

A practical exchange of knowledge on a rapidly emerging technology

Delegates from 35 countries, representing all stakeholders involved in solar-hydro hybrid and floating solar systems, convened in Juan-les-Pins Antibes in April, to exchange experience and to highlight future plans and challenges on this relatively new and rapidly developing technology.

SOLAR-HYDRO 2024, organized by Aqua-Media International, in partnership with the International Commission on Large Dams, took place on 22 and 23 April in Juan-les-Pins Antibes, and focused particularly on global potential and progress, safety, new technology, environmental aspects, and finance. The event was supported by the International Energy Agency, the French National Committee of ICOLD, Hydro Coop, ISL, and CHINCOLD.

In her opening message, Aqua-Media Director Alison Bartle welcomed delegates and before previewing the programme, commented that at least the first three general objectives of the conference had already been fulfilled:

- First, she observed that the conference had brought together, under one roof, excellent representatives of all the various parties involved in planning, implementing and operating solar-hydro hybrid schemes, and particularly floating solar PV. She added that this seemed unusual, as more often solar people and hydro people tended to circulate within their own universes. Solar PV experts, hydropower and dam engineers, utilities with big reservoirs waiting for solar panels to land on them, as well as researchers, funders, and experts on safety and environmental aspects were all present. There was much to discuss and learn about new opportunities and technical advances she said, and, for newcomers to the technology, the chance to be convinced about efficiency, environmental benefits and safety.
- Second, the delegates participating represented nations from virtually all regions of the world, and many of the 35 countries were at very different stages in their floating solar development processes and plans. This meant that the exchange of experience would be valuable, particularly for some of those from Africa, Asia and Latin America who had major plans and potential for FPVs on their large-scale hydro reservoirs, on-going needs for clean renewable energy, and in many cases a need to reduce evaporation from reservoirs with large surface areas.
- Third, in view of the rapid pace of development of



Shown right, Luc Deroo, partner in the organization of the conference, who made some opening remarks on behalf of ICOLD. Beside him is Atle Harby, who spoke on behalf of IEA.

this relatively new technology, and the global importance of solar-hydro schemes, especially floating solar, the programme had been planned with a diverse range of relevant topics for those embarking on schemes for the first time: safety aspects, design, innovation, and challenges of accessing funding.

Bartle then gave a brief introduction to the programme, drawing on material published in the FPV section of *Hydropower & Dams* to reflect on current activities in the field of floating solar PV around the world.

Luc Deroo, Chief Technical Officer of ISL, France, and also Chair of ICOLD's Technical Committee on Prospective and New Challenges of Dams and Reservoirs, first greeted the international delegates on behalf of CFBR and its President Denis Aelbrecht, and also on behalf of ICOLD President Michel Lino and Secretary-General Michel de Vivo; they could not join the opening because of a pre-arranged Board Meeting in the USA. He said that on behalf of the French Committee, he was proud to welcome SOLAR-HYDRO to France, a country with a long history of hydropower and dam development, with several GW of solar power being added to the grid each year, including several FPV plants. He underlined ICOLD's interest in solar-hydro schemes, and based on the Commission's core value of dam safety, its interest in making sure that FPV could not cause a threat to dams.

Deroo then presented a powerful opening address, which had been prepared together with ICOLD Hon. Member, François Lempérière, who was Guest of Honour at the conference. He began by noting that Antibes, a beautiful and sunny town on France's Mediterranean coast, had been an ideal choice for a conference on solar-hydro schemes. But he said that the Mediterranean region represented many more things: it was a hotspot for the effects of climate change, such as serious droughts, deadly forest fires



Alison Bartle draws attention to the value of bringing together solar PV and hydropower and dam experts for practical discussions on FPV and hybrid solar-hydro schemes.



and devastating floods, all likely to increase in intensity. It was also a hotspot for threats to biodiversity, as a result of climate change, overfishing, and urbanization. And, he continued, it was a hotspot for people to choose to cross the sea on small boats, in the hope of finding a better life. In 2023 alone, more than 2500 people had died while attempting to make this crossing. “Things could be different, should be different, and it is worth trying to make them different”, Deroo said.

He felt there were two main reasons for hope:

- *Science:* More than 200 years ago, in 1798, the well respected scientist Malthus predicted that the world would never be able to cope with its growing population. At that time the population was 1 billion. “Today this figure is 8 billion, and apart from persistent inequalities, we are much better off than 225 years ago, so the prediction of Malthus was incorrect. This, he pointed out, was thanks to advances in science and technology.

- *Discussion:* The second hope, Deroo felt, was in our inclination for discussion. “We take pleasure in discussing exciting ideas and views, and in listening to good stories”. He said that according to the author and historian Harari, this propensity for discussion dated back to our ancestors, who would gather around fires exchanging stories, and this is likely to account for how the human race became so successful.

Good news, Deroo said, was that there would be much discussion over the two days of the conference. The science and the discussion relating to solar-hydro could be a catalyst for positive change.

He pointed out that in numerous countries and regions, solar power would be essential to achieve sustainable development, and in many places there was no feasible alternative. He outlined the challenges associated with solar power, including its intermittent nature, an issue for which solar-hydro offered the solution. He drew attention to some other benefits of combining solar and hydropower, for example, its role in helping to adapt to climate change. Solar production could also, to a certain extent, replace hydro production in some countries, so that water could be used for other purposes.

A joint presentation was then given by Elín Hallgrímsdóttir and Bente Brunes of the World Bank/ESMAP, entitled: ‘Facilitating the energy transition with hybrid hydropower solutions’, based on a

recently published World Bank Report, ‘Power with flexibility’.

As pointed out in the report, the necessary scaling up, and sustaining high shares, of variable renewable energy (VRE) call for facilities that not only generate electricity, but also provide energy services to increase resilience and reliability of power systems. The presenters pointed out that hydropower hybrids not only generate electricity, but also provide these required energy services.

Hydropower hybrids use water as the primary energy source, combined with one or more renewable energy sources, energy storage, and an overarching operations and control system. This enables them to leverage the distinctive strengths of each technology to provide energy services to enhance power system flexibility and energy security.

Among the benefits to be harnessed, pointed out in the talk, were:

- strengthening energy security;
- creating multiple revenue streams from the same infrastructure;
- turning variable renewables into dispatchable energy;
- reducing costs of project preparation activities;
- sharing of project implementation, execution, and operation and maintenance;
- reducing power transmission costs;
- supporting power systems by supplying high quality power at the same connection point;
- using a site’s fullest potential sustainably; and,
- achieving economies of scale.

