Chengdu Declaration on

Dams and Reservoirs for Energy transition and Adaptation to Climate Change

Approved on 3rd October 2024, at the 92nd ICOLD Annual Meeting in New Delhi
by the International Commission on Large Dams (ICOLD)

In addressing the multifaceted challenges posed by climate change the role of dams and reservoirs is indispensable. Water storage is pivotal in providing food security, flood control, resilience to droughts and generation of low carbon energy, which is a critical component of our efforts to address climate change and energy transition. Meeting the climate change induced rising demands for water supply, addressing the heightened risks of extreme flood and drought events and balancing the intermittent renewable energy sources call for safer, smarter and more eco-friendly dams towards a significant increase in global water storage capacity and hydropower generation.

A changing world

Population growth. The world's population has skyrocketed from around one and a half billion in the early 20th century to nearly 8 billion today. It is expected to grow to around 10.4 billion by 2100. This steady rise in population directly impacts global need for water.

Global water demand has reached 4,600 km3 per year and is expected to increase by 20% to 30% by 2050. Currently, roughly 70% of total water use worldwide irrigates 20% of total cultivated land which produces 40% of total produce. Feeding a population of around 9.7 billion by 2050 and 10.4 billion by 2100 is a fundamental yet most challenging task. Climate change adversely affects water demand jeopardizing food security.

Unless more fresh water is stored by 2050, 3.6 to 4.6 billion people worldwide, and approximately 1 in 4 children, will be living in water stress areas. If all identified future dams were constructed and contribute to irrigation along with other uses, they would secure food for more than 600 million additional people. More dams are needed for providing global water and food security.

Climate change. Human activities, mainly through greenhouse gas emissions, have unequivocally caused global warming, with global surface temperature reaching an increase of 1.1°C above 1850-1900 levels in the past decade (2011-2020). Historical and current greenhouse gas emissions continue to rise, stemming from unsustainable fossil fuel energy, land-use changes, lifestyles and global consumption patterns.

The IPCC AR6 report has issued alarming forecasts on global climate change, warning of increasing temperatures, extreme weather events and rising sea levels. The uncertainty in spatial and temporal distribution of water resources is highlighted as a critical impact. Changes in precipitation patterns, increased evaporation rates and melting glaciers are expected to exacerbate water scarcity in many regions. The timing, duration, and intensity of climate crisis occurrences remain uncertain.

Clean energy transition is the top priority for meeting COP commitments, since energy is the main source of carbon emissions. According to the International Energy Agency (IEA), total global electricity generation in 2050 will be 2.5 times the current level. To achieve the goal of reaching carbon neutrality by the middle of the present century, the share of renewable energy in primary energy consumption must increase significantly. To achieve 100% carbon free electricity generation by the middle of the present century, coal, oil and gas units' capacity will need to be reduced globally at a rate of 100 GW per year. This requires complete transformation of energy production and consumption.

Hydropower is the solution. Hydropower schemes, including pumped storage plants, through low-carbon dispatchable technologies, need to step in as 'guardians of the electricity grid' for energy transition. Dams having reservoirs with long duration energy storage are the lead provider of grid flexibility and will be the backbone of reliable, safe, and decarbonized power systems. To achieve the energy transition goal, currently installed hydropower capacity has to be doubled for net zero scenarios by the middle of the present century.

Extreme events aggravated by Climate Change call for more water storage capacity in reservoirs towards a climate-resilient water supply, food, and agricultural production and environmental protection. Additional freeboard for flood control in existing and future reservoirs is required to assure higher safety levels, thus losing useful volumes of water for other uses. Ecological flows, reducing climate impacts on downstream river reaches and deltas, ecosystems and biodiversity, require additional regulated water volumes, against aggravating irregularity and uncertainty of inflows and competing water uses. Larger volumes of water storage are required to manage inland water resources in the context of climate induced water scarcity, severe droughts and increasing vital water needs of a growing population. More water storage in large reservoirs is a solution towards climate change resilience to water-related hazards, to be considered in integrated river basin management along with other options.

