Hydro-Electricity

– An Energy Appraisal for the years up to 2020 and 2030

What is Hydro-Electricity?

Hydro-electricity harnesses the power of water to create energy. It uses a series of turbines within a dam which rotate as water rushes past them downstream from a reservoir. These turbines power generators to create electricity and the water flows away as normal.

This method of electricity generation doesn't involve any burning of fossil fuels once its construction is considered. Therefore it does not produce greenhouse gases which contribute to global warming. This also means that after construction its running costs are low when compared to fossil fuel generation as the water it uses is provided free of charge by rainwater which runs into its reservoir (http://www.darvill.clara.net/altenerg/hydro.htm).

Gravitational potential energy is stored in the water above the dam. Because of the great height of the water, it will arrive at the turbines at high pressure, which means that a great deal of energy can be extracted from it. The Hoover dam in the USA famously provides all the electricity for 1.3 million people (http://www.usbr.gov/lc/hooverdam/).

Hydro in the UK

Within the United Kingdom at present only Scotland has a large amount of hydro-electric generation, with Wales having similar technology at use in the form of pump storage schemes. This is mostly a result of the geography of the countries and the fact that many of the areas which would be suitable for such generation are in national parks or other

areas of outstanding natural beauty or scientific interest, such as the Lake District in north-west England.

Of these schemes the vast majority are at present what is known as large scale and involve sizeable dams and large expanses of water. Smaller scale micro projects are however possible and are increasingly found in other countries of the world, many including Pakistan, being much less developed than the UK.

All of the hydro-electricity generated in Scotland is owned by Scottish Hydro Electric a part of the Scottish and Southern Energy group.

Other Methods of Energy Generation in the UK

Hydro makes up large percentage of the UK renewable electricity generation which includes wind power biomass solar and others. However the market as a whole is dominated by non-renewable generation from the burning of fossil fuels, coal, oil and gas and nuclear power.

Government Policy

The government of this country and others around the world have accepted that their energy strategy much change in order for them to adhere to the environmental agreements they have made. These include perhaps most importantly the Kyoto Protocol, because this set for the first time a tough limit on greenhouse gas emissions which are a cause of climate change. Energy generation through the burning of fossil fuels contributes greatly to these emissions and as such alternative non fossil fuel methods are now seen as something which will help governments to meet their targets. This was seen with the 2003 UK government white paper ‘Our Energy Future – creating a low carbon economy’ (http://www2.env.uea.ac.uk/gmmc/energy/energy_pdfs/white_paper_2003.pdf)

In the first annual report on the paper in April 2004 the government reaffirmed that addressing climate change was at the centre of UK energy policy and this is also seen in the wider environment of the European Union. The EU renewables directive has called for 22% of energy within the union to be renewable by 2010.

Scottish and Southern Energy

The company owns 1349MW of energy generating capacity in the form of hydro or pumped storage and a further 13MW capacity from wind power, representing 40% of the UK renewable energy generating capacity. They are investing £850million to add a further 600MW of renewable capacity to enable them to exceed a total of 2000MW.

Although much of this investment is in the form of wind power some of the money is being spent on the hydro-electric power generating technology. Upgrades of turbine rudders, guide vanes and generators increases efficiency and extends life. A major refurbishment programme since 2002 has seen 275MW of hydro-electric generating capacity refurbished with another 90MW expected to be completed this year 2004/5. So far these efforts have increased out put by 5% from the same amount of water. (http://www.scottish-southern.co.uk)

Environmental Implications

Being a renewable energy source, hydro-electricity is better for the environment than generation from the burning of fossil fuels. This is because aside from the initial output of carbon dioxide and other greenhouse gases used in the construction of the dam and associated technology, no gases are produced in the general operation of the generators. Greenhouse gases have been linked to the negative affects of global climate change and the UK must reduce them under its obligation to the United Nations Convention on

Climate Change and its Kyoto protocol. Similarly unlike with nuclear generation hydro-electric generation has no links to hazardous radioactive material or other highly political issues.

Therefore there are huge positive implications of increasing the use of hydro-electric generation where ever possible, however the technology is not without its slight environmental consequences. These have not been seen in the UK but in other areas where large new hydro projects have been taken on, such as China, the flooding of huge valleys for the lakes which are dammed for the hydro has lead to the destruction of habitat and the loss of biodiversity. Alongside this the displacement of vast numbers of people has also occurred as a result of these schemes sometimes in to areas of previously unspoilt environment which doubles the damage caused by the schemes as the colonisation of an area also reduces habitat and biodiversity.

