International Forum on Pumped Storage
First Meeting
3 November 2020
09:00 – 12:00 US EST (15:00 – 18:00 CET)
Introduction
09:00 – 09:10 US EST

Chair of the Meeting

Alejandro MORENO
Director of Water Power Technologies Office, United States Department of Energy
Introduction

It is time to shape the future of pumped storage

Steering Committee Members & Observers

![Flags of various countries](image)

European Bank for Reconstruction and Development

WORLD BANK GROUP

Partners

![Logos of various companies and organizations](image)
Agenda

1. Introduction & Opening Remarks
2. Keynote Address
3. Session 1
   Challenges & Opportunities of PSH
4. Session 2
   How the Forum can shape the future of PSH
5. Summary & Next Steps
Opening Remarks
09:10 – 09:20 US EST

Daniel R Simmons
Assistant Secretary,
Office of Energy Efficiency and Renewable Energy,
United States Department of Energy
Keynote Address
09:20 – 09:35 US EST

Hon. Malcolm TURNBULL
Former Prime Minister of Australia
Session 1
09:35 – 10:25 US EST

Challenges & Opportunities of PSH
Government perspective

Benoit REVAZ
State Secretary and Director,
Swiss Federal Office of Energy
7 March 2019

- Germany Variable Renewable Generation
- Cross-Border Trade Germany-Switzerland
- Generation/Pumping of Swiss Plants

24 January 2019

- NTC limited to 800 MW because of high wind, but exceeded because of loop flows
- Some correlation wind – trade – pumping
- Other factors impact: NTC limits, spot prices, demand
Multilateral Development Bank perspective

Demetrios PAPATHANASI OU, Global Director, Energy and Extractives, World Bank
Strategic Context

Hydropower is the largest single renewable electricity source today, providing 16% of world electricity at competitive prices. It dominates the electricity mix in several countries, developed, emerging or developing.

SDG7
– By 2030, Ensure access to affordable, reliable, sustainable and modern energy for all. And increase substantially the share of renewable energy in the global energy mix.

Paris Climate Agreement to strengthen the global response to the threat of climate change.

WBG Climate Change Action Plan 2016-2020 and WBG Climate Change Action Plan 2.0 (2020-25)
WB will “green” grids with the aim to enable the addition of 10 GW of variable renewable energy over the same period, and ensure that all energy investments are adapted to climate change.

Evaluation of the World Bank Group’s support for electricity supply from renewable energy resources, 2000–2017
prioritize interventions that focus on integrating RE sources into the power systems of client countries, to facilitate progress in their clean energy transitions.
Drivers for Hydropower Development

800 MILLION people remain without access to electricity

These massive energy needs will need to be met with sustainable energy solutions that do not contribute to climate change.

Energy storage and ancillary grid services are critical to the planned expansion of more variable renewable resources.

20th century hydropower served primarily as a provider to generate a product: electricity.

As power grids evolve in the 21st century, hydropower will be increasingly valued as an enabler for integrating higher shares of variable renewable energy (VRE) and thereby deliver secure, affordable and clean electricity.

Power systems in countries with high penetration rates of VRE are often enabled by significant hydropower resources.
Since 2002, the Bank supported 143 hydropower projects in 65 countries worth $30.2 billion with a total capacity of over 42 GW.

**WBG Supports all forms and sizes of hydropower depending on the need.**

**WBG helps countries develop complex, sustainable hydropower projects, minimizing risks and maximizing benefits for stakeholders.**

**Approximately 80%**

of World Bank financing for hydropower over the last decade has flowed to **Africa** and **Asia** where energy is most needed.
PSH Cost Profiles are Site-Specific

- Total project costs of PSH plants is estimated between $106/kWh and $200/kWh.*
- On a cost per kWh basis, PSH compares favourably with other energy storage methods*
- Lithium-ion electro-chemical storage technologies carry estimated costs 2-3 times greater today, between $393/kWh and $581/kWh* (but, cost reductions are expected with scale)
- Upper Cisokan PSP Indonesia US$ 636/kW (2007 study)
- Matenggeng PSP Indonesia: US$ 889/kW (2018 Pre-feasibility study)

* Source: DOE-funded Energy Storage Technology and Cost Characterization Report 2019
Opportunity to Support Clean Energy Transition

- On-going decarbonization of the power sector is underway, dropping costs of renewables, driven by economics and policy, with focus on energy storage.
- Power systems are changing fast, requiring flexible power and storage to help reduce surges, avoid blackouts, or meet spikes in electricity demand.
- Pumped Storage Hydro and electro-chemical batteries will play a significant role for integrating renewables and sustaining the clean energy transition.
- Storage hydropower is the only RE option that can presently produce commercially viable balancing power to integrate VRE at-scale.

