UKERC

UKERC RESEARCH LANDSCAPE: HYDROPOWER

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1. Overview

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Characterisation of the Field

Hydropower or Hydroelectric power defines the generation and distribution of electricity derived from the energy of moving water or water pressure. Hydropower accounts for around 21% of the world's electrical generating capacity, currently producing around 1650MW of power in the UK, with an additional 2788MW from pumped storage. However, recent surveys have shown a further 2GW of potential capacity in the UK remaining.

Hydropower can be broken down into dams, run-of-the-river schemes and pumped storage. Dams involve the impoundment of a volume of water which can be used for energy extraction at any chosen time; run-of-the-river schemes involve the harnessing of energy from the natural flow of water in river systems and pumped storage involves the use of two catchments at a head difference where generation can take place when required and pumping in reverse when excess energy is available. The technology required for effective hydropower schemes is based largely around the use of turbines which are developed to run at high efficiencies at a specific operating head and rate of flow or discharge. In general, where there is a large head and a low discharge such as large dams, Pelton turbines are most efficient and with a low head and a high discharge such as run-of-the-river schemes, Kaplan turbines are used. For intermediate head and discharge values, Pelton turbines or Crossflow turbines operate at higher efficiencies. A useful tool for hydropower development is LUREG's (Lancaster University Renewable Energy Group) Hydro Resource Evaluation Tool, also showing the turbine designs which will perform best at given heads and flow rates.

The first known reference to harnessing power from moving water was by the Greek poet Antipater of Thessaloniki in the first century B.C. who describes the freedom from toil of the young women using small hand mills to grind corn with the use of an "Overshot" vertical water wheel. From the 1700s onwards, major improvements were made to water wheel designs. From 1752 to 1759, John Smeaton conducted a series of experiments on model water wheels, publishing a paper describing the efficiency of overshot wheels over other designs. The first water turbine was invented by the French experimenter Benoit Fourneyron and patented in 1832. Tests showed that Fourneyrons' turbines converted as much as 80% of the energy from water into useful mechanical output and were used in many factories around the time.

Many turbine designs followed this, including the Francis Turbine developed by James Bicheno Francis in 1848 and Uriah Boyden as an improvement on the Boyden Turbine. In 1856, The Vortex Turbine No. 1 was developed by Professor James Thomson of Queens College and manufactured by Williamson Bros (now Gilkes) to convert the energy from moving water into electricity. Later on, in the late 1870's, Lester Pelton developed the first impulse turbine, the Pelton Wheel, utilising the kinetic energy of the water instead of the pressure or weigh of a stream, and able to achieve efficiencies in excess of 90%. In 1913, Victor Kaplan developed the Kaplan turbine as an evolution of the Francis Turbine. 1919 saw the invention of the Turgo Impulse turbine by Gilkes of Kendal, Cumbria. The design and manufacture of Small Hydro turbines continued right up until the early 60s, primarily

for private developers to produce regular energy for the expanding industrial activities and growing village populations.

Over the following two decades, small hydro activity decreased and virtually disappeared, being replaced by medium to large scale hydro schemes driven by large electricity companies, and equipping the majority of medium and large hydro schemes found in Europe today.

In recent years however, since 1980, small hydro has reappeared strongly in many countries, complimented by political support and incentives creating attractive investments. With the recent increase in investment returns from small-hydro projects, manufacturers are driving towards developing low cost, short delivery time, reliable and serviced small hydro products. Work is focussed on high quality product using new technology for research, development and design that allow cost reductions of turbines and associated equipment without loss of quality, performance or reliability.

Hydropower basic and applied research covers a vast scope of disciplinary inputs. It includes Mechanical, Civil and Electrical Engineering and focuses around turbine and generator development, transformer and power electronics, fluid dynamics, construction as well as environmental and economic aspects.

Recent research focuses on the analysis of the environmental implications of hydropower schemes bringing Environmental and Sustainable engineering into the range of disciplinary inputs.

Research Challenges

Although research into hydropower development has been active for over a century, current research and development efforts are an essential tool for continual sustainable hydropower development. Large hydropower schemes, particularly dams have many negative environmental impacts such as reduction of water availability, inundation of ecosystems as well as having low public acceptance, high initial investment and long approval and construction cycles. Further challenges include dam safety and emergency action planning as well as the rehabilitation of old dams. These problems indicate many research and development challenges, however the misconception that large hydropower is a mature technology means implementation of any advancements is slow with insufficient investment.

Small hydropower schemes such as run-of-the-river are recognised as one of the most cost effective means of producing clean, renewable electricity with higher efficiency and reliability than wind, solar and ocean energy. The energy payback ratio for run-of-the-river hydro is in the region 170-267, by far the highest of any other energy generation technology. There is currently ongoing extensive research into low head hydro power technology, improving efficiencies and outputs of turbines. However low head hydro applications remain high cost. Research challenges for small hydropower include: Low head turbine development; investment cost reduction; environmental impacts (such as impact on migratory fish); grid connection difficulties and design of intakes in sediment carrying rivers.

Applied research and development carried out by Small Hydro companies is focussed on developing new simplified designs using new technology for research and development, design and manufacture of turbines and associated equipment. The primary goal is development of small hydro products which are low cost with a fast delivery without compromising quality and performance

2. Capabilities Assessment

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The UK's capabilities vary widely within the Hydropower industry.

For many years, UK companies have been global leaders in turbine manufacture, consultancy and assessment running projects throughout Europe and the rest of the world. The consultancy and feasibility analysis sector is world renowned in the hydropower field. The UK holds a high global market share in the research and development as well as supply of hydropower technology and materials. With the limited potential for large hydropower schemes in the UK, the commissioning is led by large EU and American companies however, with the high potential for low-head small hydro power plants; it is a growing market, with UK involvement in small scale hydro manufacturing, research and development and holding a dominant position in global hydropower consulting

Table 2.1 Capability Assessment

UK Capability	Area	Market potential
High	Turbine Design and Development	UK: High 0-5 years, Medium 5-20 years Europe: Low 5-20 years Global: High 0-20 years, Medium 20+ years
High	Technical Consultancy	UK: High 0-5 years, Medium 5-20 years Europe: Medium 0-5 years Global: High 0-20 years, Medium 20+ years
High	Small Hydro Consultancy	UK High 0-20 years, Medium 20+years Europe High 0-20 years Global High 5-20 years, High 20+years
High	Hydro power materials manufacture and development	UK: High 0-5 years, High 5-20 years Europe: Medium 2-20 years Global: High 0-5 years, Medium 5-20 years
Medium	Plant Design and Construction	UK: High 0-5years, High 5-20 years Europe: Low 20+ years Global: Medium 0-20 years
Medium	Large Scale Hydro Consultancy	UK: Medium 0-5 years, Low 5-20 years Europe: Medium 0-20 years Global: High 0-20 years, High 20+ years
Low	Large Scale Hydro manufacturing and commissioning	UK: Low 0-5 years, Low 5-20 years Europe: Medium 0-20 years Global: High 0-20 years

3. Basic and Applied Strategic Research

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Basic and applied strategic hydropower research is largely university lead and includes the mapping of hydropower resources, the development of turbine technology on a variety of scales, hydrodynamic modelling, the effects of hydropower on the environment, using hydropower to provide electricity to isolated rural areas, combining hydropower with irrigation, cavitation, turbulence and the economic and development considerations of a variety of hydropower schemes.

