Energy efficiency and energy generation on farm - a guide

ADAS and WAG helping you make the most of your business in today's energy market

ADAS CYMRU WALES

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

Introduction

Renewable energy offers a real alternative to fossil fuels. Against a background of rapidly rising fuel costs, the production of renewable energy on farm could provide a new, environmentally sound income stream.

Businesses could benefit from an investment in renewable energy; particularly if situated in an area of 'fuel poverty' where mains gas is unavailable.

In addition, steps can be taken to use energy more efficiently and save money, regardless of the fuel used.

Energy generation

Energy generated from renewable fuels could be used to provide heat and power to your farmhouse, outbuildings, glasshouses etc., or on a wider scale to the local community. Further business opportunities exist where farmers establish co-operatives to supply biofuels or energy crops to larger scale energy producers.

Large-scale wind farms are already well established within Wales however, other renewable energy opportunities are available to fit different situations.

- Bioethanol and biodiesel
- Biomass technologies fuelled by wood and energy crops.
- Anaerobic digestion of farm wastes.
- Small-scale wind power.
- Small-scale hydroelectric power.
- Solar heating and solar (photovoltaic) power.
- Ground source heat pumps

This booklet aims to point out the substantial resource of technical and financial support that is available to those considering investment in renewable energy, either as fuel growers or energy producers.

Energy efficiency:

Taking steps to use energy more efficiently saves money, whatever fuel is used. Energy saving plans are the first course of action required when reviewing any investment in energy.

Sources of additional support

The sign post symbol is used throughout the booklet to help point you in right direction for the substantial resource of technical and financial support available to you.

Contact details for organisations providing funding, advice and information are provided at the back of this booklet.

Biofuel crops - overview

Climate change and concerns over Carbon dioxide (CO_2) emissions, coupled with increasing fossil fuel costs have increased the value and profile of energy crops. Biomass crops are relatively bulky but are good fuels for heat production. However, for transport vehicles high-energy liquid fuel is required, this can be produced from a number of conventional farm crops. Biofuels are a viable replacement for fossil fuel based petrol and diesel.

Liquid Biofuels

Each year the UK consumes in excess of 20 million tonnes each of diesel and petrol fossil fuel. These can be replaced in part by biodiesel and bioethanol respectively.

Oilseed crops produce the precursor oils for biodiesel production, whilst starch and sugar crops produce the feedstocks for ethanol production. Under the present support payment regime biofuel crops can be sown on set-aside land.

Biofuel crops have a key role to play in enabling the government to meet its pledges to reduce carbon emissions.

Rising crude oil prices ($70/barrel May 2006) are also instrumental to the increased interest in biofuels.

Biodiesel

Biodiesel is produced from vegetable or animal fats in a process called transesterification. Ethanol and sodium hydroxide are mixed with the oils to produce biodiesel (the ester) and glycerol. Both products are non-toxic and biodegradable.

Biodiesel can be used be used in a large range of diesel engines and is included in so-called 'green diesel' at an inclusion rate of 5%. Biodiesel has a lower sulphur content than diesel, and a higher flash point making it safer in accidents and spillages.

Oilseed rape is the chosen feedstock grown throughout Europe. Assuming a yield of 3t/ha and oil content of 40%, 1 hectare produces 1.1 t/ha biodiesel and 0.1 t/ha Glycerol. This is equivalent to 13MWh energy per annum – about an average household's consumption for half a year.

Bioethanol

Bioethanol is produced by fermentation of plant sugars. It can be used as a petrol replacement in modified engines or (as currently in the UK) as a 5% supplement in unmodified engines. The basic process involves fermenting sugar with yeast to produce the alcohol. If sugar beet is the feedstock the sugar is directly available. If starch (in cereal grains or potatoes) is used it has to be broken down to its constituent sugars before fermentation.

The Bioethanol industry in the UK is not as well developed as that of biodiesel. However, there are at least 250 petrol stations in the South East of England supplying a 5% bio-ethanol blend. In addition a handful of stations in England are also supplying an 85% ethanol blend for specially adapted cars. Whilst UK production of bioethanol is a new industry it is a rapidly developing one and the technology can be taken up almost immediately.

Summary

Biofuels provide a very significant extra market for many commodity crops. In the medium term this should result in better prices and improved profitability.

CALU can point you in the right direction for further information on the potential of growing crops for biofuel.

Energy crops - overview

Biofuel crops are conventional food crops that can also be used to produce a liquid fuel. However, if a crop is burnt to provide heat or power it is known as a biomass feedstock. Miscanthus and Short Rotation Coppice (SRC) are currently the most commonly adopted energy biomass crops in UK. They represent a change of land use and generally a longterm commitment. As a result siting and choice of crop needs careful consideration. Diversification into crops grown specifically for biomass opens up a number of options.The technologies associated with biomass energy are extremely flexible.

Biomass can be used as a source of fuel for heat and/or electricity on individual farms, or crops can be grow under long-term contract to larger energy enterprises.

Summary

Low input- Fertiliser, cultivations and pesticide usage is much lower than with conventional crops.

