SOLAR DESIGN PRINCIPLES

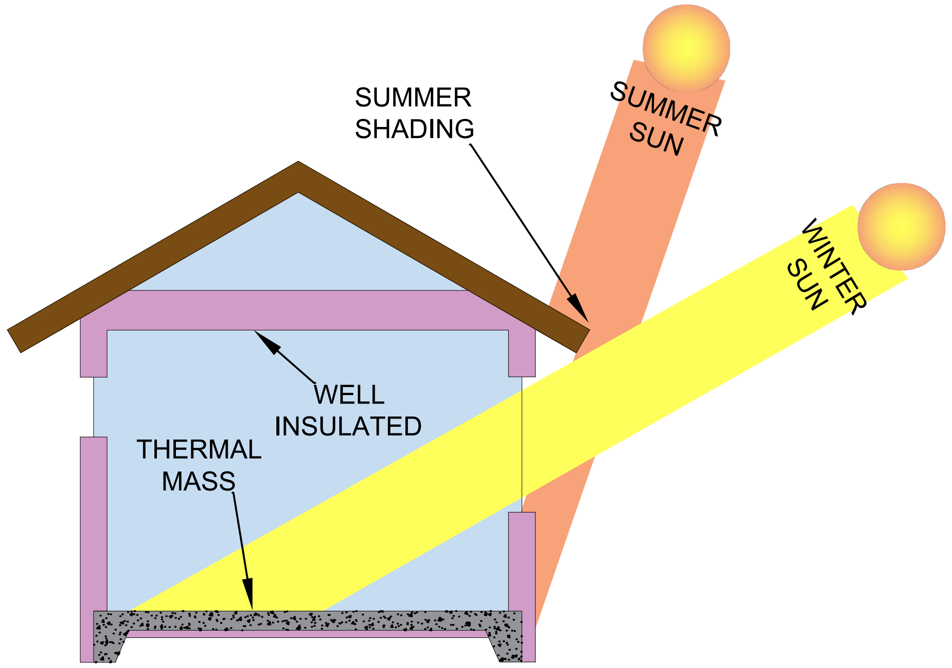
1 SOLAR ACCESS TO SINGLE FAMILY DWELLINGS

SUMMER SOLAR DESIGN

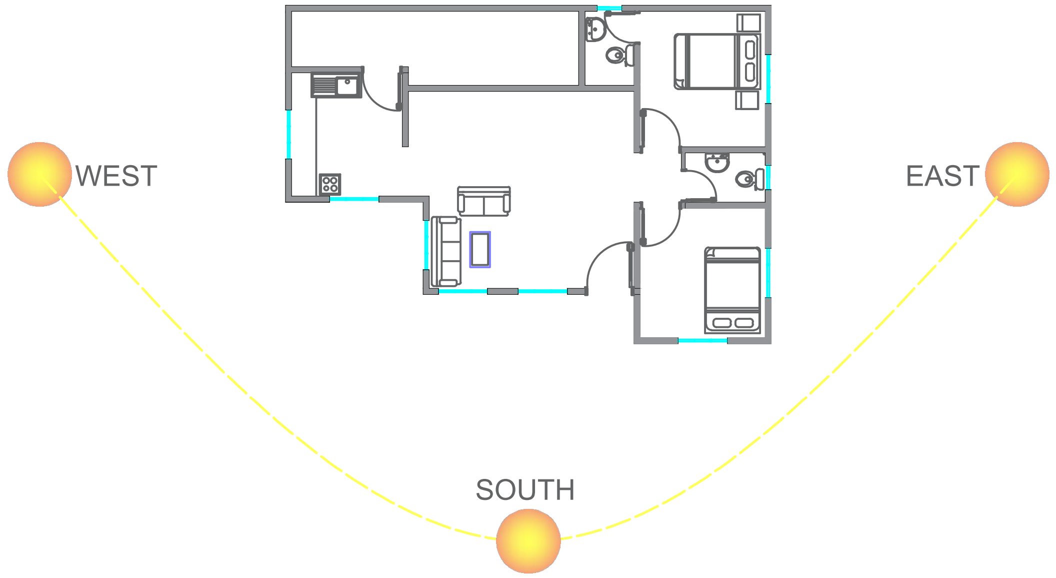
- DESIGN/LOCATE EXTERNAL SHADING AND WINDOWS TO MINIMISE HEAT GAIN DURING SUMMER MONTHS

WINTER SOLAR DESIGN

- ANGLE OF OVERHANG ALLOWS WINTER SUN IN, INCREASING NATURAL LIGHT AND SOLAR HEATING.