Source: DOE-funded Storage Cost and Performance Characterization Report 2019

Adapted from IEA
Many of these sites are concentrated in the countries the World Bank is engaged in and where energy and storage is most needed to facilitate a clean energy transition.

Source: Australian National University Study
## Snapshot of World Bank Support for PSH

<table>
<thead>
<tr>
<th>Approval</th>
<th>Closed</th>
<th>Project Name</th>
<th>Country</th>
<th>Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>2000</td>
<td>Chaira pumped storage plant*</td>
<td>Bulgaria</td>
<td>900</td>
</tr>
<tr>
<td>2003</td>
<td>2010</td>
<td>Yixing Pumped Storage Project**</td>
<td>China</td>
<td>1,000</td>
</tr>
<tr>
<td></td>
<td>2006 (dropped)</td>
<td>Dniester Pumped Storage Power Station</td>
<td>Ukraine</td>
<td>2,226.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(When complete in 2026)</td>
</tr>
<tr>
<td>Under</td>
<td></td>
<td>Upper Cisokan Pumped Storage Technical Assistance Project</td>
<td>Indonesia</td>
<td>1,040</td>
</tr>
<tr>
<td>Consideration</td>
<td></td>
<td>Analysis of role of PSH in Vietnam’s power mix (2017)</td>
<td>Vietnam</td>
<td>--</td>
</tr>
<tr>
<td>2025</td>
<td></td>
<td>Development of Pumped Storage Hydropower in Java Bali System Project</td>
<td>Indonesia</td>
<td>TBC</td>
</tr>
</tbody>
</table>

* highest head (780m) PSP in the world at the time
** Awarded China Construction Engineering Luban Prize - highest level national award for infrastructure project
How the World Bank Can Support

**Knowledge and Data** Help developing countries with financial and economic valorization of PSH

**Upstream and Midstream Work** to help prepare large-scale PSH projects

**Technical Assistance & Capacity Building** for power system planning, roadmaps, design, implementation, O&M, stakeholder engagement, E&S risk management, skills upgrading

**Forge and sustain regional and international partnerships.** Complexity of the clean energy transition requires even greater collaboration to deliver on global development commitments

**Leverage innovative financing** mechanisms for PSH development

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* highest head (780m) PSP in the world at the time
** Awarded China Construction Engineering Luban Prize - highest level national award for infrastructure project
# HydroPower Snapshot – Active Projects

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Status</th>
<th>Country</th>
<th>Additional Installed capacity [MW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>NELSAP Rusumo Falls MP SIL (FY14)</td>
<td>Active</td>
<td>Eastern Africa</td>
<td>80</td>
</tr>
<tr>
<td>Vishnugad Pipalkoti Hydro Electric Project</td>
<td>Active</td>
<td>India</td>
<td>444</td>
</tr>
<tr>
<td>Tarbela 4th Extension Hydropower Project</td>
<td>Active</td>
<td>Pakistan</td>
<td>1,410</td>
</tr>
<tr>
<td>Dasu Hydropower Stage I Project</td>
<td>Active</td>
<td>Pakistan</td>
<td>2,160</td>
</tr>
<tr>
<td>Bi-Jiji and Mulembwe Hydropower</td>
<td>Active</td>
<td>Burundi</td>
<td>49</td>
</tr>
<tr>
<td>Nachtigal Hydropower Project</td>
<td>Active</td>
<td>Cameroon</td>
<td>420</td>
</tr>
<tr>
<td>Tina River Hydropower Development Project</td>
<td>Active</td>
<td>Solomon Islands</td>
<td>15</td>
</tr>
<tr>
<td>Pumped Storage Technical Assistance Project</td>
<td>Pipeline</td>
<td>Indonesia</td>
<td>1,040</td>
</tr>
<tr>
<td>Khyber Pakhtunkhwa Hydropower Development Project</td>
<td>Pipeline</td>
<td>Pakistan</td>
<td>69</td>
</tr>
<tr>
<td>Kajaki Hydrelcic Dam Addition</td>
<td>Pipeline</td>
<td>Afghanistan</td>
<td>100</td>
</tr>
<tr>
<td>Naghlu Hydropower Rehabilitation Project</td>
<td>Active</td>
<td>Afghanistan</td>
<td>25</td>
</tr>
<tr>
<td>Nurek Hydropower Rehabilitation Project Phase I</td>
<td>Active</td>
<td>Tajikistan</td>
<td>1,005</td>
</tr>
<tr>
<td>Electricity Access &amp; Services Expansion (Rehab)</td>
<td>Active</td>
<td>RDC</td>
<td>11.25</td>
</tr>
<tr>
<td>STP Power Sector Recovery Project (Rehab)</td>
<td>Active</td>
<td>Sao Tome and Principe</td>
<td>2.2</td>
</tr>
<tr>
<td>Additional Financing to Tarbela 4th Extension HPP</td>
<td>Active</td>
<td>Pakistan</td>
<td>1,410</td>
</tr>
</tbody>
</table>