Significant funding was previously from the Joule Centre for energy research and development in partnership with North West Universities as well as commercial organisations and stakeholders involved in the energy industry. The centre aims to increase the regions research capabilities in sustainable energy technologies and provided important funding towards hydropower technologies such as the development of the North West Hydro Resource Model in collaboration with the Lancaster University Renewable Energy Group (LUREG).

There is also a large amount of funding provided by the UK Research Councils such as the Engineering and Physical Sciences Research Council (EPSRC), the Economic and Social Research Council (ESRC) and the Natural Environment Research Council (NERC), all under the Research Councils UK Energy Programme investing more than £530 million and building on a £360 million investment over the past five years, towards research and skills to pioneer a low carbon future. Many of the programmes and projects are organised and run by the UK Energy Research Centre (UKERC).

Table 3.1: Research Funding

Programme	Funding Agency	Description	Committed Funds	Period	Representative Annual Spend
Industrial Doctorate Centre: Technologies for Sustainable Built Environments	EPSRC	Research into the development and application of sustainable construction, renewable energy applications and energy management technologies, including their economic and social impacts, is the main thrust of the Centre. Attention will also extend to the way in which the adoption and use of such technologies can be enhanced through procurement and other policy	£5,968K	2009-2018	

		levers.(Hydropower 5)			
Community Innovation in Sustainable Energy	EPSRC	Community projects involve local groups developing low carbon energy solutions appropriate to local situations, and with community groups having ownership over outcomes. Examples include solar water heating clubs, or insulation clubs, which provide mutual support for system installation; energy awareness and behaviour networks, which provide guidance and reassurance to neighbours on energy matters relevant to them; and co-operatively-owned small-scale renewable energy systems, such as micro-hydro and wind. Project Aims are: 1. Analyse how diverse community-led projects diffuse through processes of replication, scaling-up, and translation; 2. evaluate the performance of local community energy projects and assess their potential in wider low carbon transition processes (using UK Foresight scenarios); 3. Provide critical reflection and empirically-backed recommendations for national policy-makers and key energy companies on how to support community approaches to everyone's mutual benefit; 4. Develop and advance innovation theory appropriate to community-led	£515K	2010-2013	

		sustainable energy. (Hydropower 5)			
Feasibility Studies - Energy, People, Buildings and Systems	EPSRC	This Feasibility Account will provide researchers, technicians and academics with a forum for bringing forward their bright ideas together with the opportunity to access the support, time and funding needed to explore their ideas more fully. The Feasibility Account will fund ideas from three theme areas. The low carbon society: energy use for all purposes, buildings, transport, industry etc; alternative energy sources, especially renewable energy technologies; government policy, social attitudes and motivations, and the role of the media and other information vehicles. (Hydropower 2)	£203K	2010-2012	
UK-India Sustainable Energy Technology Network	EPSRC	This Sustainable Energy Technologies Network focuses delivery of large-scale increases in fossil fuel generation that is both efficient and clean; and utilising technological developments to address small-scale, dominantly rural energy needs in locations beyond current electricity networks. The network team comprises academics from the University of Nottingham, Loughborough University and the University of Birmingham, industrial partner RWE npower and researchers from the National Environmental Engineering Research Institute (NEERI), Nagpur; the Indian Institute of Technology (IIT), Delhi; the Centre for Sustainable Technology,	£111K	2009-2010	

		Indian Institute of Science (CST, IISc) Bangalore and the World Institute of Sustainable Energy (WISE), Pune (Hydropower, Small hydropower (less than 10 MW) 10).			
Multidisciplinary Centre for Doctoral Training in Energy at Durham University	EPSRC	The Centre for Doctoral Training (CDT) will produce a skilled and diverse range of researchers equipped to address the challenging research problems that face every aspect of the energy sector. There are no other training programmes that offer such broad training on all aspects of the energy sector. Existing UK energy related CDTs offer training within specific fields e.g. Wind, Hydrogen Fuel Cells, Nuclear Fission, E-Futures, Low Carbon Futures and Demand Reduction in the Built Environment. The Durham University CDT will draw upon the expertise currently located within the Anthropology, Biology, Business, Chemistry, Earth Sciences, Engineering, Geography, Government and International Affairs, Law, Mathematics and Statistics and Physics Departments and will be truly unique in its multidisciplinary approach.	£580K	2009-2014	
JEFI: Beyond NIMBYism: a multidisciplinary investigation of public engagement with renewable energy technologies	ESRC	This project seeks to extend the current research base by examining a range of forms of technology which are expected to figure, to varying degrees, in the UK renewable energy profile - offshore wind, biomass of various forms, small scale HEP, large scale photovoltaics and more speculatively the various ocean technologies	£100K	2006-2009	

		currently under development. (Hydropower 20)			
UK Energy Research Centre (UKERC)	NERC	The UKERC is responsible for many energy related projects which incorporate hydro power as a renewable energy source. These include statistical energy climate forecasts, and understanding ecosystems and EnergyScapes in order to aid the deployment of land-based renewables.	1. Approx £1K for statistical hydropower climate forecasts 2. Approx £10K for Hydropower as a land-based renewable	1. 2010 2. 2010-2011	
Hydro BPT	ERDF	The ERDF Ireland-Wales Program has contributed significant funding towards development of a more sustainable water supply system in Ireland & Wales. The project is being carried out as a joint venture between Bangor University and Trinity College, Dublin. The aim is to present the water supply and hydropower industries in the Ireland Wales cross-border area with a clear framework from which to create economic activity and improve water supply sustainability.	£500K	2007-2013	

