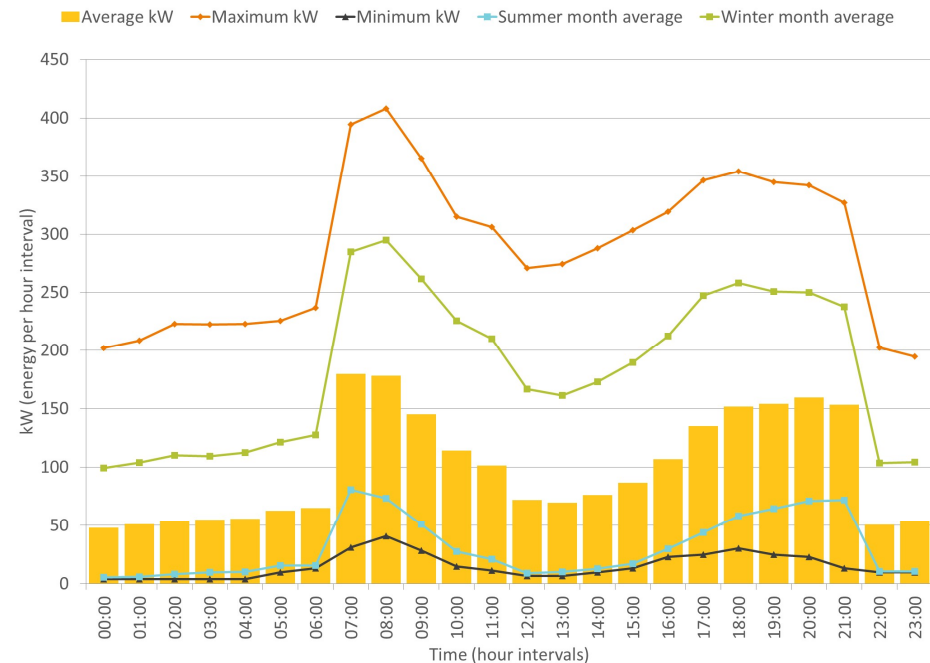
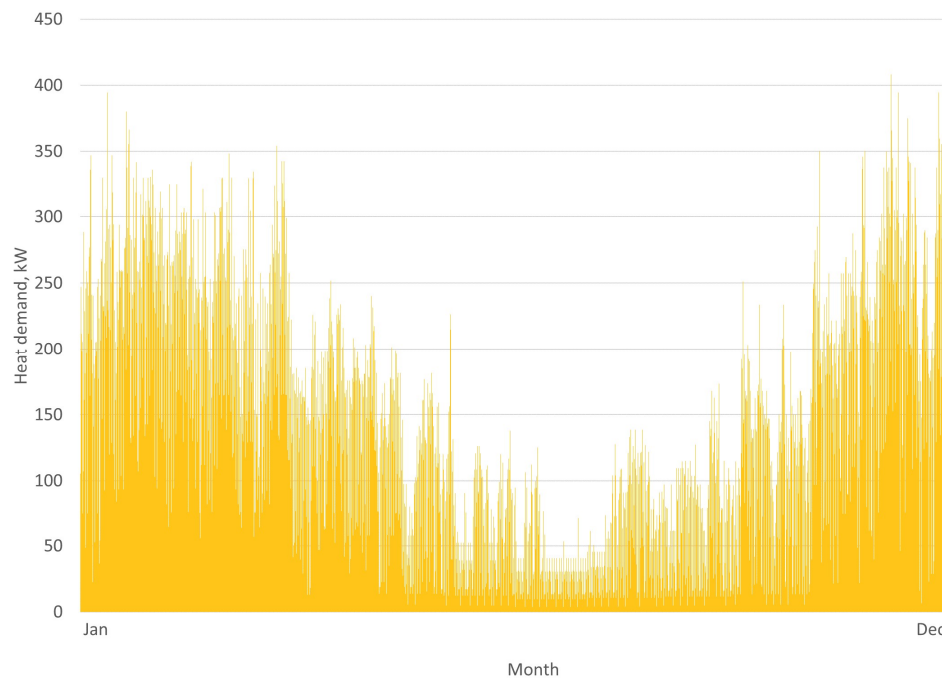
Scenario 1

Upgraded heating system demand

- Scenario 1 heat demand summary

Scenario	Annual Modelled Demand kWh	Peak heat kW	kWh per flat	Total kW per flat
1	867,641	408	9,640	4.5

- The heat demand for the site after all the above conditions are adjusted is 867,641kWh
 - 15% reduction in current heat demand



Scenarios 2,3 and 4

Fabric improvements



- As with scenario 1, scenarios 2, 3 and 4 all assume:
 - Flat fit outs for low temperature network conditions
 - Heat interface units for local heating control, metering and instantaneous hot water
 - Upgraded pipe work for the risers and laterals in each building
- With the addition of varying levels of fabric improvements as follows:
 - Scenario 2 – roof insulation improvements
 - Scenario 3 – roof insulation improvements and glazing upgrades
 - Scenario 4 – roof insulation improvements, glazing upgrades and external wall cladding

Scenarios 2,3 and 4

Fabric improvements



- Fabric improvements are to bring each element up to current retrofit/refurbishment Part L levels as below:

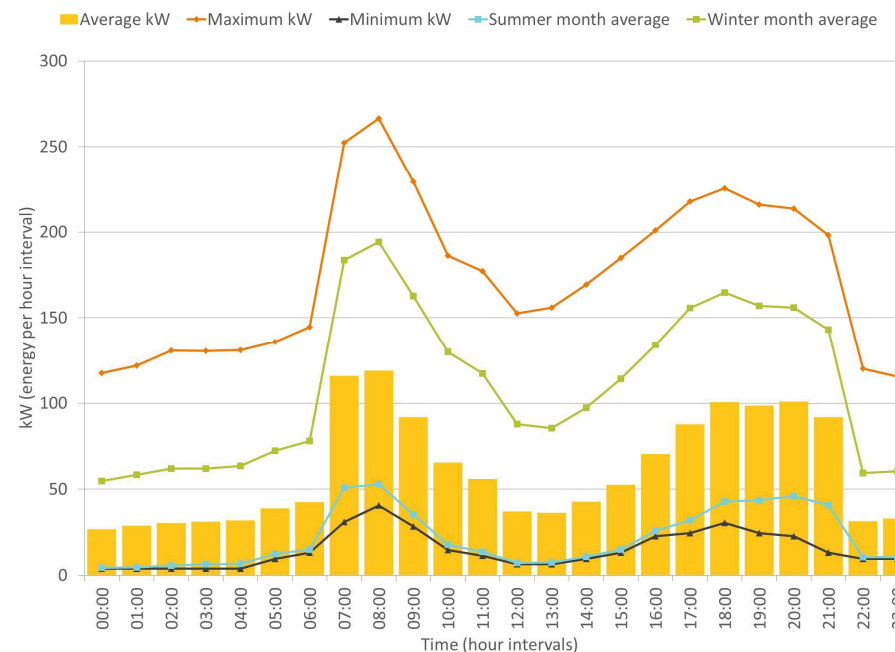
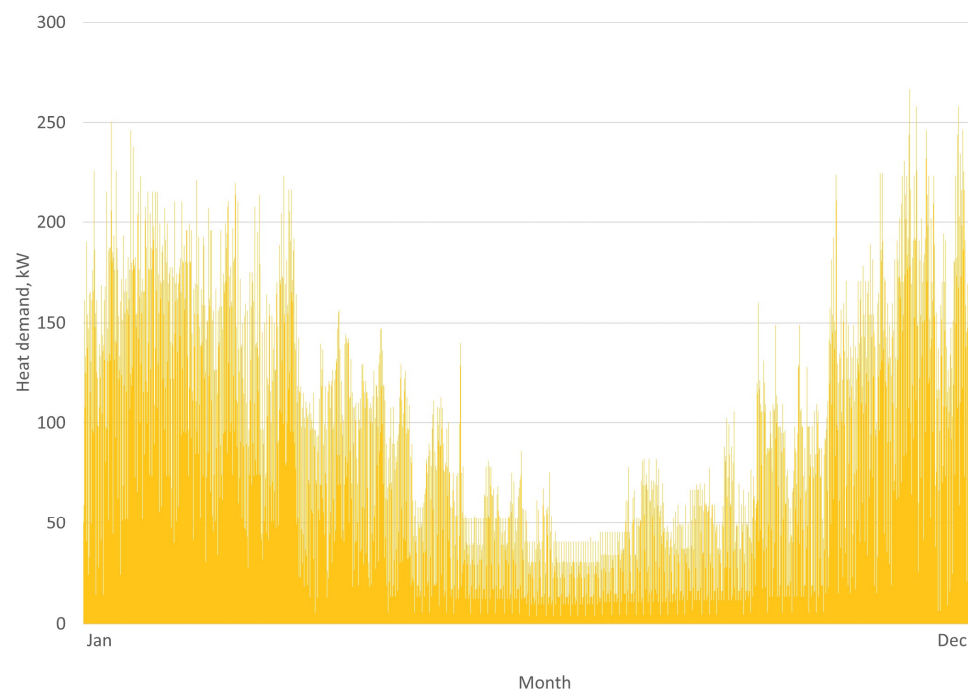
Fabric type - U-Values	Units	Scenario 1 – Existing fabric	Scenario 2 -Roof upgrade	Scenario 3 - Roof and glazing	Scenario 4 - Roof, glazing and EWI
Floor	W/m ² K	0.45	0.45	0.45	0.45
Walls	W/m ² K	0.45	0.45	0.45	0.30
Glazing	W/m ² K	2.00	2.00	1.60	1.60
Roof	W/m ² K	0.25	0.16	0.16	0.16
Ventilation					
Air permeability	m ³ /h.m ²	8.5	7.5	6.5	5.0

Scenario 2,3 and 4 Fabric improvements

- Summary of heat demands

Scenario	Annual Modelled Demand kWh	Peak heat kW	kWh per flat	Total kW per flat
2	783,851	373	8,709	4.1
3	697,203	336	7,747	3.7
4	533,289	267	5,925	3.0

- Annual heat demand profile and average, max, min daily profile for scenario 4



Supply options appraisal and feasibility



Supply options appraisal

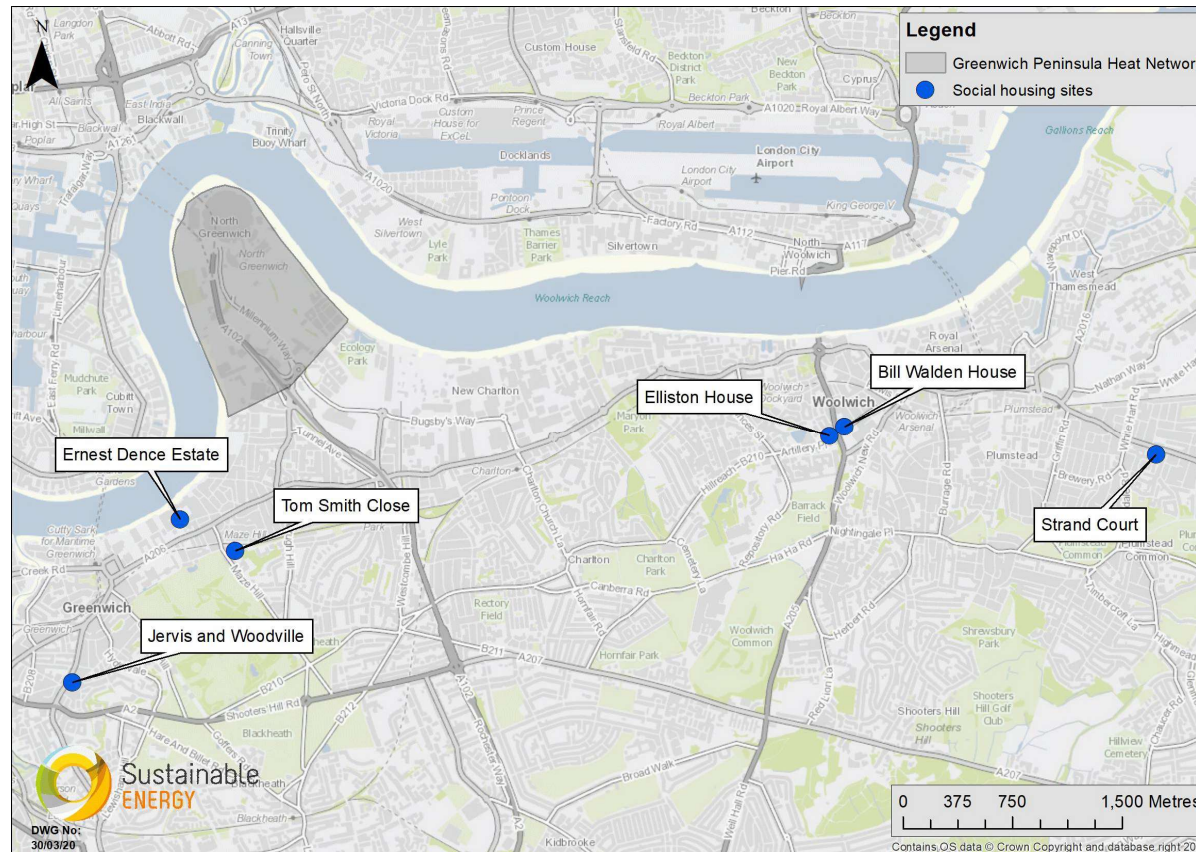


A number of different supply options were considered for the supply of heat and electricity to Elliston House:

- Connection to local district heat networks
- Heat pump technologies
 - Ground source – closed loop
 - Ground source – bore hole
 - Air source
- Solar PV
- Energy storage
 - Thermal
 - Electrical

