Hydro Power: The History and the Future.

Introduction – Overview.

Figure 1: unknown dam (Energy Information Solutions, 2003)

Hydroelectric power has been harnessed in carrying forms for well over a century on a commercial/industrial level. On a smaller scale, the use of water power may be date as far back as the ancient Greeks, who used it to power mills (The Environment – a Global Challenge, 1999). In the UK, large scale HEP (hydroelectric power) schemes (over 25MW capacity) were implemented in the 1950s and 1960s (Generating a Sustainable Future, 2003).
From this point of view, the technology surrounding HEP is well-established and most of the hitches have been ameliorates. This means that HEP is a 'safe' renewable resource. A problem with HEP which is currently only in its infancy is an effect of global warming – reduced rainfall. This could potentially reduce the efficiency and production of power. This is only a supposition, as there is no data currently available.
Today, hydro power supplies one quarter of the world's electricity, and 5% of its overall energy requirements (The Environment – a Global Challenge, 1999). Hydro power is seen as a sustainable renewable resource, and is therefore promoted, especially in the developing world as the demand for energy increases very rapidly. However, many people claim that insufficient research into its effects on aquatic ecosystems has been carried out. Also, if a large-scale hydro dam collapses, many thousands of lives could be at risk, especially in developing countries where the dam may also be a source of livelihood through fishing.

Figure 2: River Kerry Dam (Highland and Light Power, 2004)

A down side of hydro power is that it only generates electricity – there is no raising of steam involved and therefore it is inefficient to use it as a heat source. Another possible problem with using hydro power on a large scale is that there are only a few suitable areas in the country which are suitable, as it is potentially quite disruptive to the environment, as rivers may silt up and this could change a whole ecosystem.
This limitation means that other forms of hydro power are being investigated and while the large-scale schemes will be maintained and still generate energy for several decades, small scale hydro

(<5MW capacity) and micro-hydro schemes (not connected to the grid) harnessing the power of water through the river itself, rather than damming a river, is the future.

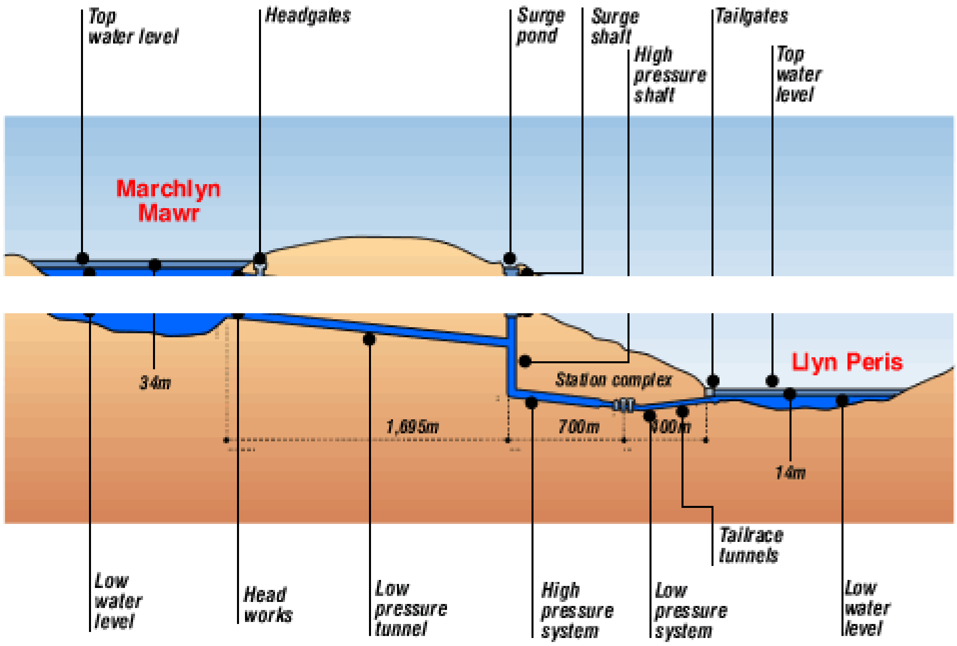

Figure 3: Dinorwic Pumped Storage Scheme (First Hydro Company, 2004)