Table 3.2: Key Research Providers

Name	Description	Sub-topics covered	No of staff	Field
Bangor University	The researchers have been awarded £500,000 in EU funding to investigate and develop small hydropower turbines that could be introduced within existing water treatment systems. These could reduce the amount of energy used in the water supply process. This will enable the water industry to reduce its CO2 emission and to reduce the operating costs of supplying treated water.	• Small hydropower Turbine development	-	Mechanical, Aeronautical and Manufacturing Engineering; Earth Systems and Environmental Sciences
Cardiff University	The Cardiff University Hydro-environmental Research Centre, established in 1997, undertakes research into the development, refinement and application of hydro-environmental numerical models for predicting flow, water quality, sediment and contaminant transport processes in coastal, estuarine and inland waters and water treatment and wastewater treatment works. Experimental and field investigations are also carried out in the areas of coastal pollution, river basin management (including floodplain systems) and ecohydraulics.	• Hydrodynamic Modelling • Sedimentation • Water treatment • Turbulence measurement & modelling	20	Mechanical, Aeronautical and Manufacturing Engineering Earth Systems and Environmental Sciences
Durham University	The research aims to review existing conversion technologies and ascertain through analysis the characteristics and technologies best suited to the low head hydropower sector. From here the aim is to enhance the state of the art of low head hydropower by the application of cutting edge technologies in fluid dynamics, control systems and ecological management.	• Development of Low Head Hydropower Converters	1	Mechanical, Aeronautical and Manufacturing Engineering
University of Edinburgh	Current research project which aims to deliver a robust estimate of the temporal and spatial distribution of the remaining unutilised potential of Scottish hydropower. The project will also investigate the impact of climate change	• Mapping Scotland's Hydropower Resource	-	Mechanical, Aeronautical and Manufacturing Engineering

	on the resource as a whole. The availability of detailed geo-spatial data, distributed hydrological models and modern computational power enable the creation of a multi-parameter resource model. This model will allow greater flexibility and accuracy than the methods used in older studies which relied upon labour intensive map analysis, and simplified representations of hydrological processes.			
Edinburgh Napier University	Development of low and zero carbon technologies (LZCT) including wind, micro-hydro, biomass, CHP, fuel cell and solar energy, and the SEC has a unique position in the market for provision of commercial technical support services; with specific strengths in the field of energy diagnostics and modelling and renewables integration.	• Micro-Hydro	15	Mechanical, Aeronautical and Manufacturing Engineering
University of Glasgow	A study is underway to investigate the possibility of small scale multi-purpose dams to deliver combined hydro-power, irrigation water for growing crops as well as drinking water - without causing significant ecological damage in the system.	• Development of combined hydropower and irrigation in rural Malawi	1	Civil Engineering
University of Hull	Hull International Fisheries Institute (HIFI), staff have a wide experience of fisheries research and consultancy, covering inland fisheries management, policy and planning, institutional development, development of management strategies, stock assessment and fisheries biology, technical and conservation regulations, social and community issues, economic policy and trade development.	• Impact of run-of-river hydro-schemes upon fish populations	-	Earth Systems and Environmental Sciences
Imperial College London	"Innovation for Inclusive Growth" has emerged as the main theme of the Rajiv Gandhi Centre, Imperial College Business School, with an emphasis on core intellectual contribution to energy, health and digital platforms. When emphasising inclusivity, the Centre examines how socially and economically disenfranchised communities can be served through low-cost or resource-constrained	• Rural Electrification (Including Hydropower)	-	Development Studies

	innovation.			
University of Leeds	Research focuses on low head hydropower and resolving the water-energy nexus.	• Low head Hydropower	-	Mechanical, Aeronautical and Manufacturing Engineering
Lancaster University	The Lancaster University Renewable Energy Group (LUREG) carries out extensive research on high, medium and low head hydropower as well as research on water aeration. With the development of the North West Hydro Resource Model, In-line and direct-drive turbine research as well as current focus on converting water pressure into air pressure for low head hydropower generation, using a Siphonic Low Head Hydro plant. There are also significant links with industry such as New Mills Hydro, Gilbert Gilkes & Gordon, Clyde Weirs Pumps and Internationally: Andritz, Voith Siemens and Alstom. There is also involvement with utilities such as United Utilities and Yorkshire water in research and development as well as significant involvement with the development of hydropower demonstration sites such as Heron Corn Mill in Beetham.	• Hydro Resource model • Siphonic Low head hydro • Counter rotating turbine development • In-line turbine research and testing • Direct drive turbines • Computational fluid dynamics application on impulse turbine development	20	Electrical and Electronic Engineering; Mechanical, Aeronautical and Manufacturing Engineering; Earth Systems and Environmental Sciences
University of Southampton	The research focuses on developing low head hydropower solutions based on modern hydrodynamic knowledge. Theoretical investigations as well as intensive scale model testing are being undertaken with the incentive to produce optimised solutions with improved geometries and materials. Performance studies are underway in the School of Civil Engineering's hydrodynamics laboratories.	• Water Wheel Development • Theoretical Considerations on the Hydraulic Pressure Machine	2	Mechanical, Aeronautical and Manufacturing Engineering
Trinity College Dublin	The research project is titled: "Towards a More Sustainable System of Water Supply in Ireland and Wales: Exploring Opportunities for Hydropower in Break Pressure Tanks (Hydro-BPT)", which runs alongside Bangor University who	• Small hydropower Turbine development • Use of breakwater	-	Mechanical, Aeronautical and Manufacturing Engineering;

	are carrying out the same research with funding provided by the ERDF Ireland-Wales Programme (INTERREG 4A).	pressure tanks		Earth Systems and Environmental Sciences
University of Ulster	There is a well equipped hydraulics laboratory for modelling of compound channel flows. A compound open channel 10m long by 0.75m wide is available together with appropriate instrumentation which includes two ADV probes for velocity measurement, digital discharge measurement devices, a sand feeder for mobile boundary studies, digital depth scales, a computer controlled mobile bed plotter and associated computer facilities.	• River Hydraulics • Hydropower Research	2	Mechanical, Aeronautical and Manufacturing Engineering
University of Warwick	The School of Engineering encompasses a wide range of top-quality research activities, covering all major disciplines in the field. As a fully integrated department, we are able to promote and pursue cross collaborative research on a wide-scale, and many of the work fits within key streams and themes.	• Cavitation • Turbulence Control	7	Mechanical, Aeronautical and Manufacturing Engineering
University of Worcester	University of Worcester researchers conduct detailed aerial survey of Chilean river by using a state-of-the-art mini helicopter system. This small and lightweight drone, the Draganflyer X6, is known as an 'unmanned aerial system' (UAS) and is capable of collecting very high resolution aerial images. The Worcester research team took the Draganflyer X6 to the San Pedro River in Chile to assist with a major project looking to map endangered river habitats.	• Effects of hydropower on river habitats and ecology	1	Science & the Environment

4. Applied Research

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Key research funding is provided by energy companies such as EDF, Scottish Power and Esk Energy supporting the development of sustainable energy resources in the UK. Significant funding is also available from large utilities throughout the UK. The Carbon Trust also provides key funding for sustainable energy applied research projects, contributing up to £500K or 60% of project costs. This has all formed part of an incentive to increase the number of small-hydropower plants throughout the UK, by providing funding towards site development costs as well as research and development into the technology to improve sustainability, reduce installation costs, improve efficiencies etc.

