Stantec

HV2024 – Session 3C

"Approach to Success with Pump Storage"

De-Risking Pump Storage - New IHA Guidance

1035 MW Rocky Mtn Pump Storage Project, Georgia

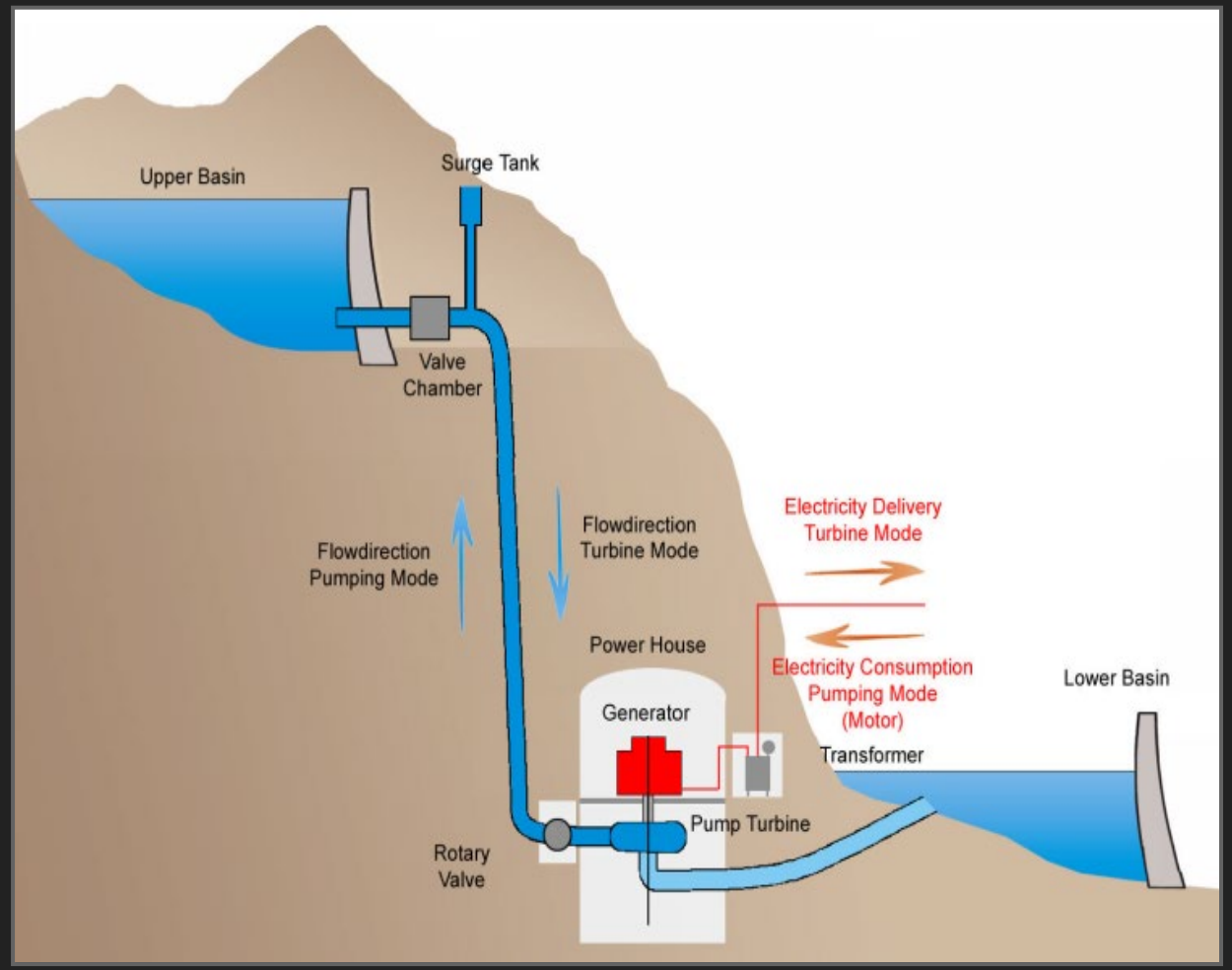
Last Utility Scale Pump Storage built in US

Designed by Stantec in 1990s

Don Erpenbeck PE
Vice President & Global Sector Leader- Dams & Hydro

What is Pumped Storage?