The presentation pointed out some research and development needs. First was the necessity to build methodologies and analytical tools for low- and middle-income countries and regions to understand how a hybrid could deliver energy services tailored to their specific needs. Second was the need to explore how remuneration for energy services would improve hybrid hydropower projects’ bankability and scale-up investments.

Remuneration is not adequate in most markets, Brunes said, where the focus has been to incentivize the increase of generation. “Remuneration ensures efficient resource utilization and makes visible the value of energy services for maintaining power system balance. Focus, therefore, needs to shift to the importance of valuing energy services for maintaining power system balance”, she concluded.

From left: Elin Hallgrímsdóttir and Bente Brunes of the World Bank/ESMAP, presenting details of the recent World Bank report; and, Alex Beckitt, (Hydro Tasmania), who gave a joint presentation with Atle Harby on behalf of the IEA.

P.T. Padi of VRA, Ghana, discussing the FPV potential of the Akasombo reservoir; and, Surbhi Goyal, World Bank, India, who told delegates of the plans to unlock India's vast FPV potential.

Integrating solar and hydropower: potential and benefits

The first session focused on the global potential for integrating solar and hydropower, including regional benefits and environmental aspects. It was chaired by Luc Deroo.

The presentations covered Europe, Africa, Asia and Latin America, and also included perspectives from the International Energy Agency, the European Union and the World Bank, India.

The first talk, from the International Energy Agency, discussed challenges, opportunities and benefits of solar-hydro hybrids. It was co-presented by two senior officers of IEA, Atle Harby (also of SINTEF, Norway) and Alex Beckett (also of Hydro Tasmania, Australia).

Their talk pointed out that land-based solar PV had a great potential for increasing renewable energy generation in many countries, but challenges included finding suitable land in areas with high competition for land use, necessary infrastructure and access, as well as the variability in generation over the day and between days. Installing floating solar PV on hydropower reservoirs helped to meet all these challenges.

The presenters explained that Task 9 of IEA-Hydro's Technical Collaboration Programme, focusing on 'Valuing hydropower services', had launched a collaboration on 'Hybrid power plants with hydropower and other renewables or storage technologies'.

Jean-Jacques Fry of France presented a paper, co-authored by Prof Anton Schleiss and Mark Morris, on the EU's European Technology and Innovation Platforms (ETIP), part of the Strategic Energy Technology (SET) plan which exists to coordinate research and innovation agendas for low-carbon energy solutions, at both European and national levels, and to provide the technological and scientific advancements necessary for the energy transition. He explained that 14 Implementation Working Groups are in charge of aligning priorities and legislative proposals with research and development efforts. In this process, the voice of industry and scientific community is carried by ETIP, which focuses on clean technology-specific issues, including solar PV and hydropower.



Jean-Jacques Fry, France, outlines how ETIP could facilitate further FPV deployment in Europe.



ETIP, he explained, gathers and fosters collaboration among the stakeholders in the value chain within the same technology, focusing on the clean energy transition, and defines research priorities, as well as creating a roadmap to overcome barriers to the deployment of research outcomes.

Fry proposed three ways in which ETIP could facilitate further FPV deployment in Europe:

- organizations could identify research and innovation actions for the Strategic Research Innovation Agenda of ETIP PV and hydropower;
- opportunities could be identified to put forward projects for the European HORIZON R&I project call, on floating solar PV, aimed at sustainable deployment of FPV in Europe; and,
- by implementation of a research and innovation project on FPV through direct collaboration of EU contracting, targeting sustainable FPV deployment.

He questioned whether enough had been done since the SOLAR-HYDRO 2021 conference to scale up FPV schemes in Europe, and then presented a SWOT analysis (of the strengths, weaknesses, opportunities and threats).

He encouraged collaboration, and said that planned ETIP HYDROPOWER strategies included: drawing up terms of reference for a research project on FPV, and submitting this to the EU Research Directorate for 2025 HORIZON calls; to encourage motivated companies and universities to launch a collaborative project, and to implement this with their in-kind contribution and public funding from their member countries; and, launching of an international working group on FPV to exchange and unify the views of industry, research bodies and authorities, through regular meetings.

Surbhi Goyal, Senior Energy Specialist at the World Bank, India, gave a talk on prospects and plans for unlocking India's floating solar potential. After giving details of the enormous potential in the country, by state, she noted that of 6 GW of FPV projects which had been announced, less than six per cent had so far been commissioned.

While she felt there was market readiness for aspects such as site investigations, and producing floaters, solar modules, and associated equipment, there were regulatory, technical and commercial barriers to be overcome; these included the lack of availability of stands, an inadequate infrastructure for testing, issues of water rights, relatively small manufacturing capacities, and an inadequate skills set for large-scale FPV, for example.



She then gave details of a recently launched World Bank report, representing a roadmap for the unlocking of potential in the short, medium and long term.

A total of 2173 reservoirs had been mapped, with details being available on the World Bank-ESMAP's open-source Global Solar Atlas, Goyal said; information included the type, purpose and characteristics of the dams, the water body areas, and potential of FPV, based on five to 30 per cent coverage.

P.T. Padi from the Volta River Authority reported on the floating solar hydro potential of the Akasombo reservoir in Ghana, the country's largest man-made reservoir by surface area (8502 km²), and the role FPV could play in helping Ghana to reach its target of 10 per cent renewable energy penetration by 2030.

Two papers were also included on environmental aspects of FPV. Marion Pinatel of Oréade-Brèche, France, spoke of an analysis of 26 Mexican reservoirs, owned by CFE, for the possible implementation of FPV. She also noted the significant role such schemes could play for Mexico's energy system, and she added that the studies done could also be of relevance to other Latin American countries.

Atle Harby of SINTEF, Norway, then discussed the modelling of environmental impacts of FPV on the 45 km² reservoir at the 388 MW Magat hydro plant in the Philippines. An integrated physical-biogeochemical reservoir model had been created to simulate the impacts of FPV on evaporation, heat exchange, light penetration and gas exchanges at the water surface. Four variants of reservoir coverage had been considered in the study, he said.

Recent, ongoing and planned projects

Dr Aries Firman, of the Dam Safety Commission of Indonesia, and Vice Chairman of the Indonesian National Committee on Large Dams, chaired the second session, on recent, on-going and planned FPV and hybrid schemes.

Delegates heard feedback from EDF about the implementation and operation of the 20 MWp Lazer floating solar plant in southern France; from Isiginere, Spain, about lessons learnt from the Alqueva hybrid scheme in Portugal and the FPV at the Urrá 1 hydro plant in Colombia; from UEGCL on plans for schemes at its large hydro schemes on the Nile; from Floatex on the design of the 600 MW Omkareshwar FPV in India; and, from the Bandung Institute of Technology and Innosea on existing and planned schemes in Indonesia. In his session summary, chairman Aries Firman drew attention to eight principle aspects that had emerged from the presentations and discussion.

