Towards Carbon Neutral Urban Housing

Urban terraced house case study

The house prior to installation

Shepherds Bush W12 - Mid terrace Edwardian house built 1908 facing east / west, solid brick walls, max. internal width 4.95m

Front bay windows ground and first floor timber and glass with acrylic sheet magnetic secondary glazing. All rear windows and French doors modern aluminium double glazed. 2nd floor loft conversion and bathroom double glazed velux windows, skylights and French door. Full building regs 2005 insulation on conversion and remaining loft space.

Heating was by a 3 year old Potterton Promax 32 condensing boiler with a pressurised water system off the mains and a 210 litre high pressure Gledhill horizontal hot water tank in the rear loft. All rooms have sufficient radiators to enable efficient heating in winter. Water supplied by 22mm plastic pipe from the street – unmetered.

Annual bill for gas and electricity 2018 / 19 - £2247.00

The Objective

To install the latest most efficient technology to make the house carbon neutral by installing solar panels and replacing the CO2 emitting gas boiler without the enormous expense and disruption of insulating walls, replacing existing radiators, triple glazing the windows and doors and replacing the almost new horizontal hot water tank.

The Set Up

Electricity procurement

There are three sources of electricity

1. We are signed up with Octopus – a green energy supplier that guarantees its sources of power are not from fossil fuels but from renewables - wind, solar, hydro and nuclear.

2. Using GESS of Chelmsford we've installed as many solar panels as is possible on the various roofs including the north facing roof over the rear element of the house. All panels are rated at 330 watt. We have 1 south facing panel, 2 east facing panels, 11 panels on the flat roofs facing straight up and 6 panels on the rear roof facing north - a total of 20 panels, max generation 6.6kw. Actual max generation 4.5 kw on sunny summer days, all panels contribute significantly to the overall generation.

View to the front

View to the rear

These panels are wired up in parallel using **Enphase micro-inverters** on each panel and the DC current is distributed via an inverter / distribution system using a **Sofar ME 3000SP storage inverter** to power the house, charge the 9.6kw of batteries and export to the grid.

Sofar inverter / distribution box and Pylontech batteries in under stairs electricity cupboard

3. We have installed 4 X 2.4kw – 9.6 kw Lithium-Ion batteries by **Pylontech.** These batteries are compact and stackable so can be added to if necessary. They provide a smooth source of power at night time and on cloudy days and are inexpensive.

GESS - Green Energy Solar Solutions of Chelmsford, who did the installation, were one of the very few companies who understood what we were trying to do and had the flexibility and broad knowledge of the available technologies in order to successfully complete the project. I cannot recommend them highly enough. **The installation was completed 10th July 2020.**

Replacement of gas boiler

As the house is mid terrace with no access to the back garden the installation of a ground source heat pump was not a viable option. The only viable option was an air source heat pump however a number of difficulties had to be overcome.

Air source heat pump criteria

1. Size – The house has four bedrooms over 3 floors including the loft conversion. Volume calculations stipulated that we would need a pump with a minimum output of 11kw but ideally between 12 and 14kw. Mitsubishi offer an 11.4 kw pump with a single fan that is Ultra Quiet but all other manufacturers use twin fan machines for anything over 11.00kw and this is a problem because of the amount of space they take up and the amount of noise two fans make when working flat out.

2. Noise - The pump has to be ultra quiet. The closer it is situated to the house the less heat loss there is in the pipework between it and the house. However the closer it is to our house the closer it is to our neighbours houses and there are regulations regarding noise emissions from heat pumps that must be adhered to. The Mitsubishi Ecodan 11.4 kw Ultra Quiet was the front runner for many months but there were serious supply issues due to Brexit and component supply and it was only just big enough. Our pump suppliers **Electric Heat Warehouse of Derby** recommended the latest pump from Vaillant – a twin fan 12kw Arotherm Plus and we decided to go with it.

Although tall at 1.5m it is not deep, a mere 45cm and would therefore not protrude far into the garden from the fence but most importantly it has very low noise levels 54db is quoted and only 60db when running flat out.

3. Adaptable for use with existing hot water tank. In an ideal world it would be much better to use the specially designed high pressure hot water tank supplied by Vaillant for use with their Arotherm plus pump. However there is nowhere in the house that could accommodate the tank as it doesn't come in horizontal form like the existing tank. The engineer from electric Heat Warehouse who fitted the system, with advice from Vaillant, was able to solve the problem by fitting a 100 litre buffer tank between the pump and the heat exchanger and the system works extremely well.

Tank now sits in a waterproof extra insulation box.

Heat exchanger and controls where the boiler used to be.

It means that there is always a large supply of hot water ready to feed into the central heating and hot water tank and the pump itself is not cycling on and off as it would if heating the hot water only via the relatively small heating circuit in our existing hot water tank.

