"**The journey to zero carbon homes**"
HEOG meeting 7:30pm 19 April at the Senior Citizen's Club

A new-build zero carbon home: presentation by David Searle

I'd like to start with a quotation, in 1931, not long before he died, Thomas Edison told his friends Henry Ford and Harvey Firestone: "I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait until oil and coal run out before we tackle that."

We haven't got very far on our journey have we? At the end of the day, the only renewable energy sources are the sun and geothermal energy. We may harvest them as biomass or wind and tides, or directly as radiation or heat.

So to start our journey, we need to ask some questions, and hopefully arrive at some answers.

What do we mean by zero carbon homes?
In an ideal world we would mean a home, which is completely autonomous, i.e. requires no energy inputs, and uses no communal services, unless they were also carbon neutral. A very good approximation is described in "The new autonomous house" by Brenda and Robert Vale. Definitely worth a read, even if you don't decide to build a house based on it, such as ours. The significant difference between their house and ours is that we do have mains water and sewerage. We didn't feel that a composting toilet and only rainwater supplies were going to be considered acceptable in Malthouse Lane. The technology and practicality are entirely proven and practical. It is just the "yuck" factor when our children come to sell the house when we have popped our clogs. Perhaps by then it will be thought of as normal. We can live in hope.

Luckily for us, in the short term, the government's definition is much less stringent, so that our house is rated at 101%, and –0.2 Tonnes of CO_2 on its Energy Performance Certificate. This is despite the fact that they estimate that we will spend £459 on energy this year, split between £90 for Lighting, £272 for heating, and £97 for hot water. Our actual net expenditure (excluding standing charges) on energy is £256, as we have loads of free wood, and have no gas. Of these heating and hot water are supplied by solar, and a woodburner with a flue boiler, and an occasional top up from an immersion heater. The immersion heater, the oil for transport of wood and chain saws, are not carbon neutral, although wood is generally regarded as carbon neutral because it is a renewable resource. However there is not enough of it to go round if the entire world were to move over to biomass for energy purposes. Hence we have to go back to solar or geothermal in the not so long run.

Realistically I have no idea how you would rate our house, if you truly wanted to have a zero carbon home, as we buy in electricity, water, and sewage services. We might have been able to use a green electricity tariff, but the buyback of our own generation appeared to be a problem.

What incentives do the government offer?
Until 1st April, we were paying a normal tariff of 11.7p/Kilowatt hour used from the grid, and receiving 28p/unit for those we exported to the grid. After that date we will get 9p per unit for all the electricity we generate, plus 3p per unit exported to the grid. These feed in tariffs apply for 20 years. As of April next year a similar scheme will apply to solar thermal installations, probably on the basis of estimated capacity, as opposed to measured input, as many installations will not be able to measure the thermal input reliably. The proposed rate is 18p/Kwh for solar hot water, and 9p/Kwh for biomass heating of space and water. Their example of a semi detached 3 bedroom house of reasonably upgraded insulation gives a repayment of £1400/year. I am guessing that our house might qualify for around £1000/year, because our space heating requirements are so low.

What are the principles of designing for a zero carbon home?

Easy peasy, get the shell of the house right, then minimise inputs of all kinds!

Seriously though:

For insulation, you need between 2 and 3 times the thickness of the recommended amounts by the current building regulations. Use a mechanical ventilation heat recovery system, because in a well insulated house, ventilation losses would account for around 75% of the total, assuming current practice, with trickle vents in windows etc.

You need thermal mass, this will stabilise the temperature so that it is cool in summer. In winter it stays warm through the night, after soaking up the daytime temperatures.

All these minimise the heat required, and keep it where you want it.

Then you need to evaluate how to supply the reduced amount of energy you need. The biggy is heat, because we tend to burn stuff to get it, either at the power station with around 25% efficiency, delivered, or gas, a fossil fuel, or biomass (renewable), or better still passive solar design, supplemented with solar thermal panels for high grade heat. Heat storage is an issue because the sun is intermittent. It has two main forms, structural mass of the building for space heating, and volumes of water for storing high grade heat. If electricity use has been minimised, with low energy lighting, and efficient gadgets, then solar PV panels become an option. They are the last thing to consider, because they have the longest payback.

On the indirect use of energy, rainwater harvesting plays a part, because one of the relatively high carbon consumers is the water industry. On payback generally, we have taken the view that the enhancements will reflect in the sale price of the house anyway. So our criterion for any one item on the menu was "will the saving exceed the loss of interest on the capital cost?" If so we deemed it to be worthwhile.