- A LONG DURATION water battery w/ long life & Zero degradation.
- A large Load center using Excess energy to pump water
- A flexible Resource that can change to meet conditions.
- A Transmission Asset
  - MVAR factory
  - Spinning Reserve Factory
  - Synchronous Condenser
  - Large Synchronous Inertial Force in the system in all modes
- Energy Security for the Region



Why Is PS Different than Conventional Hydro?

- Its Storage (not Generation) & Hydro Models don't work!
- Bi-Directional Water flow & Power Flow
- Bi-Directional unit Rotation
- An Upper reservoir that is drained and refilled every day
- An Upper Reservoir on Top of a Mountain where Geotech is less than Ideal. (lining systems)
- Pump Starting Systems (Adding 100s of MWs to grid in seconds) and DT Blow down systems
- Highest water velocities in the World (up to 88 ft/sec)
- Harmonics Interactions due to Rotor-Stator interaction can be severe (WG and runner blade tips are much closer)
- High fatigue loading of everything from TSOV to unit Breakers
- Highest Energy Concentration MW/mm of any type of Hydro Machine (due to P-T tradeoffs)
- Fast and Ultra Fast ramping and Mode Changes
- Long Tunnel Systems

Power Marketing

- PSH uses more energy than it produces. 0.7 to 0.8 ratio.
- PSH Has massive pumping loads that can destabilize the grid.
- Pumping usually governs the HV Interconnection process and is often overlooked as LGIA process is written around generators not motors.
- Asking PSH units to do more than BESS, such as fault ride thru but not giving credit for this.

Regulatory

- Can be closed loop & does not require a new dam on river.

IHA Just Published

‘Enabling New Pumped Storage Hydropower: A guidance note for decision makers to de-risk investments in pumped storage hydropower.’

“The guidance note delivers recommendations to reduce risks and enhance certainty in project development and delivery. It also equips key decision-makers with the tools to effectively guide the development of pumped storage hydropower projects and unlock crucial finance mechanisms. By utilising the recommendations provided, a new market entrant will be better able to understand the risks and create a mitigation strategy to address them.”

Download Location:
https://www.hydropower.org/publications/enabling-new-pumped-storage-hydropower

Working group members include Stantec, Bechtel, Brookfield Renewables, European Investment Bank, British Hydropower Association, GE Vernova, KPMG, Mott Macdonald, World Bank Group, Queensland Hydro, Dentons LLP and the University of Cambridge.

Why de-risking investments for pumped storage is vital to support the growth of this market

Hypothesis

The need is clear. Long Duration Energy Storage is absolutely critical to keep pace with intermittent renewables on the grid. Pumped Storage is a fundamental part of the solution.

Problem

We are not meeting the need:

1. Projects are not getting to FID, and
2. When they do, there is a long tail of cost and schedule overruns

Our industry must do better. Understanding how to de-risk pumped storage projects is vital to reduce development risk, attract increased investment, and meet the market need.

The Purpose of the Working Group

- Why are we facing these problems?
- What should we do about it?

Project objectives

Provide a platform for discussions on de-risking investments for PSH projects.