Biomass crops can be grown on set-aside without affecting the SPS.

Increased biodiversity has been observed in studies of the ecology of SRC and Miscanthus compared against conventional cereal crops.

Soil structure and nutrient content is improved. Leaf litter increases soil organic matter, whilst roots and crop water uptake helps reduce soil erosion. Improvements to the soil leads to increased soil fauna and fungi.

Habitat formation when these crops are grown has been found to be beneficial to a number of important bird species. Miscanthus can be planted to provide game cover.

The crops can provide a long-term, sustainable and secure local fuel source, less susceptible to price fluctuations and interruptions of supply.

Energy crops have additional benefits in addition to fuel supply, for example biofiltration, riverbank stabilisation, thatch and willow crafts.

Other considerations

Initial establishment costs for a crop is high and a long-term commitment is required.

Good establishment is the key to success and weed control is of particular importance in the first year.

Landscape, ecology, site archaeology, visual impact and public access need to be considered when siting a crop.

“ What many see as tomorrow’s fuel is here today. We estimate there could be 20 million tonnes of biomass available annually. The challenge for the government is how to unlock this vast potential. We have suggested several ways to develop this industry which has a vital role in climate change, sustainable development throughout the country and economic activity in rural areas.”

Sir Ben Gill Biomass Task Force 2005.

For all biomass enquiries, including supplier details – contact CALU.

Miscanthus

Miscanthus is a perennial grass crop growing rapidly to a height of up to 3 metres with a yield potential of 15 to 20 t/ha. The productive life of the crop is at least 15 years.

A chipped end product is valued at around £40/tonne. A harvest of 14odt/ha would give approx. £560/ha revenue. It can be grown on set-aside.

If grown on non-set-aside then it is eligible for a further £29 ha under the SFP rules.

20 ha of miscanthus could provide all the heat requirements for an average farm.

The crop has a number of environmental values. It does not shed seed, has low fertiliser, pesticide and herbicide requirements.

Growing the crop

Adequate moisture and weed control, during establishment are key to high yields. The crop will grow well on a broad range of soils, though sandy free-draining soils are best avoided.

In the spring 15,000 – 18,000 rhizomes/ha are planted at a depth of 5-10cm. Using contractors familiar with the crop is recommended, as good establishment is vital.

Control of weeds is needed in the first year with a broad-spectrum herbicide applied post-planting.

Senescence occurs in the autumn with the arrival of the first frosts.

From the second year the crop is harvested in Feb/March. It can be cut with a mower conditioner and baled, or chipped using a forage harvester.

Costs

Costs vary according to contractor, with a range typically of £1400 to £2000/ha for planting.

£150 to £200/ha for contract harvesting based on 14 odt/ha baled.

Yearly cost of production and harvesting (establishment cost divided by 15 year life of crop) is between £230 and £300.

Summary

Long-term commitment though the crop is easily grubbed out when no longer required.

Annual harvest means large volume storage of baled or chipped end product will be required.

A long-term market needs to be identified before committing to grow the crop.

A number of additional markets, for miscanthus also exist. For example horse bedding, worth around £100/tonne. It can also be used in papermaking and to produce biodegradable products such as plant pots.

To see energy crops demonstrations in the field – contact CALU.

Best practice guidelines for growing miscanthus can be found on the Defra website www.Defra.gov.uk.

Short Rotation Coppice (SRC)

High yielding willow or poplar is grown as a coppice shrub, planted at high density and harvested every 3 to 4 years. Willow is currently the most widely grown SRC crop.

Growing the crop

Eradication of perennial weeds is an essential pre-planting operation, with herbicide programmes starting in the summer preceding planting. Weed and pest control, together with thorough ground preparations are key to successfully establishing the crop.

Willow SRC will grow well on a broad range of soils, provided they retain adequate moisture. Fields that are subject to occasional flooding may also be suitable, though harvest occurs in the winter and you must be able to travel the ground in this period. Step planters are most commonly used for planting coppice plantations. Willow rods between 1.5 and 3 metres in length are fed into the planter, which cuts them into 18-20cm cuttings for planting. Typically 15,000 cuttings/ha are used, though planting can be successful using other densities. By the end of the first season each cutting will have produced a number of shoots and which may reach 4 metres in height. The stems are cut back to encourage further stem production at the end of the first season. First harvest occurs in year 4, by which time the crop has multiple stems approx. 7 to 8m in height. The crop can be harvested in a number of ways dependent on the end user and the storage facilities available. It can be harvested directly as wood chips using a modified forage harvester, as full rods or as shorter chopped stems using a billet harvester. Yields are dependent on location and age of crop.

First harvest yields around 12-15 odt/ha may be achieved with yield around 20-25 odt/ha possible in subsequent seasons. Conservative yield estimates should be used when planning budgets.
The crop is valued to be worth £35-£40/odt. Haulage adds around another £10 per tonne to the price for the end user if lorry transport is needed.

Costs

Establishment costs are in the region of £1500/ha.

Harvesting, transport and processing costs are in the region of £300-400/ha.

Summary

Large plantings should only be considered with proper guidance and planning.

