



# Small hydro challenges and advances discussed in Crieff

## HIDROENERGIA 2006 REPORT

SHP policy, technology and environmental aspects were debated for two days in Crieff, Scotland, at Hydroenergia 2006, co-hosted by the European Small Hydropower Association and the British Hydropower Association. About 250 participants attended, representing 34 countries. This overview of the event presents some highlights from the various presentations.

The Opening Session of Hydroenergia 2006 was chaired by Prof David Williams, Chief Executive Officer of BHA, who welcomed participants to Crieff. Opening addresses were also given by Nick Pike, Chairman of BHA, and Prof Bernhard Pelikan, President of ESHA.

David Cairns, MP, presented an introductory message on behalf of the British Government; he noted that about 85 per cent of the UK's renewable energy was from hydropower, but this only contributed about 2 per cent to national electricity generation. The UK's target was to increase the share of renewables to 40 per cent by 2020, and to reduce CO<sub>2</sub> emissions by about 20 per cent. He outlined the various UK support mechanisms, such as the Renewables Obligation Certificate systems, which supported hydro refurbishment schemes up to 20 MW, and new schemes of any size.

Green Party MEP (Member of European Parliament) Alyn Smith, in his introductory message, noted that there was potential for about 300-500 MW of new hydro capacity in the UK, and a further 250-500 MW



Prof David Williams, CEO of the British Hydropower Association, and (right) Prof Bernhard Pelikan, President of the European Small Hydropower Association, welcome delegates to Hydroenergia 2006 in Crieff.

of capacity could be gained by upgrading existing schemes. Within the EC, he felt that in about half of the Member States, insufficient progress was being made with renewables. He urged those facing problems of apparent barriers to development to make issues known to the European Commission.

Smith mentioned that in December 2007, a new EC Paper was to be published on the promotion of RE technology. One of the strongest arguments in favour of hydro, apart from its inherent environmental benefits, Smith said, was that it could give countries security of supply, by reducing dependence on neighbouring countries.

### Policy and new opportunities

The first session on this theme was chaired by Alison Bartle of Aqua-Media International. She first of all commented on how the Hydroenergia conferences had progressively grown in size and scope since the first one which had taken place in Madrid in 1988, and she added that ESHA had been responsible for enhancing world recognition of the importance of small hydro, for tackling bureaucratic obstacles and for providing networking opportunities on a regular basis.

BHA, she continued, was one of the most dynamic national hydro-

power associations, working hard to raise the profile of hydro on all scales. Together the two co-hosts represented strong and passionate forces working for the cause of small hydro.

In her brief opening remarks for the discussions on policy and opportunities, she said that small hydro opportunities included:

- a large development potential in all parts of the world: rural areas of developing countries, and at existing hydraulic works in many industrialized countries;
- relatively small environmental impact;
- the possibility to use simple technology, and in the developing world, local workforces;



A Scottish piper gives a traditional flavour to the Opening Ceremony.



A. Bartle of Aqua-Media making some opening remarks in the first session, which she chaired.





Above left, David Cairns MP, who gave an opening address on behalf of the British Government. Right, European Member of Parliament Alyn Smith. Both spoke of the considerable hydro potential of the UK.



- the possibility to work in synergy with other renewables, such as wind power;
- new possibilities afforded by carbon credits; and,
- the existence of a dynamic industry (demonstrated by those present in Crieff).

Challenges remaining included:

- Bureaucratic obstacles not favouring hydropower;
- high initial investment costs;
- more work to be done on public awareness and public acceptance;
- lack of standardization (even on definition of small hydro);
- more complex and remote sites to be tackled in the future; and,
- more stringent environmental conditions to be met.

Dr O. Pirker of Verbund-AHP, spoke of Austria's long history of hydro development, demonstrating that it had been one of the pioneering countries for hydro development, with new developments still under way today. He traced the history of hydro development, and outlined some current activities (hydro and pumped-storage stations going ahead) as well as technical developments, such as the development of Hydro Matrix turbines.



G. Weisrock, Vice President of GPAE, spoke of the image of hydro from the perspective of French autonomous producers.

M. Bartušek representing the Czech Hydropower Association, gave an overview of small hydro engineering in his country. He explained that small hydro had historically been an integral part of economic life, despite some unfavourable conditions, and in particular there had been a downturn in activity in the 1940s for political reasons. More than 15,000 small hydro schemes which had been in operation were eventually reduced to just several hundred, as the political regime at that time opted for large coal-fired plants.

