Subsidies and Subterfuge

Hydro-power and the Renewables Obligation

The Scottish Wind Assessment Project

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The Scottish Wind Assessment Project is an ongoing programme of research which seeks to collate existing studies and commission new research to promote a thorough investigation of the claims made for and against the use of wind-generated energy and associated issues. It is supported by private donations.

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Front cover: The underground turbine hall at Livishie (15 MW). Part of the Great Glen scheme and one of the last to be built by the North of Scotland Hydro Electricity Board, it was refurbished in the late 1990s.

Summary of argument

DURING CONSULTATION on New Labour's renewable energy policy and the Renewables Obligation, which ran from March 1999 to March 2001, government and stakeholders alike agreed that existing large hydro-power stations should, as a mature and profitable technology, be excluded from the subsidies regime.

However, after consultation closed, hydro generators pressed the government to reverse its decision, citing ageing plant and poor trading conditions.

Two major changes were subsequently made to the regulations, both of benefit exclusively to large generators. The first, which eased the qualification criteria for subsidies to include all hydro-power stations under 20 MW, was made public.

The second, which was all-but hidden from public view and did not generally come to light until 2004, brought an even larger portion of the UK's hydro portfolio into the scheme. It authorised owners to cut the capacity of turbines to bring them below the declared qualification limit.

As a result, since the Renewables Obligation schemes became operational, UK hydro-generation capacity has gone down, not up, for the first time in the technology's 100-year history. Claims that efficiency improvements offset the capacity cuts are disputed as losses due to increased water wastage are inevitable. These losses are equivalent to closing Pitlochry power station.

This report examines how these decisions came about and the reasoning behind them. It argues that the subsidy payments which large hydro-generation now attracts are not justified by the modest quantity of additional electricity being produced.

Compared to production before the schemes became operational, a megawatt-hour of additional electricity, typically worth around £30, is now attracting subsidies of around £500.

The policy is costing electricity consumers £60 million a year, possibly more, but has done very little to increase the quantity of new 'renewable' generation.

It is an appallingly inefficient way to cut CO_2 emissions.

This is happening at a time when emerging technologies, including marine technology and photo-voltaics, are being starved of resources – both have recently suffered significant setbacks.

This puts yet another question mark over the competence of the Renewables Obligation schemes to tackle the emissions crisis. However, discussion of this issue is explicitly excluded from the current consultations on the schemes.

Contents

Introduction

THE GOVERNMENT'S GREEN energy initiatives, the Renewables Obligation and the Renewables Obligation, Scotland (RO/ROS), promise to raise £1 billion a year for electricity suppliers by 2010 through levies on customers. OFGEM estimated the cost to consumers in 2003-2004 at £416 million.[1]

The schemes are justified by the perceived ability of electricity generators to reverse the threat of anthropogenic climate change. The need to examine whether they are efficient or even effective is self-evident.

There are certainly those with doubts. Within the last year, a substantive report from the House of Lords Science and Technology Committee, while taking a rosy view of the competence of wind-generated energy, argued that the Renewables Obligation served to 'ensure that the government's targets are not attained', a Holyrood committee drew attention to the scheme's inability to develop new technology and a House of Commons Scottish Affairs Committee report was sharply critical. A recent report from the Council for Science and Technology did not discuss the RO schemes but did describe an energy-sector R&D 'collapse'.[2]

A paper published recently by this project attracted media interest when it quantified what many in the milieu already knew: the RO/ROS schemes had created a rash of wind-power proposals which Scotland's generation system could never absorb and which the planning system was unable to control.[3]

Scotland's Enterprise Minister, Jim Wallace, who dismissed the press reports as scaremongering, had earlier said that 'more ROCs were awarded both to landfill gas and hydro output than to onshore wind'.[4] Given the pace of accreditation under the schemes, the remark had little meaning (there are few landfill gas schemes in Scotland and England is outwith his remit) although it was certainly correct to remind us that hydro-power remains a significant part of Scotland's electricity generation portfolio.

There is probably no technology more attractive than hydro to engineers in the electricity supply industry. Its fuel literally falls from the skies; unlike other 'renewables', its output is predictable and controllable; unlike coal- or gas-fired generators, turbines can go from stationary to flat-out in minutes (and stop just as quickly) without wasting fuel or stressing machinery. It is operated remotely, needs little maintenance, no back-up and lasts for decades. Unlike wind-power, it reduces the need for thermal plant. Once built, there are few emissions and no dangerous waste.

The main generator set at Scottish & Southern's Culligran Power Station by Inverness. Originally 24 MW, its capacity was cut to 17.1 MW prior to the introduction of the Renewables Obligations in April 2002. It is currently being refurbished.

While it is imperative that a renewable energy strategy pays heed to these qualities and ensures that plant is used as efficiently as possible, the effect of the Renewables Obligation on the hydro sector has hitherto attracted little public attention. Aspects of its role are examined in this report, not least to see if its failure in the wind-energy sector has parallels elsewhere.

Notes

1 OFGEM, *The Renewables Obligation, Ofgem's second annual report*, p 1.2. See also p 14, note 2.

2 See, House of Lords, *Renewable Energy: Practicalities,* 1.13; Scottish Parliament, *ECC 6th Report 2004*, para 15; House of Commons Scottish Affairs Committee, *Meeting Scotland's Future Energy Needs'* Council for Science and Technology, *An Electricity Supply Strategy for the UK,* page 6.

3 Scottish Wind Assessment Project, *A Gazetteer of wind power in Scotland*, Janaury 2005.

4 Letter in reply to objectors, 6 October 2004.

How large hydro edged its way into subsidy

THE GOVERNMENT BEGAN to consult on its plans for renewable energy in March 1999 with a series of papers called *New and Renewable Energy: Prospects in the UK for the 21st Century*. The consultation call made only general reference to hydro but a *Supporting Analysis* published that May defined its place:

> Large-scale schemes will be taken here as having an installed generating capacity of greater than 5 MW. The assumption is that large-scale schemes would be developed and operated by major electricity utilities . . .[1]
>
> Large-scale hydroelectric schemes have not been included in NFFO rounds to date because this is already a fully established, commercial technology. No new large hydro construction is likely, due to environmental objections.[2]

An *Analysis of the Responses to the Consultation Paper*, (October 1999) did not refer to large hydro but *Conclusions in Response to the Public Consultation* (January 2000) abruptly raised its qualification limit from five to ten MW:

> Eligible supplies . . . may exclude hydro-electric schemes . . . exceeding 10 MW since large scale hydro has long been established in the market and is in a position to compete in the open market with fossil-sourced energy.[3]

The shift made another dozen stations (94 MW) potentially eligible for RO subsidy. Given their age (two had been operating successfully since 1936 and a third was built in 1927 and fitted with new turbines in 1972), they could realistically be described as the 'fully established, commercial technology' which government had hitherto felt it inappropriate to support (table 1). Offering no explanation for the change, it added:

> The Government has announced that it now intends to allow electricity generated from renewable energy (with the exception of large scale hydro) to be exempt from the [climate change] levy.[4]

Over 150 hydro-stations could now apply for accreditation under Climate Change Levy (CCL) rules. As an academic recently noted:

> Remarkably, electricity from hydro schemes larger than 10 MW as well as nuclear stations does not qualify for exemption. Officially this is to 'stimulate growth in the development of renewable sources of energy' as all the major large-scale hydroelectric schemes in the UK have already been developed (HM Customs and Excise, 2004). An alternative view [is] that it was to avoid a potential windfall for Scottish and Southern . . . [5]

With the broad sweep of its renewable energy policy in place and supported by both industry and the environmental lobby, consultation on its implementation began in October 2000 with *The Renewables Obligation, Preliminary Consultation*.

Despite the subsidies concession, the government still seemed keen to ensure that funding supported emerging technologies:

> We consider that energy from waste and large scale hydro are both sufficiently commercially viable to allow us to concentrate support on those renewables which have yet to reach this stage . . .[6]
>
> Large scale hydro (i.e. exceeding 10MW installed capacity) [is] well established in the market and can compete with electricity from fossil fuels. For this reason, the Government considers that [it] should be excluded from the Obligation . . .[7]
>
> While relatively well-established technologies such as large scale hydro and energy from waste will count towards achievement of the 10% target, they will be excluded from the Obligation.[8]

RO = Renewables Obligation
ROS = Renewables Obligation (Scotland)

Station name	Capacity	Scheme	Commissioned
National Grid			
Kielder	6.00 MW	--	1984
RWE nPower			
Cwm Dyli	9.90 MW	RO	1906
Scottish & Southern			
Allt-na-Lairige	6.00 MW	ROS	1956
Cassley	10.00 MW	--	1959
Foyers Falls	5.04 MW	ROS	1968
Gaur	6.40 MW	ROS	1952
Loch Gair	6.00 MW	ROS	1961
Sron Mor	5.00 MW	ROS	1957
Striven	8.00 MW	ROS	1951
ScottishPower			
Carsfad - set # 1	6.00 MW	ROS	1936
Carsfad - set # 2	6.00 MW	--	1936
Earlstoun - set # 1	7.00 MW	ROS	1936
Earlstoun - set # 2	7.00 MW	--	1936
Stonebyres	6.00 MW	ROS	1927
Total Installed Capacity:	**94 MW**		

Table 1: Hydro stations made eligible for the RO schemes by raising the qualification level from 5 MW to 10 MW.