Within the lake questions of how natural the environment is for wildlife once a dam is added have been raised as have issues relating to the way that natural flooding and retreating of the river downstream of the lake will no longer occur because of regulation of the current.

Technical Constraints

The development of further large scale hydro-electric generating capacity in the UK will always be heavily influenced by the geography of the country and the government legislation already in place concerning potential generating areas. As such I would not expect there to be any further large scale projects in the lifespan of this appraisal.

However small scale hydro projects would be less tried down by these problems as rivers or small lakes needed for such operation are more common and more widespread throughout the UK. Because of this they are much more likely to be free from protected

areas such as sites of special scientific interest or areas of outstanding natural beauty and there stringent planning regulations.

Although such developments would each produce only a small amount of electricity, this would be renewable still and without the high initial capital costs of large scale projects. Local energy generation compliments well the theories of sustainable communities and local level control of resources. These are issues which are increasingly becoming part of the agenda for environmental pressure groups and as such are beginning to find their way into mainstream political debate.

Unfortunately, at this time the technology for such small scale projects is at a basic level leaving the projects barely cost effective. The UK does not have the fastest flowing rivers in the world either and this adds to the lack of generating capacity these small hydro schemes can produce. If monies were made available however for research into the area then technological development could be achieved quickly in much the same way that advances in wind power generating capacity developed in the last few decades of the 20th century.

A further constraint to the increased use of hydro-electric generation would be the possibility that the lakes which provide the water for the generation could freeze over in times of extreme cold. This is a common occurrence in other countries which employ such schemes including Norway and Austria and it would not be inconceivable that this could happen in the UK especially if further development of such schemes was to occur in the remote northerly latitudes of the country. It is no coincidence that at the times that the lakes freeze over a country is at its highest level of demand as heating demand will be at its highest and levels of lighting are also likely to be at a peak.

Therefore it is not beyond possibility that within the later period of the appraisal such schemes could start to come on line in the UK.

Location of Generation and Transport Issues

At present hydro-electric generation occurring in northern Scotland accounts for less electricity than it would if it were generated in England because of the losses suffered by transporting the electricity between the countries. This is another reason why further large scale hydro projects are unlikely in the foreseeable future. Up to 7% of the electricity can be lost and as the bulk of the demand is not just in England but in the south east of England the furthest point from Scotland at that, this is a real disadvantage.

This conundrum does increase the viability of smaller schemes however as they would not suffer the same transmission losses if strategically located to be near to large centres of population where demand is high.

Storage

These transport issues only occur because it is not possible to store electricity. Therefore it must be produced at exactly the time it is demanded and in exactly the right amounts. Electricity demand is highly fluctuating roughly following peak times of human activity around morning and evening rush hours. However levels required also fluctuate on larger seasonal cycles and smaller, almost instantaneous peaks, during advertisement breaks in television programmes for example. These variations put most electricity generating methods at a huge disadvantage; however for hydro-electric generation this isn't as big a problem.

Fossil fuel burning power stations have almost no scope to react to small fluctuations in demand and wind and wave generating methods are restricted to generating at levels dictated by the weather. With hydro-electric generation however by changing the levels of water flowing through the generators in the dam you can instantly increase or reduce the levels electricity produced. It is using this principle that has led to the development of pump-storage schemes, these use excess electricity, produced when demand is low, to

move water into a dam artificially from downstream rather than waiting for it to fill with rainwater. Then at times of peak demand this water is released downstream to generate instant extra electricity. However these schemes are not energy efficient as more energy is used to pump the water up in to the lake than is recovered when the water is released.

The Future Scenarios

Levels of energy consumption have increased year on year for some time now and there is no reason to suggest that this trend will change in the life of either of the energy appraisals. Therefore if the amount of energy generated by hydro methods was to stay at the same percentage we should expect to see some increase in hydro-electric generation.

However as has been observed the UK has stringent legislation protecting any potential areas for new large scale hydro projects so it is unlikely any new developments will occur. That is not to say levels of generation could not be increased from the existing projects as has been proved by Scottish and Southern who has used technology to increase the capacity of their existing generators. With investment further new technology could potentially be developed to take further power from the existing dams. However such breakthroughs are not likely to be groundbreaking and if they did occur would most likely transcend the generating boundaries and also benefit other methods as the generating technology is similar in most cases if the means of turning the turbine is not.

