A Review of Hydro Power in the UK.
By Calvin Laing, Advisor: Tim Jickells.

Introduction:

Hydropower is an old technology. Centuries ago we harnessed the kinetic energy in rivers to turn a wheel in a water mill. These days we use the kinetic energy to turn a turbine, which is connected to an electricity generator[1]. The amount of electricity generated depends on the rate of flow and the volume of water available[2]. This flow of water may be a vertical drop created by a weir or dam, for example, or just the natural flow of a river.

Currently hydro is the world's largest renewable electricity generator, producing around 20% of the world's electricity[3]. It is the largest in the UK also, providing about 2% of UK electricity generation[4].

Types of Hydro Power: - Large Hydro:

Large hydro is described in government papers as any scheme, which has greater than 5MW installed capacity. This is somewhat subjective and varies from report to report; often 10 or 20MW is stated. They usually have a dam and a reservoir to store water[4]. The dam is built to stop/limit water flow and cause a reservoir to build up behind it. Energy is then generated when we want by allowing water to flow down a pipeline in the dam, turn the turbine at the bottom and allowing the water to then flow out into a river or another reservoir. See figure 1.

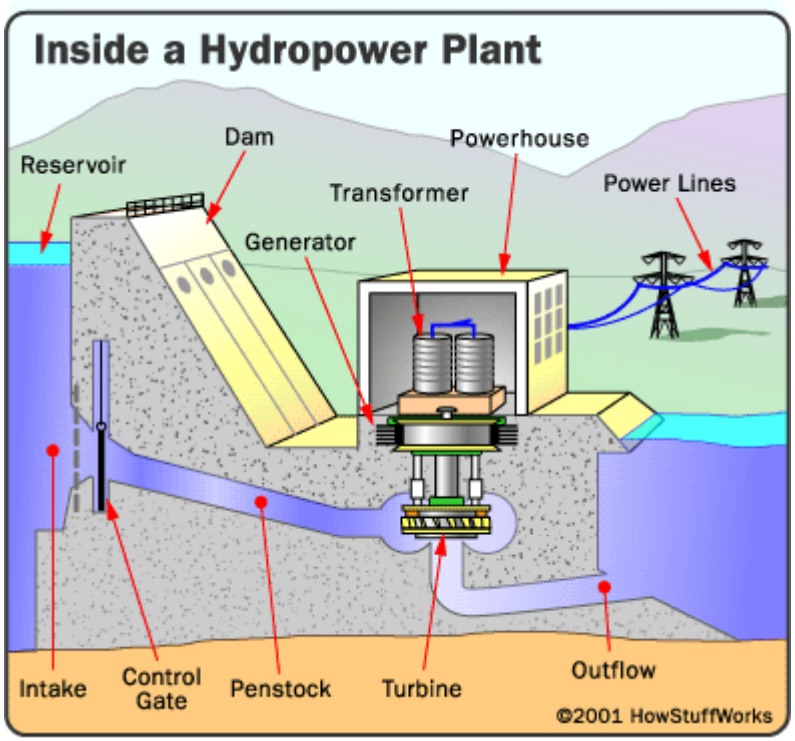

Figure 1: The design of a large hydro plant. Source: http://people.howstuffworks.com/hydropower-plant1.htm

Schemes where water flows from one reservoir to another can be used for pumped storage[2]. This works like a normal large hydro plant but at times of low electricity demand the generators can be used as motors and turn the turbines in the opposite direction to pump water up hill. When there is higher demand then this water can be released again to generate electricity.

A major advantage of hydropower plants is that they are able to come online within minutes[1]. If there is a sudden peak in demand, they can be very useful to cope with this. Pumped storage is also very useful in that we can salvage some of the energy that would have been wasted in times of low demand. Pumped storage schemes are however, not considered to be renewable as they are net users of electricity[4].

The load factor for large hydro can vary considerably though 30 – 40% is typical[5]. The efficiency of the turbine generator can be up to 90%[3].

Large schemes can take a long time to build, many years in some cases and the initial capital cost is high. However, their project lifetime is considerable, over 100 years is even possible- there is one scheme in Scotland that has been running since 1896[4]. The potential energy payback can also be very large, up to 200 times the amount of energy required to build and run the plant[3].

Large hydro schemes tend to be operated by the major electricity utilities and connected to the national grid.