On the **16th February this year (2021)** a 12kw Vaillant Arotherm Plus air source heat pump, buffer tank, heat exchanger and control electronics were installed and connected into the existing central heating and hot water pipework. **The gas boiler was removed completely thus eliminating a major source of CO2 emissions into the atmosphere.**

How it all works

Winter months – Early October to end March

The ability of the solar panels to generate electricity slowly declines as the days get shorter and the angle of the sun gets lower. However, even in December – January on a sunny day they will produce 12kwh of electricity but a heavy cloudy day will sometimes only produce 1.5 kwh. It is on these poorly performing days that the use of green electricity from Octopus really matters. The power requirements of the house is obviously far greater in the winter than in the summer and electricity is roughly 4 times as expensive as gas and so finding a way of storing cheap electricity is essential. Octopus offer a tariff called Octopus Go that runs from 12.30am to 4.30am at 5.00p per kwh, roughly one third the price of daytime electricity. There are two forms of energy storage in the house – 9.6kw of batteries and a 210 L hot water tank with a 3kw emersion heater. Both of these are switched on to be charged during this early morning window of cheap electricity so the house starts the day fully charged with the hot water tank thermostat set at 62 degrees C.

The heat pump is programmed to come on at 7.00am and, as we're all working from home, it's on all day until 10.00pm. We only have winter month data from March this year when we did have temperatures as low as minus 3 degrees C but I can say that the heat pump was more than adequate to keep the house warm using existing radiators at 21 degrees C for the whole month including those below zero cold days. The heat pump is also programmed to top up heat in the hot water tank to 50 degrees C between 1.00pm and 3.00pm. The electricity bill for that month was £160 using 1210 kwh of electricity. The solar panels contributed 304 kwh of electricity on top of that.

Summer months – April to end September

As the days lengthen and the angle of the sun increases the solar panels start to increase production so there is a gradual cross over from reliance on grid electricity to reliance on solar panel electricity. As the day time temperatures rises the heat pump is used less and less to heat the house and so the demand for electricity falls. Both April and September are crossover months.

May to present day – end July 2021. We've kept using low cost (5p per kwh) early morning electricity for heating the hot water and charging the batteries until this week 26th July when I've obtained data from Octopus that indicates we have been exporting a significant amount of electricity (360kwh for both June and July) to the grid for which we are paid (3p per kwh) That power would be better used heating the hot water and charging the batteries. Therefore both the emersion heater in the hot water tank and the charging of the batteries have now been turned off from low cost grid supply. Hot water is now supplied by the heat pump during the day and the charging of the batteries is done wholly by using solar electricity. I suspect this could have been done much earlier as the export figures are as follows. May – 70 kwh, June – 350 kwh, July – 370 kwh.

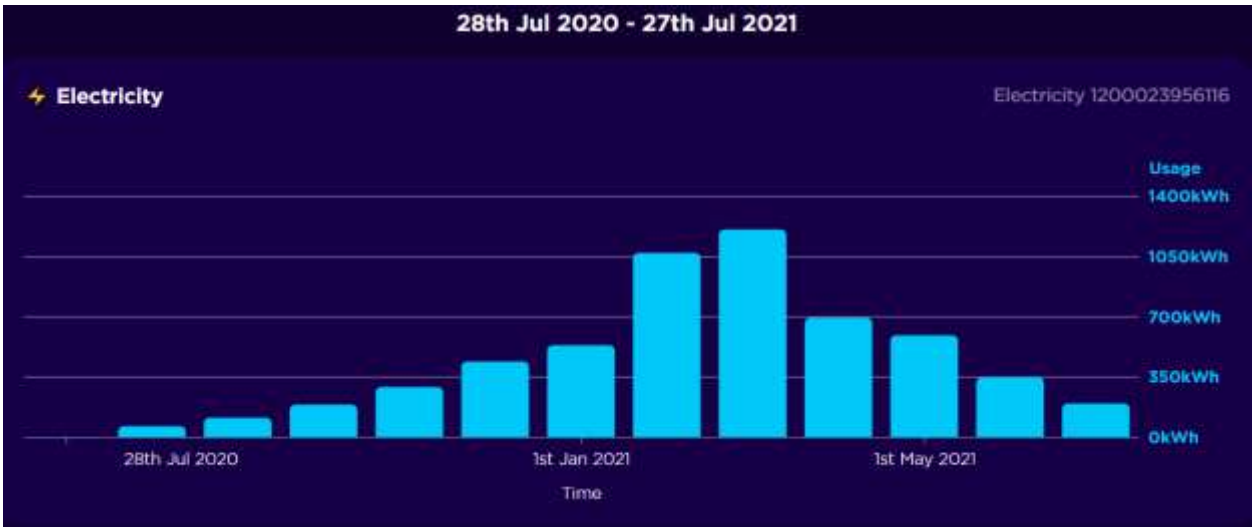
It is evident that for at least three months of the year the dependence on grid electricity will be virtually zero and that for the months of April, May and September it will be significantly reduced.

