Guidance Note on Large Hydropower Plants

February 2023

Disclaimer

This Guidance Note is not an ADB operational policy or a mandatory procedure stemming from an ADB operational policy. It is primarily intended to provide technical guidance to ADB staff and is not subject to compliance review under ADB's Accountability Mechanism.

Contents

A. Objective and Scope

1. The Asian Development Bank's (ADB) 2021 Energy Policy[1] states that "ADB's Energy Sector Group will prepare staff guidance elaborating upon the screening criteria for ADB operations involving natural gas, large hydropower plants, and waste-to-energy plants. The staff guidance notes will be updated, as needed, to reflect the criteria set forth in the joint methodology developed by the Multilateral Development Bank Working Group on Paris Alignment, in ADB's updated safeguard policy, and any other relevant policy or staff guidance issued after the approval of the 2021 Energy Policy."

2. The aim of this guidance note is to support project teams in the planning, design, and development of large hydropower plants (new or modernization[2]) based on the requirements set out under the (i) ADB Energy Policy 2021, (ii) ADB Safeguard Policy Statement 2009 (SPS 2009),[3] (iii) ADB Water Sector Directional Guide,[4] (iv) ADB Paris Agreement Alignment (PAA) Guidance Note,[5] and the (v) Common Principles of Climate Mitigation Finance Tracking.[6] In addition, the guidance note provides references to international good practices for consideration by project teams.

3. All of ADB's large hydropower projects, sovereign and nonsovereign[7], have to follow the requirements set in ADB's Energy Policy 2021, SPS 2009, and the ADB PAA Guidance Note. Furthermore, large hydropower projects should meet the requirements indicated in the Common Principles of Climate Mitigation Finance Tracking, if and when applicable.

4. This guidance note complements the information provided in the ADB PAA Guidance Note in which the complete process to assess, monitor, and report the alignment of an operation with the PAA is outlined. Users of the ADB's guidance note on large hydropower plants should refer to the ADB PAA Guidance Note for detailed information on how to screen and assess the alignment of operations with the PAA, using the ADB's guidance note on large hydropower plants as an additional resource with subsector-specific information.

5. For the purpose of this guidance note only, large hydropower plants are defined as incorporating a large dam in their design in accordance with the International Commission on Large Dams, and as indicated in ADB's Energy Policy 2021 (Paragraph 69). Accordingly, the adapted definition will be "a hydropower plant with a dam height of 15 meters or greater from lowest foundation to crest or a dam between 5 meters and 15 meters impounding more than 3 million cubic meters of water."[8]

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[1] ADB. 2021. *Energy Policy – Supporting Low Carbon Transition in Asia and the Pacific*. Manila. Approved in September 2021.
[2] Projects covering the modernization and expansion of existing large hydropower plants, including but not limited to, replacing, refurbishing or upgrading electromechanical equipment and civil infrastructure and updating control systems and beyond routine operation and maintenance practices.
[3] ADB. 2009. *ADB Safeguard Policy Statement*. Approved in June 2009. Currently under review
[4] ADB. 2022. *ADB Water Sector Directional Guide – Water-Secure and Resilient Asia and Pacific*. Approved in November 2022.
[5] Guidance Note on Implementing Operations' Alignment with the Paris Agreement at ADB. Version 1.7. Approved in October 2022 (internal document).
[6] Common Principles for Climate Change Mitigation Tracking. Version 3. 18 October 2021.
[7] As stated in ADB's Energy Policy 2021, Paragraph 116, the Policy applies to project loans, sector loans, policy-based loans, results-based loans, financial intermediary loans, equity participation, grants, and technical assistance. This includes both sovereign and nonsovereign operations.
[8] International Commission on Large Dams – Definition of Large Dams

6. In the absence of an internationally supported definition, run-of -river hydropower plants are defined here as a plant that generates power from the daily flow of a river and tends to include operational pondage limited to the mean annual flow for a 24-hour period. It is noted that many run-of-river projects operate in (cascade) series and can benefit from larger regulating structures located upstream.

7. The guidance note will apply to all types of large hydropower plants including hydropower pumped storage, modernization and expansion of large hydropower projects. The decommissioning of large hydropower plants, and all other hydropower projects that are not defined as large hydropower plants, are not covered under this guidance note.

8. Planning, designing, developing, and operating large hydropower projects, while minimizing their negative environmental and social impacts, needs to be carefully and fully assessed on a case-by-case basis due to uniqueness of each large hydropower project, and its geopolitical and transboundary context. Project teams are allowed to have a flexible case-by-case approach based on the specific project needs and risks, and to adapt their approaches subject to strict compliance with ADB policy requirements. The guidance note indicates ADB's policy requirements relevant to large hydropower projects and provides recommendations, lessons learned, and references to international good practices for large hydropower plants, for consideration by project teams.

9. Project teams can also consider other relevant ADB policies and strategic documents, which are not covered in this guidance note, such as Strategy 2030,[9] Gender and Development Policy,[10] Social Protection Strategy,[11] and Operational Frameworks, among others.