Hydro power comes from two main sources. The first is pumped storage schemes e.g. Dinorwic, N. Wales (figure 3). This picture shows a plan of the power station inside the mountain. Pumped storage involves two reservoirs, either natural or man-made. One of the reservoirs is at a significantly higher level than the second. The two lakes, in this case Marchlyn Mawr and Llyn Peris, are joined by a penstock (a pipe/conduit used to carry water to a water wheel or turbine), with a sluice gate at the top and bottom. There is a turbine and pump at the bottom of the penstock (figure 4). The water is stored in the top reservoir until a peak in energy demand occurs. The sluice gates are opened and full capacity power generation usually proceeds within 16 seconds.

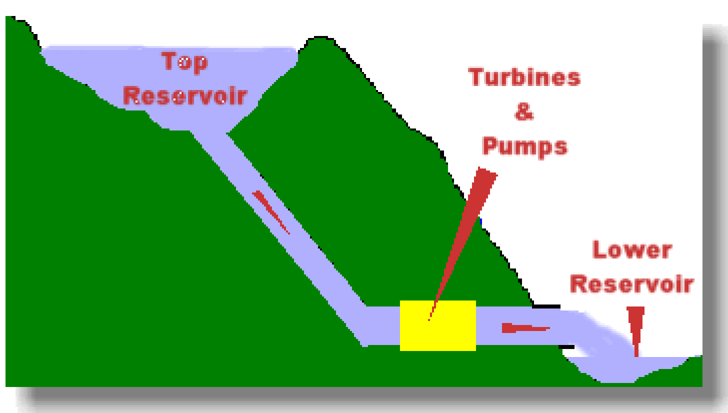

Figure 4: Simplified diagram of pumped storage (Darvill, A., 2003)

When the peak has subsided and there is excess power on the grid e.g. at night, the water is pumped back to the top reservoir. A problem or disadvantage of pumped storage schemes is that use power in pumping the water back to the top reservoir. However, this is opposed by its ability to contribute at peak demand, therefore there is no net energy loss of gain and therefore pumped storage will not be included in any projections of power production.

Figure 5: Loch Sloy Dam, Scotland (University of Strathclyde, 2004)

The second main source of hydroelectric power is large and small scale schemes involving damming of rivers, for example in the Scottish Highlands, which have large potential for HEP. These have less impact on the environment in the first instance, as smaller amounts of large-scale disturbance and construction are needed. However, the environmental disturbance by large-scale hydro plants is extensive. It may be seen that the effect of this dam at Loch Sloy, Scotland (figure 5), has had a huge effect as the water no longer flows at the same rate as prior to construction. Small-scale hydro plants are generally less damaging to the surroundings for several reasons: the height of the weir needed is significantly smaller – 2.5m compared to up to 25m in large-scale, the construction is generally carried out in local stone to reduce visual impact, and penstocks are often underground, along with power cables; this is not practical on a larger scale but has less visual effect. The drawdown of the scheme is also less – up to 2.5 of which 1.2m is natural variation, compared to artificial drawdown of up to 15m in a large scale scheme. These differences may be seen in comparing the dam at Loch Sloy (figure 5) with the weir at Garbheig (figure 6). Small scale hydro does not generally involve damming or introducing a weir into a waterway.

Figure 6: small-scale Hydro scheme, Garbheig, Scotland (Highland Light and Power, 2004)

Current Trends in Hydro power generation in the UK.

At present, hydro power accounts for approximately 2% of the UK's power generation (Highland and Light Power, 2004). It qualifies for a Renewables Obligation Certificate (ROC) (Shetland renewable Energy Forum, 2002) and therefore may make up a slightly higher percentage of power supply in the UK in the next few years, as power suppliers are obliged to provide at least 10% of their power from renewable resources by 2010, on an increasing scale from the current ~3% until that time. However, hydro schemes with a capacity of >10MW are seen to be competitive with other fuel types and are therefore excluded from the ROC scheme. This is because the technology is well-established and there are several such schemes in the UK, which are capable (with low-level maintenance) of last several more decades.