Now the situation had improved, Bartušek said, that there was a solid legal framework in place; so while some environmental and financial constraints to development remained, the prospects for the future were better.

Prof S. Panovski of the University of Macadonia FYR said that while the number of small hydro schemes in operation in his country was at present relatively small, 406 sites had been identified for possible future schemes; these could provide a total capacity of 258 MW, he said. Concessions were to be granted on some of these sites, based on conditions prepared by the IBRD which had funded studies.

Outlining present challenges in his country, Panovski said the main problems were weak hydrological data, and a lack of good past experience, as well as inadequate national legislation and weak national policies in the energy sector.

A paper which had been prepared by Dr Christian Epp of WIP International Projects and Dr Sergey Artemenko of the Solar Energy Centre, Ukraine, was presented in his absence by Maria Laguna of ESHA. This dealt with the EC-funded SHYCA project, in which ESHA

was also involved, and which was investigating small hydro development prospects in some central Asian countries.

The presentation outlined the vast hydro potential of the Caucasus and Carpathian mountains. In the past, during the era of the Soviet Union, small hydro had been neglected in favour of a centralized energy system and large-scale schemes, Laguna pointed out.

Now a technical and socio-economic assessment relating to small hydro retrofitting was being carried out using knowledge and data collected within the framework of the SHYCA research project. It had been found, Laguna continued, that there was a strong correlation between energy policy, property laws, and the number of plants already in operation. Conditions were promising in Armenia, where most facilities had been privatized by local stakeholders, and favourable support systems were in place. Azerbaijan, Georgia and the Ukraine were other areas which were found to have quite good prospects, depending on the availability of existing hydraulic works which were in a reasonable state, and providing the projects could be funded by private investors, avoiding the need for commercial loans. It would also be necessary for electricity produced to be sold directly to private consumers, at prices of at least €4.5/kWh.

Two further sessions on Policy and New Opportunities were chaired by Prof B. Pelikan.

H. Albenel, Vice President of the French autonomous producers' association GPAE, gave a paper entitled 'SHP future: tariffs without any support?'. He questioned whether, at the end of the 'feed-in tariff' stage, economic visibility for small hydro schemes should be achieved by market conditions, or whether there should be "an exception from European rules to ensure the survival of SHP?" .

General view of Hydroenergia participants in Crieff.





*G. Weisrock joins in the discussion during a session on opportunities and challenges, chaired by Prof B. Pelikan.*

He commented that a new European system should be found to help the operation and refurbishment of small hydro schemes in a continuous rhythm, after the end of feed-in tariffs.

C. Penche reviewed the history of Kyoto Protocol and gave an overview of the Clean Development Mechanism and the concept of emissions trading. He then explained how to proceed with the submission of a small scale CDM (a scheme of up to 15 MW). He gave some examples of small scale projects which had been registered under the CDM scheme, mentioning Los Algarrobos (9.73 MW) in Panama, Yukaizou (15 MW) in China, Maujhi (4.5 MW) in India, Cayumel (7.8 MW) in Honduras, Las Vacas (45 MW) in Guatemala, Poechos (14.5 MW) in Peru, and the Dolga upgrading scheme (addition of 3.5 MW) in Panama.

Turning to some shortcomings of the carbon market, Penche said that CERs (certified emissions reductions) were sold in deals where prices were not revealed, so a fair price was difficult to arrive at. The only advertised price outside Europe was by the World Bank, which paid about US\$5, he said. CER prices were much lower than EUA prices, because of the higher risks involved on projects in developing countries.

Bob Middleton of Tradelink Solutions, UK, spoke of commercialization and energy trading for small independent hydro developments in

the UK. The UK 'recipe' for small hydro schemes was complex, he said, with four separate negotiable elements: standard electricity, renewables obligation certificates, climate change levy exemption certificates, and embedded benefits. However, while it might seem to be associated with high risks, Middleton felt that the most positive aspect in the UK was that the RE market provided access to all on a fair and non-selective basis. "This gives hope to all existing and potential hydro owners, and provides an environment in which individuals and industries can be confident to invest in the future", he concluded.