How do you do it for a new build?

We did it by following the construction principles outlined by Brenda & Robert Vale in their book, in order to get the shell right, as far as our site and planning issues would allow. What is shocking to me is that their house was built in 1993, and the building regulations will reach their standards for the shell in 2016! We then added systems to reduce our resource usage (and hence costs and carbon emissions) in the following priority order. Wood burner, later fitted with a flue boiler for domestic hot water, rainwater harvesting, solar thermal panels (5sq.m.), solar PV panels (15sq.m.). Interestingly these two sizes roughly reflect the relative efficiency of solar collection of heat (50%) and electricity (15%) respectively. They harvest almost exactly the same number of Kwh. Has it worked? Minor teething and tuning problems apart, emphatically yes!

The wood burner has kept us in the range of 20 – 23deg.C. throughout this winter, and topped up the hot water system to between 50 – 60deg.C. whenever it is lit. The efficiency of the shell is such that, on average non freezing winter days, the temperature drops just over 1deg.C in 24 hours. The lowest we have seen on returning from a long week end is 17.1deg.C. when we had been running the house between 20 and 22deg.C. previously. That is zero heating other than solar hot water and 2 hours per day of one towel rail off the hot water system. A key feature is the thermal mass. I haven't calculated how much concrete is incorporated inside of the insulation, but it is many tonnes. We have no studding partitions,

all internal walls and partitions are made of dense concrete blocks. One day I will calculate the total mass! Having looked through a textbook of solar design with descriptions of actual solar houses, I was struck that the only one which attempted to be self sufficient in heating through the year, with no other source of heat, used a 63 tonne water tank in the basement as the store. It operated on a temperature range of 15deg.C. to 65deg.C. using solar collectors on the roof. They were located in Cambridge, Massachusetts at latitude 42 deg. North. We are at 52 deg. North, and only use the temperature of the indoor atmosphere to charge up the thermal mass.

We have used mains water for flushing toilets for only about ten days in the year, which represents a large saving in water usage. I can't tell you how much it saves, because we have had a silent water leak for an unknown period our side of the mains water meter. Luckily Severn Trent repaired it free and allowed me to make an arbitrary adjustment to the resulting bill! We have a tank capacity of 3500 litres, and it is sobering to think that we once had a completely empty tank in late spring last year, and overnight it filled to overflowing, i.e. we had received 3 ½ tomes of water on our roof.

The solar thermal panels have provided us with a tank full (250L) of 65deg.C. hot water on many occasions in the summer, and the pump was active on almost any day with some sunshine in winter. We even had a tank full at 52deg.C. in February. The solar Photo Voltaic panels have reduced our bills (excluding standing charge) from around £750 to £256 giving a payback in around 23 years at current prices. The total payback time will reduce year on year as the cost of fuel goes up, so a payback in 15 years in real terms sounds quite feasible.

How can you apply those principles to an existing home?

You probably won't be able to reach the standards of a new build, so the emphasis after you have done what you can, has to switch to decarbonising your energy inputs. The cheapest and most practical is to start with the shell. It's boring, but the first thing to do is to evaluate all the sources of air leaks in and out, and one by one stop them up. Door and window seals are obvious, but on older properties it can be difficult to do much.

Secondary double glazing can be very effective with sash windows. My daughter's house near Leeds has had brand new double glazed sash windows, and they still leak air around the channels and pulley holes. Suspended wood floors at ground level can be a problem, but it may be possible to get into the space under them, and spray insulation onto the underside, killing two birds with one foam, as it will fill all the air leak gaps at the same time. You could squirt silicone into the gap under the skirting boards, and rely on the carpet underlay to finish the sealing job, but still not enough insulation. Cavity walls can be injected with insulation, and the roof should be insulated to around twice the current standards. If you don't have cavity walls, then adding insulation inside or out is the answer.

After that it is worth looking at the add on systems like solar thermal and Photo Voltaic (PV), It may well be worth while putting individual room mechanical ventilation heat recovery units in the principal bathroom and the kitchen. In the kitchen extractor fans are a serious waster of heat, so recirculating cooker hoods plus the ventilation unit are a good way to go. Consider rainwater harvesting. Your heating systems need to be evaluated, to see if biomass is possible. If not and you have gas available, then a modern condensing boiler may be worthwhile, but don't bother with heat pumps. They are only viable in carbon terms if you haven't got mains gas, and even then have a high payback time as their capital cost is high.

So - what are the practicalities of doing it for an existing home? Let's ask George . . .