Applied research and development has also been aided by funding provided by the UK research councils such as the Engineering and Physical Sciences Research Council (EPSRC), to improved public awareness of sustainable technology, particularly hydropower in rural areas of the UK.

Table 4.1: Research Funding

Programme	Funding Agency	Description	Committed Funds	Period	Representative Annual Spend
Scottish Power Green Energy Trust	Scottish Power	Established in 1998, the independent charitable Green Energy Trust supports the development of new renewable energy sources in the UK - helping to reduce reliance on fossil fuels and combat climate change. The aims and objectives of the Green Energy Trust are: To assist in the creation of new renewable electricity sources in the UK; To encourage the research and development of renewable electricity sources; To promote education in the community on new renewable energy generation.	£1500K	1998 2013	
Green Fund	EDF Energy	The Green Fund awards grants to organisations who apply for funds to help cover the cost of renewable energy technology that can be used to produce green energy from the sun, wind, water, wood and other renewable sources.	£4600K	2001 - 2013	

Applied Research Grant Funding	Carbon Trust	Grant funding is for research and development projects of up to £500,000 and up to 60% of project costs. Specific Hydropower funding has also been provided for projects looking at development of hydro technology such as fish friendly turbines.	£500K	2003-2013	
Renewable Energy Funding	CO2Sense	CO2Sense is a dedicated business support programme working to reduce CO_2 emissions and accelerate low carbon economic growth in Yorkshire and Humber. For projects that help to grow the region s renewable electricity capacity funding over £50,000 for capital projects and under £10,000 to support revenue activities is available.	£50K	2010-2011	
Modelling and design of pico propeller turbines for rural electrification	Leverhulme Trust	The overall aim of this research is to provide an accurate design for cost effective low head pico hydro turbines that is scalable for a wide range of hydrological conditions. The research focuses on low head hydropower schemes of up to 10MW capacity.	£102K	2004-2007	
Grant for Research and Development (GRD)	European Regional Development fund & East Midlands Development Agency	Providing grants up to £250,000, the GRD helps businesses carry out research and development work that will lead to technologically innovative products or processes. A £75000 grant was provided for the Torrs Hydro Scheme at New Mills from the East Midlands Development Agency and similar funding is available for Research and Development into innovative hydropower technology products.	£3400K	2008-2009	
Smart	European Regional Development fund & Technology Strategy Board	Now titled Smart, and managed by the Technology Strategy Board, the scheme will support small and medium-sized companies (SMEs) across the UK. Smart supersedes the former GRD programme managed by the East Midlands Development Agency and will have similar objectives.	£250K	2012-2013	
Grant for Research	Technology Strategy	A new Technology Strategy Board scheme is offering	£20000K	2011-	

and Development	Board	funding to small and medium-sized enterprises (SMEs) to engage in R&D projects in the strategically important areas of science, engineering and technology, from which successful new products, processes and services could emerge.		2012	

Table 4.2: Key Research Providers

Name	Description	Sub-topics covered	No of Staff	Sector
Accusonic Technologies Inc	In addition to precision flowmeter systems, Accusonic offers associated technical products and services to support hydropower, fossil power, and water resource and wastewater project requirements. The Accusonic TEMS is used in a portable mode or as a permanently installed system for measurement of hydro turbine (or pump) efficiency. The system collects data from the flowmeter, power meter and pressure sensors and computes unit efficiency in real-time. The system is used to improve plant operation and to provide contractually accepted pre- and post-upgrade performance data, and is designed to meet ASME PTC-18 and IEC Pub. 41codes.	• Flowmeter Systems • Efficiency measurements	-	Mechanical, Aeronautical and Manufacturing Engineering
BHR Group	The BHR Group carry out focussed hydraulic and mathematical modelling of many large civil engineering projects including dams and hydropower. This includes scaled physical modelling, CFD, surge analysis and hydroelastic modelling for hydropower and pumped storage schemes.	• Vortex formation and drawdown • Bulk mixing of fluid layers • Sedimentation/deposition • Mobile bed studies for scour intensity and prevention • Rip-rap positioning, sizing and effectiveness • Air entrainment • Flow-induced vibration	-	Mechanical, Aeronautical and Manufacturing Engineering; Civil Engineering

		• Loss-coefficients across structures • Wave action • Turbine characteristics		
Fish Guidance Systems Ltd	FGS provide a complete range of products and support services to help clients prevent fish from entering their water intakes. They also provide a range of products for clients undertaking fishery survey and research work and are continually researching and developing ideas into improving fish screening. FGS also provide behavioural barriers and guidance systems that use underwater sound, air-bubbles, light and electric fields, either singly or in combination.	• Sound projector arrays • Bio - Acoustic Fish Fences • Artificial light systems • Graduated electric barriers	-	Mechanical, Aeronautical and Manufacturing Engineering; Earth Systems and Environmental Sciences; Electrical and Electronic Engineering
Fishtek Consulting	Fishtek have conducted extensive monitoring of low head hydro power turbines (Archimedean screw), involving live fish trials, fish behavior at the intake, outflow and within the turbine chamber. Research also looks at the turbines leading edge lead and the development of fish friendly compressible bumpers to mitigate the effects of higher impact speeds on the largest screw turbines now in use.	• Turbine Research • Environmental Impacts	5	Mechanical, Aeronautical and Manufacturing Engineering; Earth Systems and Environmental Sciences
Future Energy Yorkshire	Future Energy Yorkshire has carried out a large amount of research into sustainable energy generation technology including cost analysis comparisons between low head hydro power turbines. A particular study compares Archimedean screw turbines to Kaplan turbines for low head hydro power.	• Turbine cost analysis	-	Business and Management Studies
Gilbert Gilkes & Gordon Ltd	Gilkes manufacture and supply hydroelectric turbines and ancillary equipment in the output power range from 50kW up to 20MW. Since their first turbine	• Turbine design and development	-	Mechanical, Aeronautical and Manufacturing