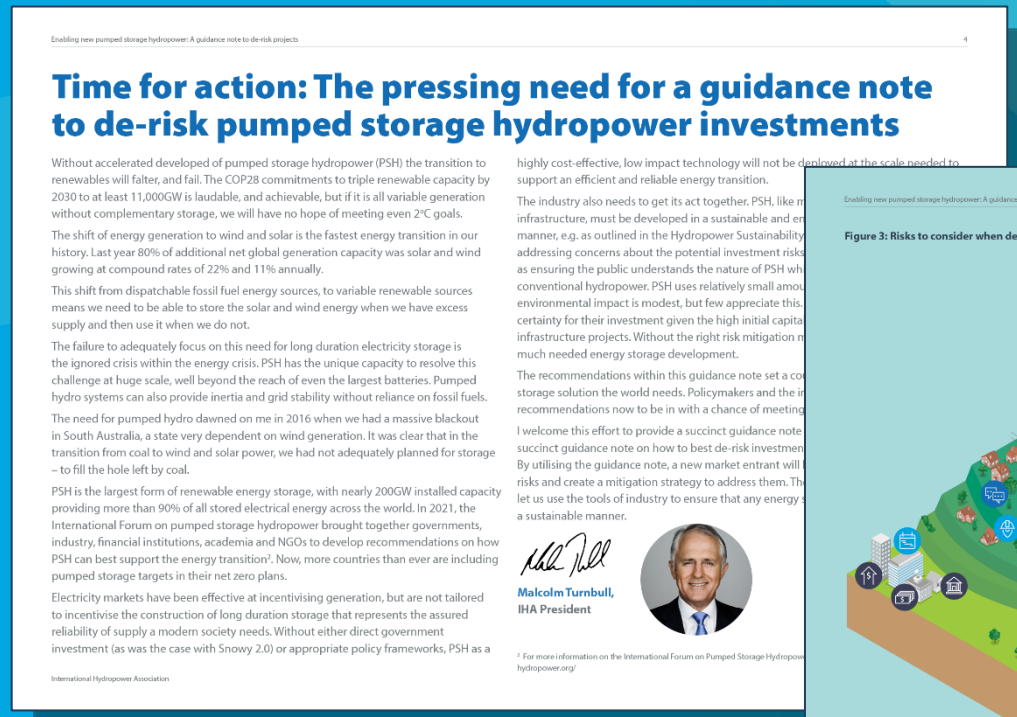
Gain further insights and views of the issues beyond working group.

Create a brief document to share working group member insights and ensure good practice principles are applied in developing pumped storage projects.

Raise awareness of issues facing PSH development through social media and events.

Guidance Note

- Introduction to PSH
- Risks critical to consider for PSH
- Path of a PSH project
- Thematic risks and recommendations



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Time for action: The pressing need for a guidance note to de-risk pumped storage hydropower investments

Without accelerated developed of pumped storage hydropower (PSH) the transition to renewables will falter, and fail. The COP28 commitments to triple renewable capacity by 2030 to at least 11,000GW is laudable, and achievable, but if it is all variable generation without complementary storage, we will have no hope of meeting even 2°C goals.

The shift of energy generation to wind and solar is the fastest energy transition in our history. Last year 80% of additional net global generation capacity was solar and wind growing at compound rates of 22% and 11% annually.

This shift from dispatchable fossil fuel energy sources, to variable renewable sources means we need to be able to store the solar and wind energy when we have excess supply and then use it when we do not.

The failure to adequately focus on this need for long duration electricity storage is the ignored crisis within the energy crisis. PSH has the unique capacity to resolve this challenge at huge scale, well beyond the reach of even the largest batteries. Pumped hydro systems can also provide inertia and grid stability without reliance on fossil fuels.

The need for pumped hydro dawned on me in 2016 when we had a massive blackout in South Australia, a state very dependent on wind generation. It was clear that in the transition from coal to wind and solar power, we had not adequately planned for storage – to fill the hole left by coal.

PSH is the largest form of renewable energy storage, with nearly 200GW installed capacity providing more than 90% of all stored electrical energy across the world. In 2021, the International Forum on pumped storage hydropower brought together governments, industry, financial institutions, academia and NGOs to develop recommendations on how PSH can best support the energy transition[2]. Now, more countries than ever are including pumped storage targets in their net zero plans.

Electricity markets have been effective at incentivising generation, but are not tailored to incentivise the construction of long duration storage that represents the assured reliability of supply a modern society needs. Without either direct government investment (as was the case with Snowy 2.0) or appropriate policy frameworks, PSH as a highly cost-effective, low impact technology will not be deployed at the scale needed to support an efficient and reliable energy transition.