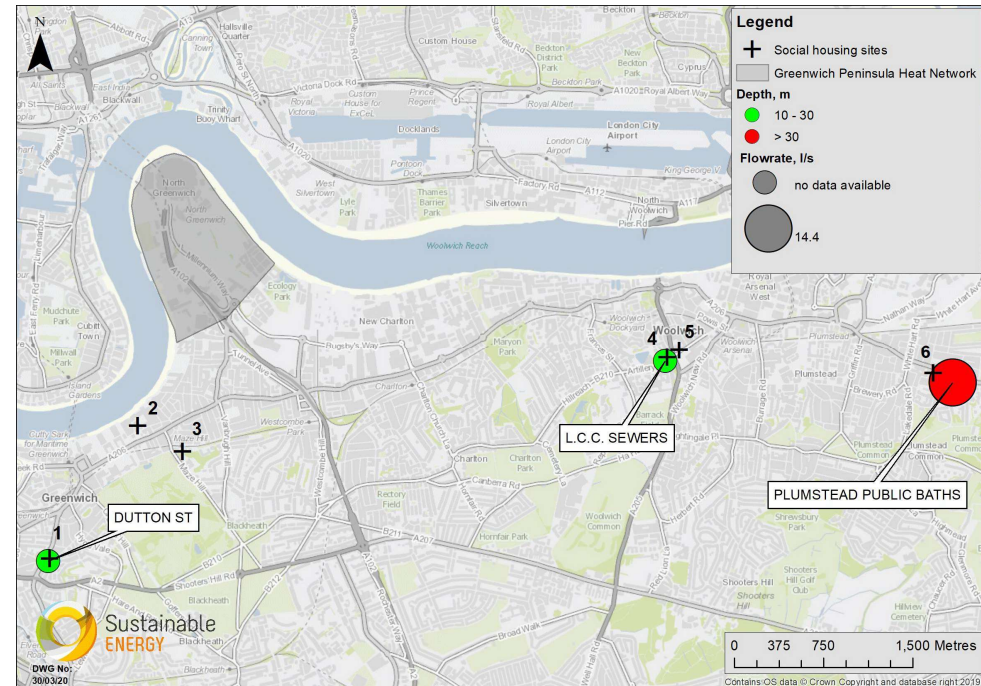
Local heat networks

- The image below shows the position of the RBG low carbon assessment sites and the location of the Greenwich Peninsula heat network
- At present there are no suitable connection points for heat supply from the existing network
- The design of the new heating systems will be compatible with connection to a large heat network if a suitable one was to become viable in the future



Ground source – open loop

- Borehole data from the national BGS resource is summarised in the GIS and table below
- Positions of gathered data is shown in the GIS
 - Colour indicated depth of bore holes
 - Width indicates flowrates measured in the bore holes
 - The assessment sites are numbered. Elliston House is shown at position 4



- Table with results of bore hole data

Location	Borehole name	Depth, m	Water depth, m	Flowrate, l/s	Strata details	Notes
Bill Waldon House / Elliston House 543240,178590	TQ47NW24 — L.C.C. SEWERS (M81) WOOLWICH	32.8	8.4	NA	0 - 0.91 m: Road surface and hardcore 0.91 - 5.3 m: Loam and sand 5.3 – 8.4 m: Broken shell and black silt 8.4 - 13 m: Loam 13 – 14.5 m: Yellow sand 14.5 – 15.1 m: Ballast 15.1 – 30.3 m: Fine sand 30.3 – 30.6 m: sand and flints 30.6 – 32.8 m: Chalk	Last examined in 1905

Ground source – open loop



- There is significant risk associated with the open loop solution
- No flowrate data is available for L.C.C Sewers located near Elliston House (site marked 4 on the image)
- A detailed hydro-geological modelling assessment would be required to understand the bore hole spacing (to prevent thermal interaction) and overall design - this may cost in the region of £20,000
- A trial well could be drilled into chalk aquifer but this will require significant CAPEX (up to £120,000 with no guarantee of a viable well or scheme)
- If a sufficient flowrate was achieved then the installation would need to be ready to apply for the RHI subsidy before March 2021
- A high level economic case for this option is shown on the next slide

Ground source – open loop



- 2no 110kW GSHP with 5,000litres thermal storage could supply 99% of the annual demand (allowing for 50weeks availability)
- A high level economic assessment is shown below:

		Current system	GSHP with Gas condensing boilers with RHI	GSHP with Gas condensing boilers without RHI
			Scenario 1	Scenario 1
Energy and carbon	Units			
Heat demand - Peak	kW	413	408	408
Heat annual demand	kWh	1,018,721	867,641	867,641
Heat annual demand - losses	kWh		-	-
Heat annual demand - Total	kWh	1,018,721	867,641	867,641
% heat demand low carbon	%	0%	96%	96%
25 year CO2e savings	tCO2e		3,970	3,970
First year CO2e savings, tCO2e	tCO2e		118	118
First year CO2e intensity of delivered heat	gCO2e/kWh		94	94
Build and run costs				
Capex of scheme + contingency	£		£704,034	£704,034
Fixed heat sales	£/day		0.65	0.65
Variable heat sales	p/kWh		7.00	7.00
Cost of heat to residence - annual	£		£912	£912
Payback period	Years		14	0
NPV	£		£101,354	-£510,594
IRR	%		4.9%	-5.4%

Ground source – closed loop

- The available green space for the installation of ground loops is limited
 - Circa 800m² total shown below
- Potential issues with positioning of trees and tree roots
 - Red circles show x1.5 canopy ranges for each tree



Ground source – closed loop

- Vertical bore positions



- Potential yield*

Array type	Heat extraction rate – figures from BS EN 15450	Installation details	Potential Capacity
Horizontal –slinky pipe	<ul style="list-style-type: none"> • 16 - 24W/m² • Figure for moist cohesive soil • 2400h p.a operation 	<ul style="list-style-type: none"> • 800m² green space 	12.8 – 19.2kW
Vertical	<ul style="list-style-type: none"> • 50W/m • Figure for normal underground and water saturated sediment • 2400h p.a operation 	<ul style="list-style-type: none"> • 10 boreholes • 0.6m diameter with 10metre spacing • 100m depth 	50kW

*Numbers shown assume all existing trees are removed and all available green space could be utilised

Air source



- Available resource with lower installation requirements
- Potential risks of noise to residents and cold plumes can be mitigated with suitable attenuation

Technology assessment summary

Heat source	Comments	Considered further?
Heat network connection	<ul style="list-style-type: none">• No suitable networks local to the assessment site	No
Closed Loop GSHP	<ul style="list-style-type: none">• Low yield potential from available land• Not viable due to land requirement for ground loops (horizontal and vertical)	No
Open Loop GSHP	<ul style="list-style-type: none">• Water source unknown• High CAPEX associated with drilling boreholes into chalk aquifer (in relation to small scheme)• No guarantee of adequate resource• RHI accreditation is time sensitive and installation of bore is time intensive	No
ASHP	<ul style="list-style-type: none">• Lower initial CAPEX than GSHP options• Potential noise restrictions close to residential developments	Yes