Small Hydro:

Small hydro schemes are, as defined in government papers, those with less than 5MW installed capacity. A "hydraulic head" is required (a change in the level of water) but this needn't be created by a dam. These schemes may take advantage of existing features such as weirs to generate electricity and old water mills even. There are also, "run-of-river" schemes, where by the natural flow of the river is used and is simply directed onto a turbine to turn it[6].

Small hydro can be useful particularly for areas remote from the grid. Smaller companies and some water/electricity utilities usually operate them[4].

Micro hydro schemes are very small hydro plants, which generate a few tens of KW typically and are not connected to the grid. These can also be very useful in remote areas.

The load factor for small hydro is similar to that of large hydro, with average values varying around 30 – 40%[5].

Although there is a large capital cost for both large and small hydro, once they are built they are highly reliable, have low running costs and no fuel costs (excluding pumped storage) [4].

Current Capacity:

In the UK we can currently generate about 11.6 PJ[7] of electricity using hydropower. Large hydro (> 5MW) constitutes around 95% of this and small hydro, the other 5%. See figure 2.

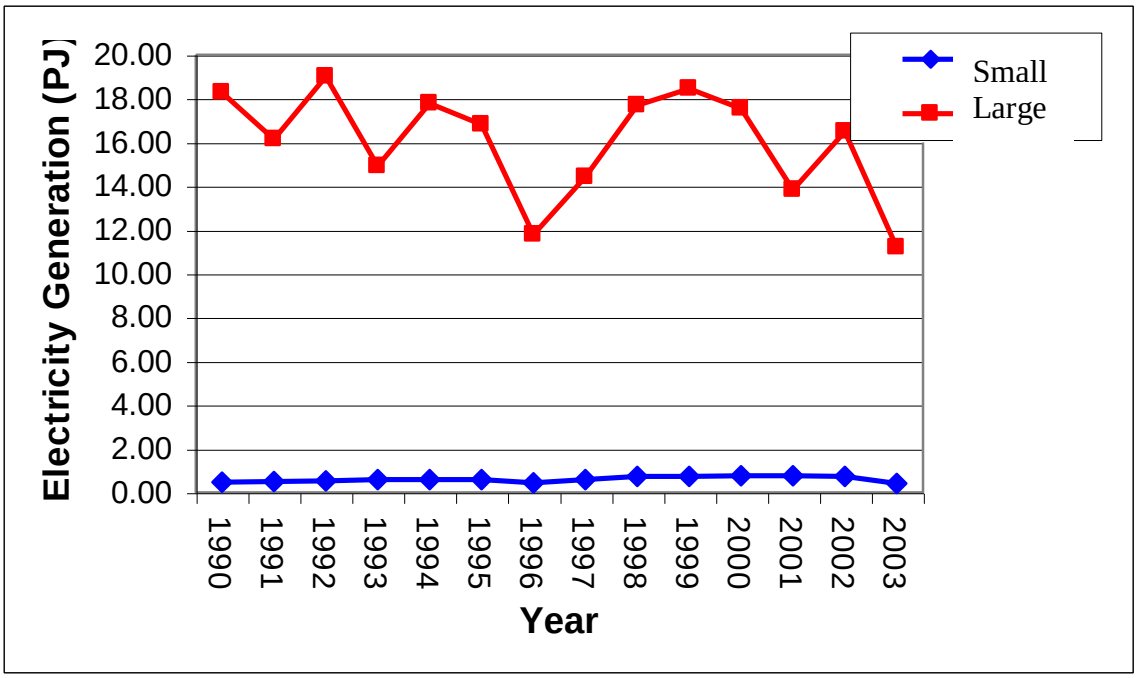

Figure 2: Recent trends in large and small hydro generation.

Increasing the Capacity:

Technologically, hydropower is advanced and therefore we cannot expect a significant increase in our generating capacity from new technologies making the process more efficient etc.

There are many UK based companies experienced in hydropower. There are those that make turbines, generators, there are civil engineers, developers etc[4]. So any expansion in our hydropower capacity means that we have the majority of expertise and construction required in this country and so one benefit of this will be to create jobs here. It also means the energy overheads arising from factors such as transporting parts are kept as low as possible.

