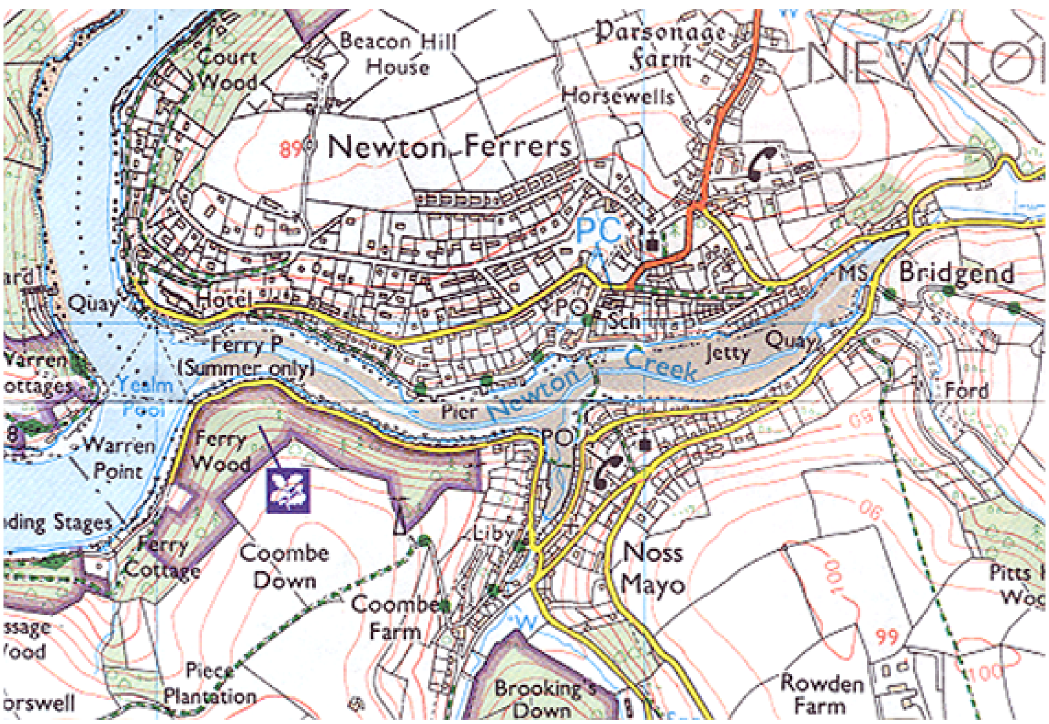
RENEWABLE ENERGY 4 DEVON

Newton Ferrers and Noss Mayo
Renewable Energy Options Appraisal
for Community Buildings



February 2009

Yealm Environment Group

Foreword

This report was commissioned from Renewable Energy for Devon and the Devon Association for Renewable Energy by the U3A Yealm Environment Group. Our purpose is to assess the potential of the two villages for renewable energy generation by virtue of their special natural resource of sun, wind, tide, river & biomass. Lord Turner estimates a 25% increase in oil-based energy costs over the next decade (Turner Climate Change & Energy Report 01.12.08). Peak Oil occurs when flow-rate capacity from new discoveries becomes less than the flow-rate capacity from existing reserves. The oil industry now concedes that this state will be reached by 2013 at the latest. There is concern that the inexorable rise in fuel prices, only temporarily reversed by the recession, will push more and more people into fuel poverty and it is estimated that 1.6 million households could be so categorized soon (Times July 18th 2008).

Commodities in general will also rise as 95% of our food is dependent upon oil due to the manufacture of fertilizers and pesticides, and transportation (Soil Association 2008 "An Inconvenient Truth about Food – Neither secure, nor resilient"). Our energy security is poor, due to our own rapidly dwindling oil and gas resources, our utility companies being based outside the UK, and Russia showing itself adept at restricting gas supplies to western Europe – if France and Germany, who own our utilities, have a shortage in their own countries they are hardly going to let the flow continue preferentially in the direction of the UK, small though this may be at present! This will affect us all, so whether we believe in the human contribution to global warming or not, there are increasing practical and economic pressures to change to a non-oil based sustainable energy supply if only to keep long term costs and supply under control. Any schemes to provide such **sustainable** energy to the village should be welcomed by the whole community.

How might we benefit? The electricity is used by the person generating it and any surplus is passed into the grid and purchased by a power company. The benefits accrue from a combination of the savings on electricity used, from the revenue paid for the surplus sold, and from government Renewable Obligation Certificates (ROCs, see report).

This document is not a proposal, but rather an overview of possible options for any grant funded community scheme. If anyone managing a community building wished to explore any of them further a more detailed specific appraisal would have to be done. Community scale installations are intended to lower carbon emissions and improve cash flow for not-for-profit organizations. Additional options do exist that fall outside such funding (e.g. tidal, wave, large wind generator) but mention is made of them to complete the picture. Finally, the principles applied to community buildings are exactly the same as those you would apply to your own home – but of course the grant system is totally different.

Peter Brown
Lead, U3A Yealm Environment Group, Feb 2009

Newton Ferrers and Noss Mayo Renewable Energy Options for Community Buildings

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1. Introduction

The applicability of renewable energy technology is very site specific. This report describes each mainstream micro-scale renewable energy technology[1]; how and where it would be applicable; and, by using specific examples from the Newton and Noss area, what application would entail and achieve. The sites described herein have not been examined thoroughly, and broad assumptions must be made. However, it is not thought that the lack of hard information will harm the intent of this work, which is to convey generalities, not design systems.

It is important that any consideration of renewable energy installations begin with a thorough understanding of the environment in which the installation would exist. The information given here must be understood in light of the specifics of a site. Understanding a site should involve understanding the potential energy saving measures available. Energy efficiency *must* go hand-in-hand with renewable energy. Efficiency will not only itself save costs, but it can reduce the demand to be placed on a renewable system, potentially reducing the cost of that system. Especially in the case of space heating technologies, which have no option to export excess energy, the cost of an appropriate system will be reduced if efficient energy use can be achieved.

It is also important to understand why renewable energy technology should be in place, and how the use of specific terms applies to these technologies. These issues are discussed below.

1.1. Site Visit

Tuesday, 18th November, 2008. – Andrew Knox – Meeting with Peter Brown of The U3A Yealm Environment Group.

1.2. kWh and kW

The terms kWh (kilowatt hour) and kW (kilowatt) are used extensively throughout this report. A thorough understanding of their meaning will clarify the descriptions of many of the systems described here, as well as the recommendations made. A kWh is a unit of *energy* while a kW is a unit of *power*. In colloquial language, “energy” and “power” are used interchangeably, but in electricity and heat generation, the distinction is very important. Energy is technically defined as the ability to do work. Described in units of kWh, energy is what we pay for when we pay electricity bills. Power, described in units of kW, is the rate of energy use (or “generation”) in a given time. While a kettle may use a certain number of kWh to boil water, it won’t boil water very quickly if there are not enough kW supplied. It takes the right amount of *power* (kW) as well as the right amount of energy. Children sometimes seem to have inexhaustible amounts of energy, but often do not have the power to lift what adults can. They have the kWh, but they don’t have the kW.

Many renewable energy systems are described in terms of kW (e.g., a 5 kW turbine, a 12 kW photovoltaic system). This type of description gives the amount of power than can be generated by

[1] Aside from hydro, which is described elsewhere.

the system. However, it does not guarantee that there will be constant delivery of power at the level stated. The number of kW used to describe a generation system is the maximum power output of that system. A 5 kW wind turbine will not be delivering 5 kW for very much of its useful life. It will only do so when the wind is blowing extremely hard, and at all other times it will deliver a number of kW between 0 and 5. A 2 kW photovoltaic array could run the 2 kW kettle by itself, but only when the sun was shining very, very brightly.

For grid connected properties, power limitations are not a problem. If a 2 kW demand is in place and a renewable system is only delivering 1 kW, the extra 1 kW will come from the national electricity grid. For off-grid properties, 1 kW may come from a generator (renewable or otherwise) and the other kW may come from energy storage systems (like batteries). What is important in either case, not only for the purposes of understanding this report, is that users of any energy system understand the nature of kWh (energy), kW (power).

2. Energy Savings

Good quality insulation, other energy-saving devices, and associated building use are the cornerstone of a sustainable energy project. If the effective heat-load and electricity requirement for the a site can be reduced as much as possible, the specifications of either conventional or renewable energy systems can also be reduced; as can initial capital costs and ongoing running costs. Energy efficient buildings make good economic and environmental sense.

2.1. Heat Energy

Most of the energy used in buildings is heat energy. There are many options for reducing heat energy used. Fuel bills can be used to construct records of energy use at a site, and these can be compared to benchmarks for similar buildings. Benchmarks can be found in publications hosted on the Carbon Trust's website (http://www.carbontrust.co.uk/default.ct). Users must register to gain access to the publications, but there is no registration cost. The publication "ECG078 – Energy use in sports and recreation buildings", for example, indicates the annual energy use per area of recreational buildings. Average and best practice figures are supplied, and the energy history of a site can be compared, providing an indication of how much scope for improvement exists. The major considerations in the saving of heat energy (air-tightness, boiler efficiency, and insulation) are discussed below, and should help direct energy saving efforts.

It will be assumed that one kWh of heat from gas costs 4 p, though this will change on a site by site basis.

2.1.1. Air-Tightness and Ventilation

Uncontrolled air loss beyond what is required for fresh air and health of occupants is a major drain on a building's energy resources. Air-tightness of buildings is measured in cubic meters of air infiltration per square meter of building area per hour. Improving air-tightness by even 1 m^3/m^2*hour, will save 37 p/year for each square meter of a building's area (assuming 8 hours of heating per day through winter months). Such an improvement in a building with just 500 m^2 internal floor space, would save £184, and 0.89 tonnes of CO_2/annum. Improving air-tightness down to 3 m^3/m^2*hour would open the option of heat-exchanging ventilation, a technology that uses a heat exchange between outgoing and incoming air to pre-warm fresh air and reduce the work load placed on a boiler. (However, 20 m^3/m^2*hour is as best as can be hoped for in buildings that have received no attention to air-tightness, and it is very difficult to improve this figure down to 3 m^3/m^2*hour). Of course, in working with air-tightness, ventilation concerns are paramount. For health reasons, people occupying a building will need a least 2 complete air changes every hour. Air-tightness can save energy, but it should not be made to compromise proper ventilation.