Again, the position seemed clear enough and stakeholders seemed to be supportive. A DTI paper of March 2001, analysing over 200 replies, commented that:

> A wide range of technologies should be included in the Obligation, including energy from waste, wave power, tidal power, photovoltaics, wind power and biomass. The exclusion of large-scale hydro power received majority support.[9]
>
> The majority view on hydro power was that the Government is right to exclude large-scale hydro power from the Renewables Obligation.[10]

In short, the consultation concluded with broad agreement on the government's RO schemes and support for its unequivocal stance on hydro subsidies.

Not everyone was happy. Dr James Martin, Generation Director for Scottish & Southern Energy (SSE), addressed a House of Commons committee on March 21. Without doubt, his was an industry voice – SSE owns some 75 per cent of UK hydro capacity.[11] He argued that times were so bad that the company could barely afford to run, never mind refurbish, its elderly sub-30 MW plants. If government saw renewables as a priority, it would have to raise the subsidy ceiling from ten to 30 MW to guarantee a future for hydro stock.[12]

Although SSE's 2000-2001 Annual Report (June 2001) reported profits for the year up eight per cent to £655 million, it noted a disappointing year for hydro due to low rainfall and added:

> We are continuing discussions with the Government about the future fiscal regime for hydro stations and the outcome of these will determine our future investment programme.[13]

This was all slightly melodramatic. Times had admittedly been tough after NETA and industry cash-flow problems that saw British Energy flounder but SSE had found £15 million virtually to rebuild its large station at Sloy (150 MW) and £10 million for Rannoch (48 MW).[14] Work was ongoing at Pitlochry (15 MW). Prospects even for its smaller stations could not have been that bad – people were not going to stop buying electricity and hydro's prices held up better than most in the 2001 price slump. The figures suggest that refurbishment was unlikely to catch SSE short (see page 13).

Brian Wilson, who became New Labour's third Energy Minister on 11 June 2001, moved quickly to overturn his colleagues' policy. On July 20, a statement from Scotland's Rhona Brankin, modestly noting that she had 'secured Scotland's future as a major producer of energy from renewable sources', said:

> The Deputy Minister for Environment announced plans to extend support for established hydro plants under the forthcoming Renewables Obligation (Scotland) to include larger power stations. This will result in the refurbishment of an additional 30 hydro-electric power stations, investment worth £250 million and secure 200 jobs in rural areas.

SSE responded with a press release on July 23:

> We are delighted that output from refurbished hydro stations of 20MW capacity and below will receive Renewable Obligation Certificates (ROCs). This means that it is now attractive to refurbish our small to medium sized hydro

The House of Commons Science and Technology Committee quizzes Scottish & Southern's Dr John Martin, 21 March 2001

The route that we have taken . . . hitherto has been to invest approximately £20 million per annum in renewable energy. The purpose of that investment has been to sustain the hydro facilities which were built in the fifties and sixties of the last century. Those machines are now obviously 40 to 50 years old and a power plant typically has a life of 40 to 50 years. All our hydro is now in that age range and to keep it going we have found it necessary to invest £20 million-odd over approximately a 15-year programme, so we had committed to a £300 million investment programme which completely dwarfs any other investment in renewables in this country.

Is that not largely maintenance of what you have?

I would submit that that investment is necessary to keep what the nation has. The position at the moment, with the decline in the price of electricity, means that that investment no longer meets our criteria so we have stopped that programme completely at the moment. I am studying at the moment de-commissioning hydro and I would like the Committee to note that point.

Because gas generation is cheaper than hydro with the high maintenance costs you have at the moment?

Fundamentally the price of electricity has come down in this country which makes that investment in keeping Scottish Hydro going less attractive than other opportunities. Indeed, it does not meet our investment hurdle rates. Therefore we have stopped that programme. The solution, to move on along that particular line, is for the plants in the 10 to 30 megawatt range to receive some form of support. At the moment they are not eligible for renewable energy certificates. As such they are not economic to refurbish. The larger schemes are, and we have done most of those.

> stations, securing the long term future of this renewable resource for the UK . . . This will help secure over 200 jobs in remote rural communities across the north of Scotland.

Speaking in July at the opening of the now-refurbished Pitlochry, Brian Wilson may have mixed his metaphors but he made his views clear, saying the change 'would give hydro its biggest boost in 50 years' and that:

> Refurbished hydroelectric power plants are roughly 10 per cent more energy efficient . . . These new measures will wash away the cobwebs on old hydro-electric power plants. They will give companies the confidence to invest in this forward-looking industry.
>
> It is expected that the deal will result in the refurbishment of around 30 hydro-electric power stations and company investment of around £250 million into hydro-electric power projects.

Brian Wilson and Rhona Brankin were both mistaken: the measure brought 13 stations, not 30, into the schemes, eleven in Scotland (178 MW) and two in Wales (28.5 MW), see table 2. Of the UK's 27 stations over 20 MW, some had already been refurbished and others were large – to subsidise these in a nominally market-driven

RO = Renewables Obligation
ROS = Renewables Obligation (Scotland)

Station name	Capacity	Scheme	Commissioned
BNFL			
Maentwrog	15.00 MW	--	1928
RWE nPower			
Dinas	13.50 MW	RO	1962
Scottish & Southern			
Aigas	18.00 MW	ROS	1962
Cashlie	11.00 MW	ROS	1959
Ceannacroc	20.00 MW	ROS	1956
Invergarry	19.98 MW	ROS	1956
Kilmorack	20.00 MW	ROS	1962
Livishie	15.00 MW	ROS	1962
Nant	15.00 MW	ROS	1963
Orrin	18.00 MW	ROS	1959
Pitlochry	15.00 MW	ROS	1950
Torr Achilty	15.00 MW	ROS	1954
ScottishPower			
Bonnington	11.00 MW	ROS	1927
Total Installed Capacity:	**206 MW**		

Table 2 Hydro stations made eligible for the RO schemes by raising the qualification level from 10 MW to 20 MW – a change made after the public consultation closed.

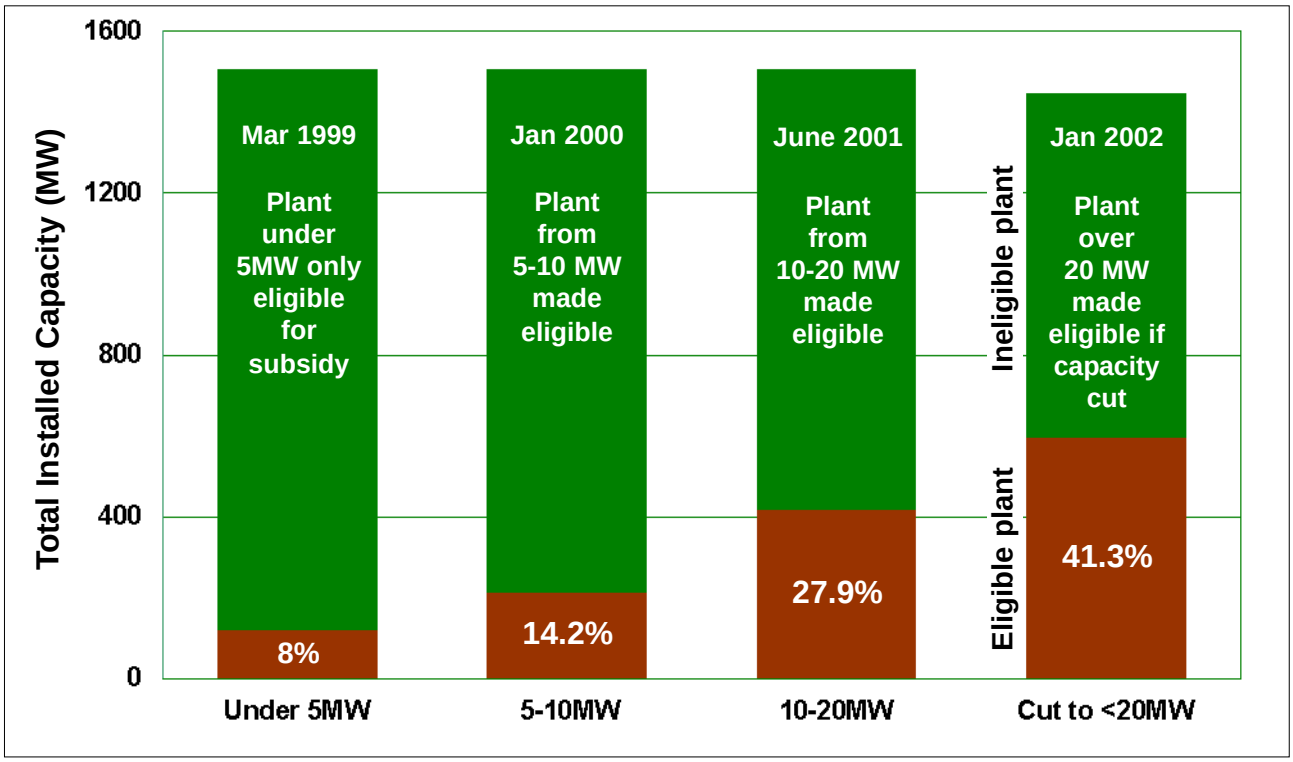


Figure 1: When and how existing UK hydro capacity was added to the Renewables Obligation schemes, originally intended to 'incentivise' new build and small-scale generation only. The lower (brown) segment of the bar represents the proportion of total capacity made eligible for ROCs at each stage.