Total additional installed capacity: 8,420 MW
OPPORTUNITIES

- PSH supports clean energy transition in regions and countries on decarbonization pathways
- Facilitates RE scale-up through large-scale storage
- Hydro and pumped storage are increasingly accepted as vital for future power systems
- PSH can simultaneously provide system services, storage, and generation by utilizing variable-speed and hydraulic-short-circuit technology
- Very long operating life and low carbon footprint
- Negligible dependency on rare materials
- Significant global potential
- Opportunity for innovative public-private financing structures
- Studies indicate that 1 MW of storage hydro from the rivers in the Himalayas can help integrate 5-6 MW of solar in India and Bangladesh (Source BTC)
- Dispatchable hydro solutions reduce need for fossil-fuel based generation
CHALLENGES

- Increasing the share of VRE in the energy mix necessitates additional measures to ensure system stability, security and reliability.

- As system demand grows and more VRE is added, the need for flexibility and storage increases, requiring careful planning to match supply with demand.

- Lack of flexibility in the generation system and associated grid stability system arising from fluctuation in system frequency has been cited as one of the major concerns against adding new VRE resources.

- Replacing traditional sources of energy with VREs impacts power grid stability and requires power system transformation.

- More flexible, dispatchable generation is needed to guarantee availability and quality of supply. Hydro Storage can help reduce curtailment and help match supply with demand.
Developer perspective

Srikant NAGULAPALLI
Chairman, New & Renewable Energy Development Corporation of Andhra Pradesh
Discussion
10:05 – 10:25 US EST

Reflections on the Challenges & Opportunities of PSH
Session 2
10:30 - 11:50 US EST

How the Forum can shape the future of PSH
Governance & Work Programme

Eddie RICH
CEO, International Hydropower Association
Governance & Work Programme

Governance

Forum aims to provide a multi-stakeholder platform:

• to **shape and enhance the role** of pumped storage in future power systems.

• to **expand and transfer best practice and experience with a strong policy focus**.

The Forum should:

• meet periodically to maintain dialogue, collaboration and exchange of knowledge.

• liaise closely with other international and regional programmes and present findings at international events.

International Forum

**Steering Committee**
Gov’ts, IFIs & IGOs

**Forum Partners**
Industry, Academia & NGOs

**Secretariat**
IHA
Governance & Work Programme

**Steering Committee (SC)**

Consists of 11 governments, five development banks

Functions include:

- to provide guidance and direction on all matters relevant to the implementation of the work programme.
- to consider and approve the work programme.
- to approve the dates and venue for meetings.
- decisions, approvals and recommendations of the SC are taken on a consensus basis.

Financial contributions to support the establishment and operation of the Forum are voluntary.
Forum Partners

All stakeholders can participate as Partners

Functions include:

• participate in Forum and working group meetings.

• support the work programme activities of the Forum by leveraging their expertise, experience and other resources.

• Actively contributing to the deliverables of the working groups.

Financial contributions are voluntary and limited to USD 10,000 per partner.
Secretariat

IHA will act as the Forum’s Secretariat

Functions include:

• organising and hosting regular meetings.

• coordinating and contributing to the work programme.

• communications and dissemination, including website development, publication of briefings, webinars and media engagement.

