Renewable Energy Within the Yeovil Urban Village – Meeting Eco town Standards.

Recommendations

- Reduce space heat demand through pasivhaus construction.
- Reduce electricity use through specification of voltage optimisation, A rated white goods, LED lighting throughout, induction hobs, private outdoor space with retractable drying lines or condensing tumble dyers.
- Facilitate provider of wood heat to install and operate district heat main, central wood chip boiler and building level heat exchangers.
- Design buildings to maximise south facing roof space and install photovoltaics to all.

Background

Urbed Matrix have been comissioned by South Somerset District Council to produce a masterplan for this development of 400 houses, restaurants and retail outlets. They have asked for further clarification of the councils expectation for renewable energy on the site and some detail as to how it can be achieved.

Context

The council expects the development to achieve eco town standards as relate to provision of renewable energy. This means that “Over a year the net carbon dioxide emissions from all energy use within the buildings on the Urban Village development as a whole are zero or below” This will be achieved by ensuring that the highest energy efficiency standards are met and by installation of renewable energy generation.

Although the definition excludes embodied carbon and emissions from transport it includes all buildings, not just housing, and the Council still wish to aspire towards low-carbon construction. Consultants will be expected to consider emerging techniques and best practice were appropriate including locally sourced construction, low embedded carbon and low energy consumption.

Reducing Heat Demand

It is expected that demand is reduced through excellent passive design. The passivhaus standard is increasingly applied to UK developments. There are local examples and local developers who have worked up designs suitable for the UK. The design aspect required to achieve passivhaus standard are described in the table below, taken from http://www.passivhaus.org.uk/index.jsp?id=669

	PassivHaus Standard	**UK new-build common practice**
Compact form and good insulation:	All components of the exterior shell of a PassivHaus are insulated to achieve a U-Value that does not exceed 0.15 $W/m^2/K$	Limiting U-values of approximately 0.25-0.35 $W/m^2/K$

Southern orientation and shade considerations:	Passive use of solar energy is a significant factor in PassivHaus design.	Some consideration is given with regard to north/south orientation, but the improved energy savings resulting from passive site design are often overlooked.
Energy-efficient window glazing and frames:	Windows should have U-values not exceeding 0.80 $W/m^2.K$ for both glazing and frames - this requires the window frame to incorporate insulation and the glazing to be triple. Solar Heat Gain Co-efficient through the glazing should be at least 50%[1].	1.8-2.2 W/m^2K typical
Building envelope air-tightness:	Air leakage (n_{50}) through unwanted gaps and cracks in the building fabric must be less than 0.6 times the house volume per hour under negative and positive pressurisation.	Design air permeability of 7 to 10 $m^2/hr/m^3$@ 50 Pa. This is approximately a factor of 10 poorer than the PassivHaus standard. Research has also shown that air permeability values for completed dwellings frequently exceed these design limits.
Passive preheating of fresh air:	Fresh air may be brought into the house through underground ducts that exchange heat with the soil. This preheats fresh air to a temperature above 5°C (41°F), even on cold winter days.	The majority of new-builds do not achieve good enough air permeability values to warrant the incorporation of a whole house ventilation system - thus trickle vents, extract fans, or passive stack ventilation is commonly used.
Highly efficient heat recovery from exhaust air using an air-to-air heat exchanger:	Most of the perceptible heat in the exhaust air is transferred to the incoming fresh air (heat recovery rate over 80%).	
Energy-saving household appliances:	Low energy refrigerators, stoves, freezers, lamps, washers, dryers, etc. are indispensable in a PassivHaus.	Dedicated low-energy lights are provided in a number of rooms in a new dwelling - if appliances are supplied they will be generally C-rated or perhaps 'Energy Saving Recommended' in some instances (as these are widely available).
Total energy demand for space heating and cooling	**Less than 15 $kWh/m^2/yr$**	**Typically 55 $kWh/m^2/yr$**

