Energy Tutorial: Energy and Sustainability

Renewable energy systems

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ELECTRICITY GENERATING SYSTEMS

There are a number of technologies which can be installed in order to generate electricity from renewable sources of energy, such as the wind and sun. Solar photovoltaic panels (PV) are by far the most popular electricity generating technology to be installed in homes. Wind turbines, micro-hydro and anaerobic digestion are better suited for community scale electricity generation.

Combined with a large battery, any of these technologies could theoretically be used to enable a domestic building or a whole community to become self-sufficient in their electricity usage. In practice however, that would probably be very expensive and far less environmentally friendly than connecting the system to the national electricity grid. Grid connected systems enable a home or community to automatically feed any excess electricity into the grid, reducing the need for fossil fuel electricity generation elsewhere and earning extra income for the owner of the system. Also, when the system isn't generating enough electricity to meet the demands of the end user, electricity can be imported from the grid.

Feed-in Tariffs

On the 1st April 2010 the UK joined many other nations, such as Spain and Germany, in implementing a Feed-in Tariffs (FITs) scheme. FITs are the government's main financial incentive to encourage uptake of renewable electricity-generating technologies. The scheme means that you can get paid by your energy supplier both for the renewable electricity you generate and the renewable electricity you export to the national electricity grid.

Eligible electricity generating systems (less than 5MW in size):

- Receive a fixed payment for each unit of electricity generated, regardless of how it is used (generation tariff). This rate will change over time for new entrants to the scheme, but once you join you will continue to receive the same generation tariff for 20 years, or 25 years in the case of solar PV.
- Receive an additional payment per unit of electricity exported to the national electricity grid (export tariff).
- Benefit from avoided electricity costs where the electricity is used at the site where it was generated.

Owners of domestic systems do not pay tax on the earned income. FITs payments are paid by energy suppliers and in order to be eligible, the system must be installed by an MCS (Microgeneration Certification Scheme) certificated installing company. A full list of certificated installing companies can be found on the MCS website – www.microgenerationcertification.org

Figure 1 below shows the FIT rates for different technologies for 2015-16. Because the scheme is intended to stimulate development in the market for renewable electricity-generating technologies, which in turn will reduce the prices for these technologies, the FIT levels reduce over time as the technologies become cheaper.

Figure 1: Table of FITs levels

Technology	Size	FITs (p/kWh) 2015 – 2016
Anaerobic digestion	250kW or less	10.13
Anaerobic digestion	> 250kW – 500kW	9.36
Anaerobic digestion	> 500kW – 5MW	8.68
Hydro	15kW or less	17.17
Hydro	> 15kW – 100kW	16.03
Hydro	> 100kW – 500kW	12.67
Hydro	> 500kW – 2MW	9.90
Hydro	> 2MW – 5MW	2.70
Combined Heat and Power (CHP)	2kW or less (Tariff available only for 30,000 units)	13.45
Solar PV	4kW or less	13.39
Solar PV	> 4kW – 10kW	12.13
Solar PV	> 10kW – 50kW	11.71
Solar PV	> 50kW – 150kW	9.98
Solar PV	> 150kW – 250kW	9.54
Solar PV	>250kW – 5MW	6.16
Solar PV (stand-alone)	Not attached to a building and not wired to provide electricity to an occupied building.	6.16
Wind	1.5kW or less	14.45
Wind	> 1.5kW – 15 kW	14.45
Wind	> 15kW – 100kW	14.45
Wind	> 100kW – 500kW	12.05
Wind	> 500kW – 1.5MW	6.54
Wind	> 1.5MW – 5MW	2.77
EXPORT TARIFF (for all the technologies above)		4.85

Solar photovoltaics

Solar photovoltaic (PV) systems convert daylight into electrical energy using a thin layer of semiconducting material, usually silicon. The potential electrical energy from a single PV cell is low, so cells are joined together to create a panel (or module). Panels are then joined together to create an array.

Solar PV installations in the UK have greatly increased since the introduction of the FITs scheme and as a result this has driven down installation costs. Prior to the launch of FITs, PV technology was prohibitively expensive per unit of energy generated. This has prompted some critics to argue that this technology will never make a significant contribution to the UK's electricity needs. Solar advocates however, counter that as well as being a great way to generate clean energy, PV also reduces demand because when solar is installed the end users often become much more energy aware.