2.1.2. Efficient Boilers

If fossil fuel boilers are to be used, they should be as efficient as possible. Each wasted kWh of fossil fuel derived heat, depending on fuel used, emits between 0.193 and 0.281 $kgCO_2$

unnecessarily. Assuming domestic rates of heating, the 500 m^2 building mentioned above would emit between 130 and 200 $kgCO_2$/year for every percentage point of efficiency lost (though there is a law of diminishing returns as efficiency increases). If a renewably powered heating system is unlikely, replacing an old boiler may be the best carbon saving measure.

2.1.3. Improved Insulation

Installing cavity wall and loft insulation where there is none makes a tremendous impact on both heat load (i.e. required boiler size) and energy consumption. Installing this kind of insulation is a simple procedure and is very cost effective in nearly all cases. Even improving insulation where there is little can very often pay for itself in 3 to 5 years. Installing floor insulation is more complex and expensive, but can be done, as can the addition of external and internal wall insulation (thought external wall insulation is often quite expensive, and internal insulation results in reduced interior space). Improving the energy performance of windows through secondary or double glazing can also reduce heat requirements, but can be expensive and difficult to obtain planning permission for. These insulating measures should be considered in every case where there is a desire for energy savings or renewable energy.

2.2. Electrical Energy

Electrical energy is the most carbon intensive form of energy used in buildings on a regular basis. As with heat energy, it is valuable in any building to compare usage history to benchmarks. Efficient lighting, fans, and pumps are discussed here, but, of course, any electricity use can be made more efficient. Old electrical domestic appliances such as fridges and washing machines can be upgraded to modern more efficient ones – look for the energy saving mark.

2.2.1. Lighting

Efficient lighting options have been developed extensively. Traditional tungsten filament bulbs can be replaced with compact fluorescent bulbs for a 75 % savings, and the efficiency of fluorescent tube bulbs can be improved by 30 – 45% by changing the fittings to dedicated energy efficient savings. Lighting tends to make up a large percentage of the electricity expenditure in community buildings, so gains in efficiency here can have valuable impacts. LED lighting offers a mercury-free alternative to CFLs. and are improving rapidly in both light intensity and in reducing the harshness of the white light as well as coming down in cost.

2.2.2. Fans and Pumps

Making up a comparatively lesser portion (6 - 11%) of total use are the fans and pumps that supply things like water and fresh air. Replacement of old fans and pumps with newer, efficient models can reduce consumption from these machines by 2/3.

3. Renewable Energy

As efficient as the use of energy can be, there will always be a need for energy inputs. With climate change, resource scarcity, and rising energy costs there is a need for energy from clean, renewable, natural resources. Renewable Energy technologies provide for this need. Installers of the technologies discussed are listed on the attached installers list.

3.1. Why Renewables?

- Reduced use of ‘conventional’ / ‘fossil-fuel’ derived energy sources (i.e., coal, oil and gas), and their replacement with renewable energy options (ultimately derived from non-finite solar-derived sources, i.e., wind, water, solar, biomass, biogas and earth energy) will help reduce Carbon Dioxide (CO_2) emissions to the atmosphere (a by-product of the fossil-fuel combustion process, and a ‘Greenhouse-Gas’ largely responsible for ‘Climate Change’).

- Renewable energy options are generally economically attractive, certainly if the initial capital costs of installations are weighed against (potentially) decades of cheap / free energy supplies.
- Many renewable energy technologies will be based on free or cheap natural resources, and as such will not be subject to fluctuating and potentially crippling fuel cost rises, which are influenced by the local and international market. The persistent availability of power sources (wind, sun, etc.) allows for more stable financial budget management by site managers. It also provides a level of energy security that does not rely on mains providers.

3.2. Renewable Obligation Certificates (ROCs)

Renewable Obligation Certificates (ROCs) are certificates that can be earned by generating renewable electricity (and not, at present, heat). These certificates are worth money to the generator. At present, they are worth 4.5 p/kWh, but the number of ROCs awarded for microgeneration (less than 50 MW scale generation) is projected to double in the Spring of 2009, raising the value to 9 p/kWh. Some Power Purchase Agreements (such as the Scottish and Southern Energy 18 p/kWh deal) require the generator's ROCs to go to the supply company, while others do not. ROCs can often make the difference between economic viability and project failure. They also represent a significant portion of income from generation. Forms required for the claiming of ROCs can be obtained from OFGEM.

ROCs are the government's current renewable electricity incentive, but there are plans in place for the introduction of a "feed-in tariff" that will provide further increases in the value of renewable electricity to the generator. The magnitude of the upcoming increase has yet to be made public.

3.3. Export Limitations (the "Export Cap")

If any system, or combination of systems, is exporting (selling to the grid), at any time, more than roughly 3.7 kW/phase of electricity, Western Power Distribution must be contacted to inquire about the robustness of the site's grid connection. More than 3.7 kW/phase can be exported, but it may require installation of special equipment at the point of grid connection. To inquire about the export cap for a specific site (which may or may not be subject to the 3.7 kW/phase export cap) call Western Power Distribution at 0845 6012989. State the nature of your inquiry and the location (with Post Code) of the building you are inquiring about, and you should be put in touch with the person responsible for new micro-generation in your area.

3.4. Photovoltaic (PV) Cells

Photovoltaic cells are capable of converting light into electricity. The most common and reliable type of PV cells are made from silicon crystal and can convert the sun's rays to electrical energy with an efficiency between 13 and 15%. The lifetime of PV cells is between 25 and 35 years. The last few years of a PV system's lifetime can make a substantial difference to the economic picture, so buying a well-made product should be a priority.

New solar electricity technologies are being developed with the aim of providing higher efficiency at lower cost. However, at this time, no such technology has been proven effective, durable, and robust.

While PV cells are expensive for the amount of electricity they supply, they have an advantage in that most sites have solar resource and can make use of PV. There is no requirement for high winds or flowing water. All that is necessary is a location where PV cells (or "solar panels") can be pointed in the direction of the sun. Offsetting the expense (somewhat) are Government incentives which effectively increase the value of electricity generated, and available grants.

In the UK (depending upon location), 1 m^2 of photovoltaic cells can provide 100 - 125 kWh of electricity per year, depending upon the roof orientation and available solar energy resource (the South West has a good solar resource relative to the rest of the UK). PV cells do not have to be dedicated to any purpose, they merely generate energy for a holding and that energy can be used or exported based on requirements and availability.

For every 2 kW of electricity generation capacity, a building may require something in the region of 15 - 18 m^2 of cells on its roof-space (see similar sized example shown), at a cost of approximately £11,000 - £12,000 without a grant (prices do vary but these are ball-park figures).

It is tempting to say, in the case of PV, that the economics should be ignored, and that even if grant funding cannot be obtained, the value of the environmental benefits is worth the high capital costs. While this may be true in some cases, the economics of low carbon technologies cannot be ignored. The most cost effective carbon savings should be made first, so that total carbon savings can be maximized. Investing in energy efficiency could potentially make the same carbon savings as a PV project would, but for less money. In this case, there would be money left over for further investment.

In the Newton and Noss area, attention must be paid to shading in the valley. Losing even 30 minutes of sunlight per day will result in a much reduced output over the lifetime of PV panels. With the economics of PV being only marginally beneficial, if beneficial at all, even a small loss is important. PV should only be place in areas that will receive little shading through all seasons. Thus, areas in the lower parts of the valley should not be considered for PV installations.

3.4.1. Application of PV in Newton and Noss: Bishop's Court

Finding a site in the Newton and Noss area that is minimally shaded is difficult, given the steep terrain and the tendency of major roads (and buildings shooting off from them) to run at the bottom of hills. However, it will be assumed that Bishop's Court, a building hosting a housing association, is sufficiently unshaded, and that PV can be appropriately applied there. Again, the information here should be transferable to other buildings. If Bishop's Court is later determined to be unsuitable, this information should be useful at a suitable site.

It is estimated that the Court has 130 m^2 of south facing roof space available for PV. At an average of 8.3 m^2 per kW, 130 m^2 allows for 15 kW of PV. 15 kW is above the standard export cap of 3.7 kW per phase (it is assumed that 3 phase power is available). Thus, Western Power Distribution must be contacted before a 15 kW scheme can go ahead. It will be assumed here that Bishop's Court is capable of exporting 15 kW, but there may be a limit of 11.1 kW imposed. The size of the system should drive the price per kW installed below £5,000, and the system should cost in the area of £73,000. According to the European Commission's PV estimation tool, a 15 kW system at Bishop's Court should be able to generate 14,400 kWh/year, saving 7.3 tonnes of CO_2 per year. Savings equivalent to 10p/kWh can be made with a system of this size, resulting in a savings of roughly £1,400 per year on electricity bills. If April's doubling of ROCs results in an additional 4.5 p/kWh, then savings will increase to £2,000/year. These savings accrue from a combination of savings on electricity used and from the revenue paid for the surplus sold to the grid.

3.5. Wind Power

Figure 1 shows the wind speeds in the Newton and Noss area, as determined by the BWEA (British Wind Energy Association) Wind Speed database. In each OS grid square, the numbers indicate average speed in meters per second in that square. The lowest number in each square is the wind speed at 10 m above ground level (agl), the middle number is the speed at 25 m agl, and the highest number is the speed at 45 m agl.