Hydro power generation is unlikely to increase a huge amount in the UK because it has a low load factor of up to 40%. In practice, the load factor could be much higher, but not all of the schemes are online all of the time, reducing the overall load factor to an average of 33%. Figure 1 shows the long-term net capacity of all small and large scale hydro projects which are connected to the national grid.

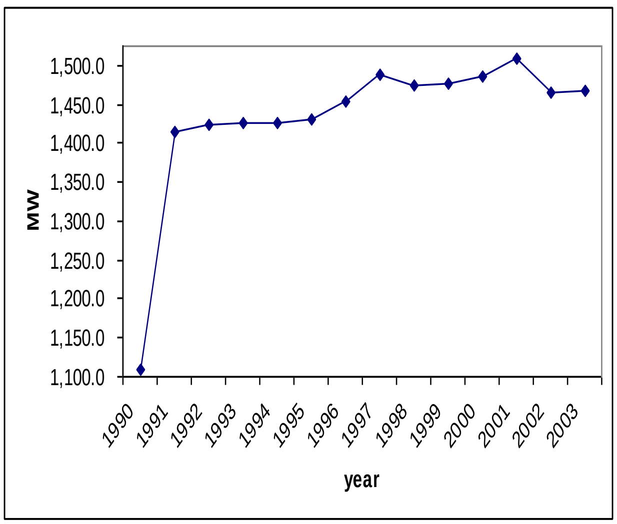

Figure 7: total net capacity of small- and large-scale hydro projects in the UK, 1990-2003

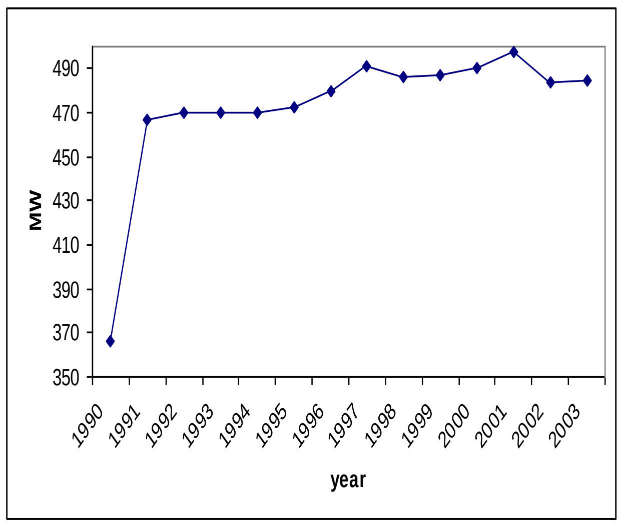

Figure 8: total generating capacity of small- and large- scale hydro projects in the UK, 1990-2003, load factor 33%

Along with the imbalance between installed capacity and load factor, there is another imbalance between areas where hydro power could be generated and areas which consume most power. The highest potential for HEP schemes in the UK is in northern Scotland, as there are plentiful rivers/lochs whose power could be harnessed. However, the greatest energy demand is in southern England, as there is a higher number of people per square kilometer. These means that theoretically the power could be generated by schemes in Scotland and enter the grid to power people all over the UK. The main problem with this is that transmission losses would then be incurred, along with the visual impact of putting power lines up all over a remote and beautiful area of the UK. There is understandable opposition to this and it is not considered a viable option. Therefore it is necessary to make use of any available hydro power. Some companies have micro-hydro projects generating electricity for their own private needs, which is therefore not introduced to the grid. There is regulation on this option, as anyone who removes water from a waterway for any purpose must first seek permission from the Environment Agency. Micro-hydro generally only produces a few hundred kW of power suitable for their needs. It is also quite a cheap and cost-efficient way of producing power for a business. The initial cost depends on the scale of the project, but all components are widely available, and after installation, with regular maintenance, the project could run for potentially several decades. There is also funding available from various initiatives, including 'Clear Skies'.

As seen from the graphs, the general trend with hydro generation is that it has decreased over the last two years. This is not the case with all forms of renewable power, and it may be that some of the new technologies are overtaking HEP generation, and also, the dry summers could mean that power generation is less efficient through lack of water.