The rules and the upper qualifying limit were incrementally altered in a way that ran counter to public consultation and was eventually to cut UK hydro's overall capacity. The last (and largest) change was not generally known to the public until OFGEM's *First Annual Report on the renewables obligations*, published two years after the schemes began.

industry would be controversial. Whitehall launched a new consultation round in August and noted the policy change:

> The majority of responses to the preliminary consultation supported the exclusion of large hydro stations, which were constructed under public ownership. However, concern was expressed by the industry over the age of current stations and the need to refurbish them, and there has also been concern that some potential new developments could not proceed without support. We, therefore, propose to exclude existing stations with a declared net capacity (DNC) of over 20MW from the Obligation, but to include any stations first commissioned after the date of the Order is made, regardless of capacity. We believe that these measures will encourage the refurbishment of existing stations of up to 20MW and will support any future schemes, if planning permission can be secured.[15]

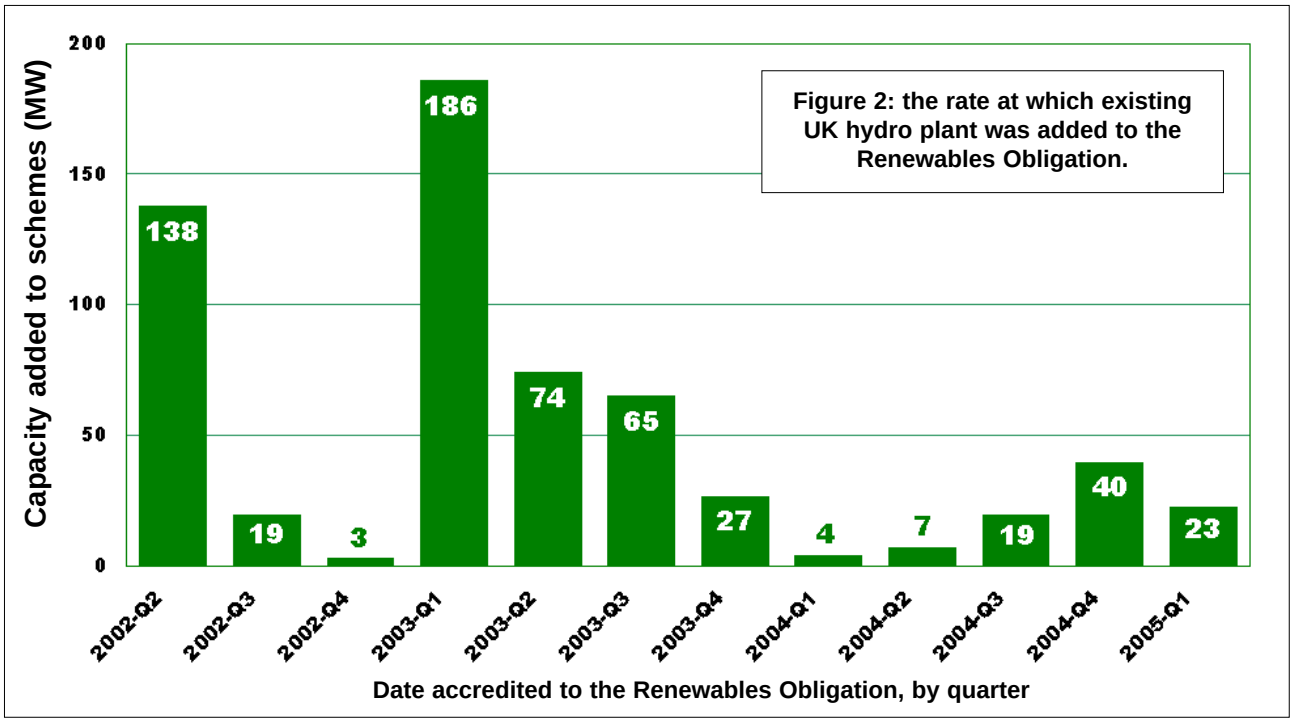
Even if the ministers were poorly informed, the rule change had at least been publicised. Publicity for another change was more discreet. The Renewables Obligation Order which came into force on April 1 2002 defined a large hydro station as one 'which has, *or has had at any time since 1 April 2002*, a declared net capacity of more than 20 MW' [emphasis added].

Few commentators grasped the significance of this at the time. If a station's capacity were cut from over 20 MW to under 20 MW before the April 1 deadline, it made it eligible for RO accreditation. It was necessary only to disable a few alternator windings: the new runner and sundries could be fitted at any time. On 26 September 2002, SSE reported that:

> Energy Minister Brian Wilson MP visited St Fillans Power Station on Loch Earn which has completed a £1 million refurbishment which will extend its life for 30 years and improve its efficiency by around 8%. Following the refurbishment of the 17 megawatt power station, it qualifies for Renewable Obligation Certificates (ROCs).
>
> The refurbishment is part of Scottish and Southern Energy's £450 million investment programme in renewable energy. £250 million will be spent refurbishing its hydro power stations in a 10 year rolling programme. St Fillans is the first of the Company's refurbished power stations to qualify for ROCs,

but made no comment on a 4.2 MW (20%) cut in St Fillans' capacity.[16] In November 2002, it said:

> Scottish and Southern Energy has announced today that five more hydro-electric power stations are to be refurbished at a cost of £4 million. The power stations involved are at Quoich, west of Invergarry, Mossford and Grudie Bridge, west of Garve, Shin, south of Lairg and Finlarig near Killin on Loch Tay. The refurbishments will extend the lives of the power stations for over 30 years and increase their working efficiency . . .
>
> The power stations are all rated at under 20 megawatts and when the refurbishments are complete the output will qualify for Renewable Obligation Certificates (ROCs). The refurbishments involve new runners and guide vanes . . .



The schemes became operational on April 1, 2002. The high figure for Quarter 2, 2002 is due to the prior accreditation of plant refurbished or built since 1989 and thereby eligible for subsidy without further intervention. The 'flurry' in Quarters 1 to 3, 2003 reflects the many larger sites by then refurbished – they dwarf small-scale and new build. Most of the work was complete by late 2003: the 'ten-year rolling programme' took barely 18 months.

Station name	Capacity		Scheme	Commissioned
Alcan				
Kinlochleven	19.50 MW	(was 30 MW, i.e. cut by 35 %)	ROS	1909
RWE nPower				
Dolgarrog High Head	18.40 MW	(was 37 MW, i.e. cut by 10 %)	RO	1907
Dolgarrog Low Head	14.98 MW		RO	1907
Scottish & Southern				
Culligran	17.10 MW	(was 24 MW, i.e. cut by 29 %)		1962
Finlarig	16.05 MW	(was 30 MW, i.e. cut by 47 %)	ROS	1955
Grudie Bridge	18.66 MW	(was 24 MW, i.e. cut by 22 %)	ROS	1950
Mossford	18.60 MW	(was 24 MW, i.e. cut by 23 %)	ROS	1957
Quoich	18.05 MW	(was 22 MW, i.e. cut by 18 %)	ROS	1955
Shin	18.62 MW	(was 24 MW, i.e. cut by 22 %)	ROS	1958
St Fillans	16.83 MW	(was 21 MW, i.e. cut by 20 %)	ROS	1957

Total Installed Capacity: 236 MW before downgrading

Total Installed Capacity: 177 MW after downgrading

Lost Capacity: 59 MW

Table 3: Hydro stations that became eligible for the RO schemes because their capacity was cut prior to April 1 2002.

The change that allowed hydro stations between 10 and 20 MW DNC to qualify for RO subsidies was made after consultation closed but it was at least public knowledge.

A later change allowing generators to cut the capacity of stations over 20 MW to qualify for RO subsidy was not generally known until an OFGEM report of February 2004, two years after the RO/ROS came into force.

These schemes impose heavy costs on consumers purportedly to stimulate the generation of 'renewable' energy.

The amendment does little for the schemes' credibility.

Again, few readers would have known that every one of these five stations had previously been over 20 MW but had had their capacity cut. Thereafter, the programme continued with little publicity: most eligible stations are now accredited for ROCs with the few remaining being added at a rate of one or more a month.

Apart from a January draft of the Order, SWAP can find no reference to the rule change in the public domain prior to OFGEM's *First Annual Report on the Renewables Obligation* of February 2004, nearly two years later. Section 5, *Down-rating of hydro generating stations*, comments:

> This provision allowed what would otherwise have been large hydro generating stations to down-rate their declared net capacity (DNC) to 20 MW or below before 1 April 2002 in order to be eligible for accreditation under the Orders.[17]

It reported that SSE cut capacity at seven stations and Alcan at one – Kinlochleven. This last, built with heavy sacrifice of labour and life, is now at its lowest capacity since commissioning in 1909 (see page 10). A ninth, nPower's 37 MW Dolgarrog site in Wales, was re-classified as two separate stations before capacity was cut at Dolgarrog High Head. In all, 236 MW was reduced to 177 MW (table 3). The report continued:

> The capacity that was down-rated equated to 59.21 MW in total. This ranged from 3.62 MW for the down-rating in respect of the Dolgarrog stations together to 13.95 MW for Finlarig. This capacity would have contributed to the Government's targets for renewable generation.