The main limit to increasing our large hydro capacity is the lack of suitable sites, those that were most attractive have already been developed and so there has been a lack of development recently[4]. Physically there are constraints, such as a sufficient rainfall catchment. There are economic constraints, some areas will cost too much for a dam etc to be developed on them. The initial capital outlay is very high as it is, with large hydro. Finally sites are limited by the environmental implications of building a dam and creating a reservoir. The change in flow of the water can alter the water quality (though not always detrimentally); it can also affect the ecology of the area[4].

There is still a large potential for an increase in the capacity of small hydro. There are many sites still to be exploited. There are environmental effects but these are usually

minimal. The complexity and cost of new schemes is also a limit to how many schemes can potentially be built[4].

There is a conflict in that most of our generating capacity is in Scotland but the major demand for energy is elsewhere. So transmission losses could be a problem. However, there is plenty of demand just in Scotland, e.g. Glasgow and Edinburgh, hydroelectricity should simply be used here.

Potential Capacity:

Most projections seem to predict that there is the potential to double our current hydropower capacity. This comes from:

- We can upgrade some of the current large hydro sites in Scotland to get about a 10% increase in capacity from those sites.
- For large hydro there is still about a 1 GW resource in Scotland, which may be exploitable but there are environmental considerations.
- For small hydro there is a resource of about 40- 110 MW that is commercially attractive now (at <5p/KWh) and there is a further resource of around 300-550 MW that may become attractive at <10p/KWh. [4]

There are many possible routes we may choose to take. We may decide to exploit all we have but this may have large environmental implications. It is likely that small hydro will increase significantly and be very useful at sites remote from the grid, or to back up an area's electricity supply.

For large hydro, we may decide to build no further stations due to their environmental impact. On the other hand, we are not even close to being on track for the Renewables Obligation figure of 10% renewable generation by 2010 and beyond that there will have to be a large effort to keep increasing this percentage. Therefore we may decide that large hydro is a technology we are experienced with and can help us meet this requirement and so exploit all the feasible resource. In this case we may see incremental increases in generation over the next couple decades up to possibly around 20 PJ, as if roughly demonstrated in figure 3.

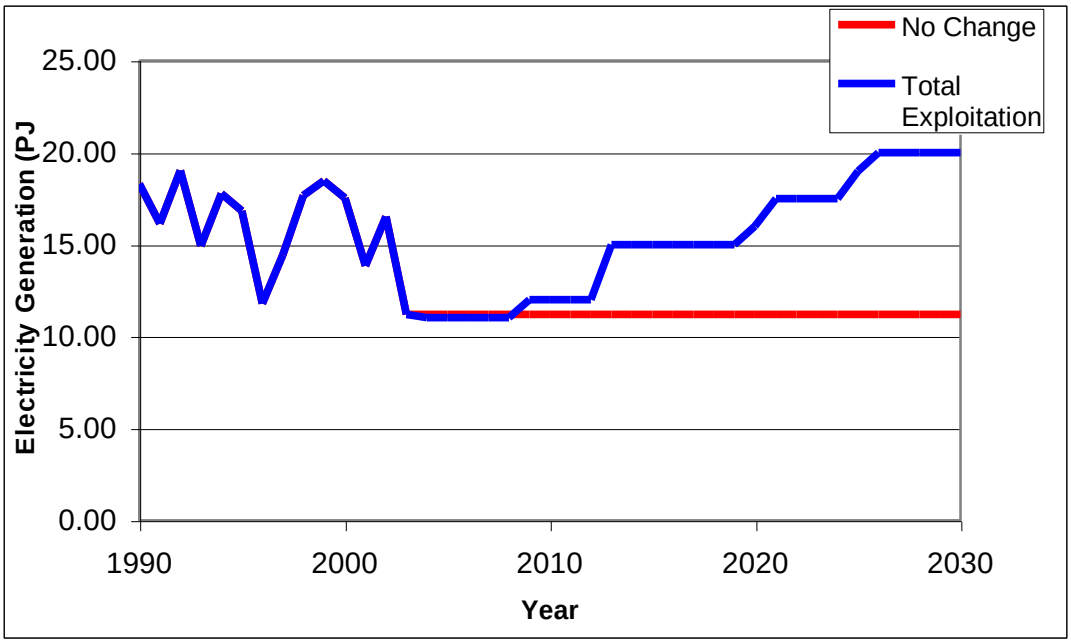

Figure 3: Future large hydro capacity- a pessimistic and optimistic scenario.
For small hydro it is likely that we will increase our capacity. We may continue along recent trends, or only install the most commercially attractive schemes (up to a little over 1 PJ) or we may exploit most of the attractive sites (up to around 2 PJ of generation), see figure 4.