	installation in 1856, they have been improving and refining designs. Gilkes has produced over 6500 turbines for more than 80 countries, and are sensitive to regional differences and requirements.			Engineering
Golder Associates (UK) Ltd	Golder associates provide important seismic hazard assessments for large hydropower plants. Their focus is currently on the Hakkari Projects one of nine planned developments under a US-Turkish Joint protocol for bilateral cooperation. The current Hakkari Project comprises a rock fill embankment dam, an 11 km-long power tunnel and an annual generating capacity of 625.5 GWh.	• Hydropower seismic hazard assessment	-	Civil Engineering; Earth Systems and Environmental Sciences
HR Wallingford	HR Wallingford specialises in hydrological and hydraulic studies to assess water availability, water recycling and water re-use opportunities for a wide range of clients involved in dams and reservoirs, hydropower, irrigation, mining and minerals, water supply and other water-dependent business sectors	• Hydrological & Hydraulic studies	-	Earth Systems and Environmental Sciences
ITP UK	The company has an active R&D programme, working with UK and European manufacturers to develop innovative designs to meet the needs of the changing marketplace.	• Mini and Micro Hydro	-	Mechanical, Aeronautical and Manufacturing Engineering
Mann Power Consulting Limited	Mann Power Limited is at the forefront of Archimedean screw generation supply and consultancy in the UK. Their research focuses on performance assessment of installed units as well as the fish friendly nature of the equipment.	• Archimedes Screw turbines	6	Mechanical, Aeronautical and Manufacturing Engineering
MWH	MWH provides a global management, technical engineering and construction service to wet infrastructure projects around the world. Their applied research has lead to significant contributions to water distribution systems, hydraulics, hydro power plant	• Hydraulics • Hydro power engineering • Hydro power electrical systems	-	Mechanical, Aeronautical and Manufacturing Engineering; Electrical and

	engineering and hydro-plant electrical systems.			Electronic Engineering; Civil Engineering
Newmills Hydro	Waterpower has been in use at Newmills Hydro since 1798. In more recent years, this has evolved into the manufacture of hydro turbines: Pelton Turbines, Francis Turbines, and Kaplan Turbines, plus a range of hydroelectricity ancillaries. Newmills carry out active turbine research and development for a range of turbine designs and applications.	• Turbine design, testing and development	-	Mechanical, Aeronautical and Manufacturing Engineering

5. Development and Demonstration Funding

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Although there are many low and high head hydropower schemes in operation throughout the UK, very few are used for the purpose of demonstration.

During the 1950's many large scale hydropower schemes were built in Scotland and Wales, however, being a mature technology even at the time meant demonstration was not necessary. The potential for new large hydropower schemes in the UK is rather limited at present due to the lower availability of commercially attractive sites as well as environmental constraints. However, Dinorwig Power station in Wales, commissioned in 1984, has been included as a large demonstration project for pumped storage as it is the largest of its kind in Europe and when commissioned, was regarded as one of the world's most imaginative engineering and environmental projects.

Apart from a few exceptions, there has been virtually no large hydropower development for the past 50 years, until the recent construction of the Glendoe Hydro Power Plant on the river Tarff, more than 600m above Loch Ness. Commissioned in 2009 and generating up to 100MW, the plant could potentially power a city the size of Glasgow, however due to a rock fall later in that year, the plant has been out of service until around 2012 when repairs are expected to be completed.

The very first VLH (Very Low Head) turbine delivered its first kW to the public network at the MJ2 Millau demonstration site in the South of France in 2007. This site remains a low-head hydropower demonstration site and although similar sites (on a smaller scale) have been developed in the UK, few are for demonstration purposes. There are however, current proposals for demonstrations sites such as the Ruswarp Weir on the river Esk, which will operate using a fish-friendly Archimedes Screw turbine of approximately 50kW. Newmills Hydro are also currently constructing a high-head demonstration and testing facility in Larne, County Antrim, Ireland.

There has, however been recent developments of small hydropower sites in rural locations which not only are able to sell power to the grid, but demonstrate the use of hydropower as a renewable technology. The UK's first Archimedean screw turbine was installed at Howsham Mill, provided by Mann Power Consulting Limited in 2006. The old mill site has been developed into an environmental study centre, demonstrating hydropower generation from both Archimedean screw turbines as well as an undershot water wheel. This project has inspired further development of small hydropower sites such as Heron Mill in Beetham and Torrs Hydro in New Mills.

There are currently numerous small and large hydropower sites throughout the UK, although not all are used for demonstration purposes. An up to date record of all the hydropower installations within the UK is provided by the British Hydropower Association. A number of these sites which not only generate a renewable energy source, but have or aim to effectively demonstrate the use of hydropower technology can be found in Table 5.2.

Funding for small schemes such as these are largely community lead, with grants provided by the local authorities and development agencies as well as from community investment.

There is also significant funding available from larger bodies such as the Carbon Trust, Large energy companies such as Esk Energy as well as funding for sustainable development within UK national park regions available from Defra through the Sustainable Development Fund.

Table 5.1 Development and Demonstration Funding

Programme	Funding Agency	Description	Committed Funds	Period	Representative Annual Spend
Grant for Research and Development (GRD)	European Regional Development fund & East Midlands Development Agency	Providing grants up to £250,000, the GRD helps businesses carry out research and development work that will lead to technologically innovative products or processes. A £75000 grant was provided for the Torrs Hydro Scheme at New Mills from the East Midlands Development Agency and similar funding is available for Research and Development into innovative hydropower technology products.	£3400K	2008-2009	
Smart	European Regional Development fund & Technology Strategy Board	Now titled Smart, and managed by the Technology Strategy Board, the scheme will support small and medium-sized companies (SMEs) across the UK. Smart supersedes the former GRD programme managed by the East Midlands Development Agency and will have similar objectives.	£250K	2012-2013	
Grant for Research and Development	Technology Strategy Board	A new Technology Strategy Board scheme is offering funding to small and medium-sized enterprises (SMEs) to engage in R&D projects in the strategically important areas of science, engineering and technology, from which successful new products, processes and services could emerge.	£20000K	2011-2012	
Ruswarp Weir Hydro Proposal	Esk Energy	The Scheme Esk Energy hope to install is a 50kW Archimedes Screw type turbine on the south side of the River Esk adjacent to the existing fish pass. The turbine would generate 50kW of green electricity, which would be sold via the local electricity network. Grants have been obtained from Scarborough Borough Council and the North York Moors and Howardian Hills AONB Sustainable Development Fund (SDF) for the development of this site as a flagship demonstration	£320K	2011-2012	

		project which will hopefully lead to further development of hydro power at other sites along the River Esk and elsewhere in the North York Moors.			
Sustainable Development Fund	DEFRA	The Sustainable Development Fund (SDF) is a grant scheme that supports new ways of living and working within National Parks in a sustainable manner.The funding is provided by the Department for Environment, Food and Rural Affairs (Defra) and is managed by the National Park Authorities and the Broads Authority. Sustainable development encompasses projects that can demonstrate social, economic and environmental development. Significant funding has already been provided for hydropower projects located within national park regions.	£9900K	2002-2009	