Maintenance and rehabilitation of existing dams, including increasing their capacity, efficiency and safety is paramount. The new conditions imposed by climate change and the demographic growth pose major challenges to the safety management of existing dams. ICOLD is committed to strengthening and improving dam safety management, rehabilitation and refurbishment, to enhancing dam and levees resilience and ensuring the safe, sustainable, reliable and environmentally friendly operation and maintenance of more than 62,000 large dams supporting human needs worldwide.

Role of Dams and Reservoirs for Energy Transition

Dams, as part of hydro-storage schemes, make energy transition viable. The penetration of intermittent renewables and the withdrawal of thermal plants cause greater complexity in the operation of the electricity system, resulting in spills and rapid variations in generation and frequency. By storing and releasing water, hydropower can ramp up and down quickly and precisely especially with artificial intelligent operation technologies, improving regulation of the response to frequency variations as needed for rapid adaptation of high voltage grid networks. Energy storage in form of water is inescapable for renewables to replace fossil fuel sources and a key to meet the climate commitments.

Pumped storage plants allow displacement of energy from off-peak to peak hours by pumping water from lower to an upper reservoir. Off-river, closed system, pumped storage plants do not depend on hydrology of the site and are versatile in terms of their location. Reversible pumped storage plants can employ existing reservoirs, preserving flood control functions and energy transport infrastructure, to minimize environmental impact. They can synergize non-consumptive uses with current uses thereby minimizing generation as well as operation and maintenance (O&M) costs.

Uncertainty. Hydropower asset owners and managers, as well as other stakeholders, make financial and economic decisions based on the projected value of their production assets. Multiple factors delay decisions and implementation of these much-needed facilities. Hindering the desired acceleration of development of new hydro as well as pumped storage schemes are the uncertainty of financial sustainability of the investment, the lack or ambiguity of regulatory framework for energy storage, pricing, and lagging administrative procedures for permitting and granting concessions. A clear, consistent regulatory framework, and administrative reforms to simplify and expedite procedures for granting concessions are essential to achieve the required hydropower development pace.

Role of Dams and Reservoirs in Climate Change Adaptation

Dams and extreme events

Floods cause huge financial losses, environmental catastrophes, and fatalities. Climate change is expected to increase the frequency and intensity of floods in the coming decades in many regions worldwide. Storage reservoirs mitigate the risk of flooding and reduce the frequency and extent of inundations. Early warning systems and land management with non-structural measures reinforce and enhance the key role of dams and levees in flood control.

Higher dam safety standards are demanded by society due to uncertainty in the frequency and intensity of floods in climate change conditions, land use changes and larger population exposure downstream. These require enhanced design of new dams increased dam quality through artificial intelligent construction, and continuous efforts to upgrade dam resilience operation both for existing and new dams.

Drought events are also expected to occur more frequently and are likely to be more persistent and geographically widespread. Annual and interannual storage and proper reservoir management along with other measures at the river basin scale are required to mitigate droughts' effects on human uses and the aquatic ecosystems. Thus, reservoirs provide resilience, addressing environment vulnerability against droughts. Artificial reservoirs often developing into valuable wetlands host important wildlife and support biodiversity.

River basins with large reservoir regulations are often more adaptable to temporal and spatial changes in water resources, making them less vulnerable to climate change. Creating new storage by constructing sustainable dams is important since around 0.8% of storage capacity is being lost annually due to reservoir sedimentation. The rate of sedimentation is expected to rise in many areas where erodibility will worsen under climate change, unless reservoir management and watershed measures are implemented.

Integrated river basin management

More reservoir volume is needed for integrated water resources management, especially in the light of climate change. Annual and interannual storages are required to ensure climate-resilient water supply for irrigation and food security, safe drinking water, energy generation, flood regulation, droughts mitigation, and other uses. The volume of water stored in reservoirs must increase to meet traditional needs and climate change challenges.