• events planning and execution including the World Hydropower Congress in 2021.
Governance & Work Programme

Points of contact

IHA - Forum Secretariat

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Forum’s Timeline

- **1st meeting of the Steering Committee**
  - July 2020

- **2nd meeting of the Steering Committee**
  - September 2020

- **1st meeting of the Forum & Official Launch**
  - November 2020

- **Working Group meetings & events**
  - April/May 2021

- **2nd meeting of the Forum**
  - September 2021

- **Working Group meeting & events**
  - 3rd meeting of the Forum at the WHC2021
Communications Plan

- **Website has been launched** and will be home to all content produced by the Forum. It can also showcase initiatives undertaken by partners.

- IHA will promote the Forum through **targeted media engagement, wide reaching email campaigns** and **social media. #PumpedStorageForum**

- IHA will **organise and host Forum events and webinars** to support the work of partners.

www.hydropower.org/pumpedstorageforum
Financial Contributions

Contributions received - US$ 120,000

Budget sought - US$ 185,000

Budget to September 2021 will cover:

• the costs of IHA staff to carry out the functions of the secretariat – this includes the time incurred by two analysts, head of communications and CEO.

• it will also cover related expenses such as external communication costs, room hire for events and travel (i.e. Congress).
The Steering Committee agreed to prioritise three areas of work:

- **Policy & Market Frameworks**
- **Sustainability**
- **Capabilities, Costs & Innovation**

We encourage all partners to join and actively participate in these working groups.

Link to join groups: [https://tinyurl.com/y4mnrzdt](https://tinyurl.com/y4mnrzdt)
Policy & Market Frameworks Working Group
Led by GE Renewable Energy
GE RENEWABLE ENERGY

KEY TECHNOLOGIES

Onshore Wind  Offshore Wind  LM Wind Power  Digital Services  Grid Solutions  Hydro  Hybrids

GE’S HYDRO SOLUTIONS

- Broad range of hydro solutions and services: from water to wire, from individual equipment to complete turnkey solutions, for new plants and the installed base.
- Complete integration with GE converter, motor generator, pump turbine, protection and control

- Capitalizing on 100+ years of experience in the industry
- 25% of global hydropower production made with GE hydro equipment
- 45+ GW installed base (incl. 3 GW of variable speed technology) installed or under construction
The energy transition is accelerating

Evolution of the power mix...
• Variable renewable energy (VRE) market growing at an unprecedented pace,
• >13% annual growth in VRE needed over the next ten years to meet the Paris Agreement targets,
• Combined with fossil power phase-out.

... impacting grid reliability
• Higher penetrations of VRE causing grid instability and reliability issues in some markets,
• Grid services (frequency regulation, voltage control, inertia etc) no longer supplied by fossil-fueled plants,
• Storage solutions to increase in order to deliver firm dispatchable renewable electricity.

80 GW of additional PSH required by 2030* to enable smooth energy transition

*Source: IRENA
PSH development under pressure

PSH offers a cost-effective way to provide **large-scale balancing and grid services** through:

- Storage of greater quantities of immediately available renewable electricity
- Providing greater flexibility and stability to the network.

Recent development **led by government / public utilities** - Very little private sector-led or financed PSH capacity

Need to foster investment in new projects **both in regulated and deregulated markets**

To meet climate change and grid imperatives, new business models must emerge.
Policy & Market Frameworks

Barriers and enablers to development

Barriers

Uncertainty around the business model:
- Current revenue streams from energy arbitrage are not always enough to justify PSH (low electricity prices, limited spread)
- In many markets, ancillary PSH services are not always recognized nor fairly valued

Long lead-time development
- 5 to 10 years, combined with high upfront CAPEX
- Large-capital Project Risks

Enablers

- Policy mechanisms and market signals required for stable investment and long-term revenue visibility
- Better recognize and reward services provided to the grid
- More robust Production Simulation Models to fairly evaluate PSH against other storage technologies
- Valorize other positive externalities (multi-purpose water use)
- Simplify licensing/permitting process to reduce lead time and development costs without diluting environmental rigour

Mitigate risks to investors by creating policy and market frameworks which deliver greater revenue certainty and value to customers
Objectives and work programme

1. Explore the various markets to highlight the current **investment barriers** (Policy/Regulation, licensing/permitting process, Economic, Environmental) but also **opportunities for PSH development** (re-positioning PSH as enabler of the energy transition - Why is development happening in some parts of the world but not others? Share best practices globally - incentives, policy).