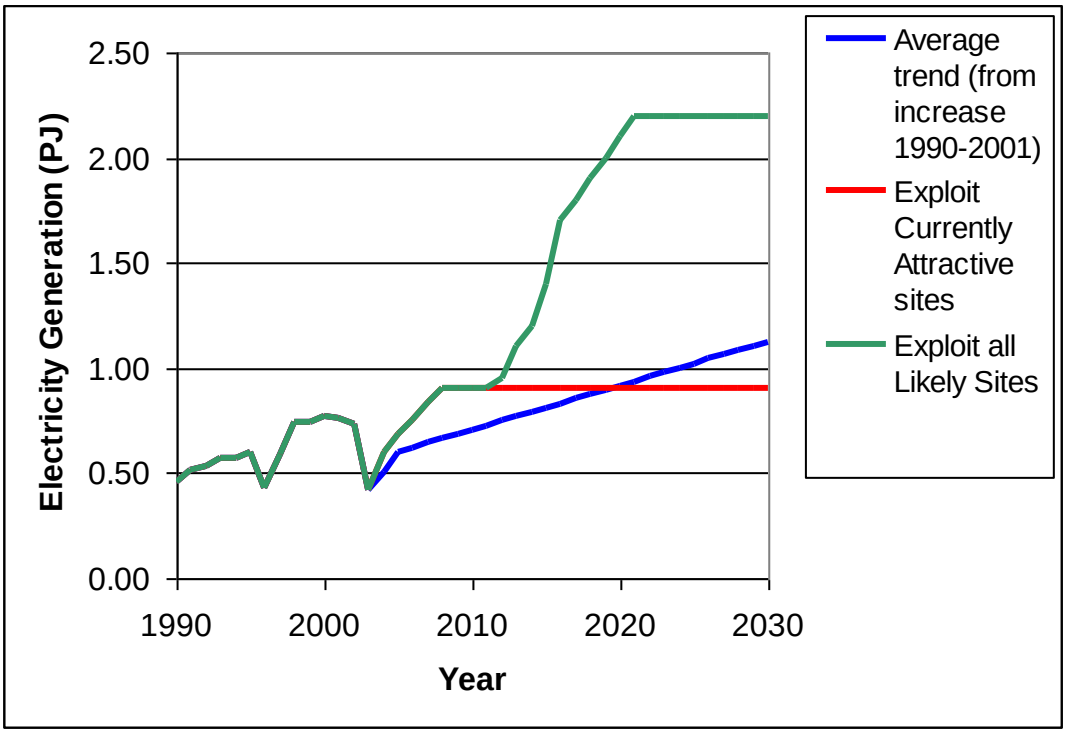

Figure 4: Future small hydro capacity, possible scenarios.

If we were to exploit most of our possible hydro resources we are likely to achieve a generating capacity of around 22 PJ, about double what we have now.

Conclusion:

We are unlikely to exploit all 22 PJ of hydropower but the option is there. The main problem with increasing our capacity in the UK is the lack of sites. There is no shortage of hydro resources worldwide; with so much UK based expertise an option might be to implement a project where UK companies build large hydro stations abroad and import that electricity, or just use it to off-set our under achievement within the UK to meet renewable targets. This would certainly be something that might work under the carbon trading regulations in the Kyoto treaty. Small hydro will almost certainly see a significant increase in capacity; however, this is only a very small fraction of the generating capacity we need to meet renewable targets. Bare in mind though, this does not undermine the usefulness of such schemes, for example, in areas remote from the grid.

References:

1- Powergen, Powergen Renewables: Building a Sustainable Future.

2- DTI, 2002, Products and services from Britain: Water power (hydro, tidal and wave).

3- British Hydropower Association, Website: http://www.british-hydro.org

4- Department of Trade and Industry, 2000, New and Renewable Energy Prospects for the 21st Century.

5- International Energy Agency, 1998, Benign Energy? The Environmental Implications of Renewables. – Appendices for small and large hydro.

6- Department of Trade and Industry, Website: http://www.dti.gov.uk/renewables/

7- Figures derived from: Department of Trade and Industry, 2004, Digest of UK Energy Statistics (DUKES).