Multipurpose dam projects support holistic river basin management and sustainable development. They allow for downstream ecological releases, and shape flood regimes allowing risk mitigation across river systems, floodplains, deltas and coastal areas. To address climate-related reduction in mean annual flow or increased hydrologic variability and heightened risk and uncertainty, reservoir storage capacity increase must be considered as a major option and smart operation be adopted. Overall, dams make an important structural component within integrated river basin planning and management aligning with techno-economic and environmental considerations.

Dams for water supply and irrigation

Dams provide a reliable source of raw water which is treated and supplied to towns, cities, large metropolitan areas and megacities concentrating more and more population. Reservoirs supplying drinking water systems provide enhanced resilience against drought through annual and interannual storage.

Increased temperature due to global warming raises water demand for crops, while food security of a growing population also requires more production, with expected reduction of rainfed crops.

An increasing proportion of irrigated land will need new regulating infrastructure including dams, and water conservation to attend to this unavoidable function.

Dams and the environment

Carbon footprints and ecological impacts of dams need to be managed. Habitat loss, methane emission from reservoirs, disruption of river ecosystems, relocation of communities, etc. should be evaluated and properly addressed in Environmental Impact Assessment and Environmental Management Plans. Despite certain adverse impacts, overall, dams and their reservoirs are an important tool, alongside other measures, for energy transition and climate change adaptation. It is noted that hydropower has one of the lowest carbon intensity factors of all electric power generation technologies.

ICOLD strongly recommends the following actions:

i) **Development of storage capacity worldwide**: Per capita storage capacity has been steadily declining since the 1980s due to population growth, sedimentation in reservoirs, and a decline in dam construction pace. New storage is needed for energy transition and to maintain the traditional benefits of dams under the new challenging conditions shaped by climate change.

ii) **Acceleration of hydroelectric development**: Policy makers and civil society to focus on sustainable pumped storage, storage based hydro-schemes, to balance growth and energy transition towards the net zero pathway.

iii) **Development of hydroelectric potential, especially in developing world**, in regions where only 10 to 30 percent of hydroelectric potential has been harnessed, demands significant efforts, commitment and cooperation amongst main stakeholders such as international organizations, governments, relevant institutions, NGOs, and civil society.

iv) **Introduction of energy storage as a new official use of reservoirs** in water acts and permitting regulations, to facilitate effective energy transition and modern water management adapted to current needs.

v) **Establishment of a clear and stable regulatory framework for energy storage** that includes additional tariffs for energy storage. Urgent policy reforms are needed to enable energy transition, and to ensure equity in energy access, guaranteeing the financial feasibility of storage-based hydropower and pumped storage projects, as keys for the energy transition commitment.

vi) **Administrative reforms** to be carried out urgently to simplify and expedite procedures for granting concessions for new hydroelectric and pumped storage projects, especially concerning environmental authorization and grid access. Concessional financing needed to boost long duration energy storage in reservoirs. Mandates and targets for development of dams and hydropower have to be clearly defined.

vii) **Highlighting the positive environmental impacts of dam and reservoir projects** contributing to water needs and energy transition, recognizing that in many cases, the positive impacts can outweigh other negative impacts.

viii) **Strengthening dam safety management** through rehabilitation and upgrading, including surveillance, real time flow forecast and early warning systems to enhance resilience, optimized reservoir management operation, smart regulation, and capacity building, in face of extreme events exacerbated by climate change.

ix) **Promoting sustainable water and sediment management** is essential to preserve the functions of dams and reservoirs, considering techno-economical, environmental and/or regulatory constraints.

x) **Promoting research and development** into new technologies that facilitate climate change mitigation and adaptation efforts. This includes exploring the implementation of hybrid hydro-battery systems, virtual power plants, automated data systems using artificial intelligence, and comprehensive information system architecture, as well as advanced materials for sustainable dam construction and rehabilitation.

"Storing Water, Secures the Future. Dams and Reservoirs Empower a Resilient World. Adaptation to Climate Change needs Safe and Sustainable Dams".

Issued on 21st May 2025 in Chengdu, by the:
International Commission on Large Dams

Endorsed by the:
International Hydropower Association
International Energy Agency
International Commission on Irrigation and Drainage
World Water Council
Institut Méditerranéen de l'Eau

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