C. Söderberg, President of SERO (the Swedish Renewable Energy Association) reviewed small hydro activities in Sweden, noting that the number of plants had fluctuated a lot during the last century. Since the 1950s in particular, the number had decreased, as a result of policies to build large-scale hydro or nuclear plants. The political will was now generally in favour of small hydro, he said, with a view to helping the country reach its renewable energy targets. But Söderberg noted that it was the Environmental Party which opposed small plants.

He reviewed current policy and the licensing situation. A positive step taken in 2003 was the introduction of a support system, involving green certificates, to stimulate renewable energy development.

But there were still many bureaucratic barriers, he noted, and to illustrate this point he described the case study of Träberna mill, where a licence application had led to a long and costly legal battle, which had eventually prevented the scheme from going ahead.

On a more optimistic note, K. Wheaton-Green of South Somerset District Council, UK, described an arrangement whereby owners of mill sites were working together to install micro hydro installations; they represented a united front to tackle regulatory and financial barriers, and had had a positive outcome, in that seven sites had already been developed, and a further five were planned.

I. Blyashko, from the Joint Stock Company Inset of the Russian Federation, reported on his country's Federal Programme for Small Hydro Development, which had been developed at the beginning of the century, with a first planning period covering 2002-2005. Sites had been identified in the Tuva and Altai Republics (18 and 35 sites, respectively), and as a result 12 business plans had now been approved to develop schemes,

three of which were proceeding to the design stage.

The fourth session on this topic, on the morning of 9 June, was chaired by K. Wheaton-Green of the UK.

E. Juliussen of NVE, Norway said that in 2002 the Norwegian Government had begun a programme to promote the development of renewable energy, including small hydro, and had allocated funding totalling around EU 3 million since that time. The country's target was to improve the power balance by focusing on sustainable electricity generation.

An intensive R&D programme had begun, Juliussen said, covering technical, environmental hydrological and data collection aspects. The national target now as to add around 5 TWh/year of production by small hydro over the next ten years.

L. Papetti of Studio Frosio, Italy, referred to legislation within the European Water Framework Directive concerning the release of minimum of ecological flows from hydropower plants, and he suggested that this could be turned "from an obligation to an opportunity". He said that "lost" flow, in cases where a head of around 2 m was available, could be regarded as a suitable site which could be used downstream of an existing structure for mini hydro generation. He gave some examples of cases in Italy where this had been done.

Dr G.P. Harrison of the University of Edinburgh, UK, stressed that renewed interest in hydropower should be backed up with the capacity to train young people, so as to "development the next generation of hydro engineers". His paper, co-authored by D.E. MacPherson of the same university, and Prof D.A. Williams of BHA, described the establishment and experience of running a hydropower design course for the penultimate year of those studying engineering at the University of Edinburgh. Key features were the use of interdisciplinary groupings, and leadership by external industry staff.

O. Paish of Derwent Hydro gave a paper, co-authored by J. Needle, which described three small and micro installations in England and Wales which had been give a "new lease of life" by refurbishment. These case studies are described in detail in *H&D* Issue 3, 2006.

### Engineering solutions

The first session on this theme was chaired by K. Hanson of Hydroplan, UK.

W. Panhauser of Kössler, Austria, described the Wave Dragon, an off-

*C. Penche of Spain discussed the opportunities and challenges posed by the CDM mechanism.*





shore wave energy converter which involved two wave reflectors focusing incoming waves towards a ramp; a reservoir collected overtopping water, and several hydro turbines were used to convert the pressure head to power. This development represented the largest wave converter to date, with units of 4 to 10 MW.

M. Arquilla of Italy described some cases of low head small hydro schemes in his country which had been developed on a turnkey basis. He underlined the importance of adopting a systematic approach at the design phase, as well as during the management of projects, to ensure a good interface between civil and mechanical engineers.

D. Krompholz of VA TECH Hydro (part of the Andritz Group) described the company's Compact Axial Turbine (CAT), which allows for various possible arrangements for installation at both new and existing hydro plants, where heads of up to 30 m were available. He described the technical features of the machines, and drew attention to their efficiency and reliability, giving some examples of case where they had been installed in Scandinavia.

A. Wilson of Gilbert Gilkes and Gordon, UK, described small hydro refurbishment schemes where high-head Francis turbines had been installed to replace Pelton units. The case studies he referred to were in Scotland and Wales.