The crop represents a long-term commitment, with a productive life of around 30 years.

Specialised machinery needs to be bought or hired for planting and harvesting, but fixed cost savings are possible if contractors are used.

Once established the crop is low maintenance compared to arable crops.

High levels of biodiversity are found in willow plantations.

There are a number of pests and diseases on willow and some can affect productivity if not effectively controlled.

Best practice guidelines for growing SRC can be found on the Defra website www.Defra.gov.uk.

Small-scale biomass installations

Biomass fuelled systems are a real alternative to boilers running on fossil fuels. They are efficient and adaptable, being suited to a wide range of situations.

Pellet and log stoves (6 to 12 kW) can provide heat on a single room scale. If used with a back boiler they may also provide hot water for radiators in neighbouring rooms. Fuel efficiency is 80-90%.

Biomass boilers (from 13kW) can provide both heat and hot water on a larger scale, for the farmhouse, workshop, livestock unit, greenhouse or grain store. Larger installations can serve the local community through shared heating schemes. Fuel efficiency is around 90%. Fuel quality is paramount to efficient operation.

As well as energy crops like Miscanthus and SRC, forestry by products (i.e. logs, sawdust, wood chip and shavings), straw, grain, or clean materials such as cardboard packaging can be used as fuel providing they meet waste regulation guidelines.

Both producing and using the fuel offers potential for greatest cost savings.

The ash produced in these systems has potential to be returned to the land as low potash fertiliser or used in compost. Analysis should be used to confirm its composition and absence of heavy metals.

Costs

Wood-burning stoves start from approx. £1500 fully fitted. Prices for a 15kW biomass boiler start from approx. £4500. Units burning pellets or logs are generally cheaper than those burning wood chips. Running costs from approx. 2.5 pence/kWh. Pellets tend to be more expensive at 4.6 p/kWh useful heat based on £180/tonne.

Summary

Small-scale biomass units are suited to areas of high heat demand, such as farmhouse, offices and glass houses.

For all aspects of biomass fuelled heating contact Wood Energy Business Scheme (WEBS).

Penpont Estate, nr Brecon Powys

Penpont is a 2000 acre rural etate which supplies all its own heat as well as running a woodfuel supply business.

Penpont takes advantage of its onsite woodland resource, chipping wood for its state of the art 149 kW wood chip boiler.

The boiler supplies all the heat and hot water for the main estate buildings, which include, Estate House, holiday wing, stable block, workshop, 2 cottages and 3 proposed holiday cottages. Annual fuel consumption is 100 tonnes of wood chip.

The Wood Energy Business Scheme offset the cost of the chipping equipment, as well as the capital cost of the boiler and the system itself.

Cost savings vs oil are £6,368/year (2006 Q1 prices)

Source WEBS

May be cheapest form of fuel in areas with no gas supply. Self-supply being the most economical option as fuel doesnt need to be brought in.

Supports the local economy, as fuel production and supply is kept local.

In common with all biomass boilers purchase costs can be higher than for equivalent fossil fuel boilers.

Fuel storage space is greater than for fossil fuels.

Boilers need to be situated close to the site to which they supply heat.

The overall capital costs need to be considered with the overall costs of energy delivery.

Systems need to take into account the type and form (e.g. pellets, chips, bales) of fuel that will be burnt, as boilers have certain specifications of fuel they will accept. They should be commissioned and fitted by accredited installers, as various regulations need to be adhered to.

CHP fuelled by biomass

Small-scale biomass Combined Heat and Power (CHP) systems are an emerging technology in the UK. They are a very efficient way of producing both heat and electricity.

CHP systems have potential to be highly fuel-efficient with costs around 30% lower than conventional electricity and heating. Typically 50% of fuel is converted into heat and 30% into electricity.

Small-scale gasification CHP systems are available from 50 kWe in size. In a gasification CHP system biomass is converted into a fuel gas. In addition biogas produced by anaerobic digestion can be used to fuel certain CHP systems.

There are a number of engine options for powering the generator in CHP systems, including external combustion (EC) engines, internal combustion engines and fuel cell. Stirling technology (EC-engine) now encompasses biomass as a fuel and are an example of an option for small-scale systems under 150kW.

The suitability and economic feasibility of each option is largely dependent upon the scale of operation.

For CHP technologies to be a viable option, electricity and heat usage needs to be high, with the economic benefits increasing in line with increasing usage.

Whilst biomass CHP is not currently considered viable on a domestic scale it is likely to become so in the near future. Small-scale systems running on natural gas are available from 1kWe.

Wider CHP opportunities can be accessed by farmers/communities working together to form co-operatives. This has the benefit of taking advantage of the economies of scale that exist for both the local heat use, and the electricity.

Costs

The price of various options varies with the range of sizes available and individual site factors. However, the figures below give an idea of possible costs.

A 12kW unit can cost upwards of £15,000, through to £45,000 for a 100 kW CHP system, excluding the costs of connection to the national grid. The latter can be a significant cost and should be investigated at the start of any planning.

Summary

Carbon savings/tonne of biomass are higher using CHP than when providing heat or power alone.