- Floating PV on dam reservoirs, although still to be regarded as an emerging technology, has already been widely adopted in numerous countries around the world, and the session had demonstrated this by including presentations on schemes in France, Portugal, Colombia, Indonesia, Cameroon, Uganda and India. The talks had highlighted both successes and challenges.
- Design criteria, construction methods and operational parameters were among the main issues requiring special attention as more and more countries move ahead with schemes, not only to secure the structural safety of the FPV scheme itself, but also dam safety.
- Anchoring and mooring systems have been, and continue to be, the subject of much consideration in floating solar schemes, with regard to geotechnical and hydrological aspects, and also reservoir parameters. The talks had reflected the various options now available, each with its own advantages and limitations.
- It had been emphasized that permanent and temporary measures need to be provided to secure FPV structures during extreme environmental loads, to avoid potential damage or failures; this was the case during the construction stage, as well as throughout operation.
- It was important for a system of monitoring and data evaluation to be established, on FPV deformation and potential fatigue, and appropriate instrumentation should be installed, including sensors, to enable real-time digital evaluation.
- From the results of monitoring and evaluation, analysis can be established to assess the status of the current behaviour of FPV installations, as a benchmark for comparison of the actual situation versus original assumptions, and also as a reference for comparison with the next evaluation, on an annual basis.
- The risk profile for FPV and also for the safety of the dam must be considered a crucial element and to be part of a continuous evaluation.
- More attention should focus on advance planning of FPV at new dams and hydro plants. So far discussions have mainly focused on the installation of solar PV at existing reservoirs, but greenfield projects should be planned with the potential for the integration of FPV considered. A paper accepted, but not presented as the

Dr Aries Firman, of Indonesia's Dam Safety Commission, chairing the session on recent, on-going and planned FPV and hybrid schemes.



Musa Mukulu, of UEGCL, Uganda, speaking of an FPV scheme to be implemented at the Isimba hydro plant, on the Nile.

Shown right, Benoit Danglade of Innosea, France, who chaired the session on design, safety and risk; and beside him, Marine Bernicot of ISL, France, who proposed best practice guidelines for floating solar schemes on dam reservoirs.



authors could not be present, demonstrates how EGAT, Thailand, intends to integrate FPV at planned pumped-storage schemes.

Design, safety and risk

Benoat Danglade, of Innosea, France, chaired a session on design issues, safety, risk and maintenance. He drew attention to the fact that the panel of speakers represented the full range of stakeholders, from suppliers to developers, to EPCs and consultants, and so on.

He commented that throughout the session, participants had seen how the development of FPV on hydro reservoirs could leverage enormous potential, with or without hybridization, as a result of the sharing of infrastructure, for example, but this needed careful design, a good set of data, and good interpretation of the data, as well as products of a high standard.

During the session, Danglade said, it had been possible to cover in some detail ongoing design issues at various projects.

He commended the efforts of the French National Committee of ICOLD in setting up a working group to share data, particularly on an approach to risk analysis, and he encouraged delegates to contribute to this work.

It had been evident in the session, he continued, that float suppliers were supplying products based on an extensive background of engineering experience and appropriate testing, and that constant improvements were being made to their supplies and services. It was also clear that developers were trying to build engineering frameworks together with the relevant authorities for dams, and an example highlighted had been Switzerland. Also, newcomers to FPV were adapting products from other applications and markets, such as the boom system of Worthington.

Speakers in the session on design and safety. From left: J. McCully, Worthington Products, USA; Lyu Kang, PowerChina Huadong; A. Hildebrandt, Blue C, Germany; I. Galliamova, Lombardi and A. Kaufmann, Romande Energie, Switzerland; S. Prouvost, Ciel et Terre, France; and, C. Kutter, BayWa re, Germany.



Danglade commented that the point of view of an EPC contractor had been valuable for the session, providing understanding of how what was probably the most complex project in the world had been designed and implemented, and commissioned last year.

Putting forward some personal opinions based on the various discussions, Danglade commented that FPV was a relatively new technology, which had started to boom in the past decade, and initial experience had been based on relatively small lakes, rather than large dam reservoirs, so site conditions, environmental conditions, and so on, had been less complex.

A big advantage for the new floating PV market, he continued, was that expertise could be gathered from a market that has existed for some time. So, while there have been, for some time, environmental experts, electrical engineers, experts in dam engineering, ground-based PV developers, geotechnicians and grid operators, now one would start to see FPV experts. But for now, FPV required a combination of different forms of expertise, and this, he felt, was a key issue, especially for future developers and owners of FPV on reservoirs.

On the subject of risk, Danglade commented that in the oil and gas industry (where he had spent an earlier part of his career) there were decades of experience in assessing and managing risk, and the consequences of an incident on human life and the environment, as well as economic risks; in the dam engineering sector there was certainly comparable experience. He observed that on the engineering side, the main issue was achieving a balance between redundancy of a system (in the case of FPV particularly the floaters and anchoring system), and excessive conservatism which would lead to additional costs. He added that in the case of FPV, experience had underlined that it was paramount to invest, at the beginning of a project, in gaining a good understanding of site conditions by thorough surveying, as this was the key to anticipating risk and derisking projects.

Innovation in floating PV systems

One session was devoted to the topic of 'What is new in FPV', to give those in the PV sector an opportunity to introduce innovation in their products or services.

Presenters represented Ocean Sun, Norway; Sombravoltaica, Spain; Planttech, Austria; Sungrow, China, and Floating Solar, Netherlands.

Atle Harby, of SINTEF, Norway, chaired the session, and commented that much had been presented which had not featured in the previous discussions. Drawing on some examples, he said it had been demonstrated that reliable mooring could be achieved with fewer



Some of the speakers in the session on technical innovation in floating solar systems. They shared experience from Norway, Spain, Austria, China and the Netherlands. Session chairman Atle Harby is shown on the right.

mooring lines (than was usual), and greater reliability was claimed at a lower cost.

He described as “fantastic news” that jumbo-sized polymer materials had been developed which were buoyant, and could virtually be “wrapped up and carried under the arm”.

There had also been a presentation and discussion on smart solutions for FPV, involving the use of drones and artificial intelligence, as well as engagement with stakeholders to achieve the best and most sustainable solutions.

A contribution on environmental aspects spoke of ways in which the ecological status of a site could be improved by the presence of floating panels, and the installation of biohuts to protect marine creatures.