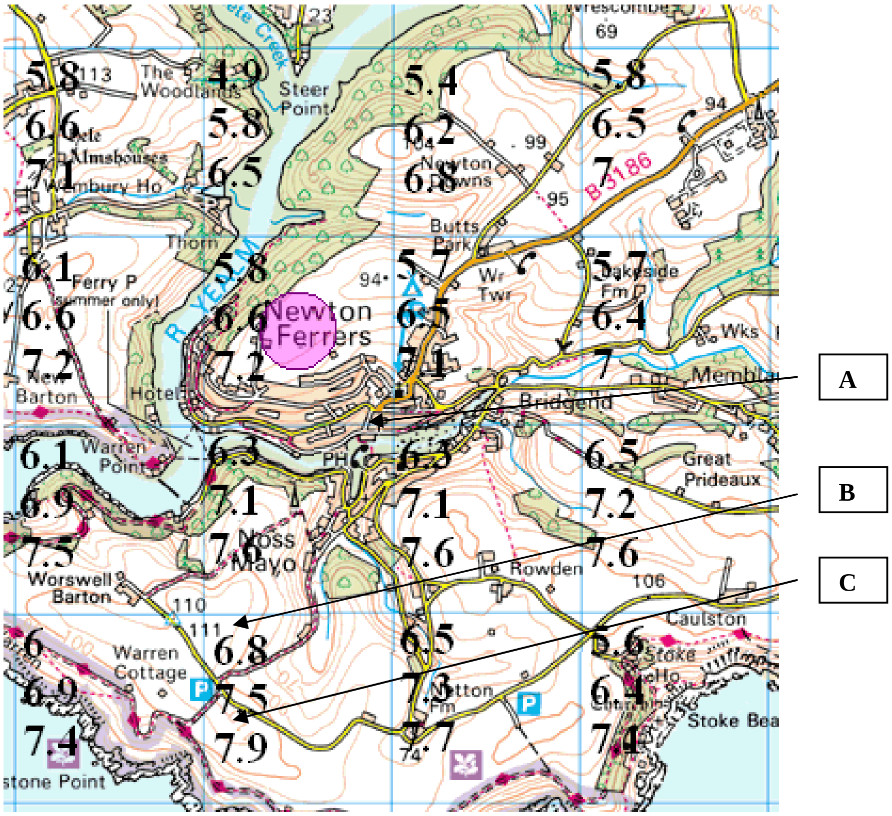


Figure 1: Wind speeds in the Newton and Noss area. Speeds are given in m/s, with the lowest speeds being those at 10 m agl, the middle numbers being speeds at 25 m agl, and the highest numbers being the speeds at 45 m agl.

Site A is using the theoretical consideration of the PO/Shop as a site, while B & C are theoretical sites chosen for better wind speeds and are located so that they would be least visible from either the villages or the coast path. The latter positions would require the installation of electricity grid connection and would be preferable for larger scale generation.

5 m/s is the threshold for economic performance for small (5 – 50 kW) turbines, so it can be seen that the Newton and Noss area is blessed with good to excellent wind speed, depending on area.

What must be understood is that the wind speeds indicated are averages over a grid square. A range of elevations is covered in each of the squares shown, and wind speeds at higher elevations will be higher than those at low elevations. A wind speed of 6.5 m/s, then, must be interpreted at an average between low elevation speeds (which would be lower than 6.5 m/s) and high elevation speeds (which would be higher than 6.5 m/s). One effect of this averaging is that the highest wind speed shown on the map (7.9 m/s) is actually exceeded at the higher elevations, meaning that there are locations with speeds above 8 m/s (at 45 m agl) available to the Newton and Noss area. With an average annual wind speed above 8 m/s, any robust turbine would be an outstanding investment opportunity.

While the areas along the coast are the best wind sites in the area, the community buildings of the Newton and Noss area on the north side of the valley will have wind speeds that are likely to be lower than the average presented, and there will be turbulence problems. Not only with the landscape (the valley itself) have the potential to introduce turbulence, but surrounding buildings will certainly introduce turbulence. Buildings such as Bishop’s Court, which are likely to be high enough in the valley to avoid too much turbulence from the valley itself, still must deal with the turbulence from surrounding buildings. Turbulence will not only reduce levels of generation, but will damage a turbine and reduce its useful life. Unfortunately, it is only for community organizations and buildings that most of the renewable energy grants are available. Despite the technical limitations presented by the surroundings of community buildings in the Newton and Noss area, the requirements for grant funding virtually demands that installations occur in these settings.

The density of buildings around the community buildings in the Newton and Noss area also presents a noise related problem. Installers of turbines will suggest that for noise reasons, a turbine should be 50 m from the owner's building, but 100 m from any neighbours. Neighbours are not so far away from buildings like Bishop's Court, the WI Hall, or the Primary School. With the proximity of neighbours, planning objections are likely to arise. If a generation site is used which is remote to where it is used then no savings accrue from use of the electricity, only from selling it on.

3.5.1. Application of Wind Power in Newton and Noss 1: Bishop's Court

For the sake of an example, it will be assumed that a turbine can be installed at Bishop's Court (A) at such a height that turbulence will not be a problem and noise will be ignored.

The turbines representing those appropriate for the site include the Iskra AT5 – 1, the Westwind 10, and the Westwind 20. These turbines have rated outputs of 5, 10, and 20 kW, respectively. Their annual generation curves are shown in Figures 2 – 4. The turbines discussed here can be fully grant funded by matching available grants.

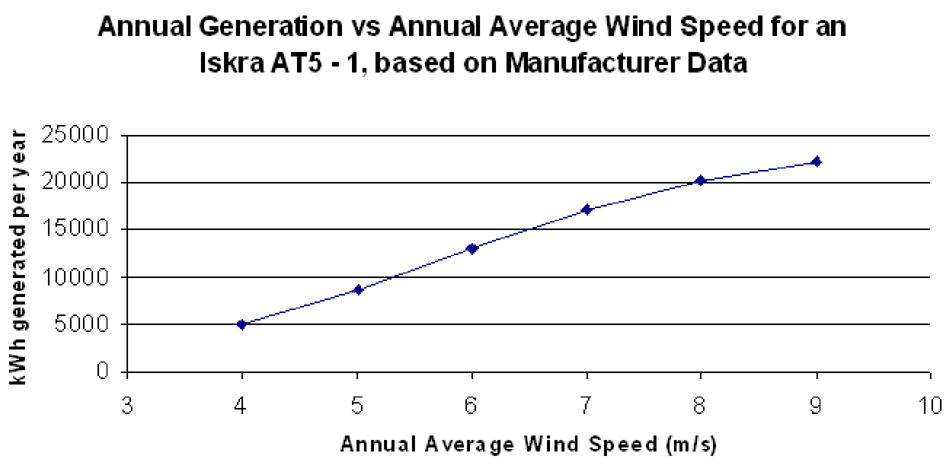


Figure 2: Annual Generation based on average wind speed for Iskra AT5 – 1

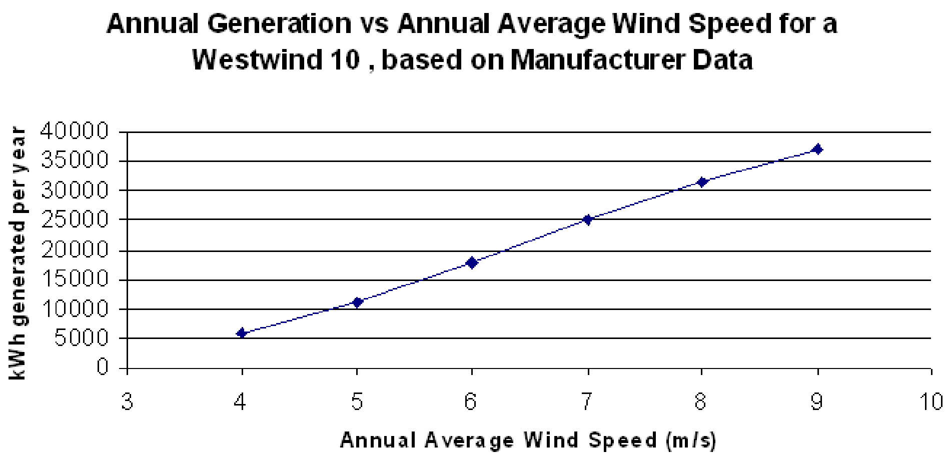


Figure 3: Annual Generation based on average wind speed for Westwind 10

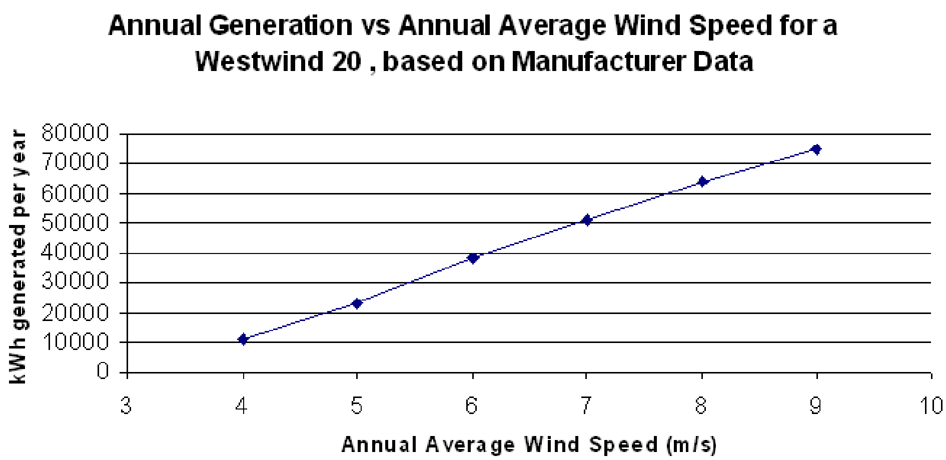


Figure 4: Annual Generation based on average wind speed for Westwind 20

Figure 5: An Iskra AT5 - 1 installed.

Figure 6: Westwind 10s installed.

Figure 7: Westwind 20s installed.

Larger turbines may be considered, but if it's unrealistic to think that even these turbines can make it through noise objections, then larger turbines will only have worse problems. Also, in combination with a PV project, these turbines would battle against the grid's ability to accept exported electricity. The Westwind 20 by itself surpasses the standard export cap.