The electricity can be sold to the national grid through renewable obligation certificates (ROC's).

Economies of scale: The smaller the scale of operation the larger the unit costs are.

Domestic scale biomass CHP is still a developing market and not yet fully commercialised.

Capital cost per unit of heat is higher than heat only systems such as biomass boilers.

For further information on CHP as a renewable technology contact your local energy agency.

Anaerobic digestion

Energy from waste represents a real opportunity in agriculture and food related businesses. Recent cost rises in fossil fuels ensure that the economic case for anaerobic digestion has improved, making it a potential integrated waste management solution.

An anaerobic digester is a large vessel from which air is excluded. With mixing and warmth it provides perfect conditions for anaerobic bacteria which break down the organic matter in the absence of oxygen. Methane rich biogas is produced in the process as well as liquid slurry and compost that can be used as fertiliser and soil conditioner. Biogas can be used to fuel boilers and provide heat, or by fuelling CHP systems it can provide both heat and power. In addition following further processing biogas can be used to fuel vehicles.

Different size systems are available from single farm digesters through to large centralised digesters using waste from the local area. Available opportunities depend upon the scale of production and must be matched to farm demand, or contracts established to sell the excess energy. There are opportunities to form business relationships with industrial or community organisations.

Waste inputs to the system can include livestock wastes as well as a range of local domestic and industrial organic wastes for which a gate fee could be charged.

Bank Farm, Churchstoke, Powys.
Farmer: Clive Pugh

A dairy farm of 131 ha with additional 35 ha of rented land. Approx 280 head of cattle and 350 ewes and some poultry. The farm has been involved with AD technology for the past 16 years and have two anaerobic digesters with a total capacity of 800m3.

Digesters are fed with cattle slurry and poultry manure from the farm. In addition green waste from the local town has been processed in the past. This attracted a recycling credit.

Heat from the process is used to heat digesters, two farmhouses and the dairy shed.

The digestate is valued as fertiliser and used on farm leading to fertiliser cost savings. *Source ADAS*

Summary

Can help you comply with legislation on the safe handling of waste by providing a reduction of pollution through integrated waste management.

Slurry odour can be reduced by around 80% and methane (a greenhouse gas) emissions to the atmosphere are also reduced.

Charging gate fees for waste taken in, and selling biogas, fertiliser and composts can generate income. Savings can be made through reduced use of fertilisers, and through use of energy generated in the AD system.

Initial outlay costs are very high.

Bio-gas cannot be liquefied and so requires large volume storage.

The electricity generated is eligible for Renewable Obligation Certificates (ROC's)

Electrical connection to the national distribution system is essential and can be costly at between £200 to £500/kWe.

For further information on AD as a renewable technology contact CALU.

Solar heat and solar power

Energy from the sun can be used to heat water, or directly converted to electricity through a solar photovoltaic (PV) system.

It is daylight rather than direct sunlight that is required by these systems. However, whilst there is easily enough solar energy striking the roof of an average UK property to meet all of its heat and hot water requirements, levels of radiation are not constant throughout the year. Solar systems need to take this into account. Systems are available that are designed specifically for the demands of the UK climate.

Solar systems don't generate any greenhouse gases and are hence very environmentally friendly.

Thermal solar systems

Thermal solar systems are the cheaper of the two technologies, with a professionally installed system starting from £2000. Thermal solar systems capture the suns' energy as heat, storing it in an insulated water tank. There are now also solar systems that use warm air storage to provide hot water, air heating, whole home ventilation and cooling. On the farm operation side they could provide hot water for the dairy etc.

Solar photovoltaics (PV)

The term potovoltaic means 'electricity from light'. PV systems use photoelectric cells to convert solar radiation to electricity.

PV systems are currently expensive. Prices for a domestic system of 2kWp in size professionally installed start from £10,000-£12,000. Prices vary depending on factors such as the size of the system, the type of PV materials used, the siting location and the installer used.

The light receptive cells in a PV system are made up of a semi-conducting material. When light hits the cell an electrical field is created across the cells, causing electricity to flow.

PV systems can be used either as stand alone systems, for areas in which grid connection is difficult or impossible, or they can be connected to the grid. Stand-alone systems use batteries to store energy that is captured during the day, so that it can be used when light levels are too low to generate electricity.

Systems connected to the grid effectively use the grid for storage. Any unused energy that is collected during the day, for example when the occupants are at work is sold to the grid. In return electricity is bought back when the PV system is not producing electricity during the hours of darkness.

There is a wide choice of design to choose from when considering a PV system. Designs range from small grey solar tiles that can be used in place of traditional roof tiles through to transparent cells that can be used on greenhouses and conservatories. Small stand-alone systems can be used in fields to power weather stations, bird scarers etc.

Siting solar systems

One advantage solar panel systems have over other types of renewable energy is that they generally don't require any additional space.