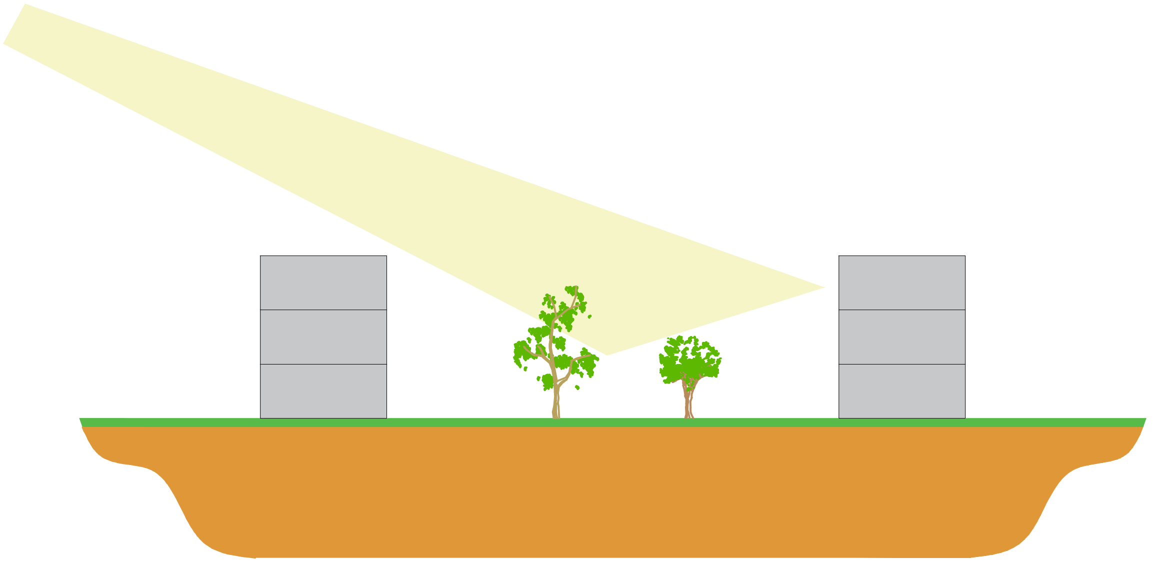
- EXPOSED THERMAL MASS CAN CAN REGULATE INTERNAL TEMPERATURES BY RELEASING STORED HEAT DURING NIGHT IN WINTER AND ABSORBING WARM AIR IN SUMMER



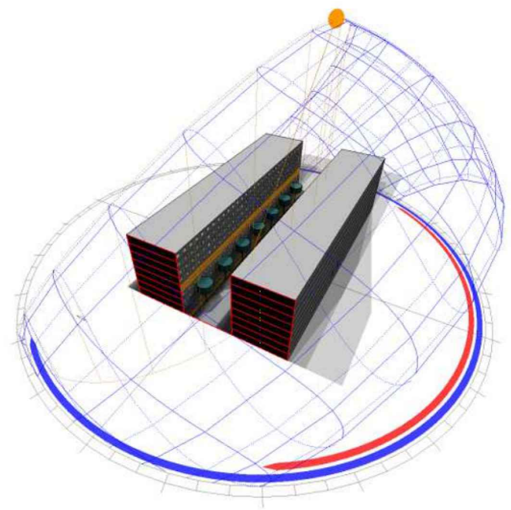
HOUSE LAYOUT FOR SOLAR DESIGN

- ORIENTATE DWELLINGS ON EAST-WEST AXIS
- MAXIMISE SOUTH FACING FACADE
- ENSURE THE MAJORITY OF HABITABLE ROOMS ARE TO SOUTH
- BEDROOMS FACE EAST WHILST EVENING ROOMS FACE WEST

2 SOLAR ACCESS TO COURTYARDS & APARTMENTS



- MAINTAIN SUFFICIENT LIGHT TO INTERNAL APARTMENT 'COURTYARDS' BY ALLOWING SUFFICIENT SPACE BETWEEN BUILDINGS.
- SITE SLOPES FROM SOUTH WEST TO NORTH EAST. ENSURE BUILDINGS AT HIGHER TOPOGRAPHIES DO NOT OVERSHADOW BUILDINGS AT LOWER LEVELS.
- DAYLIGHT MODELING CAN ENSURE SUFFICIENT LEVELS OF NATURAL LIGHT ARE MAINTAINED IN ALL APARTMENTS AND FAMILY DWELLINGS.



