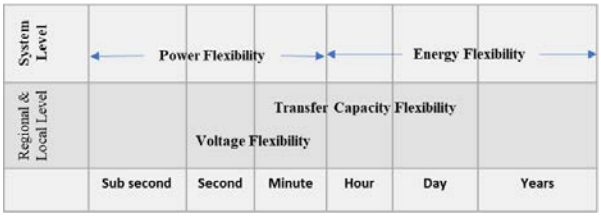
VALUING FLEXIBILITY IN EVOLVING ELECTRICITY MARKETS

Current Status and Future Outlook for Hydropower

The rapid expansion of variable renewable energy (VRE) resources combined with retirements of thermal generation give rise to increasing needs for flexibility at transmission, distribution, and the individual resource levels in the power system. The fundamental challenges associated with VRE integration and corresponding power system flexibility needs are similar across the world. Several different solutions are being developed to address these challenges, from infrastructure investments, improved (forecasting, planning and operations, and improved electricity market design.

Flexibility Needs

The power system is dependent on flexibility to maintain overall reliability by balancing supply and demand and keeping frequency and voltage within their limits in a cost-effective manner. The following table presents an overview of different flexibility services, as defined by IEA. Hydropower, with its unique operating characteristics, can provide flexibility across all the timescales, a capability that is likely to become more important in future power systems with high shares of VRE.



Survey of Flexibility Services in Current Systems

IEA Hydro Task 9 developed and conducted a survey of 14 countries/regions to better understand system flexibility services, how these services are procured, and the potential physical requirements and monetary value of the flexibility services in different markets around the world.

The resource portfolio in a system impacts what flexibility services are needed, how these services are provided at different timescales, and the technologies that provide the services.

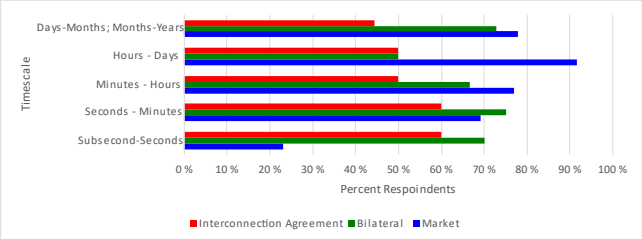
Flexibility Services

Most timescales correspond to multiple types of flexibility services. The table below illustrates the distribution of flexibility services by each timescale, based on survey inputs.

Timescale	Services		
Sub-second - seconds	1) Inertia 2) Reactive power	3) Voltage control 4) Frequency support	5) Spinning reserve 6) Special protection Systems
Seconds - minutes	1) Frequency support	2) Last minute dispatch	
Minutes - hours	1) Energy 2) Frequency support	3) Black start 4) Power unit dispatch	
Hours – days	1) Energy 2) Ancillary services	3) Long term reserves 4) Demand response	
Days-months; Months - years	1) Resource adequacy	2) Storage	

Flexibility Services Procurement

Various procurement methods used to obtain the flexibility services including market-based, bilateral contracts, or interconnection agreements. Market-based procurement dominates for short-term services, bilateral contracts for long-term services.



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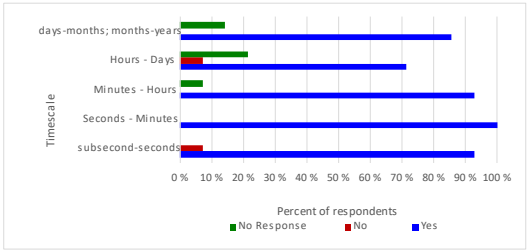
Hydropower Contribution to Flexibility Services

Survey results show that hydropower contributes to flexibility needs across all timescales in most regions.



Future Trends

Flexibility service requirements, how these services are procured, and the availability of resources to provide the services change over time based on technology characteristics, generation mix, and policy / regulatory environments. The survey identified trends and developments occurring across all timescales, the highest number of reported changes at the shortest timescales.

Timescale	Development and trends
Subsecond-seconds	8 of 12 respondents are planning developments within this timescale. Focus is on flexibility service pricing, market developments/improvements, and planning for changes in generation mix.
Seconds - Minutes	7 of 12 respondents are planning developments within this timescale. Developments include market design, implementation, and modification, adding additional services, technology developments, and changes in generation mix.
Minutes - Hours	7 of 12 respondents are planning developments within this timescale. Developments include technology improvements, changes in generation mix, market development and enhancements.
Hours - Days	3 of 12 respondents are planning developments within this timescale. New market products, market structures for offering products, changes in generation mix.
Days-Months; Months-Years	5 of 12 respondents are planning developments within this timescale. System and technology enhancements to support resource adequacy, refinement of market structures, and development of new markets.

Conclusion

The survey was accompanied by case studies from Switzerland, Norway, Canada, USA, Brazil, and Australia providing insights into specific challenges and solutions related to provision of flexibility services. Although regulatory structures and electricity market designs will have a regional flavour, these examples provide a variety of solutions that may contribute towards a more efficient provision of clean electricity. Important lessons can and should be learned between countries and regions as part of the ongoing shift towards cleaner electricity systems.

Area	Observation
Hydropower is an important contributor to reliability services	• Contributes to flexibility services across all timescales.
Procurement and compensation of grid services vary across countries	• Market-based mechanisms dominant in short timeframes. • Bilateral contracts play important in medium and longer-term.
Lack of market signals for long-duration storage (LDES)	• Lack of consistent and commensurate long-term signals for investments in long-duration energy storage such as hydropower.
Energy storage compensated through markets for reserve and energy	• Energy arbitrage (or load shifting) is currently the primary revenue source for hydropower. • Markets for reserve products tend to be thin, might not support business case for new PSH.
Market rules can distort market-based arbitrage signals for energy storage	• E.g., systems with priority dispatching rules for VRE prevent PSH from following an economically optimal energy arbitrage schedule
New market opportunities for flexibility services are emerging	• Includes fast frequency reserve products, flexibility ramping products, and higher time resolution of day-ahead markets.
Flexibility services require increased cycling, leading to wear and tear	• More VRE lead to increased stress on hydropower machinery impacting economic viability • Flexibility retrofits and O&M costs need to be balanced against flexibility services value.
Long-term contracts offer stability but mask the true value of flexibility	• Long-term contracts provide consistency and low risk for investors, enabling investments • However, long-term contracts can also limit visibility into cost and value of flexibility
Standardized product definitions facilitate efficient markets	• Enables trading and exchange of services across wider geographical areas.
Transmission capacity is a key enabling factor for hydropower	• Transmission oftentimes critical for hydropower to access regions with flexibility needs • HVDC lines can enable transmission for hydro.