Community PV projects usually involve winning grants or gathering investments from community members to fund installations. Panels are then installed on homes, community buildings (e.g. village hall/community centre) or other sites. Some or all of the income from the FITs can then be used to support other low carbon projects within the community. Another approach which has been tried is a community focused bulk buying group that can negotiate discounts and provide support to enable more local homes to invest in their own solar system.

ACTIVITY

There are a number of websites available which calculate the potential returns you could get from installing a solar PV system on your roof. Try using the Energy Saving Trust Solar Energy Calculator for your own home here: http://www.energysavingtrust.org.uk/solar-energy-calculator

Wind power

The UK has a large wind resource which could generate a huge amount of electrical energy. Indeed, the UK government sees wind power as the most important tool for reaching its renewable energy targets. So far, however, roll out of wind power has been slow largely due to planning problems, of which many are the result of objections from local people.

Larger turbines gain disproportionately better results, in terms of electricity generated per pound invested; the same is also true the higher up the turbine blades are located. Because of this, schemes focusing on commercial scale turbines are arguably the most beneficial.

Figure 2: Small scale turbine installed costs

Source: 'Renewable Energy: A User's Guide' – Andy McCrea

Wind turbine size (kW)	Typical fully installed costs (2008)	Cost per kW installed
2.5	£10,000 – 12,000	£4,400
6	£18,000 – 22,000	£3,300
10	£25,000 – 30,000	£2,700
20	£40,000 – 50,000	£2,200
50	£70,000 – 80,000	£1,500

At the other end of the scale, tiny turbines mounted on buildings usually produce very little power, especially in urban areas with high levels of turbulence. In between the two extremes are small to medium sized standalone turbines which are less efficient than bigger models but can still produce a very useful amount of power. They can also play a symbolic role, especially in an educational setting. Community owned wind hasn't taken off in the UK in quite the same way that it has in Denmark but there are a number of projects and many more in the pipeline. An example of a community owned scheme is Westmill Wind farm near Swindon where they have 5 wind turbines up and running (http://www.westmill.coop).

Hydro

If you are fortunate to live beside a river or a fast flowing stream, a small scale hydroelectricity installation may provide an opportunity to generate significant amounts of electricity. In hydropower systems, water flowing steeply downhill is diverted via a pipe called a penstock. This directs the water through an enclosed turbine, which rotates to produce electricity.

Systems vary in size from giant dams across whole valleys through to fairly tiny installations on steep streams running through people's gardens. In between are community scale projects. Although community hydro is still fairly niche, there's a huge amount of potential in the UK with promising sites located all over the country, many of them easy to spot by the presence of an old water mill. Abingdon Hydro (http://www.abingdonhydro.org.uk/) is an example of a not-for-profit company set up by local residents to generate hydroelectric power from the River Thames (by Abingdon Weir). Osney Lock Hydro (http://www.osneylockhydro.co.uk/) is another great example and started generating clean, green electricity in January 2015.

Anaerobic digestion

Anaerobic digestion (AD) is the process where plant and animal material is converted into useful products by micro-organisms in the absence of air. AD can accept waste from our homes, supermarkets, industry and farms, meaning less waste goes to landfill. The material is put inside sealed tanks and naturally occurring micro-organisms digest it, releasing methane that can be used to produce useful energy. Anaerobic digesters can also be fed with purpose grown energy crops, such as maize.

AD is widely used as a source of renewable energy. The process produces a biogas, consisting of methane, carbon dioxide and traces of other 'contaminant' gases. Biogas can be combusted to provide heat, electricity or both or alternatively it can be cleaned up and the pure methane injected into the mains gas grid or used as a road fuel. The material left over at the end of the process is rich in nutrients so it can be used as fertiliser.

The technical expertise required to maintain industrial scale anaerobic digesters, coupled with high capital costs and low process efficiencies has so far been a limiting factor in its deployment as a waste treatment technology. Anaerobic digestion facilities have, however, been recognized by the United Nations Development Programme as one of the most useful decentralised sources of energy supply, as they are less capital intensive than large power plants.

AD is not a new technology, it has actually been used in the UK since the late 1800s and there are a growing number of plants in the UK processing our waste and producing energy. Many community groups in rural areas are now looking into the technology. To find out more about this fast developing area, visit http://biogas-info.co.uk/.

HEAT GENERATING SYSTEMS

For most homes, space and water heating costs more and creates more CO_2 than electricity so it's no surprise that renewable heating systems can provide huge savings, both financially and environmentally. They've been an attractive investment for a number of years and can provide good financial returns, especially for properties which are off the gas network and reliant on expensive and polluting fuels such as oil or electricity.