The industry also needs to get its act together. PSH, like m infrastructure, must be developed in a sustainable and en manner, e.g. as outlined in the Hydropower Sustainability addressing concerns about the potential investment risks as ensuring the public understands the nature of PSH wh conventional hydropower. PSH uses relatively small amou environmental impact is modest, but few appreciate this. certainty for their investment given the high initial capita infrastructure projects. Without the right risk mitigation m much needed energy storage development.

The recommendations within this guidance note set a co storage solution the world needs. Policymakers and the in recommendations now to be in with a chance of meeting

I welcome this effort to provide a succinct guidance note succinct guidance note on how to best de-risk investmen By utilising the guidance note, a new market entrant will risks and create a mitigation strategy to address them. Th let us use the tools of industry to ensure that any energy s a sustainable manner.

Malcolm Turnbull,
IHA President

[2] For more information on the International Forum on Pumped Storage Hydropow hydropower.org/

International Hydropower Association

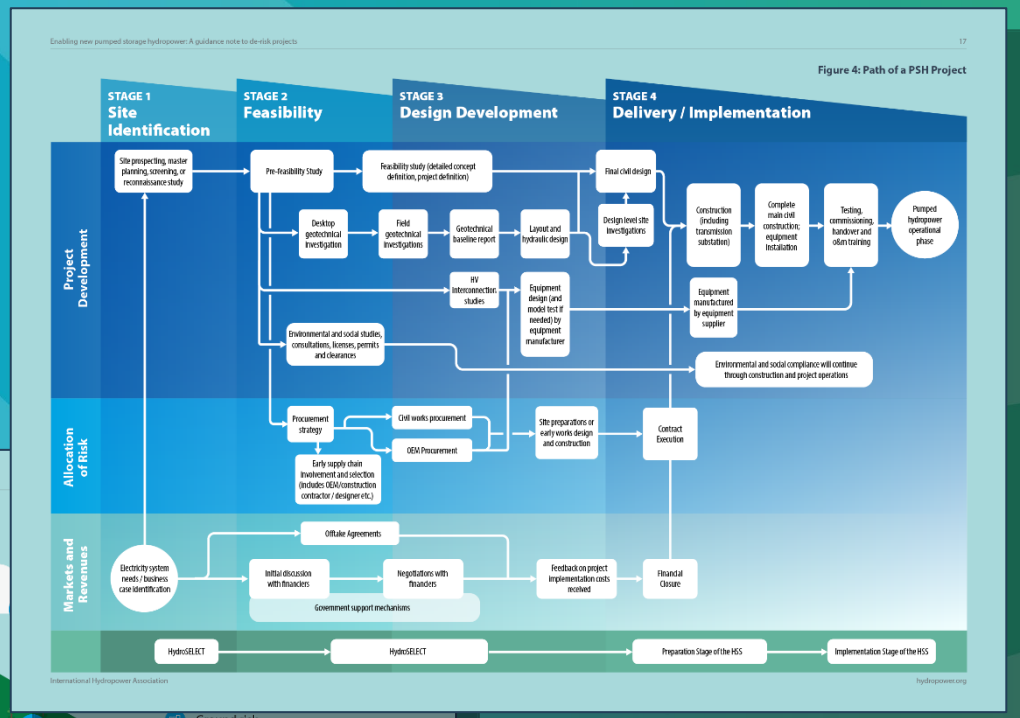

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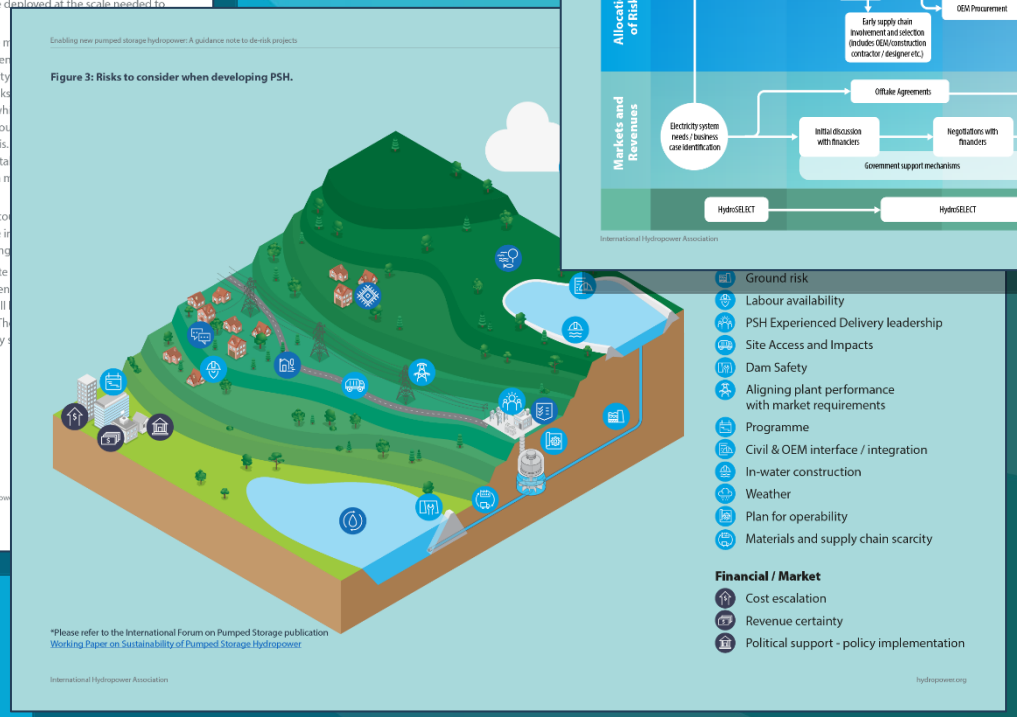
Figure 4: Path of a PSH Project

STAGE 1 Site Identification
STAGE 2 Feasibility
STAGE 3 Design Development
STAGE 4 Delivery / Implementation

Project Development
Allocation of Risk
Markets and Revenues