There was also a paper focusing on a very large-scale floating solar scheme, with a number of adverse conditions relating to wind load, wave action, reservoir depth (>100 m), and especially the very uneven topography of the floor of the reservoir, making mooring and anchorage particularly challenging. The paper demonstrated how these challenges had been overcome.

One of the concluding discussions in the session pointed out that by doing things in a sustainable way, it could be that slightly less power would be produced, but a robust system could result, with reduced need for maintenance.

Harby put forward three key take-away messages:

- there was a clear need for standards, regulations, and a ‘level playing field’ in the field of FPV development;
- comprehensive studies of environmental impact need to showcase examples of environmental consequences of FPV, with efforts made to improve the ecology; and,
- to address and mitigate risk, the way forward is to share knowledge, implement pilot projects and carry out a lot of monitoring, particularly in the case of large reservoirs, in view of the fact the technology is relatively new.

Harby concluded that there was a strong need to collect and share data, and he felt that gatherings such as SOLAR-HYDRO 2024 provided an excellent arena for this.

Hybridization: potential, planning and challenges

This session was chaired by Bill Hakin, Project Director at the Liberia Electricity Corporation. He commented that six excellent ‘cutting edge’ papers had been presented, covering a wide range of issues. He began his introduction with a definition of hybridiza-

tion, describing it as “a way of getting more from hydro and solar generating assets than they could provide working on their own”, for example cases where there could be insufficient flows in a dry season, or intermittent sunshine.

The first paper in the session, presented by Luc Deroo, focused on the question of when and where to hybridize, rather than operate separately, which could often present a simpler option. The paper outlined the various options for solar-hydro powerplants and addresses some specific questions associated with hybridization at three time scales: minutes, hours and months. The talk also discussed the conditions in which solar-hydro can be a success, both in terms of quantitative development, and a qualitative contribution for the future. This paper was published in full in *H&D* Issue 2, 2024 (the special issue distributed at the conference).

The session had demonstrated that options for hybridization varied from country to country, as well as the challenges. For example, the existing assets in Brazil, at large storage reservoirs, as described by V. Zwetkoff of CEMIG, were massively different to the situation in Liberia and similar African countries, where hydro schemes were mainly run-of-river, and very few storage reservoirs were available.

The talk by Jiehong Kong of SINTEF had demonstrated that hydrology, evaporation rates and the maturity of the electricity market could vary massively between countries. Her talk highlighted how nations with larger variations in hydrology and pronounced dry seasons would benefit more from combining more solar and hydropower, in the form of hybrid schemes.

A paper was presented by Martin Lacey of WestGlen Consult Ltd, UK (co-authored with Bill Hakin, and the



Bill Hakin, Project Director at LEC, Liberia, who chaired the session on hybridization, and also joined the Roundtable discussion which followed. He described Liberia’s plans for increasing its renewables portfolio with solar-hydro schemes, including an FPV scheme at the Mt Coffee hydro plant.



From left: Viktor Zwetkoff of CEMIG, Brazil; Martin Lacey of WestGlen Consult, UK; and, Jiehong Kong of SINTEF, Norway. They gave papers in the session on hybridization.

CEO of LEC, Monie Captan), on the subject of grid-scale solar-hydro hybridization in Liberia. This began by outlining the country's strategy to transition from fossil fuel use to variable renewable energy sources. Lacey pointed out that there was a pronounced seasonal production profile, with hydropower being optimal in the rainy season, and solar power in the dry season. He presented LEC's roadmap, which included the uprating of the Mt Coffee hydro plant, and further development of both hydro and solar power. He also gave details of the 20 MWp floating solar pilot plant at Mt Coffee. This would also include opportunities to incorporate BESS.

Optimization of the solar-hydro hybridization is currently underway, Lacey explained, with a view to maximizing stable energy delivery in a cost-effective way, with significant solar penetration. He concluded that by adopting hybridization, solar penetration could be increased, grid stability improved, and overall energy delivery maximized.

Hugo Mesnage from the Supergrid Institute, France, discussed the Manantali hydropower scheme in Senegal, where operation with solar power in a hybrid arrangement had reduced water use by 10 per cent. Mesnage pointed out that as more solar power was introduced to the systems, there would be a greater need for stability in the grid, and if this was provided by hydropower, then there would be more wear and tear on the turbines. He suggested in his presentation that this could be minimized by introducing a battery to the system.

However, as the technology of solar (especially FPV), hydro and BESS were very different, Hakin pointed out, different skill sets would be required to maximize their use; the engineering required to combine them in a hybrid way was still in its infancy.

Hakin said he felt that the cultures working in the solar PV sector, and in the hydropower and dams sectors, tended to be a bit different, particularly as regards their views on risk. But, overall, the benefits of hybridization were clear, Hakin concluded, adding: "Engineers are here to solve challenges".

Economic and financial issues

The session on economic aspects and financial support for FPV and hybrid schemes was chaired by Yann Le Bot, Director of the Energy + Group of Société Générale, France.

In his introduction he commented that the huge potential of FPV was now recognized around the world. He added that he had been impressed to see from the recently launched World Bank report that if only 10 per cent of the surface area of man-made reservoirs could be used for FPV panels, around 4 TW of capacity could be installed.

But on the other hand, he noted that the actual large-scale implementation rate of FPV had been limited, so there were hurdles to be overcome, to enable the technology to be used more widely.

As significant funding was required for FPV installations, Le Bot stressed that all available sources of finance should be mobilized. But an issue in this respect was that the technology was in a relatively early stage of development, and lenders, funders and investors needed a track record, and some long-term feedback, as a prerequisite for financing.

Despite the obvious advantages of FPV, Le Bot continued, there were of course also some drawbacks and specific risks, including complexities of operation and maintenance, and relatively high initial costs.

Interesting topics to explore in more depth, Le Bot suggested, were how FPV made sense from an economic perspective, and how its economic rationale could be validated.

During the session, a presentation was given by the Asian Development Bank's Resident Director in Tajikistan, Daler Qubodbekov, who gave details of the country's enormous potential for FPV; if just 30 per cent of the surface area were to be developed at the (seven) major hydro reservoirs in the country, it was

Lars Brandt of Seaflex, Sweden, (left) and Daler Qubodbekov of the Asian Development Bank, Tajikistan, who were both speakers in the session on economic and financial issues of solar-hydro.





estimated that 8.7 TWh/year could be produced, which was equivalent to 40 per cent of current demand. ADB has funded a Masterplan for the country's ambitious target of increasing installed capacity from 5.3 to 10 GW by 2030, and to increase the share of renewables in the energy mix by 10 per cent in the same period.