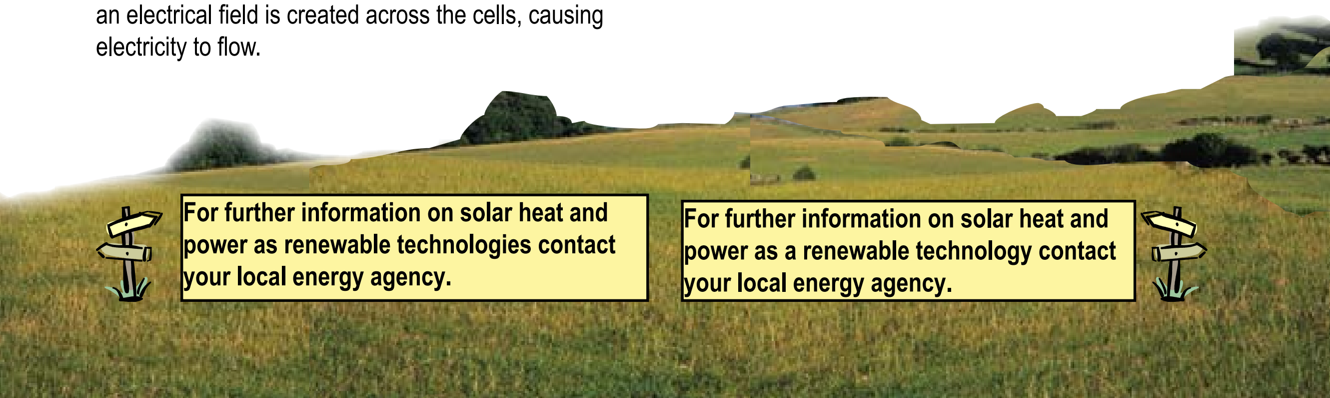
Most systems are typically fitted to a roof or wall within 90 degrees of south. Most roofs in the UK are suitably angled for solar systems. It is important that trees or other obstructions don't overshadow the siting point.

Summary

There are a number of grants available for these systems.

Depending on location and the vagaries of the UK summer, they can meet at least 50 to 60% of a households yearly hot water, heat or electricty requirements.

Planning permission may be required.



For further information on solar heat and power as renewable technologies contact your local energy agency.

For further information on solar heat and power as a renewable technology contact your local energy agency.

Ground Source heat pumps

Ground source heat pumps take the heat energy stored in the earth and transfers it to your home through an underground pipe system. The ground stores a large amount of heat energy generated from the sun, and though surface temperature can fluctuate greatly throughout the year, the temperature 1 metre down is fairly constant at between 7 to 13^{0}C year round. A water/glycerol mix circulates in the pipes and absorbs this heat.

The pump system is powered by electricity and technology based on refigerator systems is used to concentrate the heat that has been absorbed by the pipes. It can then provide sufficient heat for hot water heating systems.

A standard system is comprised of ground pipes, heat pump and a heat distribution system and works best when it is combined with underfloor heating, rather than radiators. They are best suited to well-insulated houses where heating can be provided at a lower temperature.

Costs

An 8kW system is sufficient for an average house and costs in the region of £6000 to £10000. This does not include the cost of central heating system. A much larger sized system of 40kW could cost in the region of £75000. Grants may be obtained from a number of sources, to help with the cost of installing a system.

Summary

Ground source heat pumps are the most efficient way to use electricty for heating. However, they may be more expensive and less environmentally friendly than other renewable alternatives.

System efficiency is measured by a coefficiency of performance (CoP). The CoP for fossil fuel heating sytems is around 0.9. Most ground source heating systens have a CoP value between 3 and 5 and are therefore considerably more efficient.

There are a number of different pipe layouts that can be used depending on the land available and the underlying geology of the site. Pipes can be laid horizontally, in a space saving spiral pattern and even vertically.

For further information on GSHPs as a renewable technology contact your local energy agency.

Cost will vary depending upon the type of pipework needed.

A considerable amount of ground work may be required for the installation of pipes depending upon the type of pipework installed. Large trenches or bore holes need to be dug to install the pipes.

Additional similar technologies also exist; air source, water source and bedrock source are other options that may be open to you depending on the site.

In addition to heating, reverse cycle systems can be set up to help cool the house in the summer, though these can be less efficient.

Most sytems have a 25 year lifespan.

Caerfai Farm, St. Davids, Haverford West.
Farmer: Wyn Evans.

Organic milk and cheese producers on a 160 acre farm whose ultimate aim is to be 100% energy self sufficient. Currently 40% of their energy requirements are met by a number of different renewable technologies.

Ground source heat pumps (GSHP's) provide winter heat to the farmhouse. Heat is transfered to the domestic central heating and hot water system through a fully automated condensor unit and plater exhanger. In the summer months GSHP's will be used to supplement the farms solar panels.

Solar panels provide hot water for the shower facilities at the on farm campsite.

25% of the farms electricty requirements (farm, farmhouse and holiday cottage) are being met through a 20Kw wind turbine.

A mini digester is fed by livestock waste from the 70 cow herd. The biogas produced is used in an Aga cooker.

Source Wyn Evans

Small scale wind power

Large-scale wind farms are now a familiar technology in Wales. The small-scale wind turbine systems that are suitable for generating electricity on a domestic scale are less well known.