Site prospecting, master planning, screening, or reconnaissance study
Pre-Feasibility Study
Feasibility study (detailed concept definition, project definition)
Final civil design
Desktop geotechnical investigation
Field geotechnical investigations
Geotechnical baseline report
Layout and hydraulic design
Design level site investigations
Construction (including transmission substation)
Complete main civil construction; equipment installation
Testing, commissioning, handover and o&m training
Pumped hydropower operational phase
HV interconnection studies
Equipment design (and model test if needed) by equipment manufacturer
Equipment manufactured by equipment supplier
Environmental and social studies, consultations, licenses, permits and clearances
Environmental and social compliance will continue through construction and project operations
Procurement strategy
Civil works procurement
OEM Procurement
Early supply chain involvement and selection (includes OEM/construction contractor / designer etc.)
Site preparations or early works design and construction
Contract Execution
Offtake Agreements
Electricity system needs / business case identification
Initial discussion with financiers
Negotiations with financiers
Feedback on project implementation costs received
Financial Closure
Government support mechanisms
HydroSELECT
HydroSELECT
Preparation Stage of the HSS
Implementation Stage of the HSS

International Hydropower Association hydropower.org



Enabling new pumped storage hydropower: A guidance note to de-risk projects

Figure 3: Risks to consider when developing PSH.

