Investigation into Air Source Heat Pumps

In October 2020 I looked into changing our gas central heating to an Air Source Heat Pump System (ASHPS), creating an outline of requirements to send to prospective suppliers.

House

We live in a modern 1997 4 bedroom detached house with brick built outer walls and insulating blocks inner walls, double glazed windows, and concrete suspended floor, and originally about 3 inches (70mm) of loft insulation. About 10 years ago we had the cavity filled with mineral wool and we added more loft insulation bring it to 350mm (12+ inches) over c50% of the loft plus 70mm mineral wool + 20mm chipboard flooring over the other c50%.

Ground floor rooms have wood engineered floors (lounge and dinning) and ceramic tiles (hall, kitchen and utility). Upstairs bedrooms also have engineered floors and the 2 bathrooms have ceramic tiled floors.

We had a Solar PV system with 9 panels outputting up to 3.84 kW fitted 10 years ago. This is a split system (east and south facing) and the maximum achieved peak output is just over 3kW.

Heating & Cooking

The gas boiler was replaced c15 years ago with a Worcester Greenstar Ri 24kW boiler (replacing the original 18kW boiler). It is serviced annually and the service technician says it is still in excellent order. There is a Drayton LP722 (Mk4) programmer with timers for heating & hot water.

The gas boiler heats a c150 litre foam insulated hot water tank on the first floor which can also be heated by electricity but we rarely do that (more later). There is a mix of single and double radiators with fins with most, but not all, having individual thermostats and they are usually set at level 3 on a range 0 to 6.

We have the hall thermostat (controlling the boiler) set at 20C. The central heating is typically run in spring & autumn for 8 hours per day (3 hrs. am /1 hr. midday /4 hrs. pm) increasing to 10 hours in winter. When it’s really cold we wear 2 jumpers! I spend most time upstairs where it is warmer.

The cooker hob is gas and the oven electric but the oven is not used a lot (say once a week). We aim to run the washing machine (daily) and dishwater (every 3 days) when the PV has a good output.

Energy Use (Last 12 months to October 2020)

Gas:	10,900 kWh	£619 (100% renewable (bio-gas), including standing charge)
	includes an estimated 750 kWh for gas cooking (hob only)	
	Boiler is set at c75% and outputs at 57C and return at 44C. One radiator recently showed 52C in and 28C out and later 40C in and 44C out.	
Electricity:	1,400 kWh	£380 (100% renewable, including standing charge)
Supplier:	Green Energy UK	

PV Generation: 3,500 kWh Estimated self consumption: 2,300 kWh Est. Export: 1,200 kWh

Air Source Heat Pump Investigation

After lots of reading on the web I decided that to build a spreadsheet (see appendix) to calculate the increased size of the radiators. Most radiator manufactures seem to give the heat output of their radiators based on 70C water temperature which is higher than our boiler thermostat setting.

Most ASHPS manufacturers base their systems on the standard industry temperature of 7C outside and a water temperature of 35C (half that of gas). Wiltshire has an average maximum Jan/Feb

daytime temperature of 7C and an average minimum of 2C each month but of course there are spells with very low temperatures. So, in very cold winter (when the air has little heat) it probably means running the ASHPS 24 hours a day – ASHPS do not give instant heat!

I calculated that I would need to increase the radiator sizes from a total of almost 7 sq.m. to 12 sq.m, (almost double) and to run the system (constantly on) for at least 10 hours per day. Whilst the gas system is programmed to be on 8 hours a day the system is probably only running half of that. Purchased electricity for the ASHPS is x4 the cost of gas per kWh of heat (18.9p to 4.6p Oct. 2020).

My reading suggests that ASHPS systems are better for new builds, especially for Hus houses:

- highly insulated (near zero heat loss)
- underfloor heating set into concrete on the ground floor that acts as a heat sink
- heat exchangers on the fresh air system
- solar PV combined with battery storage

I was concerned also about:

- life of ASHPS – 10 years is often mentioned – that's a large and frequent capital outlay (circa £10k). Plus the life of the water pump as it runs much longer than gas
- ideal location was where there was a large water butt, with no obvious alternative location
- need to install a large and special hot water tank – were would it go?
- finding an installer who will give an objective assessment and be around for many years
- noise – many references to complaints from neighbours as the systems are outside, noisy, and run constantly for many hours

Caveat

I may of miss-understood the technical aspects and got my spreadsheet wrong. You Tube does have videos of people who have successfully installed and run an ASHPS, so each potential installation needs evaluation. Maybe there are independent heating experts who can give an objective view with no conflict of interest (they would need to be paid).

Current Plans

I have replaced my 3kW hot water tank element with a 1kW one to be used with an Energy Management System that I am building. Based on a Raspberry Pi computer, this will gather data from 3 meters: consumption, PV generation and purchase. It will then switch the tank element on when there is surplus of PV energy.