Solar PV assessment



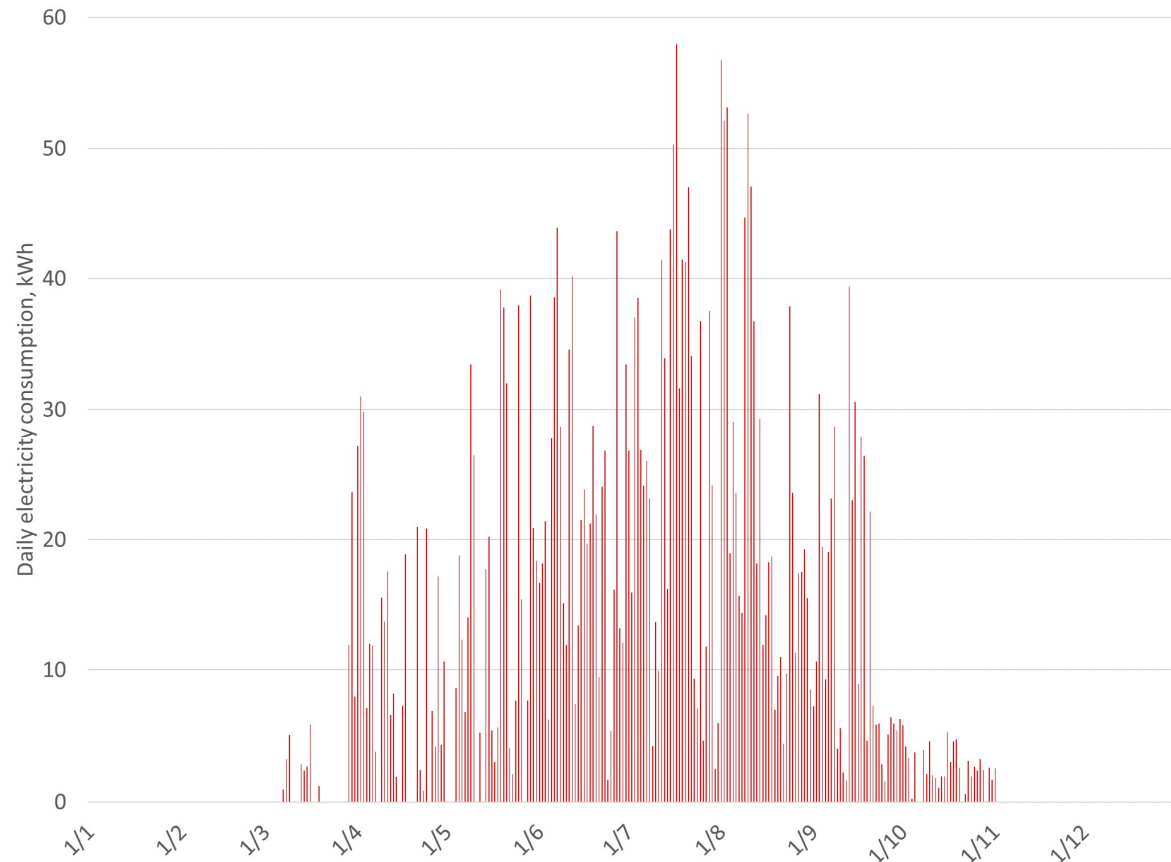
Roof top PV installation

- Circa 90m² of available roof space for installation (red)
 - South facing on flat roof
 - 30° inclination
- Potential peak load circa 11kW
 - 54no. 330W panels
- Potential generation 7,057kWh per annum
- Installation cost including cost of PV panels, inverters, roof mounts, cabling and installation - £11,000



Roof top PV – battery storage

- To recoup/store excess electricity generation on the peak day would require a discharge capacity of 58kWh
- Based on round-trip efficiency of 90% a circa 65kWh battery is required
- The income gain from storing electricity over exporting is £216
 - Excess kWh at high tariff minus kWh at export tariff = £372 - £157= £216
- The typical lifespan of a solar battery is between 5-15years; best case scenario the battery would need to be £3,235 to pay back during its lifespan (cost of a suitable battery for this site would be in the £25,000 - £45,000 range)
- Battery storage option not currently viable



Concept design



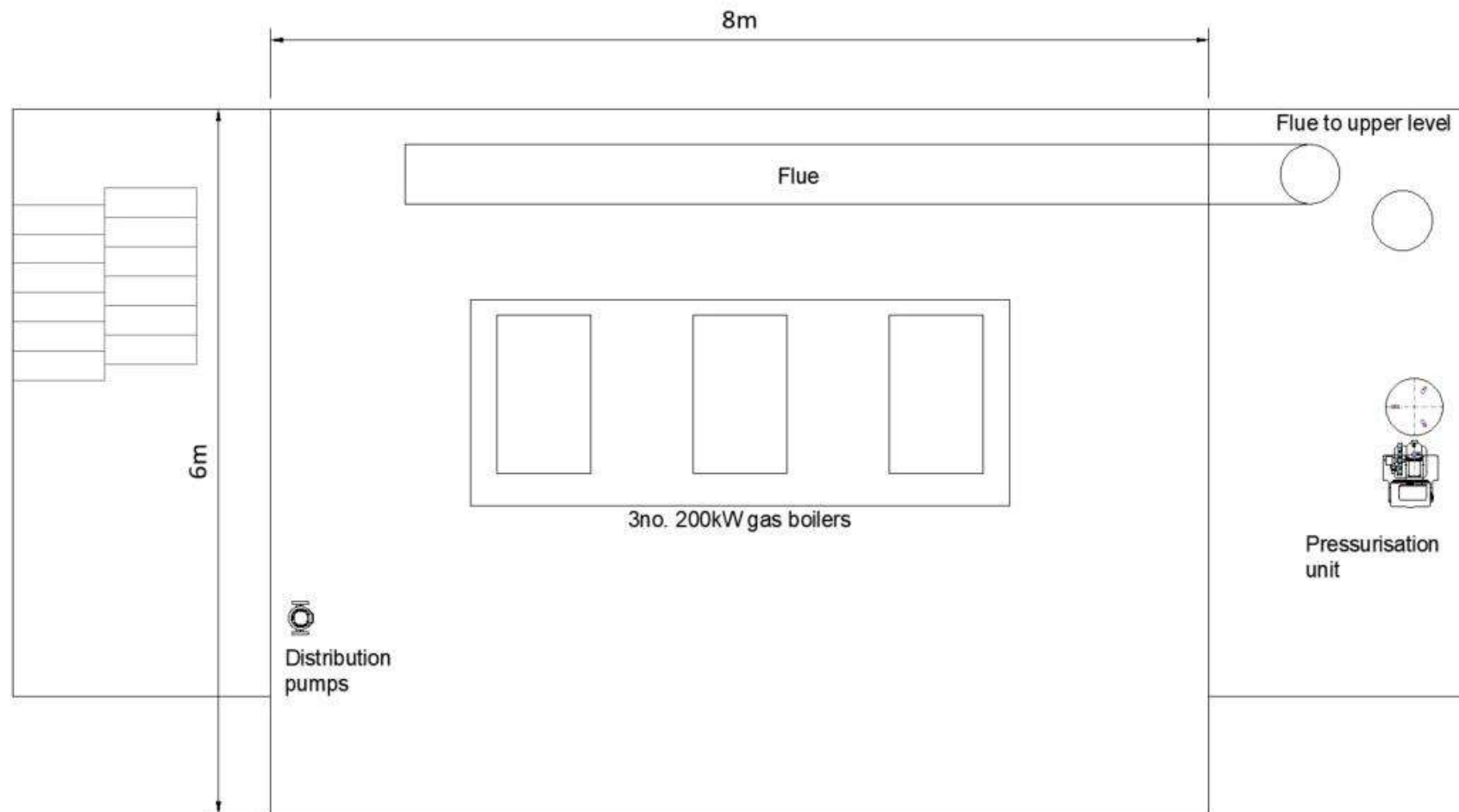
Design considerations



- Existing energy centre is split over 2 levels:
 - Lower ground level – houses main plant
 - Upper ground level – house flue dilution system
- New plant will be installed in lower ground level of the existing energy centre
- Dry air coolers positioned on the adjacent green
- Additional attenuation required to mitigate any sound issues
- Condensing gas boilers to supply full back up