*Please refer to the International Forum on Pumped Storage publication Working Paper on Sustainability of Pumped Storage Hydropower

Ground risk
Labour availability
PSH Experienced Delivery leadership
Site Access and Impacts
Dam Safety
Aligning plant performance with market requirements
Programme
Civil & OEM interface / integration
In-water construction
Weather
Plan for operability
Materials and supply chain scarcity

Financial / Market

Cost escalation
Revenue certainty
Political support - policy implementation

International Hydropower Association hydropower.org

hydropower.org

Risks for PSH projects

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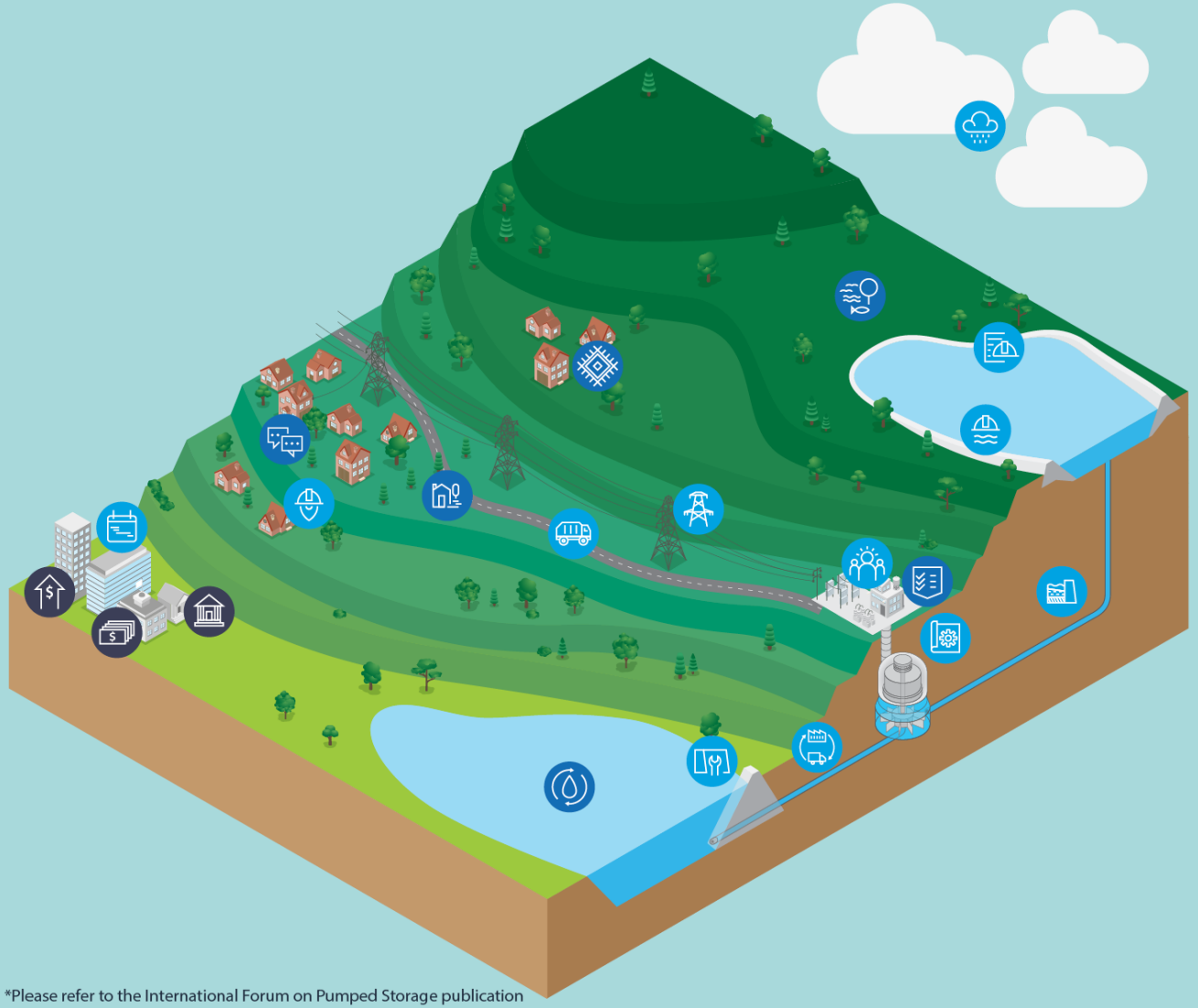