Table 5.2: Major Demonstration Projects

Name	Description	Sub-topics covered	Total Project Cost	Public Sector Funder	Public Sector Funding	Period
Dinorwig Power Station	Dinorwig Power Station is a pumped storage hydroelectric power plant located in North Wales adjacent to the Snowdonia National Park. It is one of the fastest, most dynamic power plants in the world, capable of running at full 1800MW in only 12seconds, sufficient to power the whole of Wales for 5 hours. Commissioned in 1984, it took nearly 10 years to plan and construct, and is now owned by a joint venture of International Power PLC and Mitsui &	• High head Francis turbines • Turbines operating as pumps	£425M	-	-	1984-Present

	Co. Ltd. Dinorwig is the largest scheme of its kind in Europe and is open to the public for viewing and demonstration purposes.					
Torrs Hydro, New Mills	The Torrs Hydro community energy project uses an Archimedes screw turbine with a maximum power rating of 63kW. It is located where the River Goyt and the River Sett join in New Mills, Derbyshire. The scheme has been successful in feeding all construction costs into the local community, powering the local Co-Operative and selling back electricity to the grid. The scheme has not only attracted tourism to the area, but resulted in several other hydro plants being built based on the success of Torrs Hydro.	• Low-Head Hydro Power • Archimedes Screw turbines • Environmental impact of low-head turbines • Community-based projects	£330K	East Midlands Development Agency, the Cooperative Fund and the Sustainable Development Fund	£165K	2007-Present
Heron Mill Hydropower Project	During 2009/2010, Heron Corn Mill in Beetham installed a 100kW Kaplan hydropower turbine. The scheme was designed by Inter Hydro Technology with the turbine built by NHT Engineering (Newmills Hydro).	• Low-Head Hydro Power • Kaplan turbines	£510K	Northern Rock Foundation	£167K	2010-Present
Howsham Mill	Howsham mill is located on the river Derwent at Howsham, North Yorkshire. The mill has been restored for use as an environmental study centre, generating electricity from a modern 24kW Archimedes Screw turbine and an 11kW undershot water wheel, demonstrating the energy generating potential from both modern and traditional methods.	• Low-Head Hydro Power • Archimedes Screw turbines • Hydroelectric water wheels	Ongoing (funding includes building restoration)	GrantScape Community Heritage fund (£62K); AHF (£166K); Defra Rural Enterprise Scheme (£108K); Clear Skies (£50K);	£529K	2005-Present

	The scheme will generate enough power to supply the whole village of Howsham. Payments received for generating this power will contribute towards the cost of restoring the rest of the building and in the longer term will fund its ongoing running costs.			Howardian Hills AONB (SDF)(£57K); Ryedale District Council (£13K); North Yorkshire County Council (£22K); Local Heritage Initiative (£17K); Yorkshire Forward (£11K); Nationwide Building Society (£5K); Local Trusts (£3K); Private Donations (£15K); Friends Scheme (£5K);		
Ruswarp Weir Hydro Proposal	This is a 50kW Archimedes Screw type turbine on the River Esk adjacent to an existing fish pass. The turbine would generate 50kW of green electricity, which would be sold via the local electricity network.	• Low-Head Hydro Power • Archimedes Screw turbines • Environmental impact of low-head turbines	£320K	Esk Energy	£320K	2011 2012

6. Research Facilities and Other Assets

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There are a number of research facilities in the UK for testing of large and small hydropower. This is largely focussed around turbine testing for new low head high discharge turbine technology as well as development of existing turbine designs.

Table 6.1: Research Facilities

Name	Description	Type of asset	Number of Supporting Staff	Annual Operating Budget
Newmills Hydro	Newmills Hydro Generation Ltd is currently constructing a high head testing facility in Larne, County Antrim which will become a centre for excellence for the testing of Kaplan turbines.	Testing Facility		
LUREG, Lancaster University	Low head hydropower test facilities are available including the use of siphons converting water pressure into air pressure and facilities to study the aeration of water. In-line and direct drive turbine testing is also facilitated. Novel hydro turbine topologies are also being explored including single-stage, contra-rotating and multi-stage turbine options.	Testing Facility		
Imperial College Hydrodynamics Laboratory	The hydrodynamics Lab includes a water channel and a towing tank.	Testing Facility		
AEMS	Hydro turbine testing featuring efficiency and flow measurement as well as turbine acceptance testing to IEC 60041 standards.	Testing Facility		
Gilbert Gilkes & Gordon Ltd	Turbine and Ancillary testing equipment	Testing Facility		
TUV SUD NEL Ltd	Water flow testing and measurement facilities.	Testing Facility		
KGAL Consulting Engineers	Access to Turboinstitut s laboratory in Slovenia performing turbine model tests to IEC 60193 standard.	Testing Facility		
BHR Group	Large Scale fluid engineering test facilities including stirred tank reactors, in-	Testing		

	line rotor stators, channel and pipe mixing, a wide range of viscometers, rheometers, test fluids etc.	Facility		
Water Test Tank-SEL 41	This Scottish Energy Laboratory facility was originally designed and commissioned for testing marine winches. The tank is 2.5m x 2.5m in cross-section and is 150m long. It offers a flexible facility for testing wave, tidal and hydro turbine devices. Due to its size, the tank could be suitable for test arrays of multiple devices.	Testing Facility		
ETC - Mechanical Test Facility - SEL 29	The Energy Technology Centre (ETC) is a national centre of excellence playing a pivotal role in the development, demonstration and commercialisation of low carbon and renewable energy technologies.The facility offers a range of test and development options including static, dynamic and cyclic loading test regimes. The ability to provide bespoke test rig configurations is of particular value to the marine sector where novel designs require tailored solutions. Facilities include: • Hydraulic power pack 170 kW, 200 bar oil pressure • Range of actuators (range of stroke, frequency, mean speed) • Vertical shaker table • Electrodynamic shaker tables • Bedplates with static load hydraulic actuators for bespoke tests • Bespoke rig design capability with electric and hydraulic actuation for rotational and reciprocating motion	Testing Facility		

7. Networks

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There are a number of Hydro power networks in the UK which work on a national or international level to promote the interest of hydropower. This can be in the form of publishing guides to installing small hydropower plants (ESHA), promoting suppliers of hydro plant equipment and providing a link to trade as well as linking with universities and R&D departments to provide funding and aid the transfer of knowledge. Networks such as the BHA, primarily a trade association, not only represents the interests of the UK hydro industry, but coordinates events and marketing opportunities for members, promoting hydropower to the government and funding agencies as well as providing expert technical advice and support.