It was a reasonable point to make but the change was, by then, already law. A scheme originally intended to develop small-scale and new hydro generation was, by the time it became operational, heavily subsidising much of the plant belonging to the country's largest and most profitable hydro-power generators.[18]

At least one company had lobbied for the scheme to include plant up to 30 MW or 37 per cent of its hydro portfolio. It got its way: apart from Inverawe (25 MW), every SSE station formerly between 20 and 30 MW was eligible for subsidy by April 2002. The only snag was that capacity at seven of them had been cut for political reasons. There are certainly no reported technical or environmental reasons for the move.

It was now down to SSE's contractors to complete the 'ten-year rolling programme' of refurbishment and secure RO accreditation. They did well: it was all but complete in eighteen months.

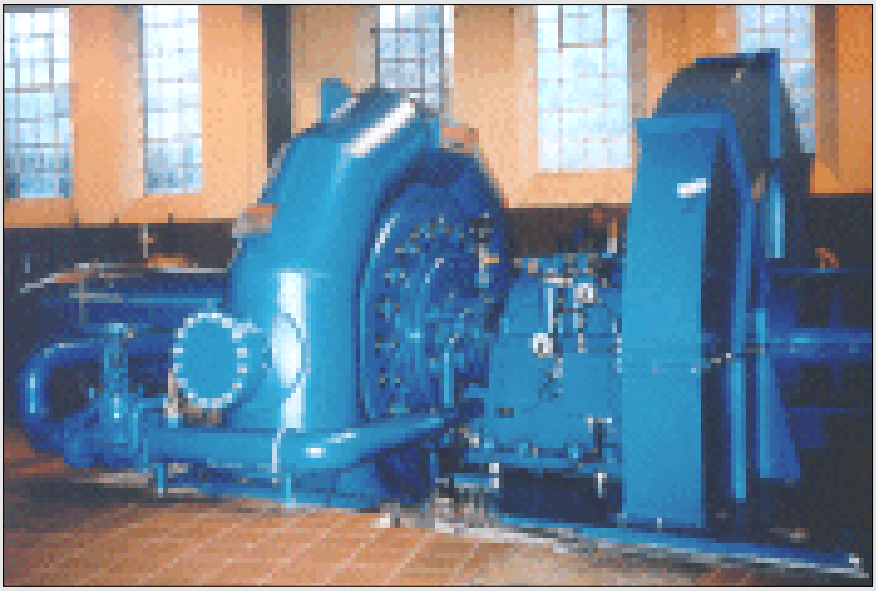
Notes

1 DTI, *New and Renewable Energy – Prospects for the 21st Century, Supporting Analysis*, May 1999, p 87, introduced by the Energy and Industry Minister, John Battle.
2 *Ibid*, p 91.
3 DTI, *New and Renewable Energy – Prospects for the 21st Century, Conclusions in Response to the Public Consultation*, p 9, introduced by the Minister for Energy and Competitiveness in Europe, Helen Liddell.
4 *Ibid*, p 13.

5 Harrison, *Prospects for Hydro in the UK: Between a ROC and a Hard Place?*, University of Edinburgh, prob 2005.
6 DTI, *New and Renewable Energy – Prospects for the 21st Century, The Renewables Obligation Preliminary Consultation*, October 2000, p 3.
7 *Ibid*, p 16.
8 *Ibid*, p 31.
9 DTI, *New and Renewable Energy – Prospects for the 21st Century, Analysis of the Responses to the Consultation Paper*, March 2001, p 1.
10 *Ibid*, p 6.
11 The rest of UK hydro is owned (by capacity) by Alcan (6%), nPower (7%), ScottishPower (8%) and small players (4%).
12 House of Commons Select Committee on Science and Technology, *Minutes of Evidence, 21 March 2001*, Q 102.
13 SSE, *Annual Report and Accounts 2001*, Chief Executive's Operating and Financial Review, page 4.
14 Although a Scottish Executive statement of 6 December 1999 quoted a figure of £115 million, SSE's *Annual Report and Accounts 2000* (p 17) gave the cost as £15 million and the efficiency gain as five per cent.
15 *New and Renewable Energy – Prospects for the 21st Century, The Renewables Obligation, Statutory Consultation*, June 2001, p 4 (introduced by a new Secretary of State for Trade and Industry, former Liberty director Patricia Hewitt).
16 SSE claimed typical improvements of six per cent, not eight, in *Annual Report and Accounts 2002*, p10.
17 OFGEM, *The Renewables Obligation – Ofgem's first annual report*, February 2004, p 40. The report should not be read, as some have done, as implying that the capacity cut led to a *pro rata* production loss – see page 12.
18 Twenty-one of 23 eligible UK hydro stations over 10 MW (383 MW, was 442 MW) are now in the RO schemes with SSE's Culligran currently being refurbished. BNFL's 15 MW set at Maentrog in Wales has not been accredited. ScottishPower did not downgrade sites although two in its New Galloway scheme are just over 20 MW.

Kinlochleven:

A site now at its lowest capacity for 93 years



The Department of Trade and Industry's *New Review* (a magazine for the renewables industry) of August 1998 carried the above picture and reported that:

'A 10 MW hydro turbine has been installed by Alcan Smelting and Power at the company's aluminium-producing plant in Kinlochleven, Argyll.

'The smelter there, which has been powered by hydro energy since its construction in the early part of the century, is scheduled for closure in the future and Alcan is utilising existing infrastructure investment as a basis for dedicated electricity generation.

'Designed, manufactured and installed by Gilbert Gilkes & Gordon Ltd, the new turbine is a low-specific-speed Francis type and harnesses a 'head' of 278 metres. A generator manufactured by GEC Alsthom was also installed as part of the package.'

The new machines (total 30 MW) replaced the original 1909 Pelton turbines (total 25.7 MW). These had provided an average annual output of 160 MkWh at a load factor of around 70 per cent.

Less than four years later, site capacity was cut by 35 per cent from 30 MW to 19.5 MW, three-quarters of what it had been in 1909. As a result, Alcan's UK hydro capacity was cut by ten per cent overall.

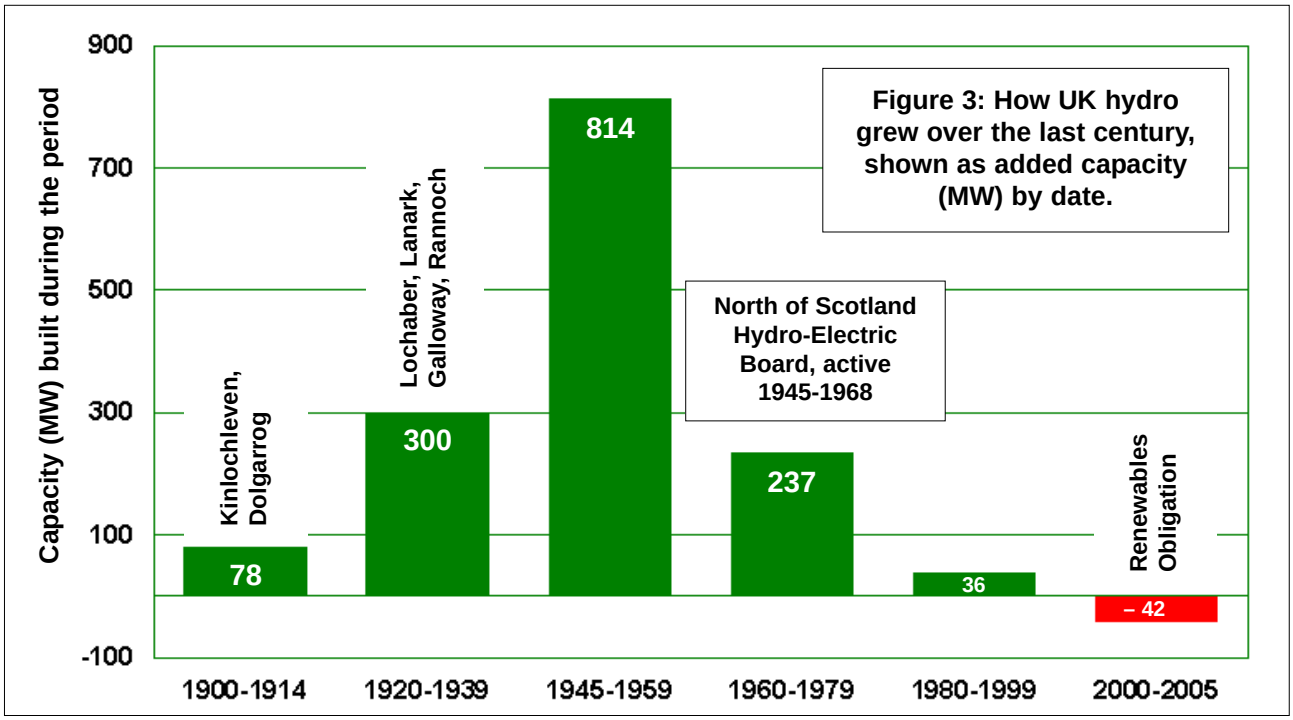
The site was accredited under the Renewables Obligation scheme on April 1, 2002.

