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EDITORIAL

Hydropower, a catalyst for energy transition in Europe

The HydroES 2021 Conference (on the first day of the Société Hydrotechnique de France [SHF] meetings, 22 September 2021) was an opportunity for the HYDROPOWER EUROPE Forum to present its vision and the results achieved for the development of hydropower in Europe. The HYDROPOWER EUROPE Forum was launched by a H2020 EU project under grant agreement No. 826010.

1. Session 1: current challenges for hydropower in Europe

Mr Schleker, European Commissioner for Research, underlined the importance of innovative technologies to achieve the objectives of the Paris Agreement through economically viable and sustainable hydropower: digitalisation, flexibility, modernisation and ecological continuity. The calls for hydropower have increased from 10 to 40 million euros between the Framework Programme 7 and Horizon 2020. The 2021–2027 calls involve equipment for hidden hydropower, digitalisation of power plants and of hybridisation, modelling of energy systems, and innovations in storage, in its integration into the grid or in off-grid applications.

Professor Anton Schleiss from École Polytechnique Fédérale de Lausanne (EPFL) presented the vision developed by HYDROPOWER EUROPE that puts hydropower back at the centre of the energy transition through its capacities to increase production flexibility, long-term storage, innovative pumped storage solutions, production through multi-purpose schemes and "hidden" hydropower, for which he presented a catalogue of solutions. The uprating potential in existing hydropower schemes could increase Europe's 2020 generation by the additional energy storage achievable by reservoir interconnection and coordinated operation has been estimated as 169 TWh. The success of new projects lies in the application of a scientific methodology in the form of a multidisciplinary approach to complex systems, aiming at a win–win solution for all stakeholders.

Alex Campbell from International Hydropower Association (IHA) was clear: "we need to decarbonise electricity if we are to stop climate change". In the International Renewable Energy Association (IRENA) scenario, 850 GW of hydropower is needed to limit warming to below 2°C in 2050, and 1200 GW to limit it below 1.5°C. The problem is that the IHA can only see 548 GW of planned projects, hence 300 GW of projects are missing! A small part of this shortfall could be found in the retrofit of the 600 GW of existing installed capacity. Apart from new projects, another part can come from increased flexibility of operation, as hydropower is "the largest source of flexible electricity generation", with 1730 TWh or 17% of the world's production.

2. Session 2: research and development needs: the Research & Innovation Agenda (RIA)

Professor Anton Schleiss described the complex system analysis applied to hydropower in Europe to help understand how a wide range of factors can interact to affect hydropower development. It establishes the reinforcing or diminishing of causal links among 103 factors identified by the wide stakeholder consultation. The analysis consists of building a matrix showing the activity of each factor by the total number of influences it exerts, and its dependence by the total number of influences it undergoes. Finally, *public awareness of hydropower* and *the share of intermittent renewable energy* are shown to be critical factors for the future of hydropower because they are context dependent. The most active and controllable factors, *communication, reservoir volume* and an *environmental mitigation measure*, are levers in the research directions of the Research & Innovation Agenda (RIA) or drivers of strategic actions of the Strategic Industry Roadmap (SIR) to improve the situation of hydropower. The priority categories of the research themes obtained from the consultation process and feedback of the Consultation Expert Panel (CEP) could be validated by the results of the complex system analysis, when comparing them with the controllable, active factors having a high impact on the network describing the hydropower system in Europe.

Patrick Clerens from European Association for Storage of Energy (EASE), and Mario Bachhiesl from VGB PowerTech e.v. (VGB), explained the approach taken to implement three core tasks:

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- to bring together hydropower value chain actors in a forum;
- to analyse and prioritise their needs; and
- to release two deliverables, the RIA and the SIR.

The RIA recommends innovation pathways, and the SIR recommends strategic actions to address the challenges of hydropower. Around 630 people registered through the HYDROPOWER EUROPE Forum consultation platform (https://hydropower-europe.eu/) to participate in the forum. The needs analysis resulted in three successively refined versions of the RIA and SIR documents over two years. Each round of general consultation included the survey of all stakeholders, and an analysis of the responses and validation of priorities by a panel of 34 experts representing the hydropower value chain, the Consultation Experts Panel (CEP). This was followed by the drafting of a new document version and its subsequent evaluation by the CEP.