It will be assumed here that these turbines would be subject to an annual average wind speed of 5.8 m/s. This is the average speed given by the BWEA database for 10 m agl. The standard mast height for an Iskra AT5 – 1 is 15 m, so it is known that these turbines will have height greater than 10 m/s, but speeds above 5.8 m/s cannot be assumed. Bishop's Court is probably at a location that sees lower than average speeds for it's OS grid square, so assuming 5.8 m/s the appropriately cautious approach.

According to the data in Figure 2 – 4, the Iskra AT 5 – 1 will generate 11,900 kWh/year in a speed of 5.8 m/s, and the Westwind 10 and 20 will generate 16,900 kWh/year and 34,500 kWh/year, respectively. At an average value of 10 p/kWh, these figures represent savings of £1,190/year, £1,690/year, and £3,450/year. If the doubling of ROCs results in an increase in the value of electricity of 4.5p/kWh, savings will increase to £1,720, £2,450, and £5,000/year.

As the av. House uses 5-6MWh/yr then this is equivalent to the power requirements of 2, 3 and 5.75 houses/annum. To power a significant part of the village MW, not kW scale turbines would be required, costing about £2M and requiring a business partnership arrangement as such a scheme would fall outside the criteria for grant application. However the payback time would be 6-8 years making a sound business proposition.

The "Guidelines to DEFRA's Greenhouse Gas (GHG) Conversion Factors for Company Reporting" (http://www.defra.gov.uk/environment/business/envrp/conversion-factors.htm) gives a trend of carbon intensity of electricity that would suggest that today normal grid electricity causes the emission of 0.51 $kgCO_2$ per kWh used. This figure can be used to calculate carbon savings from the turbines discussed above. In the case of the Iskra AT5 –1, for example, the savings are 6069 $kgCO_2$ per year (0.51*11,900).

3.5.2. Application of Wind Power in Newton and Noss 2: Valley Top Turbine

One option for avoiding both turbulence and noise would be for the Newton and Noss Environment Group to champion a turbine far from any building, and be the organization under which the grants would be organized. The site (B or C) on the western portion of the south of the crest of the valley's southern summit, would be an ideal site for such a project. Not only would technical problems be avoided, but also wind speeds at the suggested site are higher than in the built area of the village from which it would not be visible. However, but as a turbine moves further from a building, the cost of cabling to a grid connection increases. Any project far from a simple grid connection should be of a scale that it can pay for the associated grid infrastructure. Such a project would be in the 50 kW or higher range.

The WES 18 Mk1 will be used as an example here. This turbine model is manufactured by Wind Energy Solutions (http://www.windenergysolutions.nl/), and has a rated output of 80 kW. The rotor diameter is 18 m, and while a 19 m mast is available, it is suggested, for the sake of safety, that a mast be selected from the 25, 31, or 40 m options. At 25 m, at the site described above, the annual average wind speed is 7.1 m/s. This average speed will result in 229,600 kWh/year (as indicated by the data in Figure 8). or the equivalent average power consumption of ~38 houses/annum. The WES Mk1 is fundable by the Community Sustainable Energy Programme (CSEP), but not by the Low Carbon Building Programme (LCBP) Phase 2. Unlike the turbines in the previous example, it is unlikely that full funding can be achieved. However, the economies of scale are such that this larger turbine will pay for itself much more quickly than the others will. On this basis, investment can be attracted to cover installation costs such as through a partnership with for, example, a power company. 229,600 kWh/year is such a large amount of electricity that it is unlikely to be sold at 10 p/kWh. It may be better to assume a price of 7 p/kWh, and the likely electricity purchase price should be agreed with purchasers before the installation goes ahead. At 7 p/kWh, earnings will be £14,600/year (with a £1,500/year maintenance allowance). Installation costs are not known, but can be estimated using rules of thumb at £120,000. This cost figure results in a payback period of 8.2 years. Of course, the installation costs will vary depending on the cost of any required electricity grid infrastructure work. The cost of such work is entirely unknown, but expected to be a small percentage of the turbine installation costs. If a Community Sustainable Energy Programme grant (maximum £50,000) can be secured, the costs will be reduced to £70,000, and the payback period will be only 4.8 years (plus time to pay off grid work). Further grant funding will decrease payback periods accordingly.

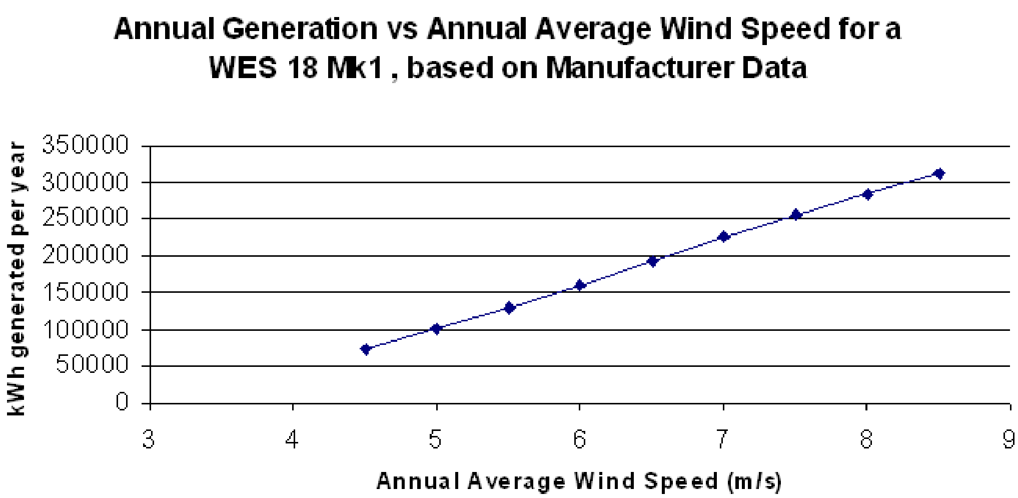


Figure 8: Annual Generation based on average wind speed for WES 18 Mk1

3.6. Hydro Generation

Hydro Generation options will be covered in a separate report as an appendix.

3.7. Power Purchase Agreement

The different value of electricity exported and electricity bought from a supplier should be detailed in an electricity supplier's "Power Purchase Agreement," (PPA). The values, terms and conditions vary between supply companies, so it pays to shop around for the deal which best suits a generator's particular circumstances.

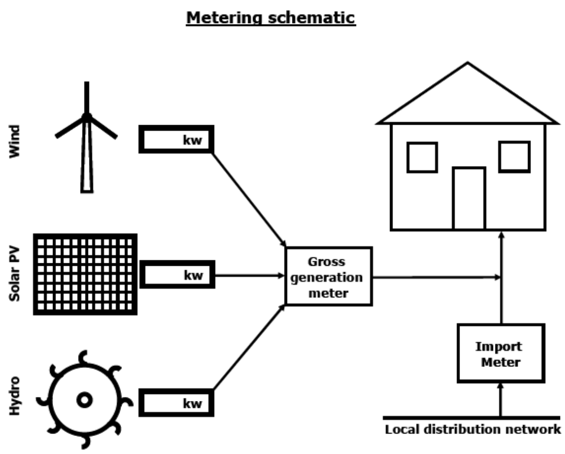
Four PPA offers the author is aware of are:

a) From EDF: 5p for all units generated, even those used on site. This rate is only available for sites exporting at less than 5 kW. For systems of 5 – 30 kW, EDF will pay either 4.5p for all units generated, or 7.6p for all units *exported*. Which of these two options is best depends on how much a site tends to export relative to how much it uses. This deal does not allow the generator to claim any value from ROCs.

b) From Good Energy: For systems less than 6 kW, exporting less than 5000 units per year, Good Energy will award 9p for all units generated, even those used on site, but Good Energy will keep the value of the generator's ROCs. Good Energy's import tariffs are higher than average, making the offer most beneficial only to users with specific generation profiles. Users may be awarded much value in generation credits, only to have to spend it on purchased energy. However, the higher tariffs are justified by an energy supply that is "entirely" from renewable sources.

c) From nPower: 12p per kWh exported. nPower will also manage a generator's ROCs, but will only pay 80% of their value to the generator. This offer is available only to generators exporting at less than 6 kW. (The 12p is for PV only, and drops to 10p for wind power).

d) From Scottish and Southern Energy: 18p per kWh exported, but Scottish and Southern retain the value of a generator's ROCs. 18p is offered for generators exporting at 5 kW or less.



The above offers are structured around ROCs at 4.5 p/kWh, and should change as the ROCs market does, as it is expected to in April of 2009. It could be that some PPAs have been put in place in anticipation of the increase in ROC value and will not be changed when ROCs do. However, the PPA market will change with ROCs, and generators of renewable electricity should give attention to this issue.

Generators will be required by all the above companies (and undoubtedly others) to use an OFGEM[2] approved meter (also required for a biannual award of ROCs by OFGEM, after an initial registration process), and to provide meter readings (at varying intervals, depending upon the company chosen) to the supply-company.

It is also worth remembering that it is a legal requirement for large grid-connected installations (such as a 5 kW PV array or a 15 kW turbine) to be automatically disconnected during a power-cut; to safeguard engineers repairing the network; even if PV panels or turbines are still generating.

3.8. Solar Water Heating

In a solar water heating (solar-thermal) system, water is slowly pumped through solar-thermal panels, warmed by the sun, then passed through (usually) a twin coil water cylinder via a heat exchanger, and is transported back to the collector via a pump to start the process again. This process increases the temperature of water in a hot water cylinder, such that conventional means of heating have less work to do. The water cylinder is also connected to a thermostatically controlled auxiliary heating supply (e.g. a conventional boiler or an electric heater coil, as a top-up in poor solar conditions). Cold water from the mains-supply is then drawn into the bottom of the cylinder as the heated water leaves the top of the cylinder and enters the required heating loop. Modern systems also include heat sensors that shut off the water pump unit if the system gets too hot (80°C+) and in some systems this pump is even run by electricity from a PV panel, providing a totally solar powered system.