Wind turbines come in range of sizes with a typical domestic system being in the region of 2.5 to 6 kW. It is also possible to install a single large turbine.

The size of the turbine needs to be matched to requirements. For example a small 2.5 kW turbine could provide enough electricity to supply a house with its electrical needs and provide enough heat for domestic water requirements. Whilst a larger turbine of 6kW may also be able to provide a large proportion of the property's heating requirements.

Systems may be stand-alone: with the energy generated being stored in batteries, or they may be connected to the national grid. Depending on the size of the system there are options to either use all the energy generated, or export some/all to the grid.

Unless you live in an area where there is no mains electricity supply, a grid-connected turbine is the most common means of harnessing this technology.

A grid-connected turbine can feed any excess power, when it is not being utilised back into the grid. There is also the benefit that grid electricity can be used at times when the turbine may not be generating enough power.

The British Wind Energy Association can provide you with information on local wind speeds and give you an idea of the possible power outputs that may be generated. Location will have a large part to play in the suitability of wind generated power. The site needs to be exposed to prevailing winds, with the turbine generally being sited on a mast to make maximum benefit of the increase in wind speed that is gained with height.

Costs

Prices vary according to the size of the turbine installed. A small domestic system of 2.5kW could cost in the region of £5,000 to £7,000 and a larger 6kW £18,000 to £20,000.

Summary

Wind speeds are not constant. The power generated by a wind turbine is proportional to the cube of the wind speed.

Batteries or connection to the grid is required to store power.

Not all sites will be suitable for the introduction of wind turbines.

Planning permission will be required.

Wind power is particularly suitable for power generation in off-grid locations. In these situations wind power may be one of the cheaper alternatives.

Systems can also be combined with diesel generators, which act as an additional support at times of low wind speed. The efficiency of a combined system is higher than a stand-alone diesel system.

For further information on wind power as a renewable technology contact your local energy agency.

Small scale hydroelectricity

A river or stream crossing your land could be viewed as a possible energy source that offers potential for utilisation by hydroelectric power.

Water falling on high land has potential energy as a result of its height. This is converted into kinetic energy as it falls over dams or down pipeways, when it is harnessed to operate a turbine or water wheel.

A modern turbine can convert over 90% of the energy in the water to electricity. A water wheel is less efficient but may still be viable on a domestic scale.

A river or steam's suitability for electricity generation is dependent on its height over which the water falls, its volume and its flow, and how many days a year sufficient flow is generated. This gives an indication of the energy potential of the site, which is expressed in kilowatt-hours.

A range of turbines are available, specifically designed for a range of heights (head) and flow rates. An engineer will be required to produce a turbine specification to suit site conditions.

Hydro systems can be connected to the national grid or use batteries to store the power generated. Grid systems have the benefit that any surplus power can be sold.

Costs

Economies of scale exist with unit costs falling for larger schemes. Larger schemes offer the potential for community projects.

Electricty can be sold to the national grid under Renewable Obligation Certificates (ROC's).

The costs for hydroelectrics are site specific and are calculated based on the energy output. Connection to the national grid is expensive and is very variable being determined by the local supplier.

The cost for a 100kW installation is likely to be within the region of £50,000 to £170,000 excluding connection to the national grid.

Viability is dependent upon an individual's circumstance, future savings, and the prospect of possible payment for any excess generated.

Summary

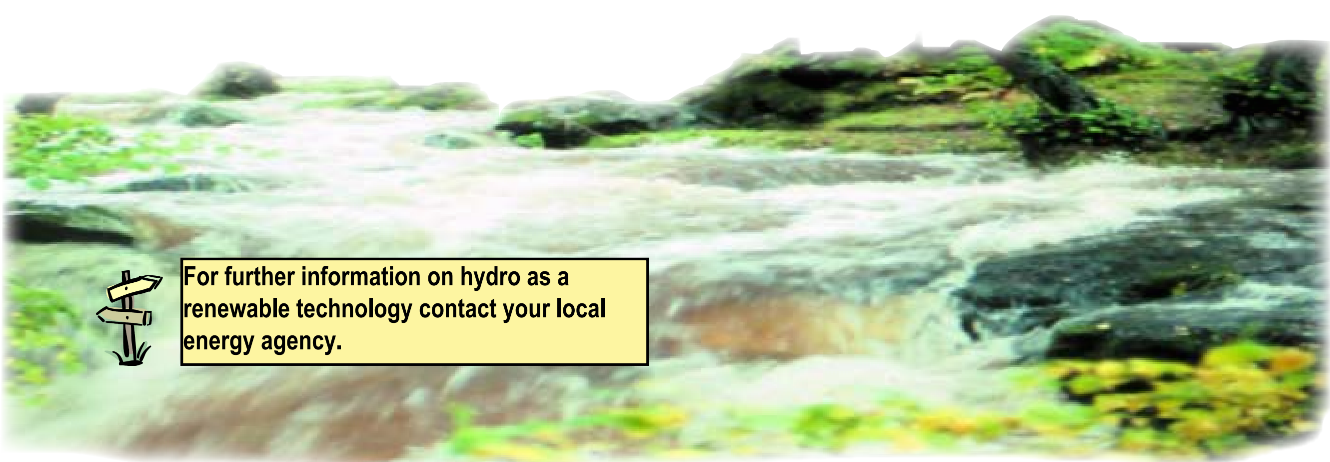
Site and feasibility assessment by a specialised hydro consultant is vital.