Stats will be produced and the system heated in the evening (by electricity) if there was shortfall of solar energy. The stats should be useful for gaining an understanding of energy generation and use.

It will probably be used in the summer only as my wife does not like the fact that the hot water pipes to the tank run under her bedroom floor and make the room too hot in summer.

Further information

For copies of my outline of requirements, my spreadsheet and a list and details of some local suppliers (as of 2020), please email (all lower case): <my first name><at><surname>family.me.uk

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v2, 22 September 2021

Appendix 1: Spreadsheet snapshots

Room Sizes and Radiator Sizes

Room	Room Dimensions				Radiator Dimensions				Window Dimensions			Room	Max Radiator Size			
Dimentsions	Length	Width	Height	Area m²	Width	Height	Panels	Area m²	Width	Height	Area m²	Heat Loss kW	Width	Height	Panels	Area m²
Lounge	4.8	3.5	2.36	16.8	1.6	0.5	2	1.60	3.30	1.30	4.29	1.88	1.6	0.5	3	2.40
Dinning	3.5	2.8	2.36	9.8	1.1	0.6	2	1.32	1.75	2.05	3.59	1.22	1.1	0.6	2	1.32
Kitchen	3.8	2.7	2.36	10.3	0.7	0.7	1	0.49	1.70	0.95	1.62	1.11	0.8	0.7	2	1.12
Hall	2.3	1.8	2.36	4.1	0.7	0.6	1	0.42	1.15	2.05	2.36	0.72	0.8	0.7	1	0.56
Utility	2.5	1.75	2.36	4.4	0.3	0.6	2	0.36	0.55	0.95	0.52	0.64	0.4	0.7	2	0.56
door									0.85	2.05	1.74					
Loo	2.0	0.85	2.36	1.7	0.5	0.5	1	0.25	0.45	0.95	0.43	0.26	0.6	0.6	1	0.36
Garage	5.0	2.5	2.53	12.5	none											0.00
Bed 1	4.3	3.2	2.44	13.8	0.7	0.5	1	0.35	1.70	1.15	1.96	0.92	1.0	0.6	2	1.20
Bed 2	3.4	2.7	2.44	9.2	0.9	0.5	1	0.45	1.15	1.15	1.32	0.66	1.1	0.6	2	1.32
Bed 3	2.5	2.3	2.44	5.8	0.5	0.5	1	0.25	1.70	1.15	1.96	0.52	1.0	0.6	1	0.60
Home Office	3.5	2.9	2.44	10.2	1.0	0.6	1	0.60	1.70	1.15	1.96	0.74	1.2	0.6	2	1.44
Bath	2.5	1.9	2.44	4.8	0.5	0.6	1	0.30	1.00	0.95	0.95	0.38	0.6	0.7	1	0.42
En Suite	2.2	1.4	2.44	3.1	0.4	0.6	2	0.48	0.55	0.95	0.52	0.27	0.5	0.7	2	0.70
Landing	2.9	2.7	2.44	7.8	none				none			0.48				
				114				**6.9**			**23.2**	**9.8**				**12.0**
								100%								175%

Lengths are in metres and are the maximum into L shaped areas but not into cupboards
Heat Loss calculator from https://www.plumbnation.co.uk/heating-calculator/

Had to select brick cavity wall with insulation rather than brick + insulated block with insulation
Had to select concrete floor with air below rather than insulated concrete floor with air below
Ignored roofs over part of lounge and dinning room – treated as room above
Exterior door treated as single glazed window in wooden frame
Had to selected for Bedroom 2 heated room under when it actually is an unheated garage, but the room is dimensioned to max size
This sheet is based on all rooms being lounge – this because we spend a lot of time upstairs and all room doors tend to be open

ASHPS Heat Output based on Heat Loss all rooms lounge – i.e. all rooms at 20C

		Current Rad Size	Max Rad Size	
Gas usage	kWh	10,900	10,900	Actual 2019/20
Less cooking	kWh	-900	-900	estimate
Less HW	kWh	-1,000	-1,000	guestimate
Net CH	kWh	9,000	9,000	
Rad output	Kw	**9.8**	**12.0**	see Heat Loss all rooms lounge sheet
at Delta	C	70	70	as per radiator manufacture
Adjust temp to	C	45	45	ASHP output temp
Target temp	C	20	20	
New Delta	C	25	25	
Adjustment		0.406	0.406	See Deltas table taken from web ref
New Rad Out	kW	4.0	4.9	Under half the current gas boiler!
Output Duratic	Hrs	2,265	1,847	= Net CH / New Rad Out
Heating Seaso	Days	183	183	
Hrs/Day	Hrs	**12.4**	**10.1**	= Output Duration/Heating Season

Current is 8 hrs / day in spring & autumn and 10 hrs / day in winter but this is programmed time not actual running time
Web ref. https://www.buildingservicesindex.co.uk/entry/136540/AEL-Heating-Solutions-Ltd/How-to-calculate-the-delta-T-for-a-radiator/