The real potential for increased capacity instead lies with small scale projects especially when the longer term 2030 prediction is considered. As the anti wind farm lobby increases its strength there is the real possibility that other land based renewable generating methods could increase their viability. If this is combined with a move towards a more sustainable way of living then local, small scale hydro projects will be an attractive option.

Optimistic

2020: No closures of Large Scale sites, technical improvements take capacity to 2000MWe. Increase in number of Small Scale sites taking capacity to 750MW (Table 1).

2030: Life extensions and further technical improvements take capacity to 2200MW. Small Scale Hydro becomes commonplace with capacity of 3000MW.

Pessimistic

2020: Early closure of some Large Scale sites through unforeseen life expiry of equipment and dam strength reduces capacity to 500MW. Objections to development of Small Scale program leads to token increase in capacity 250MW.

2030: All but a few Large Scale sites remain due to life expiry and increased maintenance costs giving a capacity of 250MW. Small Scale program stagnates due to continuing negative publicity and lack of technical development giving a capacity of just 500MW.

Likely

2020: Large Scale capacity is most likely to stay around current levels probably increasing slightly to 1500MW with technical developments. Small scale program not likely to develop that fast and will be in competition with other renewable sources. However the partial success of wind power gives an idea that complete anti Small scale Hydro feelings will not develop. An in between figure of 500MW is therefore more likely.

2030: Some Large Scale facilities are likely to close but complete life expiry is unlikely. However technological improvements are unlikely to keep improving the capacity year on year and as such advancements are likely to reach a cap of most likely the same figure

as 2020, 1500MW. Small Scale projects will advance from 2020 levels as technology levels improve and the projects become a familiar site around the country's rivers and streams. However the formation of a lobby of anything like the strength of the present anti wind power lobby would no doubt restrict development to around 1800MW (Figure 1).

	Generating Capacity (MW) for the Years	
	2020	**2020**
Optimistic		
Large	2000	2200
Small	750	3000
Total	***2750***	***5200***
Pessimistic		
Large	500	250
Small	250	500
Total	***750***	***750***
Likely		
Large	1500	1500
Small	500	1800
Total	***2000***	***3300***

Table 1: Varying predictions of the installed generating capacity of hydro-electricity in the UK for the years 2020 and 2030