SOLAR DESIGN STUDY

ENERGY STRATEGY - HEAT NETWORK

INDICATIVE HEAT NETWORK LAYOUT

1 OVERVIEW

A HEAT NETWORK WOULD PROVIDE HOT WATER FOR BOTH SPACE AND WATER HEATING TO EACH DWELLING.

THE ADJOINING IMAGE SHOWS AN INDICATIVE ROUTE FOR AN ON-SITE HEAT NETWORK.

SHOWN ARE FLOW AND RETURN PIPES TO AND FROM AND INDICATIVE ENERGY CENTRE LOCATION.

A HEAT NETWORK OFFERS SIGNIFICANT CO2 SAVINGS OVER INDIVIDUAL GAS-FIRED BOILERS.

IF AN ASSET IS TO BE RETAINED IN OWNERSHIP, MAINTENANCE OF A HEAT NETWORK OFFERS SIGNIFICANT ADVANTAGES OVER INDIVIDUAL BOILERS/HEAT PUMPS AS THERE IS ONE GENERATION SOURCE.

3 SYSTEM IN DWELLINGS

EACH DWELLING WOULD BE PROVIDED WITH A HYDRAULIC INTERFACE UNIT (HIU) WHICH WOULD INTERFACE WITH THE DISTRICT HEATING PIPEWORK.

LARGER DWELLINGS WOULD BE PROVIDED WITH A TYPICAL HOT WATER STORAGE TANK TO ENSURE CONTINUITY OF SUPPLY.