He concluded that high-head Francis machines could represent a good solution for the head range of 200 to 400 m, and would work best in situations where water was clean, and the plant could operate at its best efficiency point; problems of bad water quality could be dealt with by the adoption of wearing rings, he added.

P. Duflon of VA TECH Hydro (Andritz Group) described a case where an old 'camel back' double discharge Francis turbine had been replaced by an Eco-Bulb unit. He reminded delegates that the Eco-Bulb concept was based on directly driven bulb turbines with permanent magnetic excitation generators. They were suitable for outputs of 500 to 5000 kW, and heads of 3 to 15 m, he said. He described the case study of the Tombetta scheme in Verona, Italy, where four of the units had been installed. A particular challenge, he pointed out, had been to minimize impact on the existing civil works while keeping the discharge at least to the original level.

M. Leclerc of MJ2 Technologies SARL, France, described the recently developed Very Low Head (VLH)

turbo generator, which he said was suitable for extremely low waterfalls. This development was the result of an R&D project which had recently concluded, and the first prototype machine was now being manufactured, Leclerc said. This was a 450 kW unit, to operate under a 2.5 m head.

The second session on engineering was chaired by A. Watson of Gilbert Gilke & Gordon, UK.

J. Bard, of the Institute for Solar Energy Supply Technology, Germany, described a joint European research project, funded by the EU, for the development of a commercial concept for variable speed operation of a submersible compact turbine. This was based on an existing turbine concept, he said, which had been modified using a permanent magnet synchronous generator. A new type of runner had been developed using CFD.

I. Topliceanu of the University of Liège, Belgium, discussed hydraulic laboratory studies which had been conducted for a concept of a turbine which could be installed at lock on the Meuse river in Belgium. She described technical features and the economic analysis which had been done.

P. Mazzoli of GECO Sistema srl, Italy, presented a case study concerning the Marecchia river near Rimini in Italy, where gravel sediments, which needed to be removed, had caused channel bottom erosion. Hydraulic model studies had shown, he said, that by operating a withdrawal of discharges from the river along a short stretch, the sediment transport capacity of the river could be significantly reduced. This allowed for the possibility to install a small hydro plant, with the added advantage of maintaining ecological flows in the river, and reducing the potential for erosion.

The third session on engineering topics was chaired by V. Denis of MHyLab, Switzerland.

A. Moissonier of SEER France, the owner of a small hydro scheme in the French Alps, described his experience of having joined the SEARCH LHT project. His scheme had been the demonstration site for part of the research. The project had involved the installation of a Kaplan unit to operate under a 27 m head. His vision of a small hydro research scheme, from the perspective of an owner, revealed some challenges and frustrations, in terms of surprises which had arisen and had impacted on the project schedule and also costs. In the end, he concluded, the scheme had been a technical success



and the experience had been worthwhile, but he cautioned that owners participating in such scheme should be aware of the challenges to be faced.

S. Skuletic, a Professor at the University of Montenegro, described a proposal for the implementation of small hydro at the Otilovic dam in his country, where the reservoir was used to supply cooling water to a thermal powerplant. Advantage had been taken of the possibility to install a mini hydro scheme, which comprised two 2635 kW units, and one 326 kW machine.

J. Cox of Dulas, UK, described design challenges involved in the Auchtertyre mini hydro scheme in Scotland, where a Francis unit had been installed to replace a crossflow unit (see *H&D* Issue 3, 2006).

R. Simpson of Nottingham Trent University, UK, presented a research project now underway with Practical Action (formerly ITDG-Intermediate Technology Development Group); this was aimed at developing a simplified design for pico propeller turbines, particularly suitable for local manufacturing capability in developing countries. A 5 kW prototype has been manufactured and installed in Peru, he said.

In the fourth session on engineering, chaired by C. Söderberg, V.K. Pande of BHEL, Bhopal, India, discussed Pelton turbine design in relation to protection against silt erosion, a particularly serious problem in the

*Speakers in the first session on engineering solutions, chaired by K. Hanson.*

*E. Doujak of Austria, left, responds to a question during the last technical session.*





*M. Leclerc explains the concept of the newly developed Very Low Head (VLH) hydro generator.*

Himalayan regions. Pande said that CFD studies had shown that the shape of the nozzle and spear angle were critical in this respect.