Another talk in the session, given by Sebastian Hack of Multiconsult, Norway, drew attention to the vast water bodies in Sub-Saharan Africa which he pointed out offered ample opportunities for deploying floating solar panels, and he highlighted the global need for strategic investments to unlock the vast potential of the region. He pointed out that there are many investment challenges, first as FPV is still a nascent technology, but also as potential investors could be concerned by currency issues, political instability, limited experience in this field, and vertically integrated, single-buyer markets. He called for more attention on de-risking projects, and for funding to be provided for early-stage de-risking exercises, such as feasibility studies and capacity building, and possibilities for long-term funding.

Continuing discussion on Africa, Martin Buchenschutz of Nodalis, France, described several economic assessments of hybridization projects carried out by his company in recent years (including for Côte d'Ivoire, Mali, Burkina Faso, Cameroon), developing analytical tools for cost benefit analysis (CBA). One of the key challenges, he explained, was to justify why a solar plant (ground mounted or floating) should be located close to a hydro plant, rather than close to areas where electricity is consumed. He stressed that



the services offered by hybridization should be considered: daily and/or seasonal shifting of production, and smoothing. This raised the question of the reference scenario to be considered when carrying out the CBA. Generally, he pointed out, this is a 'no project' scenario. However, in the case of hybridization, it seemed appropriate, he felt, to make a comparison with 'alternative' scenarios in which solar PV capacity is placed close to consumption areas and the services offered by hybridization are provided by batteries. He presented some of the main lessons drawn from the Manantali hybridization project in West Africa.

During the discussion at the end of the session, there was question from a delegate from UEGCL to the panel about the best form of contract to be adopted for an FPV project, for the scheme to be bankable, and it was clear that this was currently a topic under discussion, but that if the contract needed to be prescriptive, then from the transaction and cost points of view, then the FIDIC Brown Book could be appropriate.

Discussion also took place on challenges associated with permitting, regulations and concessions, and on the need for an interdisciplinary approach to address problems of the different lifespans of FPV infrastructure and equipment, for example, a dam (>100 years), and solar panels (which could be designed for around 25 years of operation).

The question of the difficulty of involving the private sector in project financing was also raised, especially in view of the need for long-term maintenance to be the responsibility of the developer. Martin Buchenschutz commented that for Manantali, several contractual arrangements including EPC had been considered, but it had been preferred to develop the hybrid scheme as a publicly funded scheme, so that operation and maintenance would be taken care of the existing organizations.

In closing the session, Yann Le Bot commented that the potential for FPV was clearly extremely high, but the implementation of large schemes seemed to be lagging; support was available, and de-risking strategies were being applied, so he questioned what was the missing factor.

Lars Brandt of Seaflex, who had presented in the session with a paper entitled: 'Hybridization projects of floating solar and hydro have reached commercial tech status and are ready to go' replied that a standardization process, incorporating recommended practices, was key, and that this had been under development for

Above left: Yann Le Bot of Société Générale, France, chairing the session on financial and economic aspects.

Above: Speakers Daphne Ayiekoh, from the Swedish Embassy in Kampala, and Sebastian Hack of Multiconsult, Norway.

Speakers Joseph Kenfack, who spoke of hybrid schemes in Cameroon, and Martin Buchenschutz discussing contractual arrangements for the hybrid scheme at Manantali.

Julius Wamala Namusanga, Assistant Commissioner for Generation at the Ministry of Energy, Uganda, with Proscovia Margaret Njuki, Chair of the Board of UEGCL, who were panellists in the Roundtable discussion.

two years, and was nearing completion. Based on this, due diligence would be able to be done on FPV systems, he said, and the relevant authorities and stakeholders would be better informed.

Daphne Ayiekoh, from the Swedish Development Cooperation section of the Embassy of Sweden in Uganda (involved in coordinating Swedish assistance to Uganda on renewable energy development), who had presented a talk in the session, called for improvements in the information flow between the relevant development stakeholders, recommending a circular way of working between public, private and research organizations. Working together would accelerate the financing process, she felt.

Roundtable discussion: The way forward for solar-hydro

Bente Brunes (Consultant and Co-Team Leader at the World Bank/ESMAP) chaired a Roundtable discussion, which brought together a panel of international stakeholders to discuss floating solar hydro and hybrid systems from their various perspectives. The session was designed to focus on some of the issues covered in previous sessions, and to reflect on the way forward, especially in terms of some of the identified challenges.

The panel comprised: Proscovia Margaret Njuki, Chair of the Board of UEGCL, Uganda; Julius Wamala Namusanga, Assistant Commissioner in charge of Generation at the Ministry of Energy, Uganda; Yann Le Bot, Managing Director of the Energy + Group at Société Générale, France; Günther Obermaier, Head of Third Party Sales at Baywa re, Germany; Jean-Jacques Fry, Consultant and Expert on Dam Safety, France; Marine Bernicot, Head of the Hydropower & New Energies Department, ISL Ingénierie, France; Atle Harby, Senior Research Scientist at SINTEF, Norway; and Bill Hakin, Project Director at the Liberia Electricity Corporation Project Implementation Unit.

Introducing the session, Brunes, said she planned to divide discussions into two main topics: first, the added complexity in project development, implementation and execution when integrating solar and hydropower; and second, how to scale up the investments required for further innovation and research, as well as how this can be used to enhance the bankability and feasibility of projects.

“The aim”, she said, “is to collect ideas and opinions to provide valuable perspectives, and foster a meaningful exchange of ideas which can inspire and guide us in collecting information and new ideas for our journey towards a more sustainable, renewable and resilient energy future”.

In her opening remarks, Margaret Proscovia commented that UEGCL had not yet developed FPV, but that it was a priority to add solar power, and FPV to the energy mix, to reduce almost total dependence on hydro power. So prefeasibility studies had already been done for FPV.

Julius Wamala was asked to comment on how he saw the future for FPV and hybrid schemes, and how Uganda would foresee managing the complexities and policies. He replied that his country was ready to embrace such new technologies, and the first step was to prepare an enabling environment, and to have the political will to go ahead. Uganda, he said, was firmly committed to renewable energy (hydro, solar and



geothermal). So policies were in place, feed-in tariffs had been established, along with standardized PPAs, and there were also tax incentives for investors in renewable energy. He added that his country had a robust regulatory framework. So all was in place to ensure the smooth integration of FPV in the energy mix. UEGCL was now piloting a 10 MW FPV plant on the Isimba reservoir, with Swedish support, he added.

Brunes asked Yann Le Bot to comment on managing complexity from a financial perspective.

He replied that as the sector was quite new, so far there were only a few precedents for financing, but he added that SG had financed some projects a few years ago.

Rather than “reinvent the wheel”, the approach had been to focus on similarities and differences with other projects, working together with in-house engineers.