The recent installation date meant that the company did not have to refurbish the turbines to qualify for subsidies. It also meant there were no grounds for claiming efficiency increases.

Losses due to spillage increases after the down-grading are estimated to be in the region of 20 MkWh (units) per year or about 10 per cent of production.

The Renewables Obligation has effectively doubled the price of Kinlochleven's product even though it may well be generating less electricity than at any time during the previous 93 years.

An historical trend is reversed



THE GRAPHIC SHOWS the growth of UK hydro capacity since 1900. Note the construction campaigns of the Edwardian, inter-war and NSHEB years, described on page 16. Kielder (6 MW), commissioned in 1984, is the largest build since 1964. The pumped storage stations at Foyers (1974) and Dinorwig (1983) were certainly major projects but they are not generally recognised as 'renewable' and are not included here.

While private hydro facilities, mostly on rural estates, did fall derelict as the National Grid expanded particularly after 1945, the capacity was insignificant. (Some have been restored under the RO.) There is no record of any significant 20th century hydro plant going out of service once commissioned prior to the period preceding the introduction of the Renewables Obligation in April 2002.

There is little prospect that new build will correct this situation for several years at least.

- SSE, which downrated seven stations by a total of 45.2 MW prior to the RO launch in 2002, commissioned Cuileig (run-of-river, 3.3 MW) in 2002 and Kingairloch (3.5MW) in December 2004. The 7.5 MW Fasnakyle 'extension' uses the extra capacity to resolve a long-standing efficiency anomaly. The 100 MW scheme for Glendoe is, according to recent press coverage, 'unlikely' to be built if 'too many conditions' are attached. This might be yet more sabre-rattling but funding issues have also been reported.
- Alcan, which downrated Kinlochleven by 10.5 MW, has applied to build seven MW of new capacity.
- nPower, which downgraded Dolgarrog by a relatively modest 3.6 MW, commissioned Stanley Mills (0.8 MW) in May 2004. Construction is ongoing at its Braevallich (2.2 MW) and Garrogie (2.3MW) sites and the company has lodged applications for 37 MW of new capacity and reports projects in Wales.
- Glenglass (1 MW, private developer) came on-stream in 2002 and Inverbain (ditto) in 2005.

SWAP has records of two Scottish pre-applications (6 MW) but none of projects in England and Wales. This should not be taken to mean that there are none.

Note

DNC and build dates are based on owners' publications in preference to DTI or OFGEM data (there are inconsistencies). The latter were taken as authoritative for RO/ROS-accreditation and down-graded capacities. Data for 2000-2005 are slightly weighted as build dates are not known for about 20 very small sites (approx total five MW), most long-standing installations at water treatment plants and the like but otherwise assumed to have been commissioned between 2000 and 2005 even if the civil engineering is older.

Do the cuts in hydro capacity matter?

THE NOTION THAT refurbishment of the UK's hydro stations has increased their efficiency (and their output) and that this justifies the resulting subsidies is, unless qualified, potentially misleading.

SSE publicity claimed in 2002 that refurbishing a hydro turbine leads to efficiency gains of eight per cent while the then energy minister, Brian Wilson, suggested a ten per cent productivity hike. On its web site, Argyll and the Islands Enterprise started off more realistically but got carried away:

> SSE will also be investing over £250 million refurbishing some of their 50 year old hydro power stations in a 10 year rolling programme. This investment in modern technology will see an average 5% rise in the efficiency of these plants without extra water being utilised and could represent, overall, an extra 50MW of increased capacity.[1]

To win RO/ROS accreditation, a station owner must have replaced a turbine's 'runner' (i.e. the propeller or blades, according to type) and associated sundries some time after1989. Any turbine's output will indubitably fall over time as parts become corroded, worn and pitted. However, it is not generally possible to make *inherent* gains in efficiency simply by refurbishing it, although it can be restored to, or close to, its original specification. By the same token, gains made by replacing these parts will themselves be slowly eroded as the new parts wear.

An exception is where a turbine is particularly old – the new runner will be of improved design, mainly in the geometry of its blades. Manufacturers report that, in such cases, genuine efficiency gains of perhaps two to five per cent can reasonably be expected.

Claims made for production increases at the ten down-graded stations are especially hard to sustain. Where a turbine's capacity has been cut, operators will maintain or, more accurately, attempt to maintain, its output by running it for longer, i.e. by increasing load factors. While these higher load factors do almost maintain production, they are inevitably accompanied by increased spillage. The relation between load factor and spillage is well understood – see page 15.

An estimate of the production lost due to capacity cuts

The claim that refurbishing turbines increases their efficiency to the extent that it negates the capacity cuts does not stand up to scrutiny.

To maintain production at or close to previous levels, it is clearly necessary to run now-smaller turbines for longer, i.e. to increase their load factor.

It is a basic tenet of hydro-power engineering that higher load factors mean increased spillage, i.e. a loss in efficiency (see page 15).

Historical production data for the Scottish stations where capacity was cut suggest that the additional spill losses will cost over 50 million units a year in lost production. Figures for the seven SSE stations concerned are shown in table 4. Because Kinlochleven was recently upgraded and then downgraded, and its load factor was already high, the estimate of 20 million lost units (page 10) may well be conservative. Not counting Dolgarrog, for which there were no data to hand, the losses are roughly equivalent to closing down Pitlochry power station or, in current parlance, losing enough energy to power 13,000 homes.

Table 4

	Production before cuts (MKWh/yr)	Capacity		Load Factor		Estimated increased Spill Losses (MkWh/year)
		Before	After	Before	After	
Culligran	53	24	17.1	25	35	1.6
Finlarig	64	30	16.0	24.5	45.5	4.5
Grudie Bridge	78	24	18.7	37	48	3.9
Mossford	112	24	18.6	53	69	7.8
Quoich	77	22	18.0	40	49	3.5
Shin	115	24	18.6	55	70	8
St Fillans	68	21	16.8	37	46	2
Totals:	567	169	123.8			

It is difficult not to conclude that the decision to sanction capacity cuts was made to accommodate large generators keen to enjoy a subsidies regime from which they had to a degree been excluded whilst avoiding any publicity arising as a result of moving the goal posts for the third time.

Of course, design efficiencies at refurbished stations where capacity was not cut will be more or less restored with real, if modest, production gains. The cost of subsidising these is examined below.

Production losses were calculated for SSE's seven down-graded stations. (There were no data to hand for Dolgarrog and those for Kinlochleven were unreliable.) It is estimated that the down-grading will have reduced output by six per cent (table 4), roughly equivalent to closing Pitlochry power station.[2]

The figure of £250 million suggested by SSE for its refurbishment budget also needs to be qualified. It is hard to see, from internal evidence at least, how it could cost more than £60 million to refurbish its RO-eligible sites. Overhauling St Fillans reportedly cost £1 million; seven turbines at the five stations named in November 2002 were refurbished for £4 million; Contractor GE Hydro reported a $3 million tag for Shin, Quoich and Finlarig. ScottishPower's Bonnington (11 MW) and Stonebyres (6 MW) together cost just under £1.5 million to refurbish. In short, overhauling some of the largest turbines in the programme (average 14.3 MW) cost about £750,000 each, including, presumably, incidentals such as site decoration.

It is not clear what is different about the others except that they are generally smaller. Twenty-one are less than a MW, 20 are between one and five MW and only 17 are over five MW. Stations such as Livishie (17 MW) were refurbished in the 1990s.

Is subsidising large hydro good value?

REFURBISHING HYDRO UNDER the Renewables Obligation is certainly an enticing investment. It gives a site an added life expectancy of at least thirty years, longer than new thermal plant or wind turbines. Hydro tends in any case to attract above-average prices because it is available more or less on demand (nearly everyone has at last grasped that wind power tends to come on when it is not wanted and go off when it is). Its load factors are significantly higher than wind-power's capacity factors. In short, hydro-generated electricity is a superior product to wind power and, megawatt for megawatt, there is more of it.

New-build hydro's high up-front costs do make for complex trade-offs that make investors cautious but these do not concern refurbishments. Most of the costs were written off decades ago – owners get all-but new plant for £100 to £150/kW (of capacity). This compares favourably with £750 to £1,000/kW for wind power or conventional power stations without the need to navigate a costly and hazardous planning process.[3]

Best of all, the RO scheme is set fair to have the consumer pay back the capital cost through subsidies (on top of normal electricity prices) roughly once every eighteen months for years to come.

OFGEM issued hydro-generators with 1,270,337 ROCs in 2003-2004, worth £60 million at a typical ROC price of £47.50.[4] The 2004-2005 figure will rise as additional stations become accredited.