Renewable Heat Incentive

The Renewable Heat Incentive (RHI) is a UK government policy aiming to reward anyone producing low carbon heat, in much the same way that Feed-in Tariffs do for electricity. The domestic version of the RHI has now launched, providing long term support for renewable heat technologies.

Non-domestic RHI

In November 2011, the RHI opened for commercial, public sector, industrial and community renewable heating installations (referred to as 'non-domestic').

The scheme is administered by Ofgem who also undertake the inspection and certification of non-domestic systems. As with FITs, the tariffs are linked to the Retail Price Index (RPI) and therefore will rise each year with inflation. Figure 3 below shows the tariff rates for non-domestic installations.

Figure 3: Table of RHI non-domestic tariffs

Tariff Name	Eligible Technology	Eligible Sizes	Tier	RHI tariff (p/kWhth) July 2015
Small Commercial biomass	Solid biomass including solid biomass contained in municipal solid waste (incl. CHP)	Less than 200kWth	Tier 1	4.40
			Tier 2	1.17
Medium Commercial Biomass		> 200 - 1,000kWth	Tier 1	5.18
			Tier 2	2.24
Large Commercial Biomass		> 1,000 kWth	N/A	2.03
Water/Ground-source heat pumps	Ground-source heat pumps; Water Source heat pumps; deep geothermal	All capacities	Tier 1	8.84
			Tier 2	2.64
Air-source heat pumps	Air-source heat pumps	All capacities	N/A	2.54
Deep geothermal	Deep geothermal	All capacities	N/A	5.08
All solar collectors	Solar collectors	Less than 200 kWth	N/A	10.16
Biomethane injection	Biomethane	On the first 40,000 MWh of eligible biomethane	Tier 1	7.24
		Next 40,000 MWh of eligible biomethane	Tier 2	4.25
		Remaining MWh of eligible biomethane	Tier 3	3.28

Small biogas combustion	Biogas combustion	Less than 200 kWth	N/A	7.62
Medium biogas combustion		> 200 – 600 kWth	N/A	5.99
Large biogas combustion		> 600 kWth	N/A	2.24

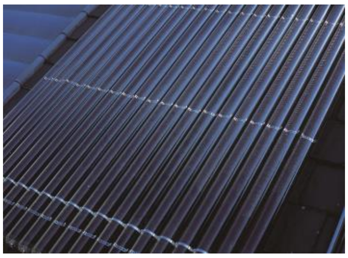
Domestic RHI

The domestic RHI was launched in April 2014 and provides financial support for seven years to householders who have a renewable heating system in their homes. Figure 4 below shows the tariff rates for domestic installations.

Figure 4: Table of RHI domestic tariffs

Tariff Name	RHI tariff (p/kWhth) July 2015
Biomass boilers and stoves	7.14
Air-source heat pumps	7.42
Ground source heat pumps	19.10
Solar thermal	19.51

Solar water heating



Sometimes called solar thermal, solar water heating (SWH) systems use energy from the sun to provide hot water to taps and showers. They have been around for decades and there are more than 100,000 installations in the UK. There are various models available and efficiency usually increases with price. SWH is especially attractive for buildings with high levels of hot water demand such as community centres, B&Bs and campsites but the technology can also work well on domestic homes.

Solar collectors are installed on the roof, in a position of good solar exposure, and transfer the sun's heat energy to a fluid which is pumped around the SWH system. The fluid used is typically a water/anti-freeze mix which heats a heat exchanger in the hot water tank which in turn heats the water stored in the tank. The liquid is then pumped back up to the solar collector on the roof and the process starts all over again. The hot water cylinder thermostat should to be set at 60°C. When the sun's energy alone isn't enough to bring the water to temperature the boiler or immersion heater can provide backup heat. SWH will supply approximately 60% of a domestic property's annual water heating and may answer all your hot water needs between March and September.

Ground source heat pumps

Ground source heat pumps extract stored solar energy from the ground and convert it into useful heat energy which can be distributed throughout a building. A length of plastic pipe is buried 1-2m under the surface of the ground, in close proximity to the building, and filled with a mixture of water and antifreeze. The fluid absorbs heat from the ground (1m below ground surface stays fairly constant 10-12°C all year round, even when the air is freezing) and an electric compressor raises the temperature to a useful level. The heat is then distributed around the building, typically via under floor heating since the system is much more efficient at supplying constant, low temperature heat.