“Where there are differences, we look at what we can recycle from other projects”, he said. He added that this could be from the oil and gas industries, where there were also floating devices.

Due diligence would be done, taking account, for example, durability of the key components, operation and maintenance requirements and costs, and so on. It would then be necessary to try to quantify what would be a reasonable contingency budget. Asked what that contingency budget might be, Le Bot replied that there was no simple answer, and this would result from quantifying specific risks.

Martin Lacey, of WestGlen Consult Ltd, UK, commented that an issue in hybrid development was monetization of the inherent added value. Le Bot replied that from the perspective of a private bank, and it was probably also the case with the IFIs, if funding a project with non-recourse financing, one of the prerequisites would be to have a stable and predictable cash flow stream so there would not be much room for variability of the revenue from the solar part of the project. Often a reservoir would pre-exist the hybrid scheme, so financing would be to ‘top up’ the new development.

“It is necessary to have one form of certainty”, Le Bot said, “either through a take-or-pay approach, or by ensuring that there would be a minimum payment for the availability of the project, so as to remunerate for the positive benefit it is bringing”.

Bente Brunes commented that from the World Bank and ESMAP side, one consideration for hybrid schemes was whether to regard them as energy generation facilities, or as energy service facilities in the context of the power system. “In terms of financial



mechanisms and solutions to start to develop a bankable project, that provides access to different ways of thinking of what the revenue is, and how you can leverage that revenue for the benefit of the project and to the wider power system". She added that at the global level, some countries were advancing their solutions so that energy services could be remunerated, and this featured in recent EU policy.

The example from India, she added, showed that energy generation was regarded as the main as foundation, but other services were recognized too, such as energy control and storage

Bill Hakin said that in Liberia, the market was quite simple: there was one tariff which was quite high, about US¢22/kWh. He added that the situation in Liberia was quite unusual because: "It is more a question of whatever we produce will be sold", he said.

Turning to the question of safety, Brunes asked Jean-Jacques Fry about the main safety issues concerning FPV on dam reservoirs.

Fry replied that in the dam engineering sector, it was key to learn from experience regarding safety: "We learn more from errors than from computations", he remarked. He added that new products, concepts, and technologies emerged thanks to ambitious pioneers, who might struggle or succeed to convince colleagues on the feasibility of their product. But sometimes engineers might not have adequate data to extrapolate, so sometimes dam failures would occur.

Regarding the integration of FPV, Fry said that quick solutions and guidance on deploying the technology were required, as well as a legislative framework.

Brunes asked Marine Bernicot how this topic was covered within ICOLD. "The main risk is dam failure", she replied. "Overtopping can occur if a spillway is blocked, for example, with floating debris or other causes. We cannot accept this risk". There was a need to work on this collectively, she added. With large dams, it was necessary to seek the lowest risk, Bernicot said, usually the 1 in 10 000-year risk, and a similar approach was needed for FPV.

Bernicot commented that dam safety was the core value of ICOLD, and the focus of the ICOLD Technical Bulletins was good practice (rather than regulations). A new bulletin being prepared at present is to cover FPV, including construction and end-of-life periods, with guidelines and proposals of design criteria, and addressing issues such as extreme load cases (wind and wave action). A risk analysis methodology is also to be included, as well as maintenance guidelines.

On the issue of withstanding extreme conditions, Günther Obermaier commented that the key to this was proper planning, and adequate assessments, based on high quality data. He also stressed that a sufficient safety factor must be adopted. In his experience, low water levels in a reservoir could be an important challenge: when the level would go down, there might be insufficient space for the floating system, and damage could be caused.

Brunes then steered discussion towards environmental and social aspects, and invited comments from Atle Harby.

He said that the main goal of the Kunming-Montreal Global Biodiversity Framework (of 2022) was to protect 30 per cent of land and water in the world, and restore 30 per cent of what has already been degraded. On the other hand, new renewable energy systems needed to be constructed, to mitigate climate impacts. So, there was a need for efficiency to manage this dilemma. In this context, Harby said, FPV offered a good solution, by avoiding land use. "But we cannot say there are no environmental impacts", he cautioned, "There are certainly both benefits and impacts".

He felt that ecosystems did not need to be brought back to a pristine condition, but rather to be functioning ecosystems, with special care being taken to preserve biodiversity and ecosystem services.

"We know how to mitigate problems", he said, adding that this might sometimes mean modifying projects.

Brunes asked whether a view could be taken that a dam would have the greater impact, so that adding FPV would be relatively insignificant. Harby disagreed, saying that even in Norway, which seemed to be in a fairly pristine state, "bits and pieces were added here and there", all of which had impact. To illustrate his point, he highlighted that that the weight of all the plastic on earth today was greater than the weight of all the animals. He concluded that land should be used for energy development, but that it was essential to prioritize and do things in an environmentally efficient way.

"We do not just need hydro and solar engineers to work together", he said, "but also environmental and social scientists".

Asked by Patsheba Ayebare of UEGCL what main considerations should be put in place for dam safety as her company started out with FPV, given that standards and regulations did not yet exist, Marine Bernicot recommended putting effort into initial studies. She commented that UEGCL was off to a good start because its own dam engineers were doing the studies. Bernicot advised not to leave the responsibility for dam safety with an EPC contractor, because the necessary expertise in dam safety might not be there. She added that there should be enough detail in tender documents to ensure these aspects were well secured.

Philip Padi, of the Volta River Authority, Ghana, asked Bill Hakin why hydro capacity was being increased as part of the uprating at Mt Coffee, when the dry season was so severe.

Hakin replied that this had been based on a basic economic assessment; the cost was low so it was beneficial for utility. "It will still be efficient, even if we can only operate it for six months of the year", he said. Originally, when considering operation as a hybrid scheme, it had been planned to add two 22 MW Francis units (to the existing four). However, it had been found that, for the same amount of money,

Bente Brunes, Consultant and Co-Team Leader at the World Bank/ESMAP, leading the Roundtable discussion.



The panel of speakers taking questions during the Roundtable discussion.

adding four compact axial turbines of 15 MW each would enable more operation during the dry season and give more flexibility as a hybrid system.

Hamim Ghufroni of Indonesia asked what could be done with an FPV system once it had reached the end of its operating life of 25 years or so. Günther Obermaier replied that recycling of floaters was not a problem, and this also applied to other components. Only the anchors could be a problem, he added, but it would depend on the site. It was likely in most cases, he said, that they could safely be left in place.

Atle Harby suggested it would be useful to be able to require, at the procurement stage, that the supplier would build in recycling, since this could represent a considerable cost later on.