There are grounds for treating the claim of efficiency increases of eight per cent following refurbishment (see p 7) with caution and it is certainly not true for Alcan's new-but-downrated Kinlochleven.[5] But, if they are accepted, it means that the increased production is costing about £500/MWh, year in and year out for the foreseeable future – ten to fifteen times the current wholesale price of electricity. If the efficiency gain is actually less than this and the calculation uses the average ROC price (which is what consumers pay for) rather than the buy-back figure, the cost of the additional generation is very much higher.

It is an appallingly inefficient way of using consumers' money to cut CO_2 emissions. Its adoption is perplexing in the light of the already high profitability of the major suppliers who get these subsidies and of criticism directed at them by Scottish ministers and others following price rises that hit commerce, general consumers and the poor alike. It would have been cheaper by far for the taxpayer just to have paid for the refurbishments and be done with it.

Speaking to the Highlands Renewable Energy Group in April 2005, Brian Wilson reportedly said that his policy of bringing hydro below 20 MW into the RO schemes had been a 'great success' and should be expanded although he made no mention of capacity cuts. The House of Lords' Science & Technology Committee and others who question the merit of the schemes might care to ask 'Where to and how far?'.

Hopefully, following the less-than-open way in which the cuts in turbine capacity were authorised, it will not be a matter of discreetly authorising re-connection of disabled windings while retaining RO accreditation.

The insistence on heavily subsidising technologies that were self-sufficient in public ownership is open to further criticism in the light of difficulties in the marine-energy sector. Funding uncertainties recently saw

Wavegen sold off to German rival Voith Siemens Hydro. One hopes that if the new owners 'brush away the cobwebs' and take a 'forward looking' approach to marine generation it will not yet again mean British innovation underpinning manufacture elsewhere. If it does, the blame will lie in no small measure with the target culture of the Renewables Obligations and its inability to provide meaningful incentive for innovation.

The concerns voiced by Holyrood's Enterprise and Culture Committee (see page 4) and others were reinforced following the recent decision by Ocean Power Delivery (OPD) to install its new wave-power device in Portugal rather than locally after the company was offered a 12-year fixed tariff of £150/MWh. Despite development funded in part by Westminster and being tested at the Scottish Executive-financed European Marine Energy Centre in Orkney, a joint £30 million ScottishPower/OPD project for a wave 'farm' near Orkney has been shelved amidst more funding uncertainties.[6]

Recent press coverage also reports the pulling of funding for photo-voltaic generation technologies:

> Renewable energy campaigners said grant allocations for solar photovoltaic schemes – which harness sunlight to generate electricity – were being phased out from this summer by the Department of Trade and Industry even though the Government had promised support from 2002 to 2012.[7]

The backs-to-the-wall scenario suggested by Dr Martin at the Westminster committee was shortly followed by greener-than-thou posturing in Holyrood in the form of leap-frogging 'renewables' targets under Lib-Dem stewardship of the Environment and Enterprise ministries. This reassured the ROC market that there was space long-term for more players than enough even if hydro had, against expectation, become a significant contender: there seemed little chance long-term that there would be too many ROCs. It also exacerbated a wind-power over-capacity crisis that the Executive still cannot confront.[8]

It is possible to paint a picture that contrasts with Dr Martin's and shows instead hydro-power generators playing fast and loose with a profligate subsidies regime by citing conditions that were, in reality, a deal less arduous than they were made to look.

As a result, inappropriate concessions were granted by a bewildering succession of ill-informed energy ministers at national and regional level which led to high subsidies for a generation sector which had never needed them before and didn't need them now.

They can be justified neither by economic conditions or the need to support emerging technologies; they are also technically inappropriate. The emissions-effective use of hydro calls for low load factor (peak load) plant but subsidy has driven it in the opposite direction.

In short, the politicians were had.

Ironically, just as the RO is failing the marine energy sector so has it all but stifled new hydro build. Received wisdom has it that cost and environmental issues, particularly EU regulation, limit hydro's scope for expansion. However, engineers claim that acceptable schemes are more inhibited by fear of long-term investment. The literature reports outline proposals for new schemes that match current capacity, much of it acceptable under modern environmental regulation. Some of these are upgrades to existing schemes.

If the public is to retain confidence in the Renewables Obligation in the light of these and other distortions of the market, these issues need to be addressed.

An opportunity might have arisen during the current consultation round on the ROs. However, discussion of the topic was explicitly excluded in its terms of reference.[9]

Notes

1 www.hie.co.uk/aie/hydro_energy.html.

2 Production data were published at intervals by the NSHEB and later by Scottish Hydro-Electric. Correlation with OFGEM data was inconclusive – the samples are too short and 2004-2005 run-offs well above average.

3 Even these seem high compared to fire-sale prices of around £20/kW SSE paid in June 2004 for Fiddlers Ferry and Ferrybridge, two old coal-fired stations in England. Both have opted out of the EU's Large Combustion Plant Directive and must close on environmental grounds by 2015. They are currently earning ROCs through co-firing.

4 See *The Renewables Obligation, OFGEM's Second Annual Report*, table B1, p 73: 'The buy-out price is intended to act as a cap on the costs to be charged to consumers'. It is not the same as a ROC's value, typically around £45.

5 Alcan appears to have made no efficiency claims and SSE spoke only for its own plant. Blanket claims of efficiency increases seem to have been made only by politicians.

6 Independent, *20,000 volts under the sea*, 26 May 2005.

7 Independent, *Government pulls the plug on solar schemes*, 3 March 2005.

8 Scottish Executive, *Scotland's Renewable future – Beyond 2010*: the forty-per-cent-by-2020 'aspirational' target.

9 Scottish Executive, *2005-06 Review of the Renewables Obligation (Scotland) Order Preliminary Consultation*, etc.

What is spillage?

'Spillage' in a hydro scheme is water that goes directly down river without generating power.

To generate in line with demand requires a constant supply of water but, even in Scotland, periods of heavy rainfall are interspersed with lengthy dry periods and flow levels in rivers regularly vary by two or even three hundred times.

To smooth out these peaks and troughs, all but the smallest projects use a storage system comprising a dam, an artificial reservoir and a power station or stations at varying distances below the dam. Water flows under gravity from the reservoir through pipes or tunnels to power turbines which, in turn, drive electricity generators.

The amount of energy a site can produce is determined by its hydrology – how much water can be induced to flow into its turbines and from what height. The capacity of its dams, tunnels and turbines is determined by this and by its intended purpose.

A hydro station can provide a lot of power in short bursts or less power for longer periods – the percentage of time it produces the equivalent of its maximum output is called its load factor.

A low load factor (i.e. more power but in short bursts) does need bigger turbines and tunnels or pipes to feed them. (Compared to the cost of dams and tunnels, turbines are cheap.) It does not, as is often suggested, reflect poor productivity. On the contrary, the increased generation capacity provides operational flexibility and ensures efficient use of water.

Unlike coal- or gas-driven ('thermal') power stations, where starting from cold can take hours and where flexibility is limited even when hot, hydro can go on- and off-line in minutes. Operators can turn a station on when demand peaks and off again as it falls. This 'peak lopping' ensures genuine fuel savings at thermal plants – being predictable or 'firm', hydro needs no thermal backup. A good example of this is Sloy, which has a capacity of 152 MW, a load factor of about 10 per cent and an output of over 120 MkWh/year.

High load factors are a feature of plants originally built for aluminium smelting where continuity of supply was essential. They were achieved by design at the cost of comparatively low generation capacity and above-average spillage. An example is Kinlochleven where a capacity of 26 MW averaged 160 MkWh/year production at a load factor of about 70 per cent.

It is imperative to use as much of the available water as possible but to use it all is an unrealisable goal. Costs for dams and tunnels rise exponentially with size and it makes neither engineering nor environmental sense to build a system capable of storing quantities of water best described as spate. In practice, if levels rise too quickly after rain, the excess is 'spilled'.

The relationship between spillage and load factor is well-understood and quantified. The lower the load factor, the lower the probability of spillage and, conversely, the higher the load factor, the higher the probability of spillage. UK hydro stations generally enjoy low load factors with an average of just over 30 per cent – few stations run for more than fifty per cent of the time.

The increased load factors following capacity cuts intended to secure accreditation under the Renewables Obligation are inevitably accompanied by increased spillage and lost production.

UK hydro in the international context

THOSE WHO BUILT Scotland's hydro power can take justifiable pride in their achievement but it is salutary to set the UK's hydro-generation in a wider context.

Water power provides a fifth of the world's generating capacity but only one per cent of the UK's (figure 4). The largest ever hydro scheme is the joint Paraguay/Brazil Itaipu scheme, commissioned in the early 1980s. Its final capacity will be 15 GW, it will produce over 75,000 GWh of electricity a year and meet nearly all Paraguay's and a quarter of Brazil's demand.[1]

In Europe, hydro-power provides 99 per cent of Norway's electricity production (93 per cent of its demand); about half of Swedish and Austrian demand and a quarter of France's.