[2] Office of Gas & Electricity Markets

Solar water heating requires an indirectly fed hot water tank, meaning a hot water tank that is heated by an internal coil through which hot water flows. Tanks that are heated *solely* by electric emersion elements will not facilitate solar water heating. Solar-thermal panels should be located as close as possible to the hot water tank to reduce plumbing costs and heat lost during transport of hot water.

Few community buildings can make proper use of solar water heating. If solar-heated water is delivered to a cylinder, the water must be used or it will cool in the tank, having made no carbon savings. Sites that are infrequently occupied or have little use for hot water do not have the hot water demand to take advantage of the technology. A community sports facility where showering was a regular occurrence would be an example of a community building where solar water heating was appropriate. Bishop's Court, if it qualified as a community organization, would be another good example. The WI Hall would not be a good site for solar water heating. A small system might be appropriate in a setting like the Primary School, where there is a small demand for hand washing.

Solar-thermal systems will deliver roughly 320 kWh/year per m^2 of panel, according to the Energy Savings Trust (corrected for greater solar resource in the Southwest). The same organization suggests a cost of not more that £5,000 for a 4 m^2 system. Such a system should deliver 1280 kWh/year. At a cost of 4 p/kWh of gas heating fuel, a 4 m^2 panel should save roughly £50/year. Such a savings would result in a 100 year grant payback period. Economically, solar-thermal is only appropriate for properties where heating fuel is more expensive than 4 p/kWh (such as those heated by electricity or oil). These figures can be scaled up (8 m^2 saves 2560 kWh/year, etc.) assuming demand exists to make use of the energy. As system size increases, cost per m^2 will decrease, but not so much that the payback period is likely to come within the lifetime of the system at present gas prices.

3.9. Heat-pumps

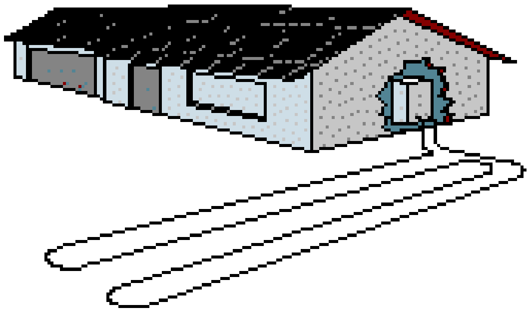
Heat-pump technology is an energy efficient method of space heating, as compared to fossil fuel boilers, in most cases. Its efficiency comes not from changing some form of energy into heat, but in moving existing heat from one source (the ground or air) into the space to be heated. A source of electricity is required to operate the associated pump and compressor, so heat-pumps are not entirely renewable unless the electricity used is from a renewable source. Nevertheless, heat-pumps' efficient use of existing heat make them a technology with a lower carbon footprint as compared to conventional space heating technology. Their long history and widespread use (in Europe) ensure that heat-pump systems are offered at a very economical price and, depending on the method of use, running costs can be very low.

Whether a heat-pump is going to effectively reduce energy expenditures and carbon emissions depends largely on its Coefficient of Performance (CoP). The CoP is the ratio of heat energy output to electrical energy input to a heat-pump. For a heat-pump to be effective, the CoP must be relatively high (3 would be a minimum acceptable value in most cases, with 3.5 or 4 being much more preferable). The need for a high CoP stems from electricity being both more expensive and more carbon intensive than most heating fuels. If the CoP isn't high enough, a heat-pump can cost more to run than conventional space heating systems and result in more carbon emissions. CoP tends to increase as the temperature required decreases. Underfloor heating uses lower temperature water to heat space, meaning that underfloor heating usually allows a heat-pump to operate with an above average CoP.

3.9.1. Ground-source Heat-pumps

An increasingly popular technology, which is based on the use of the background heat in the ground (originally emanating from a combination of the Earth's molten-core and the solar-gain from the sun's rays), is the Ground-Source Heat-Pump (GSHP) system. This is not a new idea – with over 50 years' development, this technology is now installed in hundreds of thousands of properties worldwide, including more than 55,000 installations in Sweden alone.

This system utilizes a series of water-filled pipes, which extend into the ground adjacent to a building (either horizontally in trenches, as in example left, or vertically in a borehole), absorbing



low-grade heat from the ground (approximately 12°C) and returning the warmed water back to a heat-pump. The heat-pump then compresses refrigerant and via heat exchangers, then circulates warmed water (potentially increased to as much as 50°C, but usually nearer to 35°C) to an underfloor or wall-mounted heating loop within a building, and then back to the pump, where the process starts again.

The external pipes and trenching are simple and relatively cheap. The heat-pump itself can be installed inside a structure or, if protected, outdoors and will generally be no bigger than a domestic fridge. No flues or ventilation will be necessary and the internal installation can be carried out by any competent plumber.

3.9.1.1. Application of GSHP at Newton and Noss: The Village Hall

The Village Hall is chosen as an example of a building in which a GSHP could apply. However, the Village Hall is chosen mostly for its simplistic geometry and *it is not the case* that a GSHP could necessarily be used effectively at it. It is used as an example only. It may be more correct to say that the GSHP description here would apply to a fictional version of the Village Hall where the following assumptions are correct:

- Underfloor heating is in place (oversized radiators may also work, but not as well)
- Only the main 11 by 8 meter section requires heating
- Insulation is at least up to 2006 building regulations
- Air-tightness is also up to 2006 building regulations
- There is enough outdoor space to apply either horizontal trenching or borehole based external heat collection tubing/piping.

Any building in which these assumptions are not correct (such as the non-fictional, actual Village Hall) should not have a heat-pump installed. Such a building will make only minor economic gains using a heat-pump, if it makes any gains at all, and it runs the risk of a heat-pump being a more expensive, more carbon intensive method of heating relative to current heating methods.

The heat load at the Fictional Village Hall (FV Hall), would be 14 kW. With a CoP of 4 (made feasible by underfloor heating and good insulation), the electrical input required to achieve 14 kW of heat output would be 3.33 kW. The Hall's electricity supply should not have a problem dealing with delivering 3.33 kW. A 14 kW heat pump should cost between £12,000 and £14,000, and costs will be closer to the higher end if boreholes are required. Actual cost and carbon savings depend on the rate of use, but were the Hall used 4 hours per day, savings would be £62/year (savings would increase in situations were heating was required more constantly, for example, 8 to 12 hours per day). The emission of CO_2 would be reduced by such a system by 0.9 tonnes/year.

3.9.2. Air-source Heat-pumps

An ASHP can do the same work as a GSHP, but requires more power to do so. External air is a less temperature-stable heat source than the ground is, and when the air is cold, an ASHP will have to work much harder, and will operate with a poor CoP, relative to a GSHP. The advantage of an ASHP is that the capital costs are lower, and the installation is much easier to perform. There is no requirement for digging, or for much external space. An ASHP, applied to The FV Hall, would save only £5/year, thought the carbon savings would still be substantial, at 0.7 tonnes per year of CO_2. Electrical load associated with an ASHP would be higher than that associated with a GSHP. The reduced average CoP (estimated at 2.8) would result in an average electrical load of 4.8 kW, but the load, like the CoP, would fluctuate with outside temperatures.

3.10. Biomass Heating

Biomass includes a range of potentially combustible organic matter, either waste-based or purpose grown, and either processed into a clean, uniform fuel-stock (e.g. wood-chips or pellets), or essentially non-processed (e.g. logs and carpentry waste). Consequently, biomass will often tie in with local small-holders and farmers or local forestry and timber processing interests. There is a joinery/kitchen fitters in the village, and a couple of boat builder's workshops producing possible biomass as waste, while the village is fortunate to have woodlands whose regular maintenance could do likewise. Such local sourcing would be cheaper than purchasing the commercial biofuel discussed below.

Hot water produced by biomass boilers is transferred to the main wet loop heating system and hot water tanks, as would be the case with fossil fuel boilers, to provide space heating and hot water. Insulated heat mains, which channel the hot water between buildings, lose only 1 ˚C per km, but can cost roughly £50-130/m, depending on the length required and heat loads to be met. Smaller heat loads will be at the lower end of the price range. Trenched heat mains at community buildings in the Newton and Noss area should not cost more than £50/m to purchase, but an additional cost of pipe trenching on the order of £30/m should be expected. Underground heat mains would only be necessary if either the boiler were located in a structure separate from the building to be heated, or if more than one building was to be heated by one boiler. A small Affordable Housing scheme would be an example of the latter.

There is a range of manufacturers of biomass-fuelled space heaters and many models to choose from (many of them European, as Britain is years behind Europe in the widespread use of bio-fuels). The range covers small wood-stove or "Rayburn"-sized heaters, up to large industrial sized installations of several thousand kW rated output. Also, depending on the building(s) requiring heat, and the available fuel source, there are either automatically fuel-fed systems (based on wood-pellet or wood-chip fuel, stored in adjacent fuel store with an auger fuel feed), which have sophisticated and user-friendly electronic controls; or alternatively, more basic manual or machinery-fed systems for larger and less processed fuel types (e.g. logs or straw bales). On-site maintenance and labour requirements, ash waste, loading equipment and space requirements will all vary depending on the system choice.

When comparing the economics of various fuels, when purchased in bulk, wood chips are cheaper than oil, much cheaper than electricity and LPG (bottled gas) and are comparable (and often cheaper) on a pence per kW rating to mains gas. The economic situation for biomass boilers improves considerably when purchased fuel is either supplemented or eliminated by an in house supply of wood. Wood-pellets (see picture) are roughly twice as expensive, but are still cheaper than oil. Of course, wood-chip prices (ideally purchased from a relatively local supplier via a fuel supply contract of several years), will remain far more stable than fossil-fuels; and wood pellet prices should slowly decrease as pellet production increases both regionally and nationally. We are lucky in Devon to be on the doorstep of one of the leading multi-organization initiatives to promote wood-fuel heating in parallel with development of a sustainable fuel-supply network.