2. Better understand the **existing remuneration mechanisms, services and contract options globally** ( Arbitrage, ancillary services, capacity mechanisms), and the role of the different stakeholders within the value chain (from grid operator, through TSO/DSO, to generator/user).

3. Examine how **new and innovative market mechanisms** (market configuration, incentivizations, regulatory frameworks) could be applied to PSH to incentivize and de-risk development, including learning lessons from other sectors.

4. Make **policy and market recommendations** which better recognize, and reward pumped storage’s contribution to rapidly evolving electricity systems.

**Working at regional level to cover local specificities, both for regulated and deregulated markets**
Proposed Deliverables and Communications

**Deliverables**

**Position paper highlighting:**
- Challenges to overcome
- Remuneration schemes
- Best practices
- Recommendations

With a dedicated section per region

**Intermediate deliverables**
- Barriers mapping
- Screening of remuneration schemes
- Overview of best practices

**Communication channels**

**Events:**
- Release position paper at World Hydropower Congress
- Organize regional webinars to support partners of the Forum

**Online communications:**
- Relay information on the Forum’s website
- Social media campaign on IHA’s and partner accounts

**Leverage other power associations:**
- Feed into the IEA’s Renewables Market Report (focusing on hydropower in 2021)
- Liaise with IRENA’s newly convened Collaborative Framework on Hydropower.
- Coordinate with other Renewables (Wind & Solar) associations
Policy & Market Frameworks

Key milestones and deliverables

Working group roadmap

3rd Nov: Forum Meeting
- Draft work programme presentation
- Call for partners

March '21:
- Inputs from regions:
  - Barriers
  - Remuneration schemes
  - Best practices

May/June '21:
- Draft recommendations

23-24 Sept '21:
- Paper released at World Hydropower Congress

Dec '20:
- Kick-off with Partners
  - Partners to discuss and agree on the work programme
  - Assign sectional leads

May '21:
- Intermediate feedback to SC
  - Opportunity for regional webinars to discuss progress and receive feedback

July/August '21:
- Position paper finalised

Sept/Oct '21:
- Communications
  - Regional Webinars
  - Online and Social media campaign

11 months to set the scene and make recommendations
Policy & Market Frameworks

Wide range of skills and expertise needed

Skills and expertise
We need partners from a range of backgrounds:

• Policy and regulation
• Market design/configuration
• Financiers
• Project development/negotiations
• Plant operations

Geographical spread
We need partners from different key regions:

• North America
• South America
• Europe
• Middle East
• Africa
• Asia and the Pacific

For each region, one or two partners could be leading sub-groups in charge of collecting information, consolidating and reporting to the broader group.

We need your expertise and experience to make the right recommendations to unlock greater PSH development
If you have additional ideas, comments, questions regarding the working group’s programme (objectives, content, timeline)...

Please share your feedback with us before the first meeting of the group.

Contacts:
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Nicholas Troja (IHA): Nicholas.Troja@hydropower.org
Sustainability Working Group
Led by EDF

Pumped Storage
Hydropower
International Forum

Sustainability Working Group
Led by EDF
EDF is one of the European leaders in Hydroelectric Power Generation

- EDF operates 453 hydropower stations (from 800kW to 1800MW), with a total hydropower capacity of 20 GW and produces 46 TWh of hydropower per year.

- EDF has constructed and operates 6 PSH in France, with a total capacity of 4,200 MW.

- Main EDF HPPs worldwide: Nam Theun 2 (Laos, 1070 MW), SINOP (Brazil, 404 MW) and Nachtigal (Cameroon, 420 MW, under construction).

- EDF has currently 24 hydro projects in development worldwide, including PSP projects, and many consulting and O&M services.
Sustainability is an overarching concept

Economy
- New business model
- Remove barriers to investment

Policy & Market Frameworks WG

Performance
- Positive impacts induced by the services and functions provided by PSH assets

Socio-Environment
- Limited and manageable negative impacts (avoid, minimise, mitigate, compensate)
Objectives: Set recommendations for each topic

**Topic 1**
A Life Cycle Analysis (LCA) investigation to characterize the environmental impacts/benefits of PSH development