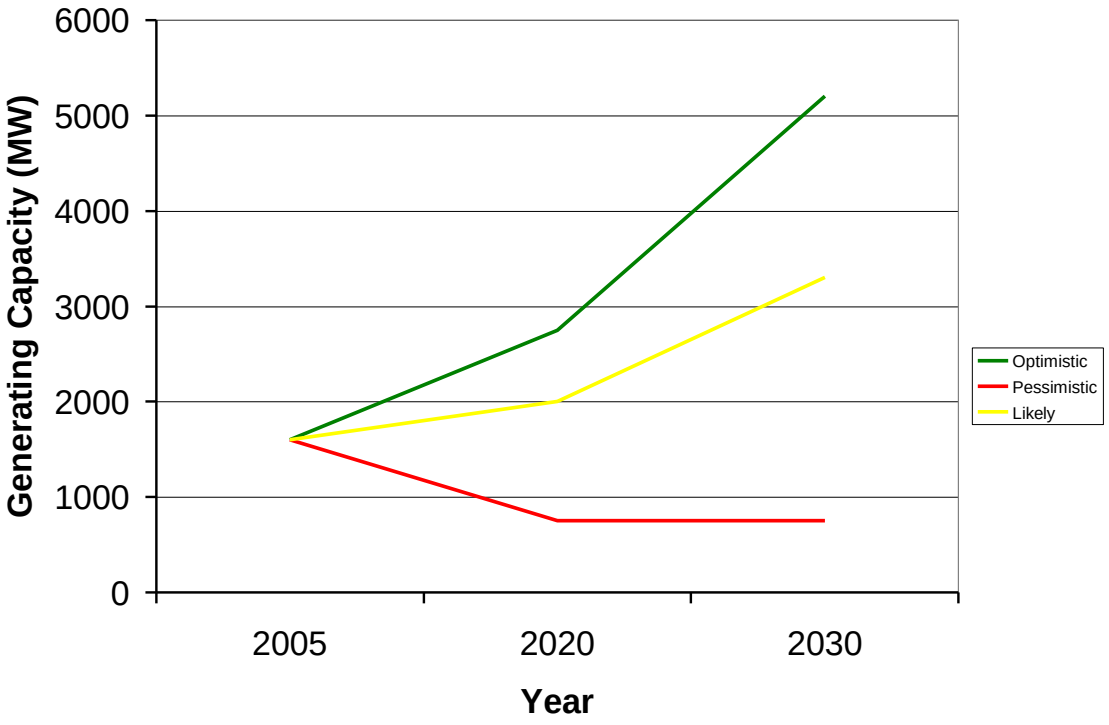

Figure 1: Predictions for Hydro-Electric Generating Capacity for the years 2020 and 2030

So how will this installed capacity provide for the electricity demands of the UK? Assuming that the hydro-electric generating equipment works at a load factor of 35% all year round then it will amount to as much as 57PJ of energy by 2030 if the optimistic predictions come true or as little as 8PJ if the negative thoughts are proved correct (Table 2). Using the likely forecast generation from hydro will increase by just 3PJ in the first 10 years of the appraisal but when technology advances in the later years it should increase by a further 16PJ from 2015 to 2030 (Figure 2).

	Energy Generated (PJ) in the Years					
	2005	**2010**	**2015**	**2020**	**2025**	**2030**
Optimistic	17	21	25	30	42	57
Pessimistic	17	14	12	8	8	8
Likely	17	18	20	22	28	36

Table 2: Varying Predictions of the amount of UK electricity that will be generated by Hydro-Electric generation methods for years up to 2030

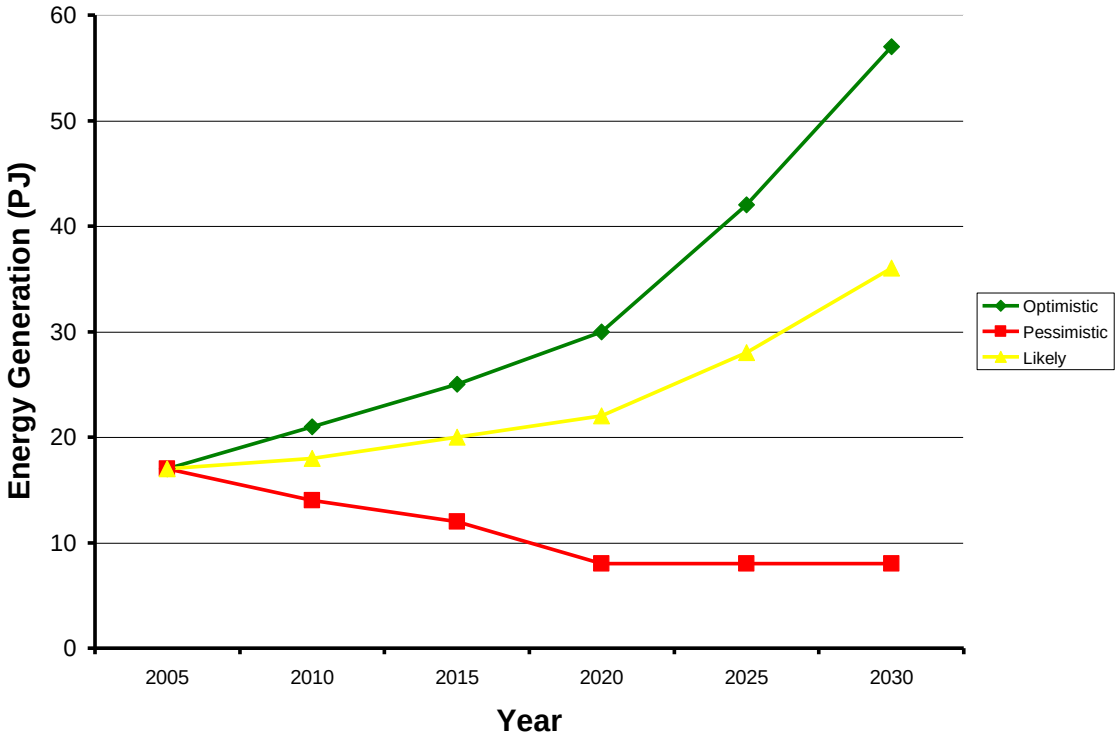

Figure 2: Hydro-Electric Generation Projections up to 2030

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