3.10.1. Automatically Fed Biomass Boilers – e.g. The WI Hall

In the example of the WI Hall (WI), pellets are the appropriate fuel. The heat load of the WI Hall is small enough to be in the range pellet boilers are manufactured for. Larger heat loads (>35 kW) would be more suitable for chip (the cheaper fuel).

An automatic wood-pellet boiler system would require a suitable plant-room, and adjacent fuel-store. Such a combined plant-room and fuel-store would also require cold water and a robust electricity supply. While 3-phase is often preferred, most biomass boilers can use single-phase.

Another requirement would be a large hot water tank, or thermal store. These tanks help heat demand match heat supply by storing heat in the form of hot water. Doing so allows the boiler to react to changes in demand at an optimum speed (slowly) while stored heat meets the demand in the short term.

A biomass boiler requires more labour (albeit not hard labour) than a fossil fuel boiler or a heat-pump does. Operators of biomass boilers on the scale required at the WI Hall should allow for a quarter day of labour per month for things like visual inspection, de-ashing, cleaning of components, and keeping to a maintenance schedule. This labour does not include boiler breakdowns, which are more difficult to repair than they would be in the case of fossil fuel boilers. The difficulty springs from the small number of people in the UK qualified to repair biomass boilers, relative to those qualified to repair fossil fuel boilers.

Biomass boilers will take longer to warm a space up than conventional boilers do. Conventional boilers are sized to bring a space from cold to warm very rapidly, and then reduce output to lower than their maximum. To size a boiler according to this principle would be a tremendous waste of capital. 33% of the boiler's capacity would have to be paid for, but would be in use less than 10% of the time. This cost is often found acceptable in the case of cheap fossil fuel boilers, but when each kW of capacity can cost £300 – 400, an extra 33% is an expensive luxury. As well, while modern biomass boilers can operate at as low as 20% of their maximum output efficiently, they are never as efficient as when running at maximum. It is best in terms of capital cost and in terms of efficiency to size a boiler so that it has just enough capacity to do its job, than to size it too large. The result is that with biomass, raising a space's temperature takes more time, so forethought and time switches should be employed.

If a fully automatic biomass boiler is chosen, the main hurdle to cross will be initial installation cost. These systems typically cost £300 - £400 per kW installed – significantly higher than installing a comparable mains-gas or oil boiler. Biomass is, however, a proven cheap and reliable alternative to oil or gas fuelled heating systems, and, of course, it will not be prone to the expected price rises in the fossil fuel sector over the coming decades – arguably a wise investment for the future. For a comparison of fuel prices, see Table 1.

The costs of heating-oil, mains-gas and LPG can substantially fluctuate (due to international market values), unlike locally derived wood-fuels which should be relatively price-stable. Wood-pellet is slightly different, as there is currently little regional pellet production, so its current price is high, and its price should slowly come down as local production increases. It should also be noted that the efficiency of the heating-appliance will have a dramatic effect on the cost of the price per unit of energy; e.g., logs burnt in an open fire at 10% efficiency will cost eight times more per unit of useful heat compared to wood-chips burnt at 80 % efficiency in a boiler, if the price of the wood was equal. Log boilers can achieve a similarly high (>80%) efficiency, as it is not the fuel, but the heating appliance that largely determines efficiency.

Fuel delivery is often a major challenge in the case of biomass boilers. Ideally a fuel store that can be tipped into and has good road access would be in place. Ease of delivery is something strongly considered when suppliers offer a price for chip, and compromises on store design lead to regret more often than not. Space and road access for a fuel store may confound biomass ambitions

Fuel Type	Tariff	Cost of Fuel (p/kWh)	Useful Heat (p/kWh)
Logs (50% MC[3])	£40/tonne	1.8	2.2
Logs (25% MC)	£70/tonne	2.2	2.8
Wood-Chip (30% MC)	£100/tonne	2.8	3.1
Wood-pellet (bulk)	£200/tonne	3.6	4.2

Table 1: Comparison of costs of heating fuel.

at most community buildings in the Newton and Noss area, but a site like the WI Hall, if infrequently used, should be able to store enough pellets (but not chip) to last a substantial part of the year. If existing buildings, or parts of them, can be used as a boiler house and fuel store, there could be substantial cost savings, especially if planning authorities demand that any new buildings fit aesthetically with the surroundings.

[3] MC = Moisture Content

3.10.1.1. Application of Automatically Fed Biomass Boilers at Newton and Noss WI Hall

For the application of a 14 kW pellet boiler, the WI Hall does not have to be fictionalized. Biomass boilers can deliver water at the same temperature that fossil fuel boilers can, so existing heat delivery appliances can be used. A mid-range cost for such a boiler would be £5,000 for the boiler alone. A thermal store and ancillaries will cost extra, but the site by site variability of such costs make them difficult to estimate. With the assumed 4 p/kWh for fossil fuel based heat, pellets do not offer savings on running costs (at 4.2 p/kWh), but the carbon savings, again assuming 4 hours per day of use, would be 1 tonne CO_2/year. Monetary savings, it would be hoped, would be realized as scarcity drives up the cost of fossil fuel and widespread pelletization lowers the cost of pellets. As mentioned, with low rates of use, a fuel store of a few (3 – 4) tonnes of pellets should not need topping up more than 5 times per year. Such a store would require roughly 1 m^3 per tonne of space.

3.10.2. Manually Fed Biomass Boilers

A manually fed boiler would be fuelled by logs. It would be very similar to a pellet boiler, except that it would cost less (roughly £3,500 vs £5,000), and logs would have to be loaded into a magazine on a daily basis in the winter, but less frequently in warmer seasons). This extra labour requirement is something many boiler operators are not comfortable with, but it does simplify some of the supply issues, and there are greater carbon savings involved (1.4 tonnes per year vs. 1 tonne). The additional carbon savings is a result of not having to chip the wood.

4. Funding Sources

There are many organizations that offer grants for renewable energy microgeneration. Some are detailed below. Most application packages for the funds discussed below will include sections on energy efficiency and "sustainability." Sustainability, as it is used in the context of these applications, means environmentally friendly actions, measures, technologies, and programmes not directly associated with the generation of energy. Energy efficiency measures would be included in this category, as would things such as rain water harvesting, community gardening, and recycling.

4.1. Low Carbon Buildings Programme – Phase 2

The renewable energy systems considered in this report are potentially supportable by government funding, via the 'Low Carbon Buildings Programme' (LCBP). The programme's details are at http://www.lowcarbonbuildingsphase2.org.uk/. To secure funding from Government grant schemes, installers accredited by the LCBP Framework Suppliers scheme must be used. The LCBP will only pay for installations completed by those accredited by the Programme. This accreditation can come directly from the LCBP *or* indirectly from the companies at the top of the Framework, such as British Gas. The LCBP saves having to accredit every local company by positioning local companies under the larger companies in the "framework". For the applicant, this means that potential installers must be able to produce, with their quote, a number (sometimes referred to as the British Gas number) that will be a requisite for the LCBP grant application.

If an applicant is successful, the LCBP Phase 2 will fund 50% of a renewable energy project's installation and capital costs. LCBP funding can be matched with the other grants discussed below.

The largest wind turbine funded by the LCBP Phase 2 is the Proven 6, a 6 kW turbine. Larger wind project cannot be funded by LCBP Phase 2.[4]

[4] Authors Note: As of February '09, many PV installers have been told by BRE that the LCBP money for PV will run out before March '09. At least one installer has been told to stop offering LCBP grants for PV. There is still money for other technologies.

4.2. Energy Supply Companies

Major power supply companies (Scottish Power, EDF, and E.ON are those most familiar to the author for giving grants) will fund renewable energy schemes that generate either heat or electricity. These companies do not have to be the electricity supply company for a site to fund that site's projects, but they will ask to be the only corporate sponsor. Contact the companies by phone to ask them to email you their applications and application guides.

EDF and E.ON provide a maximum of £30,000 up to 50% of project costs, whereas Scottish and Southern provide a maximum of £25,000, again up to a 50% maximum.

4.3. CSEP (Community Sustainable Energy Programme)

The Community Sustainable Energy Programme (CSEP), like the LCBP, will provide funds for renewable energy installations only. The maximum grant is £50,000 or 50% of the project costs, whichever is less. Find out more at http://www.communitysustainable.org.uk/. As lottery money, this fund is competitive. *CSEP also funds energy efficiency measures such as insulation* if a renewable energy installation is also involved in the project.

Installers of renewable energy technology must be certified under the BRE Microgeneration Certification Scheme. A list of certified installers is available at http://www.greenbooklive.com/search/search.jsp?partid=10013. Products to be installed (particular makes of solar panels, for example) must also be certified. Certified products are listed at http://www.greenbooklive.com/search/search.jsp?partid=10016.

Installers of energy efficiency measures must be officially associated with the trade bodies listed in section 4.5 of the CSEP guidance notes. The guidance notes can be found here: http://www.communitysustainable.org.uk/filelibrary/CSbreguidance.pdf.

5. Conclusion

It is hoped that the hypothetical applications of technologies discussed here can be useful in the consideration of renewable energy at any building in the Newton and Noss area. Many of the generalities should apply, and the specific requirements of a particular site (heat load, for example) should be available from installers of renewable energy systems. If any further information is required to bridge gaps, the author is available to the Yealm Environment Group at 01837 89200.

It is obvious that renewable energy technology, (even when considering relatively small-scale installations, potentially supportable by Government funding), generally doesn't come cheap. Long term gains via significantly reduced fuel and electricity costs will need to be weighed against significant initial capital outlay. But if any of the options suggested in this report reach a successful installation stage, it will be a valid contribution to rectifying environmental burdens placed on the planet by human activity – and will be a positive role model for all visitors to Newton and Noss.