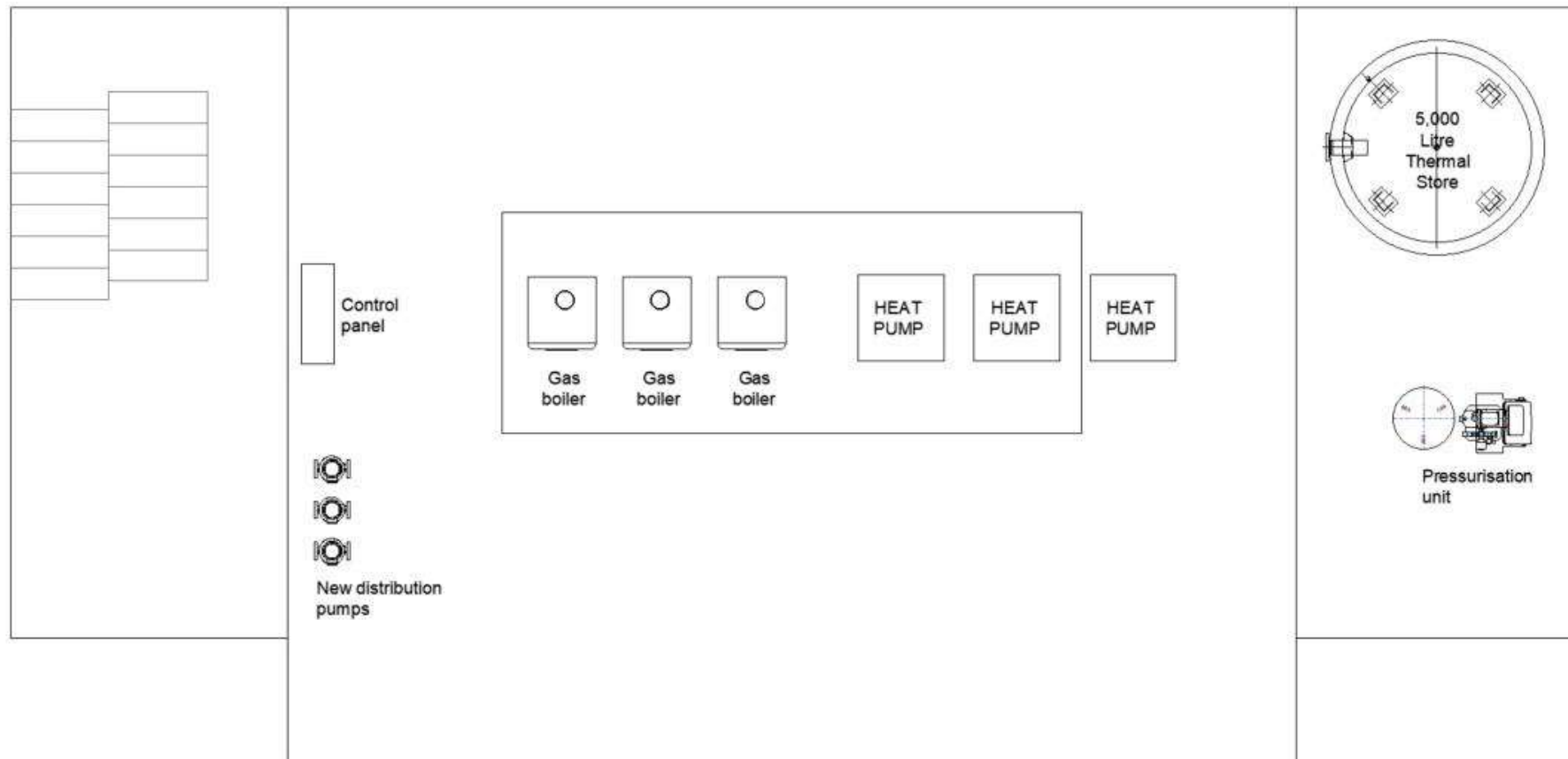
Energy centre - existing

- Lower ground level general arrangement:



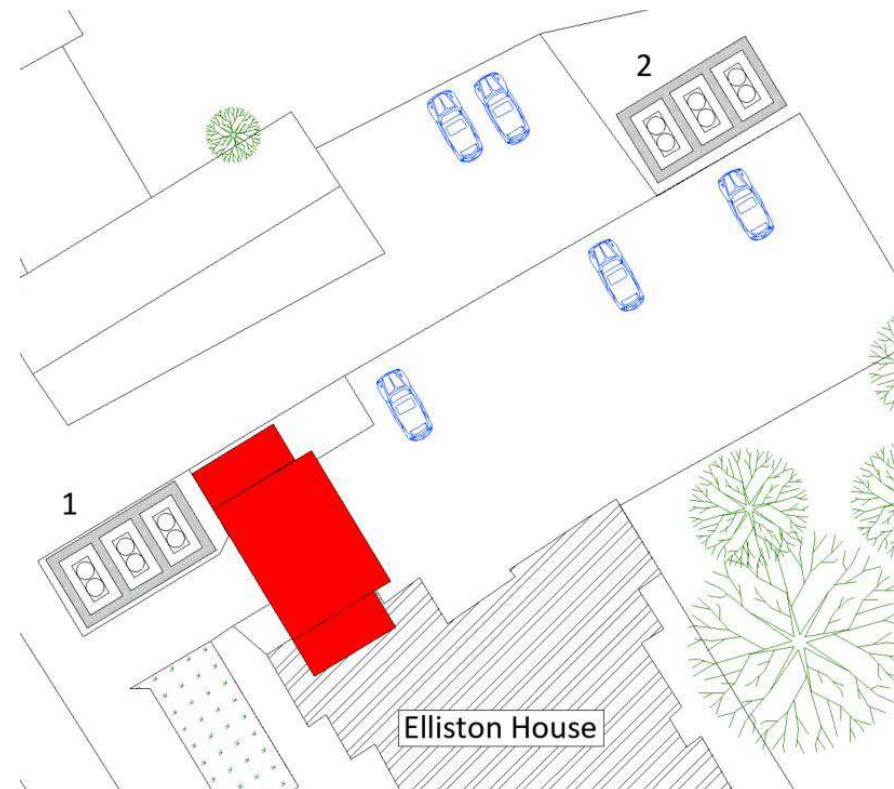
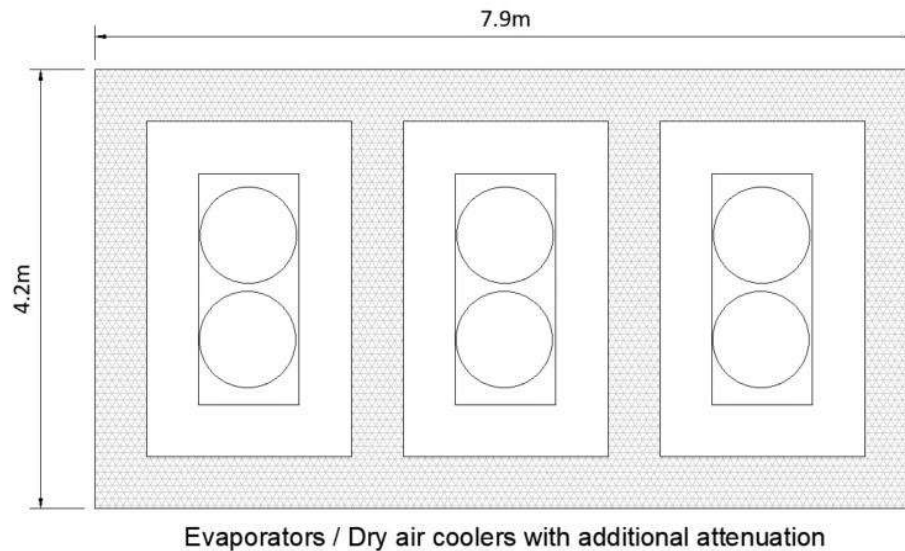
Energy centre – new plant