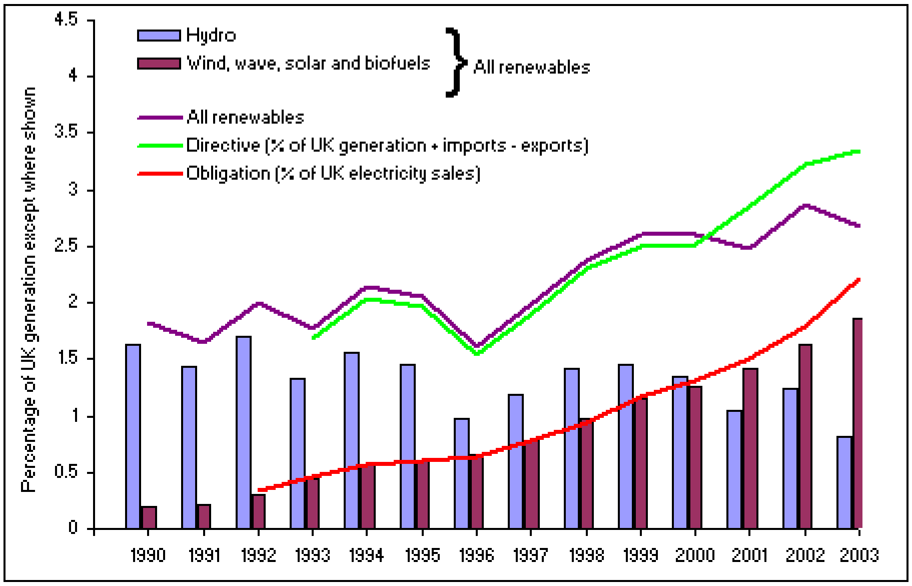

Figure 9: trends in renewable energy 1990-2003 (reStats Uk, 2005)

It is unlikely that any more new large-scale hydro projects will be commissioned in the foreseeable future (up to 2030), simply through lack of resource availability. The present large-scale hydro schemes are likely to be maintained and continue to produce the 12-15PJ energy per year as they do currently. It is unlikely that this will increase as there are no pending technological advances which will alter this output drastically (figures 10 and 11). In the future, it is likely that more small-scale hydro-electric power schemes will be implemented and this may increase the output slightly, but as they may only have a capacity of up to 5MW each, it is unlikely that there will be a huge unexpected increase.

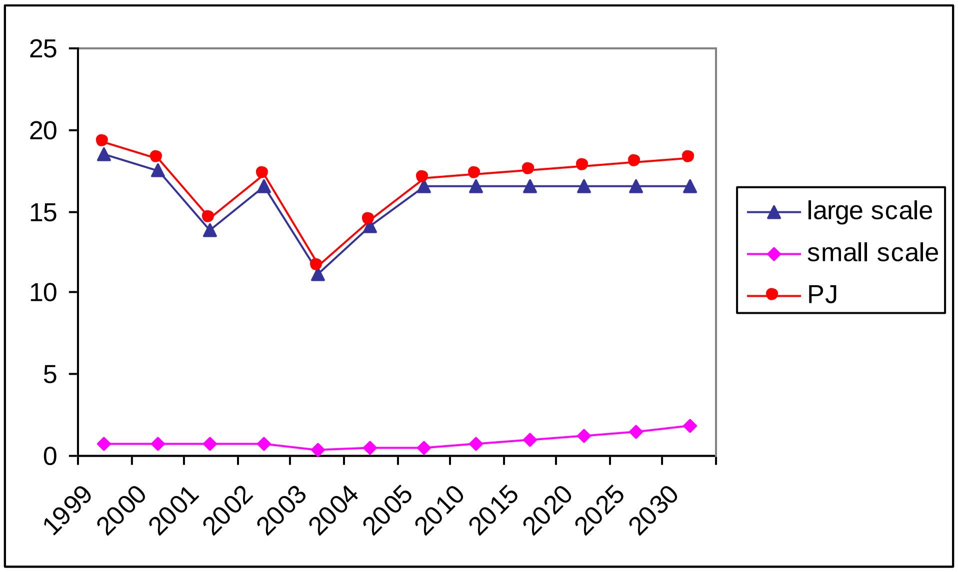

Figure 10: declared capacity projections for hydro projects connected to the grid 1999-2030