ANDREW KNOX (B.E.Sc., B.A., M.A.Sc.)
RE4D Community Sector Mentor

Appendix I: Useful Links

The following links to more information are provided by U3A:
http://en.wikipedia.org/wiki/Heat_recovery_ventilation
http://www.energysavingtrust.org.uk/Home-improvements/Heating-and-hot-water
http://www.energysavingtrust.org.uk/google/search?SearchText=insulation.
http://www.energysavingtrust.org.uk/Generate-your-own-energy/Types-of-renewables/Solar-electricity
http://en.wikipedia.org/wiki/Wind_turbine
http://www.energysavingtrust.org.uk/Generate-your-own-energy/Types-of-renewables/Ground-source-heat-pumps
http://www.energysavingtrust.org.uk/Generate-your-own-energy/Types-of-renewables/Air-source-heat-pumps
http://www.energysavingtrust.org.uk/Generate-your-own-energy/Types-of-renewables/Biomass

Foreword on Hydro Tidal & Wave Generation

On the face of it we are well served by 3 rivers, at Bridgend, Noss Mayo and Newton Ferrers. Unfortunately the one with the greatest flow (River Yealm) has the least fall, while that of the greatest fall has the smallest flow (Noss Mayo). The Bridgend (A) stream is capable of a maximum power output of 1.44kW or 5.8MWh/y or sufficient for 1 house! Even if the new rate (20p/kWh) was paid for the ROCs these would only be worth £696. The Noss stream has a maximum power output of 0.6kW or 2.0 MWh/y sufficient for 4+ months supply to 1 house. The ROCs would be worth £240/annum. Either scheme could only be done as an 'in house' project by villagers.

The River Yealm is complicated by being one of the 6 salmon spawning rivers draining from Dartmoor, and therefore subject to an Environment Agency "Dartmoor Habitats Directive", which means that most of the flow must be left for the salmon to get upstream rather than be put through a turbine. The current non-evidence based rule of thumb is to leave 50% flow for fish after taking into consideration losses from abstraction, evaporation/seepage. Global warming is leading to extreme weather conditions, the consequences of which include wetter winters and drier summers and this also needs to be factored in for forward planning. The river was the subject of an earlier report by Richard Boynton and Segen, which is available on our webpage at http://www.newtonandnoss-pc.gov.uk/Yealmbridge%20Weir%20Micro-Hydro%20Study.pdf. This scheme proposed 2 possibilities at Yealmbridge Weir. The first would have restored an 800m section of the old mill leat providing a head of 4.2M, and the second required raising the weir height by 450mm giving a head of 2.6M. The flow rate was calculated at 1.37 m^3/s, giving a rate through the leat of 0.5 m^3/s or about 5 times that of the Bridgend stream. The larger first scheme would have produced a maximum power output of 13.7 kW or 87.18MWh/y, almost enough energy for 20 homes. The second scheme would have produced a maximum power output of 8.6 kW or 58.9 MWh/y, enough to power over 13 homes. These figures are calculated for a Crossflow turbine. The first scheme was estimated to cost £124,660.00+ VAT excluding grant funding, and the second £95,565.00. An additional problem with any scheme further down stream than they proposed, is that the fall becomes progressively less and therefore less practical.

Tidal

The most efficient tidal turbine works in conjunction with a barrage. Both options considered would interfere with yachting unless lock gates were installed as at the 240 MW station at La Rance in Brittany. This would add considerably to the expense of already expensive schemes which only deliver something in the low 100s of MWH/year. Furthermore the ecological effect on the estuary upstream of the barrage is uncertain, never mind the problem of finding a way of allowing salmon to get through, and would need additional Environment Agency approval. The Precautionary Principal states that if you do not know the ecological consequence of an action, then do not take it! Unfortunately very little research has been done on this subject. Barrages of some sort may need to be considered in the future to prevent flooding of communities in estuaries. The first of these is the Thames Barrier, which has already seen the numbers of closures per year more than double since it became operational in 1982. It was designed and built before the seriousness of global warming and its consequences were understood, and already thought is being given to its replacement.

At the moment any such scheme locally must be deemed a non-starter, but marine current turbines ('in-flow' and not requiring a barrage) are being developed. There is one at Lynmouth, one in the Orkneys and one in Strangford Lough.

Wave energy is still largely experimental, but UK companies are involved with the research, and the government is encouraging this by establishing a hub off Land's End to which 3 machines can be tested *in vivo* simultaneously. Theoretically 2 off-shore Wave units of 1.5 MW, costing £5.1 million, could supply all the power demand for Newton Ferrers and Noss Mayo – but not when the sea was calm!

Peter Brown
Lead U3A Environment Group, Feb. 2009

Appendix II: DARE Hydro Generation Report

Report commissioned by Andrew Knox (RE4D) in respect of a flow at two locations at Newton Ferrers and Noss Mayo, Devon. The proposed sites are at Grid ref SX 558 482 – Newton and Grid ref SX 547 473 – Noss. Andrew Knox offers no head information (see report).

1. Limitations of Report

This report is based on a desktop study using computer software (HydrA) and information supplied by Andrew Knox in an e mail. The report is not intended to be a full design study but should be regarded as a 'pre-feasibility' only. This study therefore should be seen as offering a 'first order approximation' of possible power output and be used to inform the decision whether to go on for a higher-level study.

2. Hydro Power Theory

Hydropower is developed as gravity accelerates water through a vertical distance (head), the power output is a function of the product of head and flow and may be expressed;

Power (kW) = Head (m) x Flow (m^3/s) x gravity x system efficiency

Gravity and system efficiency for a given turbine/generator set up is a constant so can be combined to a single numerical value. For most practical purposes the 'water to wire' output can be simplified and written as;

Power (kW) = 6 x Head (m) x Flow (m^3/s)

The flow can be estimated using the 'HydrA' software package. HydrA has been developed by the Centre for Hydrology and the Environment (formerly the Institute of Hydrology). The package contains Meteorological Office data for ten years rainfall per grid square, soil type data and evaporation rates per grid square, and Ordnance Survey data. For a given grid reference the rainfall catchment area, and the average rainfall and evaporation rates within that catchment can be determined. The gross annual flow is the multiple of the area and the net rainfall (gross rainfall less evaporation). However HydrA cannot assess whether there are any other abstractions such as water taken for public drinking supplies and so does have its limitations. The flow available for hydropower will be the net flow less any abstractions less the 'residual flow' (that flow as determined by the Environment Agency as necessary that must remain in the river to ensure the health of the natural river course. This is sometimes referred to as the 'Hands off flow'). Historically this was set at the 95^{th} (Q^{95}) percentile (that amount of water that flows in the river for in excess of 95% of the year). For the purpose of this report an abstraction rate equivalent to Q^{80} is assumed.

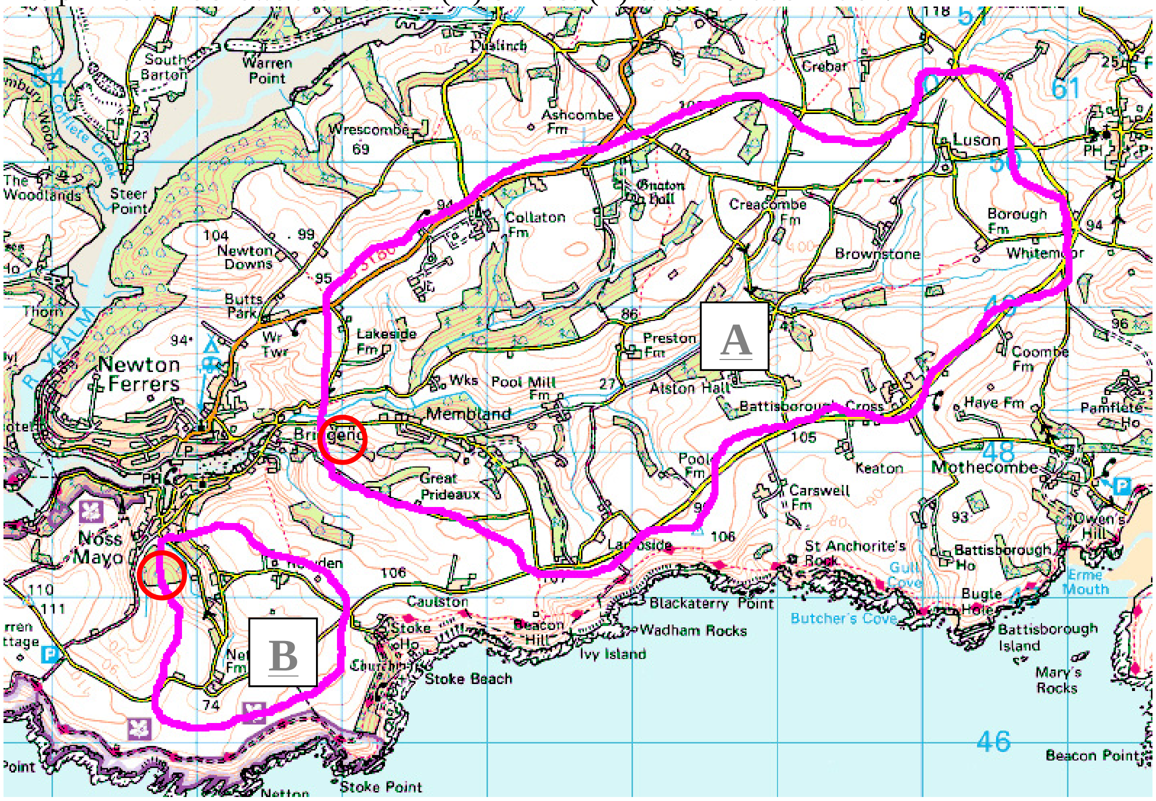
The head is determined by interpretation of OS maps and local knowledge off the topography at both sites.

3. Site Description

The Newton site collects its water flow from high ground to the east towards Battisborough Cross and the Noss site collects flow from high ground near Netton Farm.

4. Catchment Definition

The pink outline shows the Newton (A) & Noss (B) catchment definition.