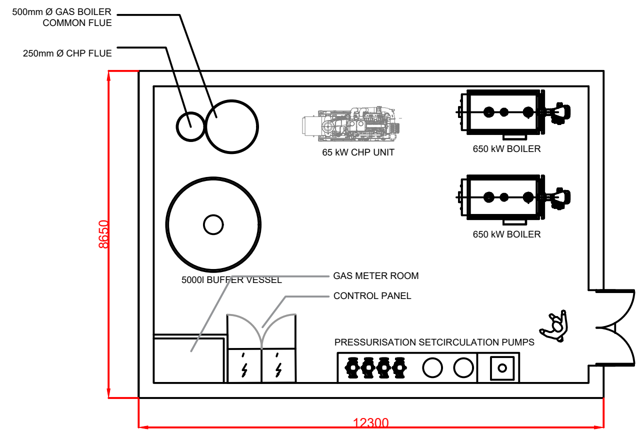
TYPICAL ENERGY CENTRE SECTION

TYPICAL SCHEMATIC AND HIU

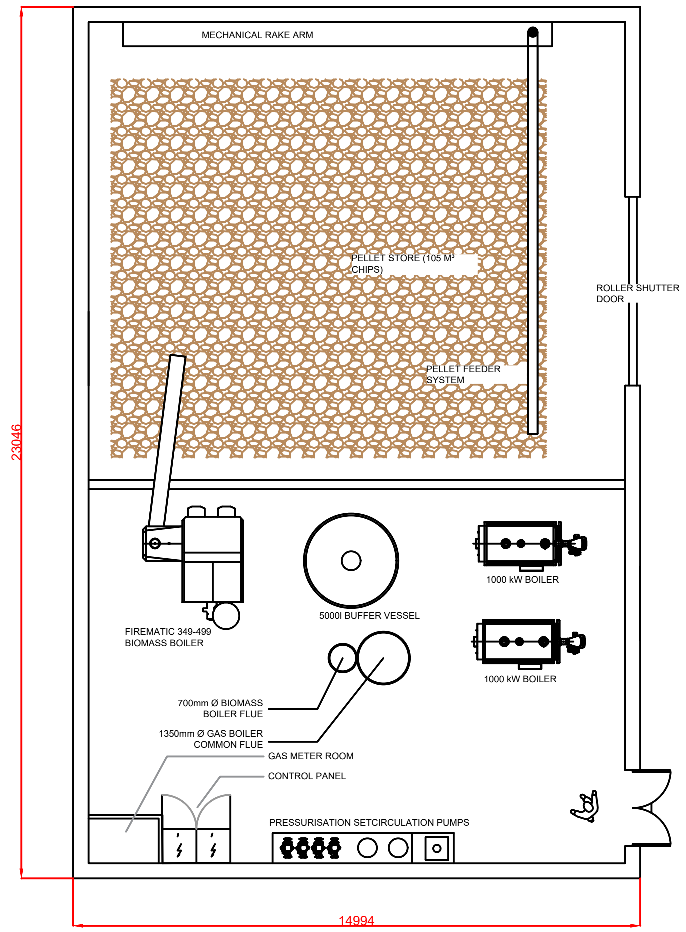
2 HEAT GENERATION

THERE ARE TWO PRIMARY OPTIONS FOR HEAT GENERATION IN AN ON-SITE ENERGY CENTRE;

A) COMBINED HEAT & POWER
B) BIOMASS



INDICATIVE CHP ENERGY CENTRE LAYOUT



INDICATIVE BIOMASS ENERGY CENTRE LAYOUT

ENERGY STRATEGY - INDIVIDUAL HEATING SYSTEMS

INDICATIVE LOCATION OF HEAT PUMP CONDENSERS

1 OVERVIEW

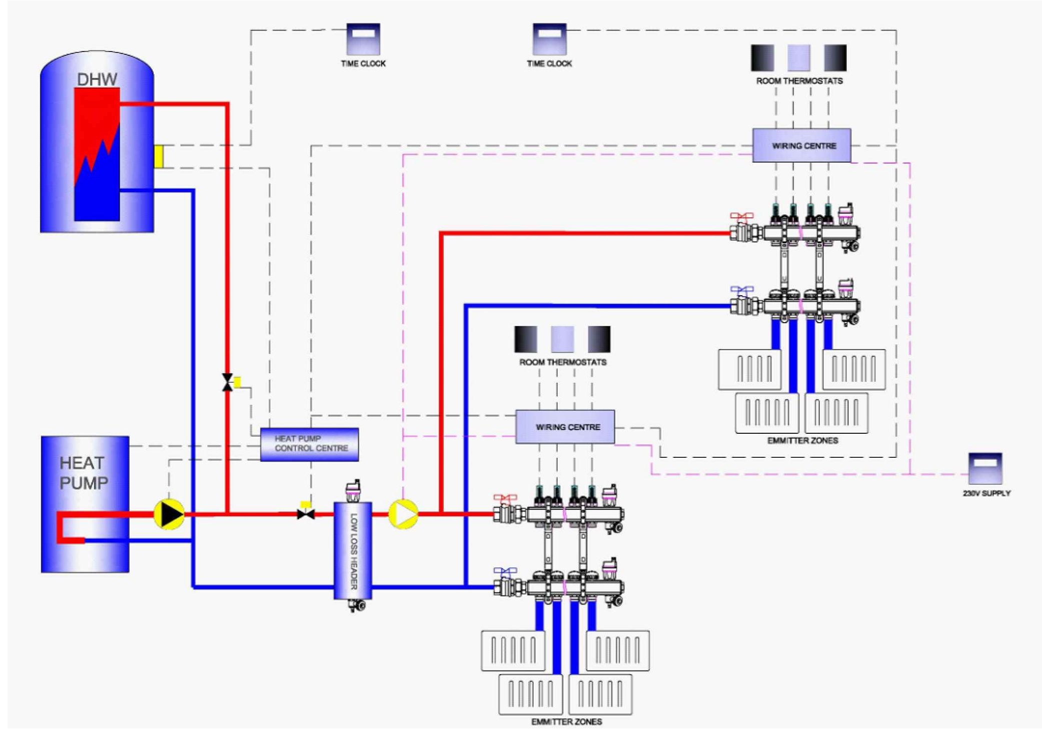
INDIVIDUAL HEATING SYSTEMS WOULD BE PROVIDED TO EACH DWELLING OR GROUP OF DWELLINGS.