Environment Agency must be consulted at an early planning stage.

Planning permission may need to be obtained from local planning authority.

An installation can have a useful life of a 100 years or more.

Clean energy source minimising atmospheric and environmental pollution.



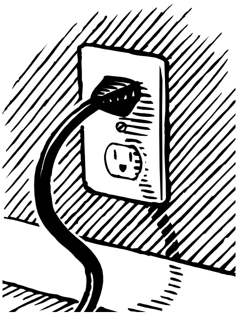
For further information on hydro as a renewable technology contact your local energy agency.

Energy efficiency / cost saving measures

Good management is the most effective route to improving energy efficiency. This means first of all being aware of existing energy consumption, the way it is distributed and how effectively it is used. In other words, how much energy is used for specific enterprises or operations and how does this compare with previous years, other operations and other farms.

On most farms savings of 10-20% of energy costs could be made relatively easily, often with minimal capital outlay.

Even systems which were efficient when installed a few years ago may be costing more than necessary because their use pattern has altered or perhaps because a new generation of equipment is inherently more efficient.



REMEMBER ENERGY COST SAVINGS CONTRIBUTE DIRECTLY TO YOUR BOTTOM LINE PROFIT.

Energy management principles

Good record keeping it essential. Only with comparable records can improvements be measured and problems identified.

Maintenance of equipment is an important factor for sustaining good energy efficiency. Regular checking of automatic control such as thermostats can be particularly important. An incorrect temperature setting of just 1°C can mean an increase of energy consumption of 15%.

Insulation levels on building are largely a consideration at the design and specification stage. It is difficult to justify the cost of adding insulation to an already insulated building. However, maintenance of the building fabric and replacement of damaged or wet insulation should be carried out. There are recommended levels of insulation (U values) for various types of building and these should be adhered to where possible.

Cutting your current fossil fuel costs

The cost of energy consumed can be significantly reduced by selection of fuel type, its supply method or the supplier.

For batch delivered fuels, the installation of larger storage facilities will usually enable a lower unit cost to be achieved through larger bulk deliveries.

Electricity

A large number of electricity tariffs and supply arrangements are available. These include night and day rates through daytime, night and weekend tariffs, and maximum demand tariffs. The multiplicity of tariffs and supply companies can make tariff selection difficult.

Choosing a tariff to match the site pattern of use and practices ensures that overall cost for the electricity power consumed can be minimised. Saving of 35% or more can be achieved through tariff analysis and selection.

Metering and detailed records will be required for accuracy and prediction of savings. For any particular tariff, the scale of implication of restrictions for the usage must be understood. It should then be possible to avoid costs. Managing equipment well and avoiding large power consuming items being operational during periods of maximum demand.

Oil

Choice of oil fuel ranges from class C kerosene to class G heavy fuel oils. Heavier grades of fuel oil cost considerably less per litre and savings can be as high as 40%. The heavier grades of fuel oil classes G and F are likely to be suitable for high-energy consumers with large combustion plant. These fuels will also require heated and insulated storage and supply lines so that the oil can flow properly and be burnt efficiently.

Solid fuel

For medium and high energy consumers solid fuel still remains one of the cheapest sources of energy available. Choice in the market place shows that prices remain competitive for large users for both home produced or imported coal.

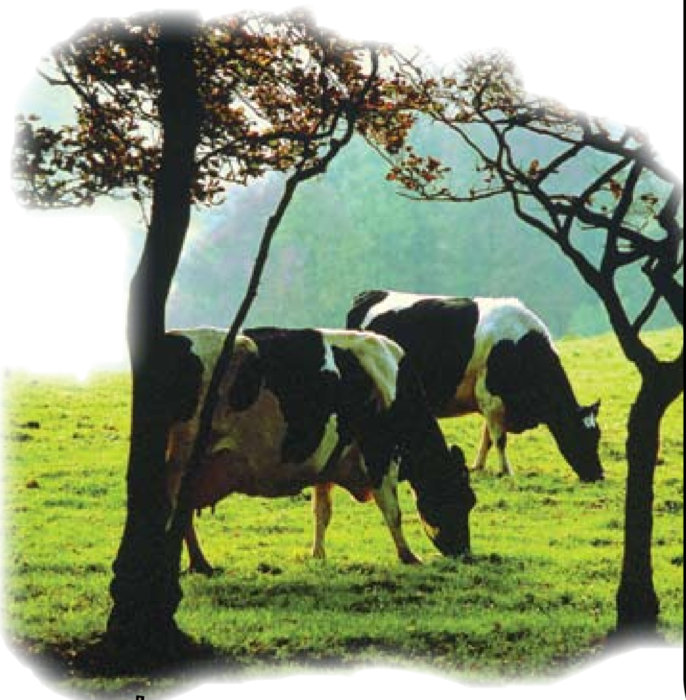
Gas

There are a choice of suppliers for gas. Switching supplier can generate savings in the order of 15% for medium sized horticultural users as an example.