- New heating plant consists of:
 - 3no. 80kW Air source heat pumps
 - 3no. 150kW condensing gas boilers
 - 1no. 5,000litre thermal store

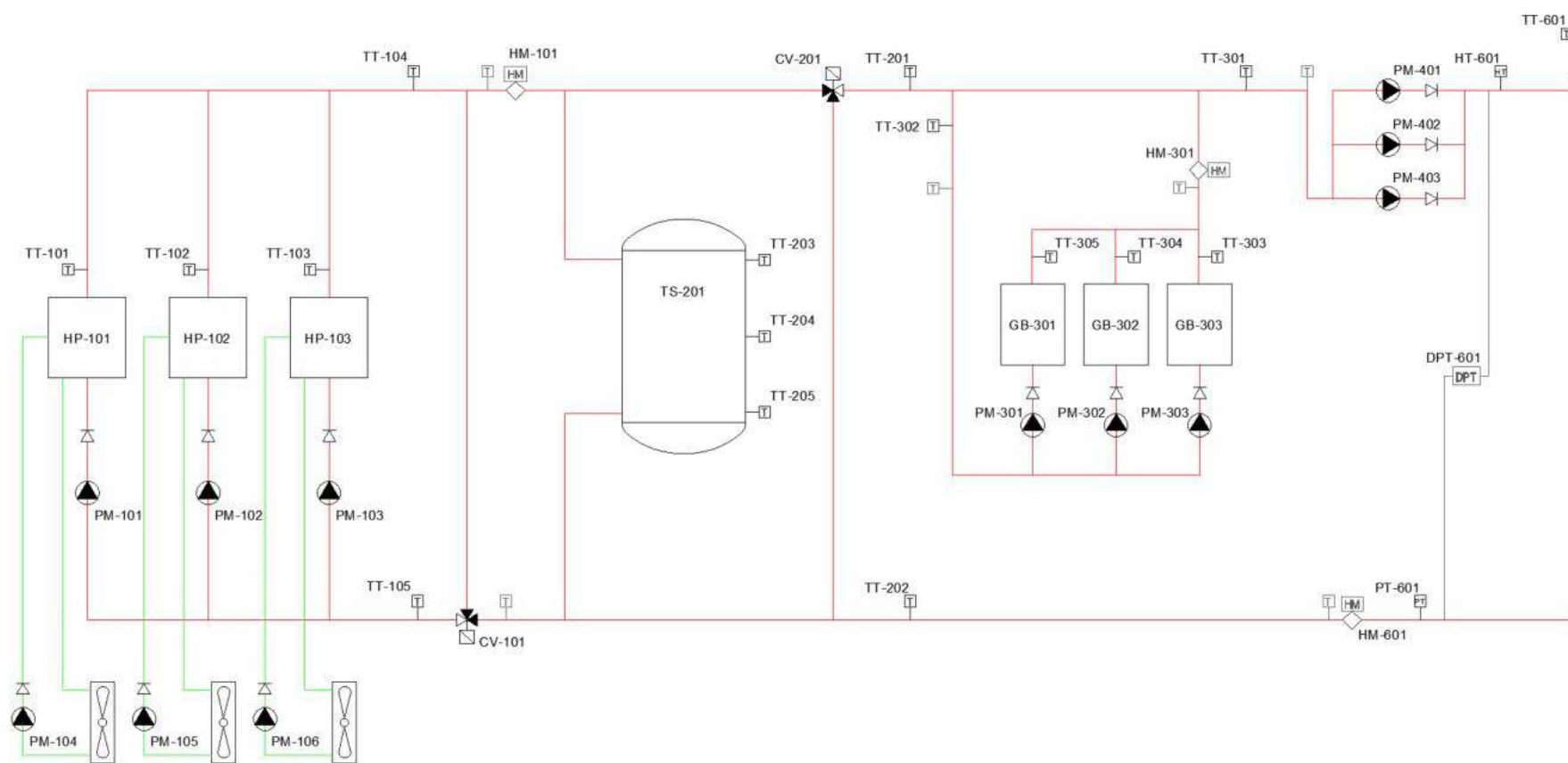


Energy centre – dry air coolers

- Dry Air Coolers (DACs) for the ASHPs can be positioned adjacent to the Energy Centre
- Typical dimensions with attenuation and some potential positions for the DACs are given below



PFD schematic



Economic assessment



Condensing gas boiler - full scheme CAPEX



	CAPEX	CAPEX inc. contingency
Preliminary		
Contractor prelims including welfare and storage	£45,000	£54,000
Energy Centre works		
Peak and reserve gas boilers	£16,000	£16,800
Peak and reserve gas boiler flues	£5,000	£5,750
Pressurisation	£5,000	£5,250
Water treatment, flushing and testing	£6,500	£7,475
Electrical connection upgrade	£19,000	£23,750
Plantroom controls	£40,000	£48,000
Cabling and electrical housing blocks	£25,000	£30,000
Other energy centre M&E (pipework, pumps, temporary PHE)	£89,449	£107,339
Building Works	£10,000	£11,500
Network - Usual		
Customer HIUs and flat fit out	£360,000	£414,000
Risers and laterals	£225,000	£281,250
Planning, design and management		
Resident liaison officer	£10,000	£11,000
Professional, design and contracting fees	£50,000	£52,500
Clients Engineer - technical support for construction and commissioning	£30,000	£33,000
Total	£935,949	£1,101,614

Condensing gas boiler - gas boiler only CAPEX



	CAPEX	CAPEX inc. contingency
Energy Centre works		
Peak and reserve gas boilers	£16,000	£16,800
Peak and reserve gas boiler flues	£5,000	£5,750
Electrical connection upgrade	£19,000	£23,750
Plantroom controls	£40,000	£48,000
Cabling and electrical housing blocks	£25,000	£30,000
Other energy centre M&E (pipework, pumps, temporary PHE)	£89,449	£107,339
Professional, design and contracting fees	£50,000	£52,500
Clients Engineer - technical support for construction and commissioning	£30,000	£33,000
Total	£274,449	£317,139

ASHP and condensing gas boiler scheme – full scheme CAPEX



	Total	Total inc. cingency
Preliminary		
Contractor prelims including welfare and storage	£55,000	£66,000
Energy Centre works – common to ASHP and gas options		
Peak and reserve gas boilers	£16,000	£16,800
Peak and reserve gas boiler flues	£5,000	£5,750
Pressurisation	£5,000	£5,250
Water treatment, flushing and testing	£6,500	£7,475
Electrical connection upgrade	£25,000	£31,250
Plantroom controls	£60,000	£72,000
Cabling and electrical housing blocks	£25,000	£30,000
Other energy centre M&E (pipework, pumps, temporary PHE)	£89,449	£107,339
Building Works	£20,000	£23,000
Network – common to ASHP and gas options		
Customer HIUs and flat fit out	£360,000	£414,000
Risers and laterals	£225,000	£281,250
Energy Centre works – ASHP only		
Heat pump	£120,000	£132,000
ASHP attenuation	£15,000	£16,500
Heat pump M&E works	£40,000	£44,000
Thermal store	£6,000	£6,600
Energy centre civils works	£20,000	£23,000
Planning, design and management – common to ASHP and gas options		
Planning application and fees	£10,000	£12,500
Resident liaison officer	£10,000	£11,000
Professional, design and contracting fees	£65,000	£68,250
Clients Engineer - technical support for construction and commissioning	£40,000	£44,000
RHI Application	£4,500	£4,725
Total	£1,222,449	£1,422,689