THERE ARE TWO PRIMARY OPTIONS FOR THESE TYPE OF SYSTEMS;

A) **HEAT PUMPS**
HEAT PUMPS WOULD PROVIDE SPACE AND WATER HEATING TO EACH DWELLING. HEAT PUMPS OFFER SIGNIFICANT ENERGY EFFICIENCY AS FOR EACH kW OF ELECTRICITY CONSUMED IN EXCESS OF 3kW OF HEATING WILL BE EXTRACTED. WITH THE CONTINUING DECARBONISATION OF THE NATIONAL GRID, HEAT PUMPS HAVE THE POTENTIAL TO OFFER SIGNIFICANT CO2 SAVINGS. CONSIDERATION WOULD HAVE TO BE GIVEN TO THE LOCATION OF EXTERNAL CONDENSERS AND THE MITIGATION MEASURES REQUIRED FOR THE NOISE EMISSION.

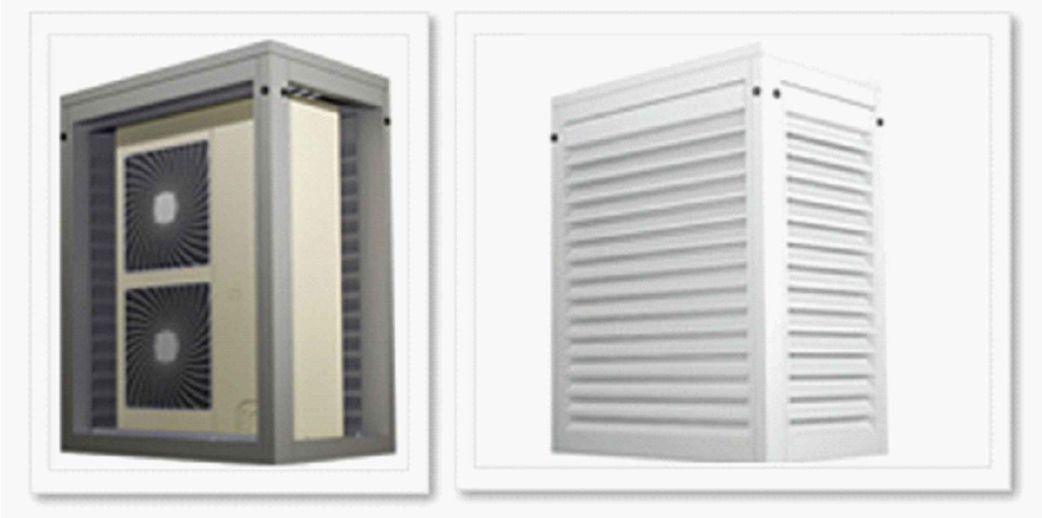
B) **GAS-FIRED BOILERS**
GAS FIRED BOILERS OFFER THE MOST CONVENTIONAL FORM OF HEATING IN THE UK, AND ALTHOUGH NOT AS EFFICIENT AS HEAT PUMPS, THEY CAN OFFER HIGH EFFICIENCIES WHEN COMBINED WITH FLUE-GAS HEAT RECOVERY SYSTEMS. CONSIDERATION WOULD NEED TO BE GIVEN TO BRINGING GAS CONNECTIONS TO EACH DWELLING.

2 HEAT PUMP EQUIPMENT



TYPICAL HEAT PUMP SCHEMATIC

3 TYPICAL KIT



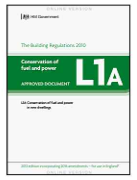
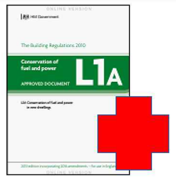
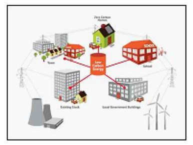
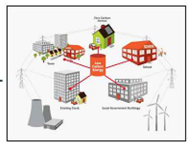
TYPICAL EXTERNAL CONDENSER WITH ACOUSTIC LOUVRES

TYPICAL HEAT PUMP ARRANGEMENT (INTERNAL)

TYPICAL GAS BOILER SCHEMATIC

ENERGY STRATEGY - SAP ANALYSIS (TYPICAL DWELLING)

Note: an update to the carbon emissions factors for gas and electricity is proposed and currently in consultation, this dramatically changes the carbon factor for electricity (reduced by 55%) and as such would make a significant difference to the results below. It is likely that ASHP would show approximately 10% additional improvement and that gas-fired CHP led emissions would become far less viable.