Performance Data

We now have data from the past year to illustrate the effectiveness of the solar system.

These two charts need to be read from 08/20 to end 07/21. Also note that the scale on the two charts are slightly different and we lost 10 days of data in January due to an update glitch and so December and January will have been very similar. What can be concluded is that from 08/20 to the end of 2020 the panels generated 1,280 kwh and from 01/21 to end 07/21 they generated 2,850kwh – a total of 4,130 kwh for the year.

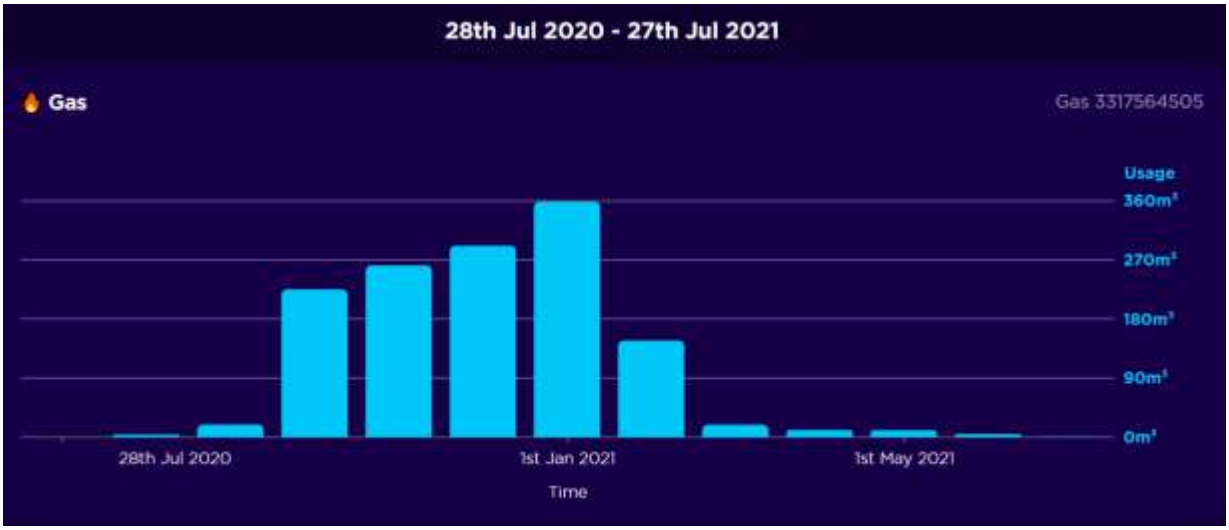
Projected electricity usage after installation of heat pump on 16th February 2021



Heat pump installation was fully functioning by the 16th February and March was a cold month so we can assume that for the winter months of 1st Nov through to 31st March monthly electricity purchased from Octopus is likely to be in the region of 1200kwh per month. Approx 30% of this would be at 5p per kwh - £60.00 and the rest would be at 15p per kwh - £120.00. This gives a monthly total of £180.00 for 5 months is £900. For the summer months of April through to end October purchase of electricity from Octopus should be negligible - £20 per month giving a total of £140.00. I anticipate that the annual cost of

all energy consumption will be in the region of £1040.00. This is less than half of our annual bill of £2240.00 for the previous year.

The Objective Achieved - the elimination of gas as our main energy provider



The only use of gas in the house is for cooking on the four burner gas hob. This is very minimal and will be eliminated completely when we purchase an all-electric cooker.

The Capital Outlay

The full cost of all components, installation and scaffolding for the solar panel system was £14,000. At the time there were no grants or subsidies available for solar energy. GESS helped us enormously in working out the best combination of panels, micro-inverters, distribution unit and batteries and are accredited by the various professional and government organisations. I would definitely use them again.

The full cost of all components and installation for the air source heat pump was £13,000. Electric Heat Warehouse were endlessly helpful and supportive for over a year as there were many issues to overcome and their engineer was superb. We did eventually succeed in claiming £5000 toward the cost from central government's short lived Green Home Grants Scheme but it was incredible tortuous and stressful. Electric Heat Warehouse are registered and accredited to be able to administer the Renewable Heat Incentive an excellent government scheme and we will receive 90% of the balance in quarterly payments from the government over the next 7 years. I would also definitely use them again.

As we become better at making the system work efficiently, running costs will definitely fall, but accurate annual real time data will not be available until next July.

But - it all works and we're no longer pumping CO2 into the atmosphere with our gas boiler!!!!!

Brian Thresh 30.07.2021