Users, who have a steady consumption of gas throughout the year, are in the most favourable position. Maximum supply rates tend to increase the supply network cost component of the overall contract. Dual fuel capability on firing equipment allows interruptible gas supply contracts. This enables overall costs for the unit of gas to be reduced by up to 25%, but with the risk of supply loss at critical times. Gas supply contracts usually place limits on supply rates and the minimum purchase required. The seasonal usage of gas should be analysed before entering into a contract for supply.

Examples of energy saving opportunities.

The following example shows how energy can be saved on a dairy farm. You may require specialist advice to fully analyse complex operations on your own farm but this example gives a broad indication of where energy savings can be made in a farm based situation.



The best source of information on energy efficiency measures is you local EEAC.

DAIRY FARMS account for the highest overall energy cost per farm type, with energy costs representing 2% of all costs.

Correct use of hot water: *Savings up to 50%- (about £2/head). Once a day hot washing. Use of hot water should be critically examined to avoid unnecessary use and excessive temperature. Check thermostat setting and leaks. Overall priority must be given to hygiene. Solar power could be considered.*

Prudent use of heating appliances: *Savings are variable. Minimise and enclose any heated areas and install time switch controls and insulation etc.*

Improved insulation: *Savings of up 20% Good tank and pipe insulation saves significant heat loss costs.*

Correct tank thermostat: *Savings of up to 20%. Small inaccuracies can result in large significant costs e.g. 1°C overcooling.*

Automatic lighting controls: *Savings up to 50%. Using time switches or photosensitive controls can cut out unnecessary high level of lighting or wasteful usage.*

Low energy lighting: *Up to 80% saving (about £2/head). Changing conventional incandescent lighting to low energy fluorescent lighting is a low cost option with significant benefits.*

Correct refrigeration plant location: *Saving up to 40% (about £4/head).Cost of installation is minimal if done at design stage. Refrigeration condenser runs more efficiently where location gives adequate inlet and outlet ventilation*

Double wash capacity: *Savings up to 65%. Savings can be made by installing a double, instead of single wash capacity water heater where hot water is required twice daily and an off-peak tariff operates.*

Off peak electricity: *Saving up to 65% (about £28/head). Off peak tariff can provide major savings on dairy units. Maximise savings using bulk tanks with controllers especially with milk pre-cooling.*

Further help and support

Biomass crops and associated technologies

CALU transfers technology to any business in Wales that is interested in horticulture, biomass, alternative crops, alternative livestock and/or farm woodlands. CALU runs a number of open days and events, offering opportunities to see energy crops demonstrated in the field.

Information on local renewables and energy efficiency measures

Your local Energy Agency or Energy Efficiency Advice centre offers impartial information, guidance and support for enquires on all energy related measures, including renewable energy and sources of funding.

Grants and financial assistance for renewable energy and energy efficiency measures

Grants are available from a number of sources. The Energy Savings Trust has extensive information on a range of schemes and grants that may be helpful to you. The Carbon Trust and Forestry Commission are two further examples of providers of financial support for renewable energy schemes. Your local energy agency can also give you information on local level grant sources.

Example schemes

The Low-Carbon Buildings Programme

Provided by the DTI. Grants towards the cost of renewable energy technologies, such as solar photovoltaics, wind turbines, small scale hydro, solar thermal hot water, heat pumps, bio-energy, renewable CHP, micro CHP and fuel cells.

Wood Energy Business Scheme

Provided by the Forestry Commission. An initiative for Wales aiming to establish a network of wood fuelled installations. Grants are available for capital costs associated with wood fuel heating systems, CHP and processing.

Energy Loans

Provided by the Carbon Trust. Interest free loans of between £5,000 and £100,000 for investment in energy-saving equipment such as lighting, boilers or insulation.

Contacts

Centre for Alternative Land Use (CALU) Tel: 01284 680450 e-mail: calu@bangor.ac.uk www.calu.bangor.ac.uk	*Energy Saving Trust Wales (EST) Tel: 01443 845930 www.est.org.uk*	*The Carbon Trust in Wales Tel: 01443 845944 e-mail: info@thecarbontrust.co.uk www.thecarbontrust.co.uk*
Carmarthenshire Energy Agency Tel: 01944 230003 www.ynnisirgar.org.uk	*The Conwy Energy Agency Tel: 01492 651024 www.conwyenergyagency.co.uk*	*Mid Wales Energy Agency Tel: 01654 703064 www.mwea.org.uk*
South East Wales Energy Agency Tel: 0800 512012 www.sewenergy.org.uk	*Energy Efficiency Advice Centre Free energy advice Tel: 0800 512012 (this will put you through to your nearest EACC e-mail: advice@ecocentre.org.uk www.ecocentre.org.uk*	*Wood Energy Business Scheme (WEBS) Tel: 01970 821219 e-mail: woodenergybusiness@forestry.gsi.gov.uk www.woodenergybusiness.co.uk*