Bente Brunnes then moved on to the topic of bankability, and the associated barriers and solutions.

She invited Julius Wamala to comment, and he replied that the main barrier was that the technology was so new. But a positive point was the amount of collaboration and a good exchange of experience. It should be helpful, Wamala said, that FPV was being incorporated in national policies, for example, including feed-in-tariffs.

Uganda's energy policy was based on a least-cost generation plan, he said, adding that although FPV was a bit more expensive, it could compensate for about 20 MW of small hydro capacity which was not available in the dry season.

Margaret Proscovia added that another challenge for FPV was that of floating debris. In this respect, she commented that she had learnt a lot during the conference, and would take this into account in future planning. "We are glad to have been here at the time of setting out with our schemes", she said, "especially because of what we have learnt about dam safety aspects".

Benoat Danglade, of Innosea, France, asked Le Bot whether due diligence on any project had led to a decision not to go ahead, or to require to design modifications. The reply was that in terms of energy projects in general (not specifically FPV), the answer was yes. "If we see that risks are not properly mitigated, we would say that the project won't fly, and that these aspects should be developed further", he said, adding that the appetite for risk tended to vary between lender and promoter.

Hamim Ghufroni, Indonesia, asked if there were any standards available from international funding institutions, for example, in the form of a step-by-step guide, for those wanting to present a project.

Le Bot replied that there were no standards comparable with those in other areas of energy sector. "Most institutions do risk assessment in their own way, and have different appetites for risk", he said. To make sure a project would be bankable, he suggested meeting with the lender early on, for discussion, possibly also with an advisory counsel.

Brunnes asked Le Bot at what level his bank would evaluate project technologies in terms of the risk; for example, the project as a whole, or details such as the floaters?

Le Bot replied: "We look at the design of each component, and the track record of the supplier, the contract, and so on". He added that there was a support team of engineers available at the bank for consultation when required.

Brunnes then invited Harby to make some final comments on E&S aspects.

He replied that it was important to be certain how a project was going to operate after the addition of FPV, and to consider climate change. "We need to consider any effects on creatures, even if we have known the reservoir for a long time" he said. There could be implications from adding the FPV, and also climate issues, he pointed out. "We need to look at how to make things better, not just mitigate impacts". Aspects to be considered, he added, included evaporation, water quality and oxygen depletion. More needed to be learnt about the changes caused by FPV, he concluded.

Pierre Courtel, DN&T, Belgium, asked about the total impact of FPV in terms of CO₂ emissions, taking the whole lifecycle into account.

Harby replied that research was needed to undertake life cycle assessment. In general, care should be taken to select the right materials, and not necessarily the cheapest. For installation, and for O&M, use could be made of electric vehicles and drones. Overall, as in other renewable energy sources, there would be some CO₂ emissions, he said, but not necessarily worse (and probably much better) than would be the case with other options.

Nicholas Rugaba, of UEGCL, Uganda, asked J-J. Fry whether ETIP was open for non-European participation. Fry replied: "We have about 850 members, 10 per cent of whom are not from Europe. So, you are welcome!"

Fry added that there were three working groups, covering Flexibility, Biodiversity, and Climate change and mitigation. Most meetings took place on line, Fry pointed out, so it would be easy for those interested to join in, which he encouraged.



Closing session

As SOLAR-HYDRO 2024 drew to a close on 23 April, in addition to some short addresses and takeaway messages from session chairpersons (incorporated in the report above), there were three talks from eminent representatives of ICOLD.

Secretary-General Michel de Vivo had travelled back early from a Board Meeting in the USA to join the conference, and he drew attention to the importance of bringing together solar and hydro experts for the first time at a live conference (following the virtual event in 2021). The great interest in FPV is evident, he pointed out, with the combined use of the power of water and the sun having obvious advantages. He added that it was a perfect solution for this purpose to make use of existing dams and water infrastructure, along with power lines, transformers, and the large areas available on reservoirs for FPV plants. He also drew attention to innovative solutions which were constantly emerging, such as devices that could track the sun.

De Vivo observed that ICOLD had been supporting this technology for several years, and noted progress particularly in Asia, Africa and Europe. He commended the fact that this technology brought together the competences of dam engineers and solar PV experts, describing them as ‘architects of water and sun’. He invited participants to the next Annual Meeting of ICOLD in New Delhi, India, (29 September to 3 October 2024), to continue the collaboration.

Luc Deroo, who had been a major partner in the planning and organizing of both SOLAR-HYDRO 2021 (on line), and the present conference in Antibes, then offered some concluding remarks. He felt that SOLAR-HYDRO 2024 had been an informative conference on two distinct technologies: FPV on dam reservoirs; and, hybridization. He described both as ‘game changers’ with very strong potential throughout the world. “Both topics are new”, he said, “and they both come with challenges”.

He felt that FPV on reservoirs certainly presented the greatest challenge, which was a potential threat to the dams. To tackle this, three sets of actions were necessary:

- guidelines, and a set of good practices;
- monitoring of the FPV structures, to detect any signs of ageing or potential loss of safety margins; and,
- learning from past accidents or incidents, which requires the well managed gathering of data.

Deroo mentioned that ICOLD was showing great interest in the technology, and had put it on the agenda for the next triennial congress, taking place in Chengdu, China, in 2025 (16-23 May), see p68.

As far as hybridization was concerned, Deroo continued, the main challenge was complexity, including issues associated with solar variability, water resources management, hydraulic machinery, grid codes, solar cells, sometimes batteries, the need for fast frequency response, power arbitrage, long-term storage, and so on. He added that it was difficult to be sure about whether the industry had yet achieved a clear and complete picture of the challenges, but he felt that good progress had been made over the two days of the conference.

Deroo commented that the session on financial and contractual issues had included discussions on how to remunerate not only the electricity produced, but also the additional services delivered. Environmental and social issues had also been demonstrated to be important subjects, especially as the world was facing a biodiversity crisis, with rivers and freshwater lakes struggling. FPV and hybrid schemes can have an impact on freshwater habitats, Deroo said, and he felt greater efforts needed to be made to understand those impacts, and to protect biodiversity. But overall, it could be said that FPV and hybrid schemes have the power to produce “reasonably sustainable electricity at a reasonable cost”.

On social aspects, Deroo said that it was important to ensure that project benefits were shared, but he added that FPV and hybrid schemes represented clean and cheap energy.

More use of solar power would also put less pressure on water, so that more water could be available for other purposes.

Luc Deroo then introduced Guest of Honour (and Honorary Member of ICOLD), François Lempérière, whose career spanning more than 70 years had been devoted to the construction and design of dams on some of the world’s largest rivers, such as the Rhine, Rhône, Nile, Zambezi, Congo Indus, Euphrates and Yangtze. He is well known for having proposed and developed innovative concepts in the field of dams, flood discharge works, pumped storage and tidal energy.