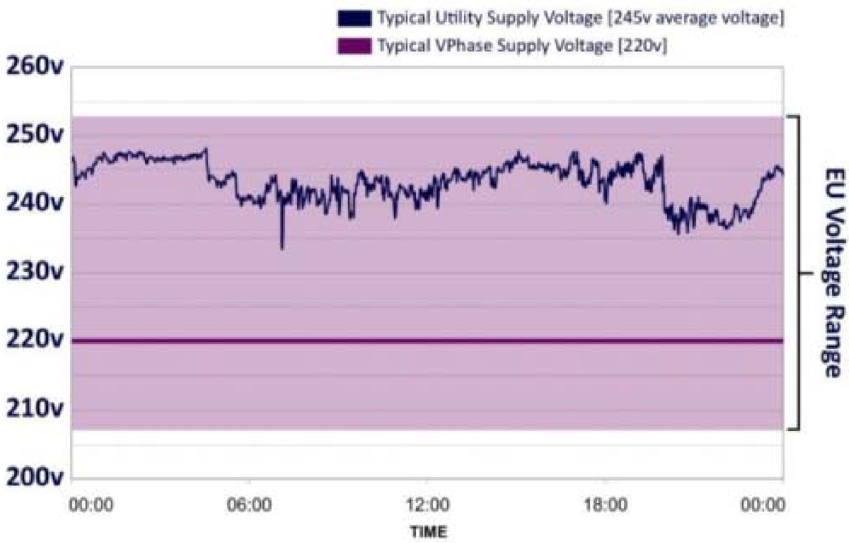
The basic concept is that, through solar heat gain and heat recovery, excellent insulation and airtightness, virtually no space heat is required. Through solar orientation to perfect south, with no shading from obstructions, the daytime living spaces are fully lit with daylight. The main implication for the Urban Village Masterplan is that all buildings must be solar orientated and therefore, the arrangement of all building in relation to roads and other features is the start point. All the other concepts so beloved of architects (and master planners) must be of secondary consideration. This point cannot be made strongly enough.

Reducing Electricity Demand

Electrical demand can be minimised by specification of Voltage Optimisation equipment to accompany electrical consumer units, LED lighting, LCD (as opposed to plasma) televisions, use of retractable outdoor clothes lines rather than tumble dryers, A rated white goods and cooking appliances.

Voltage Optimisation

Incoming voltage to a property varies according to location but is typically 235 – 250 v. Electrical equipment is built to operate to a European Standard of 220 v and operates most effectively and with longer life at that voltage. Voltage optimisation equipment reduces the voltage to a flat – unchanging – 220 v. Ampage is therefore also reduced and annual savings of 8 – 15% can be made. A domestic unit costs £300 inc VAT.



LED lighting

The availability of LED lamps and luminaires is currently rapidly improving with a greater variety of lamp types and reducing prices. Due to their Lux/Watt ratio being twice that of flourecents and their longer life, it is likely that they will replace other lamp types. Developments starting from about 3 years hence have the opportunity to leap frog compact flourecents and specify LED lighting throughout. The benefit will be a halfing of electrical consumption for lighting as compared to flourescents.

LED lamps currently available

Flexible, splashproof LED strips are now available.



These can effectively provide targeted lighting with very low energy use.


Cambridge University (2009) have calculated that use of LED lighting will reduce the proportion of household electricity bills for lighting from the current 20% down to 5%. Based on the 2008 average household consumption in South Somerset of 4922 kWhy, this would result in a figure of 246 kWhy for lighting per residence.

Energy Efficient White goods

It is particularly important to specify the best A rated fridges and freezers as these are “always on” devices with relatively high annual consumption.

If hot water is supplied from a zero carbon source (such as wood fired district heat) then installation of individual thermostatic mixers to control the mix of hot and cold water supplying each dishwasher and washing machine will reduce electrical demand to heat the water within the machine.

Cooking appliances

The only realistic choice of oven for a relatively dense new development is electric, and these don't vary significantly in their efficiency. However, the majority of cooking is undertaken on a hob. If gas is supplied then a gas hob is the most carbon efficient option. However, if – as this study will advise – space heating and hot water is supplied via a district network, then it may not be viable to supply gas to each residence just for cooking. In that case, electric induction hobs should be specified as they use on average 65% of the electricity required by a conventional electric hob to get the same cooking result. Based on commonly reported efficiencies of gas hobs as 50% and induction hobs as 90%, 1 kW of effective cooking heat will result in 0.37 kg CO_2 as compared with 0.58 kg CO_2 for an electric induction hob.

Tumble Dryers

According to National Statistics, 54% of households in the UK own a vented tumble dryer. A family would dry an average 4 loads a week each using an average of 3.5 kWh. Each household with a tumble dryer would therefore average consumption of 728 kWhy from its use. Assuming 54% ownership takes the average across the district to 393 kWhy. For the last few years, condensing tumble dryers using on average 2 kwh per load have been available. If outdoor space and a retractable line dryer is specified for the majority of residences within the urban village, it should be possible to reduce average electricity consumption for clothes drying by discouraging the majority of households from owning a tumble dryer. Consumption of 300 kWhy is assumed for the purposes of this study.