	large scale		small scale		total	
	GWh	PJ	GWh	PJ	GWh	PJ
1999	5128	18.46	207	0.75	5335	19.21
2000	4871	17.54	214	0.77	5085	18.31
2001	3845	13.84	210	0.76	4055	14.60
2002	4584	16.50	204	0.73	4788	17.24
2003	3113	11.21	115	0.41	3228	11.62
2004	3900	14.04	130	0.47	4030	14.51
2005	4584	16.50	145	0.52	4729	17.02
2010	4584	16.50	210	0.76	4794	17.26
2015	4584	16.50	270	0.97	4854	17.47
2020	4584	16.50	335	1.21	4919	17.71
2025	4584	16.50	420	1.51	5004	18.01
2030	4584	16.50	500	1.80	5084	18.30

Figure 11: hydro generation trends and projections (excluding pumped storage)1999-2030

These projections are based on the fact that in 2003 there was a drought during the summer, leading to lower than expected generation. The assumption was made that large scale hydro plants would return to 2002 levels of production by 2005 and no more capacity would be declared. It is worth noting that the graph above shows net capacity, not generation, and that it is likely that generation would not be as high as this due to not all schemes running constantly. From recent trends it may be seen that the growth of small-scale projects has increased consistently in recent years and the assumption was made that the technology would continue to develop and gradually larger numbers of schemes would join to the grid in forthcoming years.

This is the likely outcome, as illustrated above. A pessimistic view would be that no maintenance would be carried out on the existing large scale schemes and their capacity would gradually decrease, and that small-scale plants would develop slowly in terms of technology, and be met with opposition from the general public, meaning that only a few were to go ahead. In this instance, capacity would be greatly reduced.

An optimistic but equally unlikely outcome would be that as new technology is developed, the generating capacity of existing schemes would be increased to perhaps 3-5 times their present size, and that the small-scale schemes would develop equally quickly and become common as a generating source throughout the country, supplying power on a local scale, in a similar way to isolated wind turbines which supply the surrounding area.

Conclusion.

Overall, HEP is unlikely to be the answer to the UK energy crisis, as there is limited potential in the UK for large scale development. However, it is likely that HEP schemes will always exist on a large scale in the UK, although no new schemes will be developed through technical and locational constraints. On a small scale, there is the potential both from technology and location for great development in the future. As our reliance on renewable sources increases, hydro power will become increasingly more useful, especially in its pumped-storage form to supply energy at peak times of demand. The supply/demand inequality is likely to limit the potential of hydro-electric power supply, as it becomes less desirable compared to other forms of energy which have no limits on location.

There is a possibility that hydro electricity could increase internationally and that the UK could import excess power from this renewable source in order to supplement its own supplies. Local supply from small-scale plants will be important in the future as the renewables obligation for power suppliers increases.

Hydro power plays an important part in the UK energy future, as well as all other forms of renewable energy which are currently being developed. It is possible that between all renewable sources we could reduce our use of fossil fuels dramatically in the relatively near future and potentially halt or start to reverse the global warming process which the human race are currently encountering.

References:

Pictures
Figure 1: unknown dam, courtesy of Energy information Solutions, http://www.energyinfosolutions.com/consult.aspx
Figure 2: River Kerry Dam, and Figure 6: Garbheig weir, courtesy of Highland Light and Power, 2004, http://www.highlandlightandpower.co.uk/explaining.html
Figure 3: Dinorwic Pumped Storage Scheme, courtesy of First Hydro Company, 2004, http://www.fhc.co.uk/DIN.htm
Figure 4: Simplified diagram of pumped storage scheme, from Energy Resources, 2003 http://www.darvill.clara.net/altenerg/pumped.htm
Figure 5: Loch Sloy Dam, courtesy of the University of Strathclyde, http://www.esru.strath.ac.uk/EandE/Web_sites/03-04/wind/content/storage%20available.html
Figure 9: trends in renewable energy 1990-2003, courtesy of reStats UK, http://www.restats.org.uk

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