Option	Strategy		Total Unit Floor Area (m^2)	TER	DER	Total CO2 (kg.CO2.yr)	% Improvement Over Baseline	EPC	KPIs				Notes
									Building Regs Compliance	20% reduction through renewables (CS15)	Best Practice (35% improvement)	Net Zero Carbon (100% improvement)	
1	Baseline - Part L Compliant Buildng		92.82	19.52	19.41	1,801.64	0.56%	B 83	✓	x	x	x	All inputs in line with a Part L compliant dwelling, including; - Higher than average U-Values; - Gas-fired boiler solution; - Low Air Permeability Solution
2	Enhanced Constructions - Part L compliant		92.82	19.52	17.14	1,590.93	12.19%	B 85	✓	x	x	x	Enhanced Part L compliant building with Accredited Construction Details applied.
3	Enhanced Constructions - With District Heating		92.82	19.52	13.22	1,227.29	32.26%	B 85	✓	✓	x	x	Enhanced Construction scheme as presented above with suitably sized CHP-led district heating
4	Enhanced Constructions - With Electric led ASHP		92.82	19.52	17.12	1,589.08	12.30%	B 85	✓	x	x	x	Enhanced Construction scheme as presented above with electric led ASHP for heating and hot water generation - no fossil fuels on site.
5	As option 4 - with whole roof solar PV on SW facing roof	 	92.82	19.52	8.09	750.91	58.56%	A 94	✓	✓	✓	x	Enhanced Construction scheme as presented above with electric led ASHP + 12.8sqm (1.96kWp) of whole roof solar PV (south west facing)
6	District Heating - with whole roof solar PV on SW facing roof	 + 	92.82	19.52	5.06	469.57	74.08%	A 93	✓	✓	✓	x	Enhanced + District Heating + 12.8sqm (1.96kWp) of whole roof solar PV (south west facing)
7	As option 5 - with PV to get to 'Zero Carbon'	 	92.82	19.52	0.00	-	100.00%	A 102	✓	✓	✓	✓	Strategy as presented in Option 5 with electric led ASHP + 20 sqm (3.7 kWp) of whole roof solar PV (south west facing) to get to *Zero Carbon*

When determining the baseline (TER) for each solution, it was assumed that the heating would be provided by gas boilers, in line with national best practice methodology. This leads to a consistent Target Emission Rate (TER) for each solution allowing for a 'like for like' comparison.

Please note that for the electric heat pump solution, in Part L and SAP, the TER is significantly higher as it reflects the higher fuel factor for electricity, ultimately it will be possible to demonstrate greater savings against Building Regulations than is shown in the note. The 'Total CO_2' column would not change in this instance - which reflects actual CO_2 emissions.

Enhanced Measures	Residential
External Wall U-Value (W.m²K)	0.11
Wall to unheated corridor/stairwell U-Value (W.m²K)	0.11
Exposed Floor U-Value (W.m²K)	0.11
Roof U-Value (W.m²K)	0.11
Window U-Value (W.m²K)	1.1
Glazing G-Value	0.72
Lighting	All LED
Metering and Controls	Provided

District Heating Specification	Residential Areas
CHP Thermal Efficiency	51.0%
CHP Electrical Efficiency	30.3%
CHP Fraction of Heat Load	0.6
Gas-fired Boilers Efficiency	95.7%
Boiler Fraction of Heat Load	0.4
Metering	Metering linked to usage, variable flow rate
Water Heating	150 litre cylinder, by DH System
Pipework	pre-insulated, low temperature

ASHP Heating Specification	Residential Areas
Space Heating Efficiency	364.4%
Manufacturer	Mitsubishi
Model	ECODAN - PUHZ-SW40VHA
Gas-fired Boilers Efficiency	95.7%
Water Heating	150 litre cylinder, by ASHP system
Pipework	pre-insulated, low temperature, variable flow

PV Specification	Residential Areas
Installed Peak Power	1.96kWp
Apprixmate Area (m^2)	12.80
Tilt	30°
Orientation	South-West
Overshading	None or very little
Notes	PV connected to house electrical metering

Accredited Construction Details – assumed every junction is designed and constructed as an 'Approved Detail'