N. Frosio, of Studio Frosio, Italy, discussed waterhammer problems and solutions in the case of a small hydro plant with a long penstock (where dangerous stresses could be caused by negative waterhammer pressures). In the case study he described, problems could arise because of the rapid increase in flow rate (30 per cent in about 1 s) when Kapan units shut down at full load. He explained that if this problem were not taken into account at the design stage, there was a possibility of an absolute vacuum forming in part of the penstock, with possible severe damage to pipes and adjacent installations.

E. Doujak of Vienna University of Technology, Austria, gave an overview of the use of trashrake machines at small hydro plants. He observed that sometimes as a result of budgetary constraints, the trashrake machine had to be low cost. His paper dealt with state-of-the-art CAD method used to design trashrack cleaning machines.

V. Denis of MHyLab continued on the subject of CAD tools for design; his presentation focused on CAD for small, low head turbines. MHyLab, he said, had been working on the development of techniques for small turbines to make their implementation more efficient as regards construction, integration to site conditions, cost, performance and O&M requirements.

*Prof David Williams and Prof Bernhard Pelikan draw Hydroenergia 2006 to a close, on 9 June.*



*Jon Cox of Dulas, UK, responds to a question about the Auchtertyre micro hydro scheme in Scotland, in the session on Engineering solutions chaired by V. Denis of Switzerland.*

Systematic design criteria had been developed for various components, Denis said, and it had been possible to validate laboratory results on site.

I. Uglow of SLR Consulting Ltd, UK, discussed the effect of slope instability on small hydro schemes, with particular reference to peat soils in Scotland and Ireland. He called for this to be taken into account at the detailed design stage of projects.

### Environment and planning

Two sessions on this theme were chaired by L. Papetti of Studio Frosio, Italy, and G. Weisrock, Vice President of GPAE (French Group of Autonomous Producers).

B. Fitzgerald outlined the small hydro potential of Ireland, and then discussed ways of designing mini hydro plants to have a minimal negative impact on the environment. He presented some case studies, one of which was a mill in County Kerry, and the other related to the installation of mini hydro at an existing water supply system in Ireland.

G. Sabas of Vilnius Technical University, Lithuania, looked at the potential environmental impact, in particular the influence on river regime, which could be caused by mini hydro plants, especially in the case of frequent starting and stopping of the machines which could be a cause of river bed erosion. One of his conclusions was that two or more turbines of different capacities could be beneficial in reducing the influence on flow, and on the environment. He added that crossflow turbines could be recommended for operation over a broad range of small hydro applications.

D. Upadhyay of IT Power, UK, described studies for the development of fish-friendly turbines, which had been supported by the UK Carbon Trust. A new turbine design

had been conceptualized, he said, and tested using CFD (see *H&D* Issue 3.)

Recent legislation in Lithuania, described by P. Punys, prevents any dam construction at present on the country's major river systems.

Punys presented the results of two recent studies which demonstrated in quantitative terms that such a prohibition, without exceptions, compromises other beneficial river uses such as inland navigation, flood defence, recreational activities and environmental enhancement of the surrounding area.

### Conclusion

In the concluding session, it was agreed that European small hydro is facing a number of challenges, as a result of: the implementation of the Water Framework Directive; the implementation of the Directive for the Promotion of Electricity Produced from Renewable Energy Sources; and, the urgent need to increase public acceptance of small hydro. In this context, it was agreed that Hydroenergia had shown the SHP sector to be "strongly alive and interconnected"; networking activities were bringing together not only technicians, but also environmentalists, project developers and public administration. Hydroenergia concluded that in view of the target set by the RES Directive, of 22 per cent use of electricity from renewables by 2010, SHP development would be a fundamental part of the energy mix.

In closing Hydroenergia 2006, ESHA President Prof Bernhard Pelikan said that there had been a "good feeling" throughout the conference in Crieff, with nearly 50 presentations, and two Workshops. He stressed the importance of such networking, noting that hydro operators had many problems to share and discuss. Sharing problems was a good way of solving them, he felt.

He noted that a great variety of topics had been covered in the presentations, including much innovation. "Small hydro may have a long tradition", he said, "but this does not mean that it is old-fashioned".

Looking to the future, Prof Pelikan said that although one could not yet say that small hydro had reached its golden era, perhaps it had reached bronze, on was on the way to silver.

More work lay ahead, he felt, in learning about environmental aspects, challenging the opposition to SHP, correcting wrong statements, and above all constructing more small hydro plants. "We should be proud of small hydro", he said in conclusion.