His message was profound, putting the topic of renewable energy development needs, and the need to combat climate change, in the context of global inequality.

Lempérière began by pointing out that the future of new dams and hydro projects would be much more for the storage of energy, rather than for the direct supply of electricity.

Turning to the world situation, and the difference between the developing and the rich countries, he said that within the tropics, close to the equator, there were no rich countries, and beyond the tropics there were virtually no poor countries. He continued that in the

Some key outcomes from the sessions being presented by chairpersons, during the closing session of SOLAR-HYDRO 2024.

*SOLAR-HYDRO
Guest of Honour,
François
Lempérière,
addressing the
delegates during
the closing session.*



poor tropical areas, the population was about six billion and the per capita income of these people was around 20 per cent of that of the population in the richer countries. Ensuring their socio-economic development would require adequate supplies of electricity. In these regions, most rivers remain dry for some months, there is not much wind, and the average temperature is 20 to 25°C. In these developing countries, which are also sunny, the ideal solution is clearly solar PV, Lempérière said, with a direct cost much lower than that of other solutions, leaving a large margin for investment in storage from day to night.

To achieve some parity with the richer countries, regarding per capita income, six or seven billion Africans and Asians in the next few decades are likely to require around 10 TW for about 3000 hours/year, of which more than 3000 GW would require storage, Lempérière point out. He then put forward some proposals for the storage of more than 3000 GW, which were:

- traditional storage between two reservoirs with a difference in elevation of 100 m or more (possible only in mountainous areas);
- off-river storage in large areas;
- the concept of twin dams at existing or new schemes;
- directly linking an upper reservoir with a very large river; and,
- exploiting the huge potential along cliffs, with the sea (or very large lakes) being used as the lower basin, and the upper reservoir being above the cliff, and possibly one or two km away from it.

Regarding the financing of large-scale storage schemes for the less developed countries, Lempérière pointed out that the activities of rich countries were adding 2°C to the climate in the poor regions, which already had high temperatures. Therefore, he felt, it would be logical for the richer nations, over several decades, to support, both financially and technically, the required storage investment in Asia and Africa. Direct agreements could be made between countries, to enhance efficiency, he suggested.

To underline the logic of this suggestion, Lempérière mentioned that some 140 years ago, European countries had officially “shared” African countries among themselves, so a good solution could be for these countries now to share the investment costs of renewable energy storage, through direct agreements. He concluded that such assistance would represent only a very small part of the revenue of the wealthier nations.

Concluding remarks

In preparation for the closing Alison Bartle had surveyed all participants about their views on the predicted way forward for solar-hydro schemes, both in terms of necessary new developments and also challenges. Delegates had also been asked about about topics which they would like to see added or expanded next time.

She reported that there was plenty of consensus among the replies, and so after the chairpersons had presented some takeaway messages, she summarized the opinions expressed, as follows:

Future general needs

- International standards relating to materials, to grid codes, and to environmental aspects.
- A better definition of the maximum reservoir surface area that can be covered, without creating environmental impact when breaking the islands.
- More work on social acceptability of projects and on environmental protection and water quality.
- Addressing and mitigating risks by gathering knowledge through pilot projects.
- Better support for monitoring by investors and authorities, and improvement of access to funding.

Future technical needs

- Adoption of AI for floating solar PV in mature markets, such as Europe and the USA.
- Better critical assessments of design and construction aspects for anchors, mooring systems and floater fatigue, as these can make or break a project.
- Higher efficiency of PV panels.

Key takeaway messages

- A participant from a major solar PV manufacturing company described the potential for PV at large hydro dams and reservoirs as “amazing.” He said that considering the technology is relatively new, the scale of the schemes planned is impressive.
- A hydropower manufacturing company, not yet involved in FPV schemes, observed that many projects had now been built, mainly small, so the return on experience was only starting; clearly more experience on larger schemes would lead to the definition of good practices and the emerging of a few ‘industrial giants’.
- In this very young industry, the economic aspects are still to be proven (including induced costs for grid integration).
- A number of people commented on how dynamic this rapidly emerging industry is seen to be.

Regional and national issues

- *Africa:* The main challenge will be crystallizing the financial, economic and bankability aspects for floating PV, especially in sub-Saharan Africa. It is important to be sure that electricity regulatory authorities in Africa are ready for floating solar PV projects.



- *Honduras*: Many hydro projects have long-term contracts with pre-established prices according to the generation technology (hydroelectric, geothermal, solar, thermal, or wind), and where the price of each form of generation is differentiated to incentivize solar or wind energy, it is crucial to integrate the models of new technologies to define new financial schemes.
- *Switzerland*: The Swiss Federal Office of Energy reported that it is starting a working group to establish a directive for FPV projects in Switzerland. During the conference, the delegates from SFOE had been able to meet counterparts from many relevant organizations, and this had led to good prospects for collaboration with other countries to obtain consolidated criteria.

Suggested future topics for inclusion

- Economic analysis on CAPEX and OPEX.
- The role of pumped-storage integration with FPV.
- Pre-conference solar training session for young engineers and students.

- Contractual aspects.
- Life cycle analysis of solar-hydro schemes.

Closing

In conclusion, Alison Bartle thanked all who had come along to SOLAR-HYDRO 2024 from utilities across the world, as well as consulting practices, research institutes, financial institutions and manufacturing companies. She felt the ambience had been excellent, and said that one could really feel strongly that people had come from around the world to learn from each other.

Discussions had focused on a new technology, which had been rapidly emerging over the past 20 years. So even those with the longest term experience over that period had been able to hear about new technology, and of course development opportunities, at sites which have been studied in detail in some parts of the world. Those nations with the greatest solar-hydro potential are also those that have the greatest need for more clean renewable energy. ◇

Additional networking opportunities during SOLAR-HYDRO 2024

Several social events were arranged for international participants to continue discussions while appreciating the ambience of Antibes, renowned for its history, its coastline, and its world-famous jazz festival. Some examples are shown below. Many more photos of the conference sessions and these events can be found in the SOLAR-HYDRO 2024 photo gallery on our website: www.hydropower-dams.com



Speakers and chairpersons taking aperitifs before their dinner at the former villa of Scott Fitzgerald, in Juan-les-Pins.



The welcome reception on 22 April, at the Congress Centre, provided some local specialities, including traditional jazz.



One of the refreshment breaks during the conference, in the exhibition area.



The final dinner, overlooking the Mediterranean sea. It was generously supported by ISL and Hydro Coop, France.