Table 7.1: Networks

Network	Date Established	Description	Membership Profile	Activities
European Small Hydropower Association (ESHA)	1989	The European Small Hydropower Association (ESHA) is a lobby organisation promoting the interest of small hydropower in Europe and globally. ESHA was established in 1989 and is a founding member of EREC (European Renewable Energy Council). ESHA is ideally located with other renewable energy sources (RES) Associations in the Renewable Energy House in Brussels just a block away from the European institutions.	• Hydropower Associations • Hydro Engineering Suppliers • Consultancy Firms • University Departments • Individual Experts	ESHA wants to use synergies at the European, national and local level in order to develop the small hydropower sector. ESHA serves to create a platform for actors in the field of SHP and to represent their interests at European level. ESHA is structured as a federation of EU national hydropower associations and is open to members from all sectors involved in small hydropower. Through the diversity of its members, ESHA is at the forefront of information on ongoing research and market trends regarding small hydropower. ESHA has as its goal to raise the awareness and the interests of the small hydropower sector at European level.
British Hydropower	Mid 1990s	The British Hydropower Association works to maintain its	• Hydro Engineering Suppliers	BHA has clear objectives, enabling specific outcomes in line their vision. They are to

Association (BHA)		position as the leading trade association representing the interests of the UK hydropower industry (from micro to large) and its associated stakeholders in the wider community, both in the UK and overseas.	• Consultancy Firms • University Departments	be a vehicle for: • Effective lobbying of government and other agencies/NGOs • Liaison with and monitoring of government and other agencies • Co-ordination of events and creation of marketing opportunities for members • The promotion of hydropower to government, financial institutions and the general public in the UK • Technical advice and sourcing resource • Exporting opportunities for UK hydropower • Networking and support
Renewable Energy Association	2001	The Renewable Energy Association (REA), previously the Renewable Power Association until 2005, the REA represents UK renewable energy producers, including hydropower, with members ranging from generators, project developers, fuel and power suppliers, equipment producers and service providers.	• Hydro power generators • Hydro project developers • Consultancy Firms • Hydro Engineering Suppliers	The main objective is to secure the best legislative and regulatory framework for expanding renewable energy in the UK. To achieve this, the REA undertakes policy development and provides input to government departments, agencies, regulators, NGOs and others. The REA also provides information, knowledge transfer and networking via conferences, seminars, workshops, training, publications and newsletters. Information is also provided on technical, legal, commercial and environmental matters.
The Renewable	2000	The Renewable Energy Centre.co.uk is made up of 11	• Hydro Engineering Suppliers	The Renewable Energy Centre is an

Energy Centre		technology subjects From Home Energy Saving to Combined Heat and Power (CHP). As well as these subjects are comprehensive details of Conferences & Exhibitions, Trade Associations & Journals, Government contacts and Ecological Organisations. Within each technology subject are company directories which offer the visitor access to your website and a simple way to contact you via email.	• Consultancy Firms • Conferences • Trade Associations • Ecological Organisations	effective channel through which you can • Raise your brand awareness, • Generate public goodwill and positive PR and • Generate a steady stream of sales enquiries.
Envirolink	2000 - 2013	Late news – January 2013 : Envirolink was placed into liquidation earlier this month. *"Envirolink is the business support organisation for the low carbon and environmental goods and services sector. As a not-for-profit company, our aim is to support the growth of the low carbon and environmental goods and services sector thereby contributing to sustainable economic growth and environmental protection which is vital for the UK s transition to a low carbon economy."*	• *Hydro Engineering Suppliers* • *Consultancy Firms* • *University Departments*	*Through collaboration with suppliers, end-users, research institutes and funders we facilitate the development and uptake of innovative low carbon and environmental technologies. We do this by helping businesses to develop and market low carbon and environmental products and services whilst also promoting them to end-users and acting as a link between suppliers and buyers.*
ERDF Ireland-	2007	The European Commission	• University	The programme seeks to develop the cross

Wales Program		approved a cross-border cooperation programme between Ireland and the United Kingdom for the period 2007-2013 on 17/09/2007. This programme involves Community support for the regions of Dublin, Mid-East and South-East in Ireland and the regions of Isle of Anglesey, Gwynedd, Conwy and Denbighshire as well as South West Wales in the United Kingdom.Projects carried out vary over a range of topics, however work is being funded on the exploitation of potential energy recovery from Break Pressure Tanks (BPTs), carried out by Bangor University and Trinity College Dublin.	Departments • Hydro Engineering • Suppliers • Consultancy Firms	border region and • Contribute to improving its competitiveness and sustainable development; • Improve its overall economic, environmental and social well-being; • Achieve more cohesive, balanced, sustainable development of the area, enhancing overall competitiveness in a globalised world. Issues such as sustainable development, environmental protection, climate change and research and development require a coordinated response and can be more successfully addressed through intervention on a cross-border basis than at national level.

8. UK participation in EU Activities

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Table 8.1 Participation in EU Framework Programmes

Project	Objectives	Action Line	Type of Action	UK Participants	Co-ordinator and Partners	Total Funding	EU Funding	Duration	Annual Spend
ACQWA	The proposal will assess the impacts of a changing climate on the quantity and quality of water in mountain regions. Modelling techniques will be used to project the influence of climatic change on the major determinants of river discharge at various time and space scales. Regional climate models will provide the essential information on shifting precipitation and temperature patterns, and snow, ice, and biosphere models will feed into hydrological models in order to assess the changes in seasonality, amount, and incidence of extreme events in various catchment areas. Environmental and socio-economic responses to changes in hydrological	FP7-Environment	Large-scale integrating project	University of Birmingham University of Dundee	University of Genève 29 partners	€8560K	€6490K	2008-10-01 to 2013-09-30	

	regimes will be analyzed in terms of hazards, aquatic ecosystems, hydropower, tourism, agriculture, and the health implications of changing water quality.								
Hylow	Hylow is a research project which has the aim to develop novel hydropower converters for very low head differences / pressure differences. The project has 10 partners from 5 countries in the European Union.	FP7-Energy	Small or medium-scale focused research project	University of Southampton	University of Southampton 10 partners	€4720K	€3630K	2008-03-01 to 2012-02-29	
SHP STREAMMAP	The action aims at defining a clear and consistent Stream Map for the small hydropower sector (SHP: Small Hydropower refers to hydropower plants with an installed capacity of 10 MW) in Europe, applicable to the current prospects of the ongoing EU Energy and Climate Packet regulations based on the real situation of the SHP sector at present and the recommendations for the future.	Intelligent Energy Europe	Electricity Production	British Hydropower Association (BHA)	European Small Hydropower Association 10 Partners	€958K	€719K	2009 - 06-01 to 2012-06-30	

9. International Initiatives (including IEA operating agreements and UK contacts)

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There are a number of international hydropower networks in which the UK plays a part. These span from international organisations such as the International Hydropower Association, founded under UNESCO's International Hydrological Programme and comprised of nearly 100 corporate members worldwide, to research consortiums such as the UK-China Joint research consortium on Sustainable Power Supply. There are also Implementing Agreements such as the International Energy Agency (IEA) Hydropower Agreement to promote the recognition of hydropower worldwide as a sustainable resource and advance the development of new and existing hydropower. Other International research networks such as Worldwide Universities Network (WUN) has hydropower-focussed research ongoing, and Energy for Development is researching the use of small hydropower as a power source for third world rural communities.