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Environmental and Social*

- Permit approvals (ESIA etc)
- Land acquisition & resettlement
- Water availability and quality
- Biodiversity & ecology
- Cultural heritage
- Community support

Technical

- Ground risk
- Labour availability
- PSH Experienced Delivery leadership
- Site Access and Impacts
- Dam Safety
- Aligning plant performance with market requirements
- Programme
- Civil & OEM interface / integration
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Financial / Market

- Cost escalation
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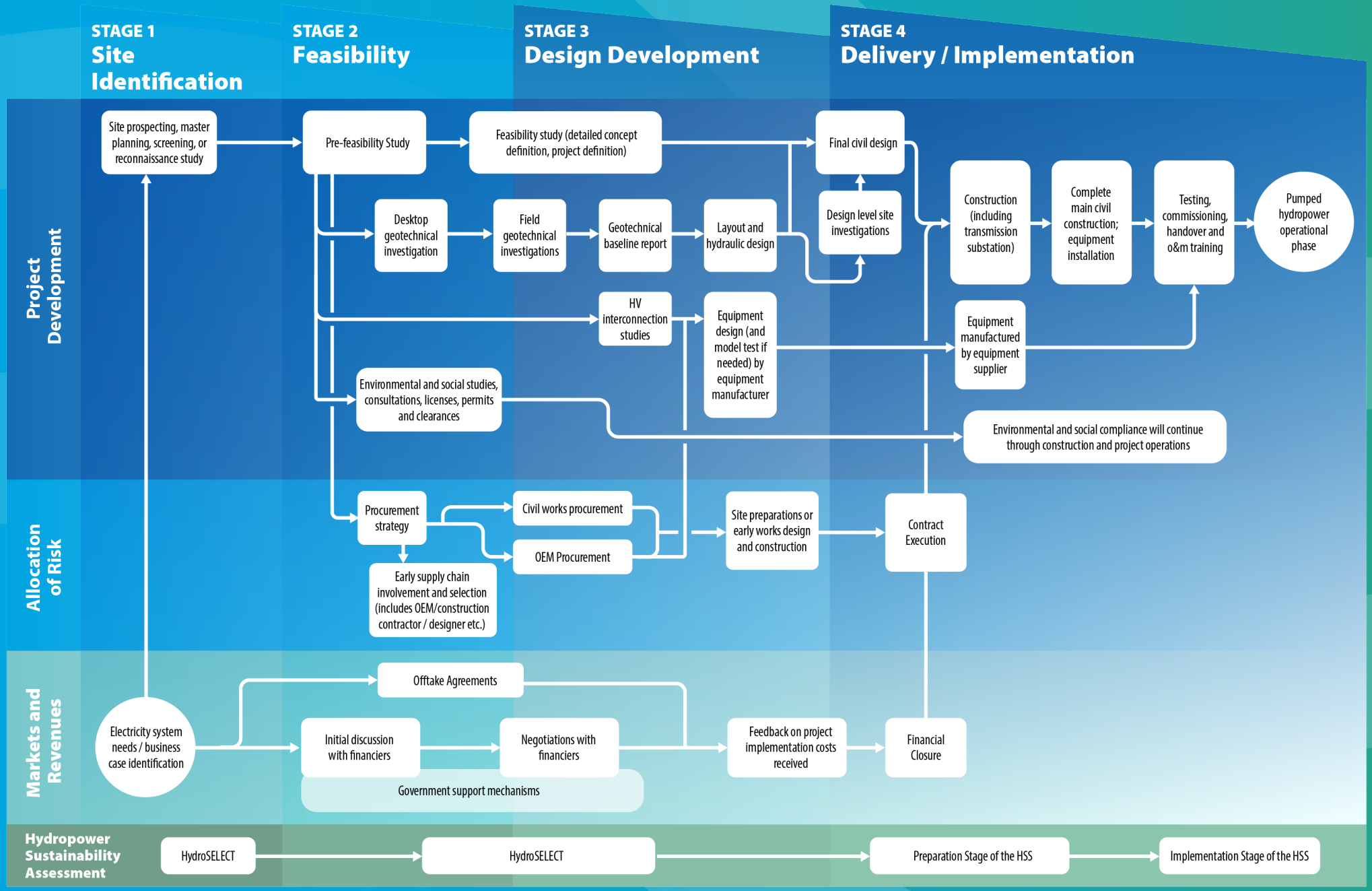
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Procurement strategy
Civil works procurement
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Site preparations or early works design and construction
Contract Execution
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Focus Areas of De-Risking