Ingo Ball (WIP Renewable Energies) introduced seven challenges resulting in 18 research theme headings which comprised some 80 detailed topics documented within the RIA. These address most of the objectives of the European Green Deal initiative and align well with the results of the global system analysis (Figure 1).

Hydropower is the world's leading source of renewable electricity generation. Its sustainable growth potential will be based on:

- run-of-river plants crossed by fish and sediment,
- closed-cycle Pumped Storage Hydropower PSH;
- increasing the volume of existing reservoirs by raising dams;
- digitalisation making hydropower cheaper and more environmentally friendly;
- hybrid solutions using wind or solar power and hydrogen;
- new multi-use reservoirs for climate mitigation.

Hydropower Europe recommended R&I themes — **Consultation Feedback**

Challenges	Research Themes	Priorities	Recommended Call	Recommended Funding Scheme
Increasing flexibility	3.1.1. Innovation in flexibility, storage design and operation	Very High	before 2025	€ 26-35 million
	3.1.2. Innovative design of turbines including reversible pump-turbines and generators	High	before 2030	€ 16-25 million
	3.1.3. New models and simulation tools for harsher operation conditions	High	before 2030	€ 8-15 million
	3.1.4 Development and application of a business model for flexibility	Very High	before 2025	€ 8-15 million
Optimisation of operations and maintenance	3.2.1. Digitalisation and artificial Intelligence to advance instrumentation and controls	High	before 2030	€ 16-25 million
	3.2.2. Monitoring systems for predictive maintenance and optimised maintenance intervals	High to Very High	before 2030	€ 2-7 million
Resilience of electro-mechanical equipment and infrastructures	3.3.1. New materials for increased resistance and increased efficiency of equipment	Medium High to High	before 2030	€ 8-15 million
	3.4.1. New materials and structures for increased performance and resilience of infrastructure	Medium High to High	before 2030	€ 8-15 million
	3.4.2. Databases of incidents and extreme events, integrated structural risk-analysis models and innovative solutions for multi-hazard risk analysis	High	before 2030	€ 8-15 million
	3.4.3. Innovative sediment management technologies for sustainable reservoir capacity and river morphology restoration	High to Very High	before 2025	€ 8-15 million
	3.4.4. Innovative techniques for enhancement of working life of concrete structures	Medium High to High	before 2030	€ 8-15 million
	3.4.5. Innovative techniques for enhancement of overtopping safety of embankment and rockfill structures	High	before 2035	€ 2-7 million
Development of new emerging concepts	3.5.1. Development of innovative storage and pumped-storage power plants (e.g. multipurpose PSH, sea water PSH, etc.)	Very High	before 2030	€ 16-25 million
	3.5.2. Marine energy	Medium High to High	before 2030	€ 8-15 million
	3.5.3. Hybrid & virtual power plants	High to Very High	before 2030	€ 8-15 million
Environmentally compatible solutions and mitigation of the impact of global warming	3.6.1. Flow regime management, assessment of environmental flow release, innovative connectivity solution for fish and biodiversity protection and improvement of stored water quality in reservoir	Very High	before 2025	€ 16-25 million
	3.6.2. Assessment of the general impact and contribution of hydro-power to biodiversity and the identification of innovative approaches and guidelines to support more sustainable hydropower	Very High	before 2025	€ 8-15 million
	3.7.1. Innovative concepts of hydropower infrastructure adaptation and tapping hidden hydro	Very High	before 2030	€ 16-25 million

Figure 1. Research themes as obtained through a wide stakeholder consultation, with indication of priority levels, time perspective and needed budget.

Dr Antonio Jarquin Laguna (TU Delft) coordinated and introduced the H2020 Augmenting Grid Stability Through Low Head Pumped Hydro Energy Utilization and Storage (ALPHEUS) project. With a budget of 4 million euros over four years (until 2024), it aims to make profitable 10 MW pump turbines (with efficiency between 70 and 80%, eight blades at 50 rpm or seven blades at 45 rpm, Permanent Magnet Synchronous Motor [PMSM] synchronous motor) in shallow seas and flat topographical areas of less than 20 m.