10. The Sustainable Development and Climate Change (SDCC) department, and in particular the Energy Sector Group (ESG) team, is available to advise project teams on large hydropower projects.

11. This guidance note was prepared by the ESG with inputs from the ADB's Water Sector Group (WSG) and the Safeguards Division.

B. Introduction

1. Typology of Hydropower

12. A common way to differentiate hydropower is in terms of purpose: run-of-river, storage (or reservoir), and pumped storage. In addition, there are further distinctions made in hydropower such as "low-head" and "high-head;" "small," "medium," and "large."

13. The boundary between the categories is not distinct. Run-of-river projects usually involve more limited storage, with a smaller ratio between the water volume stored and the rate of water discharged by the hydropower station. Run-of-river projects may, for example, store the equivalent volume to that which would be accumulated by the mean flow at the site in one or more days. Storage projects usually involve sizeable reservoirs that can store water for long periods of

[9] ADB. 2018. *Strategy 2030: Achieving a Prosperous, Inclusive, Resilient, and Sustainable Asia and the Pacific*. Manila.
[10] ADB. 2003. *Policy on Gender and Development*. Manila.
[11] ADB. 2001. *Social Protection Strategy*. Manila.

time, including across wet and dry seasons, and sometimes even storing water to manage inter-annual variability.

14. Pump-storage hydropower is a type of energy storage using the potential energy of water to balance electrical supply and demand. Pump-storage hydropower normally has a configuration of two water reservoirs at different elevations. The station generates power (discharges) as water moves down from the upper to the lower reservoir, passing through a reversible unit in turbine mode. In times of surplus electricity in the system, the unit can be switched to pump mode (recharge) by drawing power from the system to pump water back to the upper reservoir.

15. There are multiple variants and hybrids of pump-storage hydropower. Open-loop pump-storage hydropower tends to be located on a river course, abstracting water as a consumer when there is surplus electricity in the system. Closed-loop pump-storage hydropower utilizes two water bodies that are isolated from a river system (save for the abstraction necessary for their impoundment). Often there is some natural inflow to the upper reservoir (local precipitation and runoff), which avoids a certain proportion being pumped before release for generation. The contribution of upstream inflow and downstream pumping creates a hybrid spectrum between conventional reservoir storage hydropower and pump-storage hydropower typologies. Another variant is when water is augmented by pumping from additional sources at interim levels between the two reservoirs.

2. Role of Hydropower in the Clean Energy Transition

16. Hydropower remains the largest source of renewable electricity worldwide—more than all other renewable energy generation combined. By 2021, global hydropower installed capacity reached 1,360 gigawatts (GW), of which about 50% is in Asia and the Pacific. Hydropower is the main source of electricity generation for several of ADB's developing member countries (DMCs) such as Bhutan, Cambodia, Georgia, the Kyrgyz Republic, Lao People's Democratic Republic (Lao PDR), Nepal, and Tajikistan.

17. In 2021, an additional 26 GW of hydropower capacity was installed globally, of which 24 GW (92%) was in Asia and the Pacific, mainly in the People's Republic of China (PRC) with 21 GW. According to the International Hydropower Association (IHA), most of the unutilized hydropower potential (excluding hydropower pumped storage, where the potential is widespread) lies in Asia and the Pacific, with estimates of 359 GW in East Asia, Southeast Asia, and the Pacific and 355 GW in South and Central Asia. [12]

18. The International Energy Agency (IEA) projects that hydropower capacity would need to increase considerably to achieve net-zero by 2050.[13] Based on IEA's net-zero emission scenario, an average 48 GW of new sustainable hydropower capacity would need to be added worldwide every year between 2020 and 2030—almost double that of the global hydropower capacity added in 2021 and well above the 22 GW average annual capacity added in the last 5 years. Assuming 2021 global weighted average total installation costs of $2,134 per kilowatt capacity for hydropower, the total hydropower installation costs would amount to at least $1,024 billion in 10 years (more than $100 billion per year).[14] Hydropower plays a major role in the transition from

[12] IHA. 2022. *Hydropower Status Report – Sector Trends and Insights*.
[13] IEA. 2021. Hydropower has a crucial role in accelerating clean energy transitions to achieve countries' climate ambitions securely. Press release. 30 June.
[14] International Renewable Energy Agency. 2021. Renewable Power Generation Costs in 2021.

fossil fuels like coal and oil, especially if early retirement of coal-fired power plants continues to materialize and the proportion of variable renewable energy continues to increase. The energy transition represents a paradigm change in power system operation: moving from a system of fully controllable power generation that has to follow non-controllable load demand, into a variable renewable energy-rich generation mix where neither side of the equation were fully controllable. This change calls for adaptation and innovation in how generation equipment and operations needed to respond, across the entire time spectrum—from microseconds to seasons.