1. Markets and revenues
2. Project development
3. Allocation of risk

Markets and Revenues

Key Considerations

- Storage capacity and grid services should be considered based on a dedicated storage masterplan to quantify the future needs of the national power system in line with their energy and climate plans.
- Policymakers should engage with the market to design tailored support mechanisms for PSH, ensuring clarity on policy timelines and setting energy storage targets.
- Policymakers and project developers when performing economic comparisons between different storage technologies should follow a consistent and technology neutral approach and consider the full-lifecycle benefits of assets.

Markets and Revenues

Questions

Consider the market and business case upfront and develop an initial economic analysis.

- What does the grid need and how would a PSH asset address that need?
- Once the project is ready to operate, what will the project be offering to "the market" and who are "the buyers"? Do those markets / buyers currently exist (or, if not, will they exist when the project is operational)?
- Have you identified market mechanisms that provide revenue? Are they fixed / quantifiable or 'merchant'? Are there any regulatory risks involved with these revenue mechanisms?
- What's required by financiers / lenders? Do you know what is required to reach your financial investment decision?

Project Development

Key Considerations

- Appoint complete delivery teams early in the development process, including Owner, Operator, Designer, Constructor, OEM etc.
- Invest in development, for example ground investigations, to de-risk, and specialist expertise of delivery teams.

Project Development

Questions

Understand the risks specific to your project and invest in the key activities to best deliver through well-coordinated project teams.

- Do you understand the big site-specific risks for your project? (e.g. geological and subsurface conditions, topographic, hydrological, labour and equipment availability, etc.)
- When and what expertise do you need to bring in to address these risks? Are you engaged with the project stakeholders (e.g. investors, planning, local communities, etc.)
  - How can any risks or challenges associated with those conditions be addressed? Have you engaged with the supply chain market to align on how best to achieve this?

Allocation of Risk

Key Considerations

- Parties need to be clear that the balance of risk will be different in PSH projects than in other sectors
- Procurement and contract management should ensure fair, transparent, and economically most advantageous conditions of the project.
- Contracting strategy should reflect and foster environmental and sustainability (E&S) aspects of the project.

Allocation of Risk

Questions

Consider where the risk will sit and how the delivery team will think about cost and schedule.

- What is the delivery/commercial model and associated procurement strategy?
- What responsibility does the Owner assume in respect of any designs, plans, or technical information as provided by the contractors? And how far can the Contractor rely upon information given by the Owner (Employer)?
- Is the contract based on a well-known standard form of contract?
- Should the Owner have a one or two stage procurement process? i.e. Does the Owner keep multiple contractors in competition or appoint a preferred contractor relatively quickly?

IHA Conclusions

While the private sector is ready and able to deliver, to do so at the required scale the market needs to be **private sector developed but public-sector enabled**. Lack of clarity on government support mechanisms and revenue streams is stalling progress.

PSH is at the more complex end of infrastructure development. **Owners must invest in project development to de-risk**. The greater the investment in preparation and the earlier a single, experienced delivery team (Owner and Supply Chain) is focused on it, the more de-risked the project becomes.

Good project management is good risk management: Ensure well-coordinated teams to support interface risk mitigation.

Development of the right delivery and commercial model and associated allocation of risk is vital. Risk should not be taken by the organisation best placed to manage it, rather **risk should be minimised by those best placed to manage, and residual risk should be shared by those best able to bear it**.

De-Risking Pumped Storage

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