Table 9.1 International Actions

Name	Type	Description	UK Contact Point
Energy for Development	International Network	The Energy for Development Network aims enable a step-change in collaborative research and project development addressing the energy needs of rural communities in developing countries.	Sustainable Energy Research Group School of Civil Engineering and the Environment University of Southampton Highfield Southampton SO17 1BJ, UK T: +44 (0)23 8059 2051 E: serg@soton.ac.uk
IEA Hydropower Agreement	IEA Implementing Agreement	The Hydropower Implementing Agreement is a working group of International Energy Agency member countries and others that have a common interest in advancing hydropower worldwide. Countries that are not members of the IEA can also join. The member Governments either participate themselves, or designate another organization in their country to represent them on the	ieahydro@iprimus.com.au

		Executive Committee (ExCo).The members of the Executive Committee of the Hydropower Agreement see their Vision as:*"Through the facilitation of worldwide recognition of hydropower as a well-established and socially desirable energy technology, advance the development of new hydropower and the modernisation of existing hydropower."* In recognition of this Vision the Executive Committee believes its Mission is: *"To encourage through awareness, knowledge, and support the sustainable use of water resources for the development and management of hydropower."*	
International Hydropower Association	International Collaboration	The International Hydropower Association is a non-governmental mutual association of organizations and professionals. Through its international membership, the Association is established as a global organization advancing sustainable hydropower's role in meeting the world s water and energy needs by: • Championing continuous improvement and sustainable practices; • Building consensus through strong partnerships with other stakeholders; • Driving initiatives to increase the contribution of energy from renewables; hydropower in particular The IHA was founded in 1995, under the auspices of UNESCO's International Hydrological Programme, to advance knowledge on all aspects of hydropower and to promote good practice. IHA's Central Office in the United Kingdom coordinates the work of the Association.	IHA Central Office Nine Sutton Court Road Sutton London SM1 4SZ United Kingdom T: +44 20 8652 5290 F: +44 20 8643 5600 E: iha@hydropower.org
International Network on Small Hydropower (IN-SHP)	International Collaboration	Co-sponsored by the United Nations Development Program (UNDP) and United Nations Industry Development Organization (UNIDO), Ministry of Water Resources (MWR), Ministry of Foreign Trade and Economic Cooperation (MOFTEC) of People's Republic of China, the	Prof. Dr. Liu Heng PO Box 202, Nanshan Road 136, 310002,

		International Network on Small Hydro Power (hereinafter as IN-SHP) is an international coordinating and promoting organization for the global development of small hydro power (hereinafter as SHP), which is established on the basis of voluntary participation of regional, sub-regional and national focal points, relevant institutions, utilities and enterprises and with social benefit as its major objective. IN-SHP aims at the promotion of global SHP development through triangle technical and economic cooperation among developing countries, developed countries and international organizations, hence to supply the rural areas in developing countries with environmentally sound, affordable and adequate energy, which will lead to the increase of employment opportunities, improvement of ecological environment, poverty alleviation, improvement of local living and cultural standards and economic development in rural areas.	Hangzhou People s Republic of China T: 0086 571 87079113 E: director@inshp.org
International Commission on Large Dams (ICOLD)	International Network	ICOLD leads the profession in setting standards and guidelines to ensure that dams are built and operated safely, efficiently, economically, and are environmentally sustainable and socially equitable. ICOLD wishes to be the world's leading professional organization, dedicated to advancing the art and science of dam engineering and promoting the wise and sustainable development and management of world's water and hydropower resources. ICOLD is assisting nations to prepare to meet the challenges of the 21st century in the development and management of the world's water and hydropower resources.	Peter J. Mason Institution of Civil Engineers 1 Great George Street LONDON SW1P 3AA UK T: (44-207) 665 22 E: bds@ice.org.uk
International Journal on Hydropower & Dams	International Network	The bi-monthly International Journal on Hydropower & Dams publishes, for its readers in more than 180 countries, research papers, descriptive case studies, project updates, business and financial news, and policy papers aiming to help advance the state-of-the-art of dam engineering and hydropower development. An Editorial Board comprising the world's most eminent experts in various fields helps to steer the policy and content of the Journal, and the editorial team travels extensively worldwide, to identify	Publisher / Editor: Mrs Alison Bartle Aqua-Media International Ltd, PO Box 285, Little Woodcote Estate, Wallington, Surrey

		the most important issues for editorial coverage.	SM6 6AN, UK T: + 44 20 8773 7240 E: ab@hydropower-dams.com
UK-China Joint Research Consortium on Sustainable Electric Power Supply	International Network	Established in 2009, goal of the Network is to disseminate and promote in China the research that the EPSRC SUPERGEN consortia have carried out in the UK. The proposed consortium extends the scope of the Network to the organisation of joint research between the UK SUPERGEN researchers and leading Chinese scientists of nationally funded research programmes. It is thus built on the basis of an existing link between members of the Network, Chinese universities and the Chinese Academy of Sciences. It also expands this collaboration to the two largest research institutes in power engineering in China: the China Electric Power Research Institute (EPRI) and the Nanjing Automatic Research Institute (NARI). All of the 9 UK investigators play a leading role in one or more of six SUPERGEN consortia that are sponsored by EPSRC to carry out focused collaborative programmes of research on various aspects of sustainable energy systems.(Hydropower 15).	Professor H Wang Electronics Electrical Engineering and Computer Science Queen's University of Belfast T: 02890974664 E: hf.wang@qub.ac.uk
World Universities Network (WUN)	International Network	The Worldwide Universities Network comprises 16 research-intensive institutions spanning 5 continents. Their mission is to be one of the leading international Higher Education networks, collaborating to accelerate the creation of knowledge and to develop leaders who will be prepared to address the significant challenges, and opportunities, of our rapidly changing world.The WUN runs a number of research projects including Eco-Hydrology, to develop and understand behavioral responses of fish which can be used to develop fish passage criteria and used to design environmentally friendly hydropower systems. Knowledge transfer from the United States and Europe to China is envisaged.	General Manager Ms Louise Heery The WUN Foundation, University of Leeds E: info@wun.ac.uk