Dams remain environmentally controversial. Over 45,000 large dams world-wide (more than one new dam for every day of the 20th century) have fragmented 60 per cent of the world's major rivers. An authoritative November 2000 report published by the World Commission on Dams claimed that, for many dams, especially in hotter regions, '… in some circumstances the gross emissions can be considerable and possibly greater than the thermal alternatives'.[2]

In contrast, total UK hydro capacity (excluding pumped storage) is about 1,400 MW and produces one per cent of UK demand. Nearly all of it is in Scotland (figure 5).

Britain's first hydro-electric plant opened in Surrey in 1881 and Scotland's in Greenock four years later.[3] Early schemes of significance were driven by an emerging aluminium industry's voracious appetite for power. The North British Aluminium Company's Foyers hydro-plant started production in 1896 and an ambitious construction programme saw the creation of an eight-mile reservoir behind Europe's then-largest dam driving turbines at Kinlochleven. Generation began in 1909. High war-time demand saw the site's expansion using PoW and conscript labour.

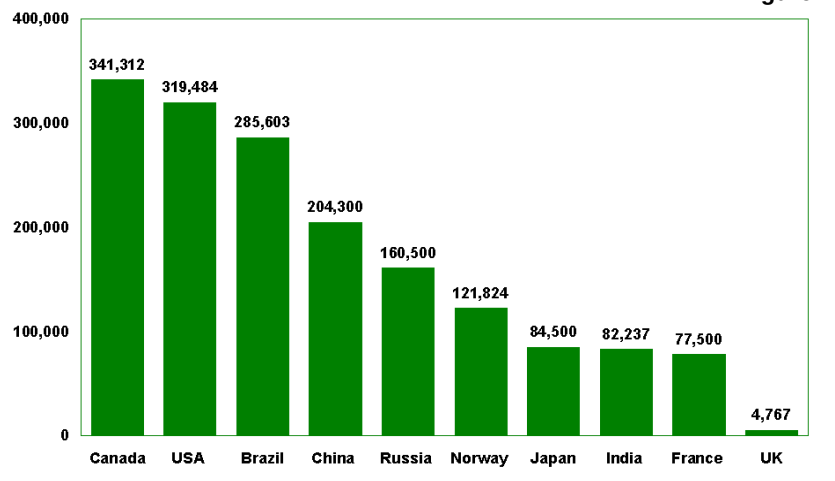
The inter-war years saw new schemes in Lanarkshire, Galloway and the Highlands as well as aluminium-extraction projects at Lochaber by Fort William and Dolgarrog in Wales.

Hydro's zenith years were from the mid-1940s to the mid-1960s. Led by Tom Johnston (see page 18), the North of Scotland Hydro-Electric Board was as much an engineer of social change as an administrator of engineering. Under a 'social clause' that reflected Johnston's political aspirations, it sought to reverse Highland de-population by attracting investment and, through electrification, to improve the quality of life for those who stayed.[4] Success with the first of these ambitious aims was limited but it undeniably achieved the second. It retained both a public service ethos and widespread respect until disbanded after privatisation.

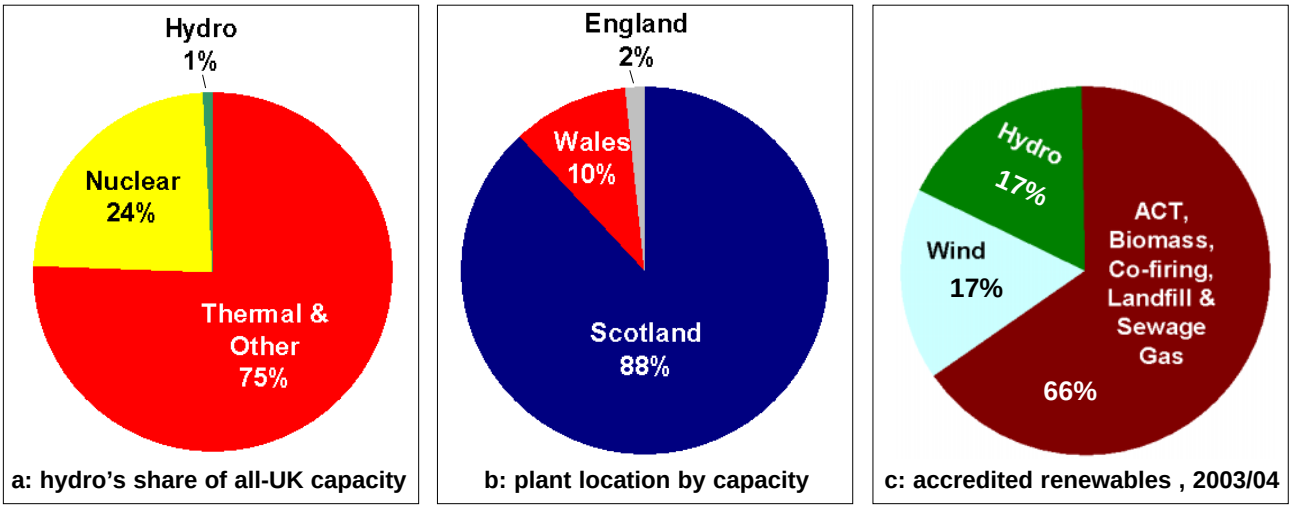
Between 1945 and 1963, the Board built 28 schemes with 66 dams, 51 power stations, 170 miles of tunnel, 100 miles of aqueduct, nearly 20,000 miles of power line and a total capacity of over 960 MW. It brought affordable electricity to almost every home in the north of Scotland, a very considerable achievement. It is worth noting that it never used public funds or received any subsidy.

A 1961 review of Scotland's generation by the Mackenzie Committee and the 1965 rejection of the Fada-Fionn proposal by the incoming Labour government effectively ended what had been heady days.

Figure 4



UK hydro-power production (GWh) compared to the world's large producers.



a: hydro's share of all-UK capacity **b: plant location by capacity** **c: accredited renewables , 2003/04**

Figure 5: Hydro-power's contribution to the UK's total energy portfolio is one per cent of capacity (a); the plant is mostly located in Scotland (b) and, compared especially to thermal 'renewables', hydro's share is small (c). Note that the first two graphics are by capacity (MW), the third by production (MWh).

Pumped Storage schemes at Cruachan and Foyers were still to come but as adjuncts to ever-more dominant thermal plant. Although the Board retained its political independence, it was, by the mid-1960s operationally part of a national authority.

Board historians cite a Conservative agenda and even far-right plots for the construction halt but the truth is perhaps more prosaic.[5] However cheap it was to run, hydro's up-front costs were seen as too high realistically to expect it to meet a demand that was, by the early 1960s, increasing at an unprecedented rate. Thermal competitors seemed to offer a more viable alternative.

In modern generation terms, UK hydro is a long-established but niche technology confined largely to Scotland but with a limited presence in Wales.

Notes

1 China's Three Gorges Dam will have higher capacity but a lower load factor.

2 World Commission on Dams, *Dams and Development, a New Framework for Decision-Making*, Nov 2000, p 75.

3 Precise details differ but all sources agree that the technology has its roots in the early to mid 1880s.

4 Not all of them. The NSHEB's first project, Sloy, dogged by labour shortages due to grim working conditions and plentiful alternative work, was allocated German PoWs in 1946. At times providing ninety per cent of the workforce, they could be as reluctant as paid colleagues to tolerate their lot though less able to evade it. Their first task, an access road by Loch Sloy, became known as The Burma Road. They were repatriated late in 1948 along with PoWs from other NSHEB projects.

Sloy's workforce also included 'Displaced Persons' working on half pay to win the right to stay in Britain. Attitudes to the Geneva Convention and asylum seekers were, it seems, ever robust. Ironically, Tom Johnston's newspaper, *Forward*, had, much earlier, interviewed Patrick McGill, chronicler of equally rough conditions at Kinlochleven (1904-1909). Johnston later took vigorous steps to improve housing conditions on NSHEB projects. See Miller, *The Dam Builders* and Wood, *The Hydro Boys*, both 2002 but especially Payne, *The Hydro,* 1988. (The latter, an authorised history of the NSHEB, is indispensable.)

5 *Ibid*.

Sell and Buy Back

An arrangement whereby a company generating 'renewable' electricity for its own use instead sells it to a licensed supplier and buys back whatever power it needs, thus qualifying its output for ROCs.

Originally intended to assist the funding of e.g. small-scale photo-voltaic arrays, where a company which would otherwise buy power in the normal way instead installs its own plant, Sell and Buy Back agreements have been widely made by the water treatment and sewage industries where operators have had on-site hydro-generation facilities for many years.

The effect is to provide a long-term subsidy in return for the modest refurbishment of small-scale plant that has, in most cases, worked perfectly satisfactorily for decades. The capacities involved are modest.

Tom Johnston

TOM JOHNSTON'S place in Scotland's political and economic history is assured not least because contemporary politicians are given to hinting that they follow in his footsteps. His story is relevant here because of his role in the North of Scotland Hydro-Electric Board which supervised the construction of many of the schemes examined in this report.

Born into a middle-class family in 1881 and educated at Lenzie Academy and Glasgow University, he set up the left-wing newspaper *Forward* in 1906 which he edited and published for over 30 years.

Elected to Kirkintilloch Town Council in 1913, he pioneered municipal banking in Scotland and other welfare services then seen as innovative. He left the Council on election as MP for West Stirlingshire in November 1922 and travelled to Westminster as a colleague of the 'Red Clydesiders'.