ASHP and condensing gas boiler scheme – ASHP and condensing gas boiler only CAPEX



	Total	Total inc. contingency
Energy Centre works – common to ASHP and gas options		
Peak and reserve gas boilers	£16,000	£16,800
Peak and reserve gas boiler flues	£5,000	£5,750
Electrical connection upgrade	£25,000	£31,250
Plantroom controls	£60,000	£72,000
Cabling and electrical housing blocks	£25,000	£30,000
Other energy centre M&E (pipework, pumps, temporary PHE)	£89,449	£107,339
Energy Centre works – ASHP only		
Heat pump	£120,000	£132,000
ASHP attenuation	£15,000	£16,500
Heat pump M&E works	£40,000	£44,000
Thermal store	£6,000	£6,600
Planning, design and management – common to ASHP and gas options		
Professional, design and contracting fees	£65,000	£68,250
Clients Engineer - technical support for construction and commissioning	£40,000	£44,000
Total	£506,449	£574,489

Fuel Tariffs

- Tariff inputs

Gas tariff (excl. CCL)	2.161	p/kWh
Gas standing charge	19.67	£/day
CCL - natural gas (2021)	0.406	p/kWh
CCL - natural gas (2022)	0.568	p/kWh
CCL - natural gas (2023 onwards)	0.672	p/kWh
CCL - electricity	0.775	p/kWh
Energy centre electricity tariff - day	12.77	p/kWh
Energy centre electricity tariff - night	8.79	p/kWh
Electricity standing charge	0.2483	£/day

OPEX and REPEX assumptions

OPEX

- Annual cost for O&M of £2,343 used, which covers the following:
 - Annual servicing for communal heating and hot water (gas only, current maintenance contract only covers gas based systems)
 - HIUs (presumed HIUs for all below estates based on rate receiving for some estates which already have HIUs)
 - Service of BMS with annual servicing of heating and hot water
 - Pressurisation units and expansion vessels
 - Quarterly water treatment
- Annual spares and repair costs £5,467
 - Using estimated of 70% of total costs for maintenance contract from spares and repairs
- Metering and billing cost - £8,100 per annum

REPEX

- Pro-rata cost added per year based on the cost of the asset and its economic life
- Economic lifetime of the technologies used:

Technology	Useful economic lifetime (years)
Heat pump	20
Gas boilers	20
Heat network connections	25

Assessment scenarios



- ASHP sized to provide 93% of the heat demand
- For the assessment cases it is assumed that the availability of the ASHP to supply the heat demand is 92% (2 weeks for maintenance and repairs)
 - The techno economic model has a function to compare 100% (52 weeks), 96% (50 weeks) and 92% (48 weeks) availability
- Table below shows the contribution of the ASHP against the different heat demand scenarios

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Total heat demand	867,641kWh	783,851kWh	697,203kWh	533,289kWh
Peak heat demand	408kW	373kW	336kW	267kW
Heat pump capacity	240W	240kW	240kW	240kW
Thermal store capacity	5,000litres	5,000litres	5,000litres	5,000litres
% heat demand potentially met by low carbon / renewable technology				
52 weeks availability	93%	95%	98%	100%
50 weeks availability	92%	94%	97%	99%
48 weeks availability	91%	94%	96%	98%

Assessment scenarios



- Two CAPEX scenarios are presented:
 - **CASE 1** – installation of condensing gas boiler and energy centre upgrades
 - **CASE 2** – installation of condensing gas boiler, installation of ASHP and energy centre upgrades
 - These cases include the CAPEX associated with installation of the heat generation technology systems only
- Two heat demand scenarios are presented:
 - Scenario 1 – existing fabric with upgraded heating system
 - Scenario 4 – upgraded fabric (roof, glazing and EWI) with upgraded heating system
- Additional economic assumptions:
 - ASHP cases will include income from RHI
 - Impact of PV array installation will also be presented
 - Electricity generation to offset the energy centre requirements at electricity day rate
 - Excess generation exported at 5.5p/kWh

Economic assessment (heat demand scenario 1)

		Current system	Option 1: Gas condensing boilers	Option 2: Gas condensing boilers and ASHP	Option 3: Gas condensing boilers, ASHP and PV
Energy and carbon	Units				
Heat demand - Peak	kW	413	408	408	408
Heat annual demand	kWh	1,018,721	867,641	867,641	867,641
Heat annual demand - losses	kWh				
Heat annual demand - Total	kWh	1,018,721	867,641	867,641	867,641
% heat demand low carbon	%	0	0	92%	92%
25 year CO2e savings	tCO2e		500	3,697	3,710
First year CO2e savings, tCO2e	tCO2e		17	102	104
First year CO2e intensity of delivered heat	gCO2e /kWh		210	112	110
Build and run costs					
Capex of scheme	£		£274,449	£506,449	£517,449
Capex of scheme + contingency	£		£317,139	£574,489	£586,589
OPEX – Fuel costs	£		£34,255	£47,267	£46,714
OPEX – (O&M + fuel/elec costs)	£		£50,165	£68,177	£67,624
Fixed heat sales	£		£21,353	£21,353	£21,353
Variable heat sales	£		£60,735	£60,735	£60,735
Potential annual Income - RHI	£		-	£21,893	£21,893
Potential annual Income – PV export	£		-	-	£162
Economic indicators – 25 year case					
Fixed heat sales	£/day		0.65	0.65	0.65
Variable heat sales	p/kWh		7.00	7.00	7.00
Cost of heat to residence - annual	£		£912	£912	£912
Payback period	Years		15	21	21
NPV	£		£56,703	-£155,129	-£154,834
IRR	%		5.1%	0.5%	0.6%
Assumptions	Capital costs excludes heating systems, water treatment and ancillaries Fixed tariff of £0.65/day				

Economic assessment (heat demand scenario 1)

		Current system	Option 1: Gas condensing boilers	Option 2: Gas condensing boilers and ASHP	Option 3: Gas condensing boilers, ASHP and PV
Units					
Resident costs – Fuel only					
Cost of heat to residence – Fuel (variable)	p/kWh	4.79	3.95	5.45	5.38
Cost of heat to residence - annual	£	£461	£381	£525	£519
Resident costs – Fuel + O&M					
Cost of heat to residence – O&M (fixed)	£/day	0.48	0.48	0.64	0.64
Cost of heat to residence – Fuel (variable)	p/kWh	4.79	3.95	5.45	5.38
Cost of heat to residence - annual	£	£637	£557	£758	£751
Subsidy requirement per apartment					
Cost of heat, savings per apartment (fuel only)	£/year		-	-£64	-£58
Cost of heat, savings per apartment (fuel + O&M)	£/year		-	-£121	-£114
Remaining RHI income (whole scheme - fuel + O&M)	£/year		-	£10,890	£10,260
Assumptions	No accounting has been made for initial capital costs or replacement costs over lifetime. Capital for energy centre and network are part of the building and therefore will be part of the rent rather than in the energy bills.				
Social Economics – 25 year case					
Social IRR			6.0%	5.1%	5.1%
Social NPV			£95,360	£110,359	£111,906
Assumptions	Fixed tariff of £0.65/day Variable tariff of 7.00p/kWh (in line with Heat Trust costing)				

Economic assessment (heat demand scenario 4)