5. Site Flow Data Newton Catchment A

Catchment area	A	= 10.06 km^2	(see map above)	(Source HydrA)
Average rainfall across catchment	R	= 1089 mm		(Source HydrA)
Average evaporation rate	E	= 563 mm		(Source HydrA)
Gross annual flow [A x (R – E)] Q_{gross}		= 5,291,560 m^3/y		
Mean annual flow Q_{gross} ÷ (8760 x 60 x 60)		= 0.167 m^3/s	(Q_{mean})	
Residual flow (assumed to be Q^{80} of mean flow)		= 0.048 m^3/s		(Source HydrA)
Design Flow ($Q_{rated} = Q_{mean} – Q^{80}$)		= 0.119 m^3/s		

Head

The head developed across the length of the site is assumed as 2.0m.

Power output

Maximum electrical power output = 6 x H x Q_{rated}
= 6 x 2.0 x 0.12 = 1.44 **kW**

Annual energy capture

Annual energy capture = electrical output x no. hours operational per year x load factor. (The load factor will vary according to the type of turbine installed) (assumed to be 6000 hours/annum)

Turbine type	Gross annual energy capture MWH/y	Mean annual energy capture MWH/y	Maximum power kW	Rated power kW	Minimum operating flow m^3/s
Crossflow	5.8	5.4	1.5	1.4	0.071

6. Site Flow Data Noss Catchment B

Catchment area	A	= $1.27\ km^2$	(see map above) (Source HydrA)
Average rainfall across catchment	R	= 985 mm	(Source HydrA)
Average evaporation rate	E	= 564 mm	(Source HydrA)
Gross annual flow [A x (R – E)] Q_{gross}		= $534{,}670\ m^3/y$	
Mean annual flow $Q_{gross} \div (8760 \times 60 \times 60)$		= $0.017\ m^3/s$ (Q_{mean})	
Residual flow (assumed to be Q^{80} of mean flow)		= $0.007\ m^3/s$	
Design Flow ($Q_{rated} = Q_{mean} - Q^{80}$)		= $0.010\ m^3/s$	

Head

The head developed across the length of the site is assumed as 10.0m.

Power output

Maximum electrical power output = 6 x H x Q_{rated}
= 6 x 10.0 x 0.010 = **0.6 kW**

Annual energy capture

Annual energy capture = electrical output x no. hours operational per year x load factor. (The load factor will vary according to the type of turbine installed) (assumed to be 6000 hours/annum)

Turbine type	Gross annual energy capture MWH/y	Mean annual energy capture MWH/y	Maximum power kW	Rated power kW	Minimum operating flow m^3/s
Propeller	2.0	1.9	0.7	0.6	

7. Confidence

I have confidence that the figures offered are likely to be the *minimum* power output for the assumed head and flow parameters used.

8. Comment

The catchment is relatively low lying and the rainfall across both catchments is about 1m per annum. Being cultivated land the soil evaporation is relatively high so the resultant rainfall runoff is low. In its lower reaches the stream at Bridge End has a shallow gradient so developing any meaningful head on this stream will either involve damming the river or digging a leat along a contour to develop the head. Either solution will involve significant civil engineering works and in turn either create a lake or a depleted reach. On the smaller stream at Noss, from local knowledge, it may be possible to develop a head of approximately 8m with minimal civil engineering works.

Newton stream - 5.8MWH sold to grid @ £120.00/MWH (wholesale value of electricity at 2008 plus Renewable Obligation Certificates (ROC's) plus Climate Change Levy) would attract an annual income of £696.00. However, the average three bed-roomed semi consumes about 5MWH/y of power and 17MWH/y (equivalent) of heat, so 5.8MWH would supply the electrical power needs of one house.

Noss stream - 2.0MWH sold to grid @ £120.00/MWH (wholesale value of electricity at 2008 plus Renewable Obligation Certificates (ROC's) plus Climate Change Levy) would attract an annual income of £240.00. 2.0MWH would supply about 40% of the electrical power needs of one house.

Probably the best way to use the power is to grid connect using a grid tie inverter.

9. Conclusion

To arrive at a conclusion a number of assumptions have been made in terms of likely civil engineering works needed to develop schemes. Both schemes will need some civil works with the attendant cost implications. Both schemes offer a very small amount of energy capture and careful consideration will be needed to determine whether either scheme is seen as economically viable. The potential annual income is so low it is unlikely to pay to use a professional hydro engineering company to develop a design study to install either site. At best any development should be seen as a DIY project.

10. Recommendations

Using conventional economic wisdom neither site has a reasonable prospect of achieving economic viability, however if development is considered the following steps need to be taken. It is suggested;

- Establish early informal contact with the Environment Agency. (The EA prefer to be involved at an early stage so they can identify any 'show stoppers' before you become too heavily committed. They have a statutory duty to protect the rights of existing licence holders and ensure compliance with environmental legislation. The particular stream you are on is not subject to the Dartmoor Habitats Directive but the EA will want to ensure any aquatic life in your stream is protected.)
- Establish early informal contact with the Planners. I suspect any development will be fairly low key so don't anticipate a major problem but the planners may want you to undertake a flood risk assessment for the site and possibly an environmental impact assessment.
- Contact Western Power Distribution to establish how much power the local electricity grid can accept without the need to upgrade power lines. (The power levels here are so low I doubt there will be an issue.)

Prepared by Richard Pymm 18th December 2008 email: richard.pymm@btinternet.com

11. Useful Contacts

Environment Agency
Tamsin Sutton – National Permitting Centre, Team leader
Tel; 01392 352311
E mail; tamsin.sutton@environment-agency.gov.uk

Some web sites you may wish to research for DIY options.
www.navitron.org.uk - a company who imports and supplies cheap Chinese turbines in a range of sizes.
www.powerpal.co.uk - a company who imports and installs a range of low head turbines (below right).

The Navitron turbine left is suitable for a 2.0m head.

The MGH500LH (right)
Is suitable for a 2.0m head. However Powerpal are reluctant to supply the DIY market. A 2kW Powerpal has recently been installed on the River Teign at a cost of £20,000.

For a 10m head

Picture left – The Navitron intermediate head turbine supplied in a range of sizes.

Picture right – The Streamengine.

www.genasyspowersystems.co.uk/Streamengine.htm - a small turbine suitable for a 10m head called the "Streamengine".

Appendix II: Current Power Purchase Agreements

Company details	Size systems	Export meter required? You should have an Ofgem accredited total generation meter fitted to system.	Price paid for electricity you generate and use in your home/premises	Price paid for electricity you generate and export to the grid	Standing charge	ROC's Prices vary over time, but will be consistent across suppliers.	Do you need to be a customer to sell back?
EBICo Ltd. www.ebico.co.uk 0845 456 0170	Domestic (PV)	Yes, fitted for free.		18p/kWh		?	Yes
	Domestic (hydro/wind/CHP)	Yes, fitted for free.	5p/kWh	5p/kWh		?	Yes
Ecotricity *Renewable Rewards* www.ecotricity.co.uk 08000 326 100	<10kW	No.	9p/kWh	9p/kWh		Signed over to Ecotricity.	Yes
	>10kW	No scheme set up yet.					
EDF www.edfenergy.com 0800 051 1905	'Export' <10kW (>10kW is case by case basis)	Yes (£70 with Western Power Distribution).		Wind and PV – 7.64p/kWh Hydro– 5p/kWh		Customer needs to do it, eg through Tradelink.	Yes
	'Total Generation' <5kW	No.	5p/kWh	5p/kWh		Signed over to EDF.	Yes.
	'Total Generation' 5-30kW	No.	4.5p/kWh	4.5p/kWh		Signed over to EDF.	Yes.
	Unmetered	No.	Flat rate of £10/kWp installed per year				Yes.
Good energy www.good-energy.co.uk 0845 456 1640	*Home* (can be non-domestic) *generation.* <6kW	No. (Trust based)	9p/kWh	9p/kWh		Company owns them.	Yes
	Smart Generation 6kW-75kW (5MWh for less than 30kW generators. 25MWh for greater than 30kW generators.)	<30kW - £75 >30kW - £500 pa	Case by case basis, reviewed annually	Currently 4.5p/kWh. (Charge for data collection and admin: <30kW - £94 pa, >30kW - £768 pa)		ROCs and REGOs are currently worth £42.10/MWh	No, although we would obviously like them to.
Green Energy UK www.greenenergy.uk.com 0845 456 9550	**Currently updating schemes.**	Yes.		4p/kWh	15p/day for export meter	£30/MWh(total generation) for ROC's	
npower *Juice* www.npower.com/at_home/juice-	<6kW only **Updating schemes, will**	No. Customer provides readings from tot gen meter twice a year.	10pkWh	10pkWh		£34.30/MWh paid to customer annually.	Yes.

clean_and_green/microgeneration.html 01905 340646 Thomas Harris	**email info on hydro in 4 wks**	Juice buys back 50% of total generation.					
Company details	**Size systems**	**Export meter required? You should have an Ofgem accredited total generation meter fitted to system.**	**Price paid for electricity you generate and use in your home/premises**	**Price paid for electricity you generate and export to the grid**	**Standing charge**	**ROC's Prices vary over time, but will be consistent across suppliers.**	**Do you need to be a customer to sell back?**
Powergen *Solarnet* http://www.eonenergy.com/At-Home/Products/Technology-And-Initiatives/Solarnet.htm 0845 301 4928	PV only, <5kW	No.		Same as import tariff. 10.58p/kWh (Or 15p/kWh if you're already on Economy 7)		Customer needs to do it, eg through Tradelink.	Yes.
Scottish and Southern *Power2* (green tariff) http://www.southern-electric.co.uk 02920 249 065 – Microgeneration team	<10kW	Yes, free of charge		5p/kWh		£50/MWh (total generation).	Yes.
	>10kW	Yes, free of charge		3-3.5p/kWh (based on whole sale market)		£50/MWh (total generation).	Preferably.
	PV <5kW (Solar Energyplus tariff)	Yes, free of charge		18p/kWh		Included in export price.	Yes.