**Topic 2**
Testing PSH projects against existing sustainability tools like HESG Gap Analysis Tool

**Topic 3**
Evaluation of the territorial value creation of PSH assets for local communities
Sustainability

Topic 1: Investigation of Life Cycle Analysis (LCA) to characterize the environmental impacts/effects of PSH

Method: Compare PSH to other forms of energy storage which provide similar services

Assessment of impacts/effects will include intrinsic impacts of PSH projects and indirect effects of services provided by PSH

Deliverable: Benchmarking favorable for PSH
Sustainability

Topic 2: Testing PSH projects against existing sustainability tools like HEG Gap Analysis Tool

Hydro Sustainability Tools
- Evaluate how existing sustainability tools (e.g., HESG Gap Analysis tool and G-res Tool) are applied specifically to PSH and what lessons could be learnt given the unique operating regime of PSH projects.

PSH development
- Focus on PSH projects in development could allow to compare different design options and their direct impact on assessment results.

Xflex Hydro
- ‘XFlex Hydro’ European project can also provide interesting insights when considering change of operation modes for existing PSH assets.
Topic 3: Assessment of the territorial value creation of PSH assets for local communities

Comparison with other forms of energy storage that would provide equivalent services

What is the local created value?

To quantify the value creation at the local level
Seeking partners from all over the world

- Experience with relevant sustainability tools such as the Hydropower Sustainability Tools and the G-res Tool.

- Knowledge on environmental impacts and mitigation options (e.g. scientists and environmental engineers).

- Experience with quantifying the wider benefits & local impacts: financial, direct or indirect activities.
Proposed Timeline of the Working Group

1st WG meeting before Christmas

2nd WG meeting Before Steering Committee

Webinar on the sustainability characteristics of PSH

Feedback to SC

Drafting deliverables

Steering Committee May 2021

3rd WG meeting June 2021

Final Recommendations

Input from partners & preparation of webinar

Forum 3rd Nov 2020

Discussion paper sent to all partners

Sustainability

Proposed Timeline of the Working Group

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Steering Committee May 2021

3rd WG meeting June 2021

Final Recommendations

Input from partners & preparation of webinar

Forum 3rd Nov 2020

Discussion paper sent to all partners
Feedback sought

Beyond today’s discussion, comments on the WG’s proposed topics are welcome by email:

Contacts:
Frederic Hofmann (EDF): Frederic.hofmann@edf.fr
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Please share your feedback with us before the first meeting of the group
Capabilities, Costs & Innovation

Electricity from Voith Hydro

25% of electricity generated by hydropower worldwide is produced with technologies and services from Voith Hydro.

Voith Hydro is a full-line supplier, our portfolio of products covers the entire life cycle of new and existing large & small hydropower plants and also pumped storage.

Run of River Plants

Storage Plants

Pumped Storage Plants since 1908
Capabilities, Costs & Innovation

**Frades II: Variable Speed Pump Turbines**

Portugal is focusing on pumped storage to stabilize their electricity grid.

Voith supplied **Frades II with the most advanced variable speed pump turbines and asynchronous motor-generators.**

**Results:**

- Total number of operating hours in pump mode was increased
- Boosted operational efficiency
- Higher wind integration and more revenue
Capabilities, Costs & Innovation

Snowy 2.0: 2 GW of PSH on existing reservoirs

• Australia has currently the **highest rate of wind and solar expansion** per person per year

• South Australia has already a high share for renewables of > 50%

• 2 GW of PSH from six reversible Francis pump-turbines with 330 MW each, three of them with variable speed (DFIM)

• Snowy 2.0 PSH helps to:
  ✓ cope with intermittency of wind & solar power
  ✓ compensate weather forecast errors > 1 GW
  ✓ add substantial rotating inertia to the grid
  ✓ provide reactive power for voltage control
Characteristics & key capabilities of PSH

**Proven, long-term, low-cost:**

- PSH is the only proven large-scale power storage solution for 112 years
- Durable and extremely cycle-proof: 60-100 years of lifetime with designs > 50,000 storage cycles
- In 2019 over 90% of the global capacity is provided by pumped storage (158 GW)
- High efficiency of 78% - 82%
- Very low storage energy costs (e.g. 165 USD / kWh)

Sources: IEA 2020, US DOE, IHA, Schluchseewerk
Flexible and reliable:

- Provision of reliable available capacity and fast balancing/regulating power, which helps to flexibly integrate volatile renewable energies and to smoothen the residual loads.
- Re-dispatch and other ancillary services like reactive power control.
- Black start: self-starting capability to restore power in the event of a total or partial shutdown.