Electricity is used to drive a compressor and move the fluid around the heat pump. If the building is well insulated, the total energy cost and carbon emissions will usually be far lower than with a typical off gas grid heating system. In poorly insulated buildings, the benefits are greatly reduced because the pump has to work much harder, consuming valuable electricity. If you combine a ground source heat pump with a solar PV system or a wind turbine, your reliance on fossil fuels will reduce even further. Some systems can also work in reverse to create cooling during the summer months, particularly useful in larger buildings with high levels of daytime activity e.g. office blocks. Large buildings undergoing major works could also consider inter-seasonal heat transfer – see the example of Howe Dell School here: http://www.icax.co.uk/howe_dell_school.html

Air source heat pumps

Air source heat pumps work in a similar way to ground source models but exploit the low level heat in the air rather than the ground.

Air source heat pumps are usually easier to install than ground source as they don't need any trenches or drilling, but they are often less efficient.

Wood fuelled heating

Biomass, in the context of heating, refers to wood in the form of logs, chips or pellets (compressed sawdust). When wood is burnt, it releases CO_2 but this is then absorbed by new trees which have been planted to replace the ones that have been felled – 'carbon neutral'.

Open fires are the least efficient way of burning wood as approximately 40% of the potential heat energy enters the room and the remaining 60% is lost up the chimney. Also, when not in use, chimneys can be a source of draughts. Therefore, a modern wood burning stove is a far more fuel efficient option. Some wood burning stoves can be integrated with an optional back boiler.

Biomass boilers are comparable to oil fired heating systems and achieve high thermal efficiency (around 90%). Ignition and control is automatic but ash will need removing manually on a regular basis. Pellet boilers are larger than conventional domestic oil boilers and a pellet fuel store is approximately three times the size of an oil tank, with the same calorific value. Pellet boilers are suitable for domestic properties whilst chip and log boilers are more commonly found in non-domestic locations with plenty of space available for a much larger fuel store e.g. farm.

Biomass boilers are yet to catch on in a huge way in the UK, but they are a proven technology – Austria alone already has more than 100,000 installations.

HEAT AND ELECTRICITY GENERATING SYSTEMS

Combined heat and power

Large scale combined heat and power (CHP) systems use waste heat from the generation of electricity (normally dumped into the atmosphere, rivers or the sea) and distribute the heat as a secondary output. Although it is possible to run CHP on wood, or some other renewable fuels, gas is currently used in the majority of installations. Conventional power stations extract as little as a third of the energy from their fuel and the rest becomes heat, which in most cases is treated as a waste product and expelled via a cooling tower. Further inefficiencies occur in transmission over the grid. By contrast, CHP systems can extract almost all the energy from the fuel by creating a mixture of heat and electricity for use in nearby buildings that require both.

Micro CHP (mCHP) can be used in domestic properties where the main output of the system is heat, with some electricity generation, at a typical ratio of about 6:1. The gas powered Baxi Eco Gen is currently the only mCHP system available but many other models are in the testing phase. Although gas fired mCHP isn't carbon free but it's still much greener than buying electricity from the grid and creating heat separately using a boiler. Currently there is also a Feed-in Tariff available for electricity generated via a mCHP system.

A community energy group could explore installing a medium to large scale CHP system to supply a community building or group of homes, and a district heating network could be used to distribute hot water to homes from the local CHP plant. This is becoming increasingly popular in some European countries, and it is hoped that the Renewable Heat Incentive will help it catch on in the UK.

FURTHER RESOURCES AND INFORMATION

- Check out "Renewable Energy Systems Compared" back on the Energy Tutorial webpage to compare power, income, cost, space and planning permission requirements for each kind of renewable energy technology.

- The YouGen website has lots of extra information and advice about different renewable technologies, FITs and RHI here: http://www.yougen.co.uk/renewable-energy/

- Visit the Ofgem website to find out more about the FIT and RHI rates and how they have changed over time here: https://www.ofgem.gov.uk/environmental-programmes/feed-tariff-fit-scheme/tariff-tables

  https://www.ofgem.gov.uk/environmental-programmes/non-domestic-renewable-heat-incentive-rhi/tariffs-apply-non-domestic-rhi-great-britain

  https://www.ofgem.gov.uk/environmental-programmes/domestic-renewable-heat-incentive-domestic-rhi/about-domestic-rhi/tariffs-and-payments-domestic-renewable-heat-incentive

- To find out more about community owned renewable energy projects and what they involve, have a look at these National Energy Foundation action packs: http://www.aceforcommunities.net/content/action-packs