3. Session 3: supporting the industry: the Strategic Industry Roadmap (SIR)

Jean-Louis Drommi from Electricité de France (EDF) introduced the six full-scale experiments (Z'Mutt; Frades 2; Grand Maison; Alqueva I–II; Alto Lindoso; Vogelgrün) used to demonstrate the feasibility and profitability of innovative flexibility solutions for the XFLEX Hydro project.

Dirk Hendricks from European Renewable Energies Federation (EREF) explained that after spending several billion euros to improve the ecological continuity of rivers, small hydropower (SHP) needs action from politicians to:

- promote SH as an important component of the renewable energy mix;
- establish European and national development targets up to 2050;
- harmonise the notion of sustainability of energy and environmental policies;
- integrate SH as a component of and solution for water management policies;
- base environmental policies on more site-specific scientific assessments and cost–benefit analyses;
- develop support mechanisms for multi-purpose developments and network services;
- help fund R&I by European industry to maintain its global leadership.

As editor, Jean-Jacques Fry introduced the SIR. The three highest priority actions identified were for stakeholders to improve (1) the flexibility market, (2) public awareness, and (3) regulations. Thirty-eight high-priority strategic actions are grouped under three guidelines:

(1) Provide economic and legal support for flexibility and storage through improving flexibility markets, better practices for investing under uncertainty and developing a more relevant regulatory framework.
(2) Preserve biodiversity and enhance river ecosystems through best practice in sustainability and biodiversity protection, improved knowledge of environmental impacts, application of innovative compensation measures and development of holistic approaches that promote synergy and trade-offs.
(3) Raise public awareness through communication and dissemination, increasing societal resilience and local employment, developing best practices for sustainability and win–win situations, increasing security, decentralisation and independence of the European energy system through Pumped-Storage Hydroelectricity (PSH) and launching a collaborative platform for hydropower.

After a century of silent development, hydropower needs to communicate that it:

- is the renewable energy with the best climate, energy gain and return on investment factors;
- is far from being a competitor, as it integrates other energies;
- provides all ancillary services to the grid;
- avoids the collapse of the grid (e.g. 2006, 2019 and 2021);
- can provide many opportunities to develop storage and flexibility;
- supports development in remote areas (taxes, jobs, infrastructure and tourism);
- protects society and biodiversity from climate change (droughts and floods);
- contributes to the water–food–energy nexus and to the achievement of the Sustainable Development Goals.

4. Session 4: future of the HYDROPOWER Europe Forum

Greg Arrowsmith from Association of European Renewable Energy Research Centres (EUREC) and Maria Laura from Smart Networks for Energy Transition (SNET) described the structure and purpose of a European Technology and Innovation Platform (ETIP). It is a group of volunteers who contribute to the development of the disruptive technologies of the Strategic Energy Technology (SET) Plan energy policy. The SET Plan is the EC's structure gathering representatives of member states for accelerating the energy transition. The goal is for all technologies to participate by 2022. Hence the HORIZON-CL5-2021-D3-02-15 call, which includes a provision to select and fund an organisation administrating a HYDROPOWER ETIP.

Mark Morris (Samui) introduced the proposed approach for the future of the forum: to meet the needs of both industry and the energy transition, to follow RIA and SIR, and to avoid duplicating the work of other

organisations. The HYDROPOWER ETIP aims to support achieving the goals and objectives of the RIA and SIR, with potential funding between 2022 and 2025. Thus, the forum submitted a bid to implement the Hydropower ETIP with a business model ensuring sustainable funding from industry after 2025. The concept is to support hydropower participation in the SET Plan alongside facilitation of R&I actions, as prioritised by industry through the RIA and SIR. Three levels of projects might be undertaken: small projects involving only a few members, utility actions (R&I, communication) financed by the sector, and projects financed by European and other international funds.

5. Conclusions

(1) Hydropower still has great potential and room for development that must be achieved for a successful energy transition in Europe.
(2) The hydropower sector needs strategic actions, in terms of recommendations not only to the European Commission, but also to the whole industry in terms of communication.
(3) The industry needs to unite its forces to speak with a permanent voice in Europe.

Disclosure statement

No potential conflict of interest was reported by the authors.

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