→ Rapid PSH growth in China: Between 2016 and 2019 17 new pumped storage plants have already been awarded with a total capacity of 22.5 GW!
However, challenges remain...

- **Lack of understanding or some indifference** about the technology, its capabilities, costs, potential and innovations.

- **Common perception that most PSH potential has already been exploited**.

- **Stronger marketing and incentivisation for other storage technologies (e.g. chemical batteries and hydrogen storage)** – PSH often left out of discussions about energy storage.

- **Seen as an old technology with little room for further innovations**.
Abundant potential:
• Open and closed-loop
• non-powered dams
• conversion of conventional hydro
• saltwater PSH

Hybrid and innovative solutions:
• Combining with wind or solar,
• Provision of clean freshwater and irrigation
• Coupling saltwater PSH with reverse osmosis
• EU funded XFLEX HYDRO demonstration project
Proposed Objectives and Work Programme

1. Improve the understanding of PSH and its role in providing storage and flexibility services, including its capabilities, values, costs and potentials in addressing the needs of future electricity systems

2. Comparison with other energy storage technologies

3. Raise awareness beyond the hydropower community via deliverables that are digestible by policy makers and the media

4. Highlight the latest technological innovations in PSH
Capabilities, Costs & Innovation

Proposed Deliverables

Comparisons with other storage technologies
Comprehensive comparison on capabilities, life-time & costs. This comparison should also merge results of the Sustainability Group (energy stored on energy invested (ESOI), LCA including CO₂ footprint)

PSH Potential Mapping
Interactive map of PSH potential leveraging on existing research of potential sites around the world

PSH Cost and Performance Benchmarking
Sharing data on cost (CapEx & OpEx), performance (duration, ramp rate, response time, efficiency, etc.), and financing (WACC, debt-to-equity ratio, etc.) data to inform investment and planning decisions

Innovative PSH Technologies Roadmap
Compendium of latest innovations and projects under development that policy makers may not be aware to capture its full benefits
November 2020:
Forum Meeting
• Draft work programme presentation
• Call for partners

December 2020:
Kick-off with Partners
• Partners to discuss and agree on the work programme
• Assign topical leads

March 2021:
Inputs from regions:
• PSH Potential Mapping
• Cost and Performance Benchmarking
• Innovative PSH examples

May 2021:
Intermediate feedback to SC
• Webinars/workshops to discuss progress and receive feedback

May/June 2021:
Draft recommendations

July/August 2021:
Deliverables finalized

23-24 Sept 2021:
Deliverables released at the World Hydropower Congress

Sept/Oct 2021:
Dissemination
• Regional Webinars
• Online and Social media campaign
Wide range of skills and expertise needed

We need partners from a range of backgrounds:

- Project Developers
- Equipment Suppliers
- Experience with all other storage technologies (chemical, thermal, etc.)
- System Operators
- EPC Contractors
- Plant operations
- R&D departments
- Academia
Feedback sought

Please share your feedback with us before the first meeting of the group.

Contacts:
Klaus Krueger (Voith Hydro): Klaus.Krueger@Voith.com
Juergen Schuol (Voith Hydro): Juergen.Schuol@Voith.com
Samuel Law (IHA): Samuel.Law@hydropower.org
Discussion
11:25 – 11:50 US EST

How the Forum can shape the future of PSH
Summary & Next Steps
10:50 – 12:00 US EST
Summary of Proposed Deliverables

**Policy & Market Frameworks**
- Position paper
- Barriers mapping
- Screening of remuneration schemes
- Overview of best practices

**Sustainability**
- Life Cycle Assessment (LCA)
- Sustainability tools implementation
- Value creation for local community

**Capabilities, Costs & Innovation**
- Comparisons with other storage technologies
- Potential Mapping
- Cost and Performance Benchmarking
- Innovative Technologies Roadmap

**Dissemination**

**Events:**
- World Hydropower Congress
- Regional webinars & topical workshops

**Online communications:**
- Forum website
- Social media campaign

**Linkage with international initiatives:**
- IRENA Collaborative Framework
- IEA Market Report
- XFLEX HYDRO
- IEA Hydro
Closing

We look forward to partnering over the coming year to shape the future of pumped storage!