		Current system	Option 1: Gas condensing boilers	Option 2: Gas condensing boilers and ASHP	Option 3: Gas condensing boilers, ASHP and PV
Energy and carbon	Units				
Heat demand - Peak	kW	413	267	267	267
Heat annual demand	kWh	1,018,721	533,289	533,289	533,289
Heat annual demand - losses	kWh				
Heat annual demand - Total	kWh	1,018,721	533,289	533,289	533,289
% heat demand low carbon	%	0	0	99%	99%
25 year CO2e savings	tCO2e		307	2,416	2,427
First year CO2e savings, tCO2e	tCO2e		11	67	68
First year CO2e intensity of delivered heat	gCO2e /kWh		210	105	103
Build and run costs					
Capex of scheme	£		£274,449	£506,449	£517,449
Capex of scheme + contingency	£		£317,139	£574,489	£586,589
OPEX – Fuel costs	£		£23,859	£32,706	£32,232
OPEX – (O&M + fuel/elec costs)	£		£39,769	£53,616	£53,142
Fixed heat sales	£		£21,353	£21,353	£21,353
Variable heat sales	£		£37,330	£37,330	£37,330
Potential annual Income - RHI	£		-	£14,461	£14,461
Potential annual Income – PV export	£		-	-	£194
Economic indicators – 25 year case					
Fixed heat sales	£/day		0.65	0.65	0.65
Variable heat sales	p/kWh		7.00	7.00	7.00
Cost of heat to residence - annual	£		£652	£652	£652
Payback period	Years		25	0	0
NPV	£		-£100,445	-£378,508	-£379,013
IRR	%		0.3%	-5.8%	-5.4%
Assumptions	Capital costs excludes heating systems, water treatment and ancillaries Fixed tariff of £0.65/day				

Economic assessment (heat demand scenario 4)

		Current system	Option 1: Gas condensing boilers	Option 2: Gas condensing boilers and ASHP	Option 3: Gas condensing boilers, ASHP and PV
Units					
Resident costs – Fuel only					
Cost of heat to residence – Fuel (variable)	p/kWh	4.79	4.47	6.13	6.04
Cost of heat to residence - annual	£	£461	£265	£363	£358
Resident costs – Fuel + O&M					
Cost of heat to residence – O&M (fixed)	£/day	0.48	0.48	0.64	0.64
Cost of heat to residence – Fuel (variable)	p/kWh	4.79	4.47	6.13	6.04
Cost of heat to residence - annual	£	£637	£442	£596	£590
Subsidy requirement per apartment					
Cost of heat, savings per apartment (fuel only)	£/year		-	£98	£103
Cost of heat, savings per apartment (fuel + O&M)	£/year		-	£41	£47
Remaining RHI income (whole scheme - fuel + O&M)	£/year		-	£14,461	£14,461
Assumptions	No accounting has been made for initial capital costs or replacement costs over lifetime. Capital for energy centre and network are part of the building and therefore will be part of the rent rather than in the energy bills.				
Social Economics – 25 year case					
Social IRR			1.2%	0.0%	0.1%
Social NPV			-£76,685	-£205,171	-£204,602
Assumptions	Fixed tariff of £0.65/day Variable tariff of 7.00p/kWh (in line with Heat Trust costing)				

Increased gas tariff



- The gas tariff for Elliston House at the time of this assessment is 2.161p/kWh
- This figure is relatively low and an increase in this tariff has a significant affect on economic case for the condensing gas boiler only solution
- The following table presents the cases with the gas tariff increased to 2.92p/kWh (the point at which the economics are similar for the gas condensing case and the ASHP with condensing gas boiler and PV case)

Economic assessment (Increased gas tariff scenario 1)

		Current system	Option 1: Gas condensing boilers	Option 2: Gas condensing boilers and ASHP	Option 3: Gas condensing boilers, ASHP and PV
Energy and carbon	Units				
Heat demand - Peak	kW	413	408	408	408
Heat annual demand	kWh	1,018,721	867,641	867,641	867,641
Heat annual demand - losses	kWh				
Heat annual demand - Total	kWh	1,018,721	867,641	867,641	867,641
% heat demand low carbon	%	0	0	92%	92%
25 year CO2e savings	tCO2e		500	3,697	3,710
First year CO2e savings, tCO2e	tCO2e		17	102	104
First year CO2e intensity of delivered heat	gCO2e /kWh		210	112	110
Build and run costs					
Capex of scheme	£		£274,449	£506,449	£517,449
Capex of scheme + contingency	£		£317,139	£574,489	£586,589
OPEX – Fuel costs	£		£41,572	£47,870	£47,317
OPEX – (O&M + fuel/elec costs)	£		£57,482	£68,780	£68,227
Fixed heat sales	£		£21,353	£21,353	£21,353
Variable heat sales	£		£60,735	£60,735	£60,735
Potential annual Income - RHI	£		-	£21,893	£21,893
Potential annual Income – PV export	£		-	-	£162
Economic indicators – 25 year case					
Fixed heat sales	£/day		0.65	0.65	0.65
Variable heat sales	p/kWh		7.00	7.00	7.00
Cost of heat to residence - annual	£		£912	£912	£912
Payback period	Years		24	23	23
NPV	£		-£94,413	-£167,588	-£167,293
IRR	%		0.4%	0.3%	0.4%
Assumptions	Capital costs excludes heating systems, water treatment and ancillaries Fixed tariff of £0.65/day				

Economic assessment (Increased gas tariff scenario 1)

		Current system	Option 1: Gas condensing boilers	Option 2: Gas condensing boilers and ASHP	Option 3: Gas condensing boilers, ASHP and PV
Units					
Resident costs – Fuel only					
Cost of heat to residence – Fuel (variable)	p/kWh	4.79	4.79	5.52	5.45
Cost of heat to residence - annual	£	£461	£462	£532	£526
Resident costs – Fuel + O&M					
Cost of heat to residence – O&M (fixed)	£/day	0.48	0.48	0.64	0.64
Cost of heat to residence – Fuel (variable)	p/kWh	4.79	4.79	5.52	5.45
Cost of heat to residence - annual	£	£637	£639	£764	£758
Subsidy requirement per apartment					
Cost of heat, savings per apartment (fuel only)	£/year		-	-£71	-£65
Cost of heat, savings per apartment (fuel + O&M)	£/year		-	-£127	-£121
Remaining RHI income (whole scheme - fuel + O&M)	£/year		-	£11,430	£10,890
Assumptions	No accounting has been made for initial capital costs or replacement costs over lifetime. Capital for energy centre and network are part of the building and therefore will be part of the rent rather than in the energy bills.				
Social Economics – 25 year case					
Social IRR			1.8%	4.9%	4.9%
Social NPV			-£55,756	£97,900	£99,447
Assumptions	Fixed tariff of £0.65/day Variable tariff of 7.00p/kWh (in line with Heat Trust costing)				

Summary and next steps



Summary



- Under current assumptions, the economics of the gas condensing boiler are more favourable than the heat pump options but offer far lower CO₂e savings
- ASHPs are the only technically viable renewable heating option with an acceptable level of risk
- Solar PV only slightly improves economics and increases CO₂e savings
- Low gas prices support the economics of the gas boiler option, when gas prices reach 2.92p/kWh then economics reach parity with the ASHP with condensing gas boiler and PV case option and the social IRR of the ASHP is higher in each case

Next steps

- Detail dimensions for full energy system and network
- Draft tender specification for energy centre and phased works