Predicted energy demand

The Department of Energy and Climate Change publish annual energy consumption data at district level. The last data set was published for 2008. In South Somerset, average household electricity consumption was 4922 kWhy and gas consumption was 14,757 kWhy. Electricity consumption has decreased by an average of 1% and gas by an average of 4.5% since 2003. Increased uptake of compact flourescent lighting, A rated white goods, condensing tumble dryers, electrical devices with much lower standby mode consumption, flat screen TVs and laptop computers will have driven down electricty use, and the gradual reduction seen is likely to continue because saturation point for these products is not yet reached. Reduced heat demand will be due to improving average insulation rates.

Electricity use

To predict electrical demand of the households in the Urban village development, the difference between a typical household in 2008 and that when the development is expected to be constructed - around 2013 - can be estimated. Of particular note is that, as compared to 2008 energy consumption, the urban village residence will have a minimum 8% saving from installation of Voltage Optimisation equipment and 75% saving on lighting from LEDs. The estimated energy consumption below for the urban village is based on A rated white goods, LEDs and electric induction hobs throughout, 2 40 inch LCD TVs per household used for 5 hours per day and two laptops, each used for 3 hours per day.

Comparison of known household energy use in 2008 with estimated energy use for Urban Village in 2013

Average domestic electricity use (excluding heating)	% UK average	South Somerset average 2008 kWhy	Urban Village 2013 kWhy
Fridges and Freezers	18%	886	270
Ovens and hobs	15%	783	637
Dishwashers, washing machines	12%	591	459
Tumble dryers	8%	393	300
Lighting	19%	935	246
Consumer electronics inc TVs	19%	935	358
Domestic ICT	9%	443	90
Total	**100**	**4922**	**2360**
			- 8% with VO
			2171

The total annual demand for 400 dwellings plus an assumed 10% extra for commercial buildings would therefore be 955.24 **MWh**.

Provision of renewably generated electricity

It is first assumed that all buildings are closely aligned to due south and are designed so that unshaded south facing roof space is maximised.

The options to consider are;

1. A wind turbine
2. A combined heat and power plant (CHP)
3. Roof mounted photovoltaics

Option One

There is insufficient wind at the development but a reasonable wind speed of 6.m metres/second on elevated land 500 m due south of the development site. However, developers of Phase one of the Urban Village – Zero C – have investigated the possibility of locating a wind turbine to the south of the site and met with opposition due to landscape and biodiversity issues.

Option two

EON – suppliers of combined heat and power (CHP) for developments – have stated that (CHP) cannot currently be delivered for a development smaller than about 2000 dwellings.

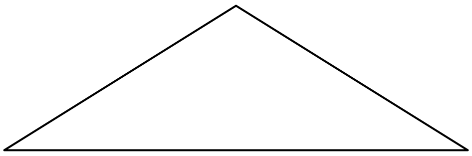
Option 3

If the average dwelling is assumed to be 60 m^2 then it will have a south facing roof area of around 18 m^2 at a pitch of 30^0, which would enable installation of 2.57 kWp of PV. This would generate 2,441 kWh/yr, which is greater than that estimated to be required by the average household in the Urban Village. The total south facing roof space required to generate the estimated 955.24 MWh/yr required for the Urban Village is 7039 m^2. The efficiency of the PV deteriates the less well aligned it is to due south and so more roof space would be required with less than perfect solar orientation.

	Roof area (m2)	PV array size (kWp)	Annual generation (kWh/yr)
Single dwelling	18	2.57	2,441
Required for zero carbon from PV only	7039	1,005.5	955,240

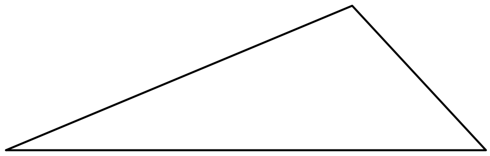
The area of south facing roof space available within the developed urban village is obviously dependent on the layout and design of individual buildings. For example, it the standard symetrical roof design is used – as assumed above, then only half the roof area is south facing. However with an assymetrical roof, the south facing area can be increased significantly.

Roof area 18 m^2



Two story dwelling 60 m^2 (6 x 5 m)

Roof area 24 m^2



Two story dwelling 60 m^2 (6 x 5 m)

Using the estimates above, it can be seen that it would be possible to meet Eco town standards in the supply of electricity with the use of roof mounted photovoltaics only, provided these are designed for from the outset.

The advantages to the developer of using roof mounted PV array are;

- With the correct design and materials Pv can be used as the weather barrier saving costs on materials.
- With no moving parts or maintenance required, PV is genuinely fit and forget.
- Dwellings and commercila premises can be sold or rented at a premium because electricity the feed in tariff will provide an income considerably in excess of any electricity bills.