When Ramsay MacDonald became prime minister in 1929, he appointed Johnston Under-Secretary of State for Scotland. Although promoted to Lord Privy Seal in March 1931, cabinet rank was short-lived – he refused to join the National Government established that August in the wake of a financial crisis that had paralysed the Labour government.

He lost his seat in the election that followed but returned to the Commons in November 1935. Appointing him Scottish Secretary in 1941, Churchill allowed him to pursue distinctive but successful war-time policies in collaboration with a Scottish Advisory Council comprising his predecessors in the post.

He set up the NSHEB in 1943 and, after leaving the Commons in 1945, was its (unpaid) chairman for 14 years. He compared its role to the Tennessee Valley Authority – public works as a vehicle for economic and social development.

He also chaired the Scottish National Forestry Commission (1945-48) and the Scottish Tourist Board (1945-54). Although chiefly remembered for his work on hydro, his contribution to Scotland's fledgling tourist industry was arguably just as substantial though much of what is almost hagiographic biography downplays it. Some have suggested that his tenure of the latter post helped to reconcile amenity and hydro but Johnson undeniably treated tourism as an economic sector with a prescient seriousness that his successors might do well to emulate.

As he developed into an outstanding administrator, the young man's socialist rhetoric inevitably mellowed into an organiser's impatience but he seems never to have abandoned either a deeply-held commitment to public service or high standards of personal conduct.

A (more balanced) biographer says that 'the privatisation of hydro power under a Tory government would have been the final blow to his ambitions for the Highlands', a fair claim but, of course, speculation. Likewise, we can but guess at his reaction to a Labour regime which has encouraged the Forestry Commission to clear-fell land for subsidised wind power with scant regard for tourism or his reaction to downgrading hard-won hydro in a fiscal three-card trick.

Johnson is remembered for a best-selling book, *Our Scots Noble Families* (1909), 'a furious denunciation of Scotland's gentry and its stewardship of the land'. Recently reprinted even though he disowned it, it is perhaps of more interest to polemicists than historians. He remained proud of the more substantive *The history of the working classes in Scotland* (reprinted 1974).

He died on 5th September 1965.

A glossary of technical terms

Alternator – a machine for converting mechanical energy into electrical energy. See *turbine*.

Buy-out – suppliers meet their Renewables Obligation by producing ROCs to OFGEM or making buy-out payments or both. Buy-out payments are recycled to suppliers *pro rata* to the ROCs they submitted whether targets are met or not. It is currently £31.39 per MWh. Payments to suppliers were £165 million in 2003/04.

Capacity – here, a measure of a generating set's ability to produce electrical power. See *Megawatt.*

Climate Change Levy – a levy on commercial energy users of 0.43p/unit administered by Customs & Excise. Businesses that buy power from accredited 'renewable' sources avoid the levy. It is 'fiscally neutral' in that funds are recycled to employers as reductions in National Insurance. It raises the price of electricity from accredited sources, making them more attractive to generators. The CCL on electricity is higher than other sources to allow for transmission losses.

Compensation – the provision of 'compensation' water downstream of dams to those parts of a water course that would otherwise be depleted by a hydro-power facility. There is a statutory requirement for a continuous minimum flow to protect aquatic life.

Compensation Set – a turbine installed in the path of a compensation flow. As this is usually located at a system's dam, a compensation set may be some way upstream of a station's main turbines. The largest compensation set in the UK is one MW but most are much smaller. Recognised by OFGEM as separate from other turbines in a scheme, they are described as e.g. Clunie Dam or Cwm Rheidol CS.

Declared Net Capacity (DNC) – the net capacity of a hydro power station, i.e. all its turbines less what is required for its own operation.

Down-rating – a little-understood provision of the Renewables Obligation Order whereby generators were permitted to cut the capacity of generating plant prior to April 1 2002 so that it might qualify, after refurbishment, for ROCs.

Generator – a generator is licensed to operate an electricity generating station and sell its product to a licensed supplier. The distinction between generator and supplier is crucial to the structure of the privatised, market-driven electricity supply industry. A vertical structure prevails in Scotland and efforts to bring it into line with the English model have had mixed success. See S*upplier*.

Head – the difference in height between the water stored in a hydro station's reservoir and the level at which it exits the turbines. The power that can be generated is proportional to the head.

Hydro-power – the generation of electricity by passing water under pressure and gravity through a turbine. 'Run-of-river' exploits the natural flow of a suitable watercourse but any sizeable scheme requires an extensive system of dams and tunnels.

Large Hydro – hydro-power stations defined by the Renewables Obligations Order as too large to qualify for ROCs unless new build. There are now only 17 'large' sites in the UK (approx 848 MW).

Load Factor – the proportion of time a generating set runs at the equivalent of its full output. It is a function of a scheme's design. Load Factors are usually measured over a year: a turbine that ran all day, every day would have a load factor of 100 per cent, for 12 hours a day, 50 per cent, etc. UK hydro load factors average 30 per cent (see page 15).

Load Following – since electricity can be neither stored nor discarded, system operators must vary power levels in line with a continuously varying demand. The process is called 'load following'.

Hydro power's ability rapidly to vary power levels is a prime asset in this regard and contributes to emissions reduction.

Megawatt (MW) – a million watts; the unit of capacity usually applied to electricity generating plant, a measure of a machine's *ability* to do work. It is frequently confused with Megawatt Hour.

Megawatt Hour (MWh) – a measure of work done. If a one-MW generator runs for an hour, it produces a MWh of electricity. It is therefore an index of electricity production and distinct from the *ability* to do work. Engineers tend to measure production in millions of kilowatt hours (MkWh) whereas political circles use MWh.

Micro Hydro – privately-owned (as defined by the

1989 Electricity Act) plant of 1.25 MW or less. It qualifies for ROCs without refurbishment. Many very small sites are not accredited.

New Electricity Trading Arrangement (NETA) – an electricity trading scheme that replaced the 'pool' and designed to curb alleged price fixing. When Scotland came into the scheme, it became the British Electricity Trading and Transmission Arrangement (BETTA).

New Build – in this context, new hydro-power installations. New build qualifies for ROCs regardless of capacity.

North of Scotland Hydro-Electric Board – the 'Hydro Board' was set up by Parliament in 1943, its task primarily to oversee the electrification of the Scottish Highlands by constructing generation and power distribution facilities. A 'social clause' charged it with attracting employment to the region. It was disbanded in 1990 in the aftermath of privatisation. See page 18.

OFGEM – the state-run regulator of the UK's gas and electricity markets. It administers and reports on the Renewables Obligation schemes.

Peak Lopping – the meeting of relatively short but intense peaks in electrical demand. To meet these with thermal plant requires that it be kept hot (and thus polluting) for significantly longer than it is producing. Hydro is the only current renewable technology able to displace conventional plant.

Pumped Storage – a power station that uses thermally-generated electricity at times of low demand to pump water from a lower to a higher reservoir. The pumps are later used as turbines to generate power. Despite significant losses, it increases the efficiency of the generating system as a whole. However, unlike landfill gas, it is not regarded as a 'renewable' technology.

Refurbishment – the Renewables Obligation Orders allows owners of older renewable-technology generating plant to qualify for ROCs if they refurbish, or have recently refurbished, the plant in compliance with DTI stipulations.

In the case of hydro plant, refurbishment involves replacing a turbine's rotating element (the 'runner') and associated sundries.

Renewables Obligation – the Renewables Obligation Order (2002) requires licensed electricity suppliers either to produce ROCs or pay a 'buy-out' fine corresponding to a proportion of the electricity it has sold during the year. It obtains the ROCs either from its generators or on the open market. See *buy-out*.

Renewables Obligation Certificates (ROCs) – under the Obligations, a 'renewables' generator demonstrates sale of its product to OFGEM which issues it with a ROC for each MWh it sells. Generators usually sell ROCs with the product to suppliers who use them to meet their obligation or for trade. It can also sell ROCs to other suppliers or retain them in the hope of selling later at a higher price. They currently trade at around £45.

Renewables Obligation Target – in England and Wales, an annually increasing increment of a supplier's total sales that must be met from an accredited 'renewables' source. It increases by an average of one per cent per year. In Scotland, the target has been subject to politically-coloured increases and it is not clear quite what it represents.

ROC Pot, the – energy traders' jargon for the Buy-out fund.

Small Hydro – hydro-generating plant of less than 20 MW capacity, excluding 'micro-hydro'. If it was built or refurbished after December 31 1989, its output qualifies for ROCs.

Spillage – when water rises too quickly for a dam and reservoir to retain, the excess flows directly downstream, not through the turbines. See page 15.

Supplier – Licensed electricity suppliers buy from licensed generators and sell to end users. It is a supplier's name at the top of electricity bills. They must prove renewables purchase from accredited sources but they receive 'Buy-out' money.

Turbine – in this context, a machine that converts the potential energy of water flowing under gravity and pressure into mechanical energy by turning a bladed rotor. It is coupled to an alternator to produce electrical power.

Shot of the refurbishment at Ceannacroc (20 MW), by Fort Augustus. It was accredited for ROCs in April 2003.