The disadvantage to the developer is that PV will add costs of around £12,000 per dwelling. (£4,000 per kW installed)

The advantages to the occupant are:

- Direct PV generation can be expected to provide about 50% of the building electrical requirement (saving average £156 pa)
- There will be times when there is a surplus of generation over consumption for which the occupant will be paid 3p/kWh (expected average £36 pa.)
- The occupant will be paid the feed in tariff for all electricity generated (expected average £881 pa)

Heat Demand

It is first assumed that the building will be exceptionaly well insulated and air tight, with very (only occasional) low demand for space heat. Buildings meeting the passivehaus standard require just 15 kWhy / m^2. Assuming an average of 60 m^2 per dwelling gives 900 kWhy requirement for space heat. Such buildings require 26 kWhy / m^2 for hot water equating to 1560 kWhy for an average 60 m^2 dwelling.

	Passivhaus heat demands	annual demand for dwelling 60 m^2
Space heat	15 kWhy / m^2	900 kWh
Hot water	26 kWhy / m^2	1560 kWh
Totals	**41 kWhy / m^2**	**2460 kWh**

The annual heat demand for the 400 dwelling plus an assumed 10% extra for commercial buildings would therefore be **1082.4 MWh**.

Provision of renewably generated heat

To meet ecotown standards, the heat needs to be generated from a zero carbon source. The options are;

1. Individual small combi gas condensing boilers for each dwelling to provide occasional space heat via a wet radiator system and hot water on demand.
2. Individual log, pellet or wood chip boiler, combined with large thermal store and solar thermal panels for each dwelling.
3. Anaerobic digestion delivering gas to the gas grid or hot water for a heat main and electricity.
4. Single or multiple Wood chip or pellet boiler with district heat network providing space heat and hot water.

Option 1

Gas condensing boilers are relatively cheap and very reliable because they are supplied to the building trade in very large numbers. However, they would be using fossil fuel gas, which would not meet the required Eco town standard unless renewable energy genertated on or off site could be allocated to offset the carbon emissions. This could be large scale photovoltaics or bio gas generated by an AD plant and injected to the gas grid. There are currently just two examples of the latter in the UK.

Option 2

Given the location and high density of the development, log and wood chip boilers for each dwelling is not likely to be practical because of the space constraints and high cost. A decorative pellet stove to provide space heat to the main living room and hot water via a hot water storage tank also fed from solar thermal panels is a realistic but relatively expensive option at around £5,000 - £7,000 per dwelling.

Option 3

There is sufficient organic waste in the vicinity of Yeovil to supply an anaerobic digestion (AD) plant but insufficient space within the Urban Village for such a plant. The recycling register compiled by Somerset Waste Partnership indicates that 14,856 tonnes of putrecible food waste was collected in Somerset during 2007/2008. An AD plant in Vienna using such material uses 17,000 tonnes p.a. to supply district heat to 3000 households. Scaling down to the heat requirement of the 400 dwelling in the Urban Village, this would equate to 2266 tonnes p.a. of waste. The actual tonnage would be lower due to the expected low heat demand of these dwellings. Suppliers of AD plant state that the smallest viable plant is a 3000 tonne p.a. plant. It is therefore evident that an AD plant would be a project for a larger area than just the Urban Village.

Option 4

Three companies – EON, Dalkia and Alpheon Energy have expressed an interest in, and therefore been asked to supply details of how they would install, retain ownership of and maintain a wood powered district heat system for the Urban Village. This would include the boiler, heat main/distribution system and heat exchanger located at each dwelling / comercial building. The supplier / installer would become the energy supply company for heat for the development. They would have the opportunity to persuade the leisure complex (which includes a swimming pool) and Wilkinsons adjacent phase one of the Urban Village, and possibly the council who own Goldenstones swimming pool 500 m from the western edge of the development, that they should connect to the heat main to reduce their heating costs. The financial viability of this method of heat supply is underwritten by the Renewable Heat Incentive to be introduced during June 2011.

The advantage for the developer is that;

- Build costs are reduced because they are no longer required to provide a boiler, storage tank or solar thermal panels.
- No space within the buildings are required for a boiler and storage tank.
- There is also the opportunity not to connect the development to the gas main because the only use for gas would be for gas hobs. As explained above, electric induction hobs offer a carbon efficient means of heating.

The disadvantage to the developer is that space must be found within the development for a boiler house and wood chip store.

The advantage to the householder is that;

- The cost of heat from the gas main is guarenteed always to be lower than the equivalent from gas.
- They have no responsibility for maintenance of a boiler within their home.

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December 2010