19. Both run-of-the-river (typically supplying base-load generation) and storage hydropower (providing base- and peak-load generation) will need to enhance their characteristics in relation to scheduling, dispatch, and flexibility of supply. Moreover, there is increasing demand for large-scale energy storage to manage rising variable renewable energy generation surpluses. Hydropower pumped storage is seen as one of the most cost-effective storage technologies today.[15] Overall, a net-zero emission scenario will require more investment in hydropower plants in a short-time span, whereby hydropower projects with reservoirs and hydropower pumped storage would have an ever more important role. It is extremely important to assess the future system needs and specify the type of hydropower that has the best system fit.

20. Equally important is the modernization of existing hydropower to enhance energy security, improve performance and flexibility to support the uptake of variable renewable energy, and better manage water flows with expected increase in global temperatures and extreme climate events (i.e., droughts and floods).[16] By 2030, approximately one-third of the existing hydropower capacity in Asia will have undergone, or may be due for modernization. This number increases to 50% if excluding PRC.[17] Opportunity should be taken to modernize older assets, rather than restoring their as-built characteristics. Experience from the previous operational life, and assessing the needs of the system, will be key.

21. Another aspect of the changing demands on hydropower assets is the change in remuneration for generation services to the grid. The trend in electricity markets is for them to become more fragmented, leading to greater complexity in terms of revenue streams. For example, traditionally, long-term power purchase agreements (PPA) have been the basis for the project's viability. While PPAs remain fundamental to building the business case, an increasing proportion of revenues will be derived from demand-based markets. These developments included the forward market (capacity auctions for months and weeks ahead), spot market (day-ahead and intraday markets), along with system-based "real-time" balancing markets (including frequency containment, restoration, and replacement reserves).

22. The majority of large hydropower investments in ADB's DMCs are dependent on government budgets complemented by sovereign loans from multilateral developments banks (MDBs), bilateral development agencies and other donors. MDBs will need to continue to play a critical role to ensure that the DMCs account for the future demands on hydropower operations to ensure that projects have a good system fit, and uphold the highest environmental and social standards and international good practices in the design, construction, and operation of sustainable hydropower projects. The section below highlights ADB's extensive experience in the

[15] Pacific Northwest National Laboratory. Energy Storage Cost and Performance Database.
[16] IEA. 2021. IEA Tracking Report on Hydropower.
[17] If excluding the PRC.

development of large hydropower projects and reflects on lessons learned from past ADB experience.

3. ADB's Hydropower Investments and Lessons Learned

23. In the last 20 years, ADB has financed 29 hydropower projects, almost all of which include a large dam (Annex 1). A total of 20 hydropower projects were sovereign projects, 8 nonsovereign, and 1 project was supported by both sovereign and non-sovereign loans. The overall ADB funding provided for hydropower projects over this period amounted to approximately $4.7 billion with a total installed capacity of almost 6 GW.

24. The types of hydropower projects previously supported by ADB comprise a variety of designs:

(i.) greenfield run-of-river hydropower plants which include a large dam;

(ii.) greenfield storage hydropower plants with large dams;

(iii.) retrofit of existing hydropower with an upper or lower reservoir to create a pumped storage system;

(iv.) rehabilitation and upgrades to increase capacity and energy output;

(v.) installation of new generation capacity at the outlet of an existing hydropower plant;

(vi.) greenfield hydropower plants that do not include a large dam; these are limited to off-grid "micro" and "mini" hydropower designs and include upgrades of traditional water mills, and installations on irrigation canals.

25. **Lessons learned from ADB's Independent Evaluation Department**. Since 2002, ADB's Independent Evaluation Department (IED) completed project performance evaluation reports for the following four large hydropower projects:

(i.) Nam Theun 2 (2020), a 1070 megawatt (MW) greenfield hydropower plant;[18]

(ii.) Song Bung 4 (2018), a 156 MW greenfield hydropower plant;[19]

(iii.) Erlongshan (2015), a 50.5 MW greenfield run-of-river hydropower plant;[20] and

(iv.) Xiaogushan (2013), a 102 MW greenfield run-of-river hydropower plant.[21]

26. These four projects are representative of ADB's portfolio, which is dominated by greenfield hydropower projects. The evaluation reports for the four projects above are publicly available and lessons learned are highlighted below.

27. IED rated Nam Theun 2 and Song Bung 4 as overall *successful*. Both these projects have reservoirs and are in the Lao PDR and Viet Nam, respectively.

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[18] IED. 2020. *Lao People's Democratic Republic: Greater Mekong Subregion - Nam Theun 2 Hydroelectric Project Evaluation Document*. Manila: ADB.

[19] IED. 2018. *Viet Nam: Song Bung 4 Hydropower Project Evaluation Document.* Manila: ADB.

[20] IED. 2015. *People's Republic of China: Gansu Heihe Rural Hydropower Development Investment Program— Erlongshan Hydropower Project Evaluation Document*. Manila: ADB.

[21] IED. 2013. *People's Republic of China: Gansu Clean Energy Development Project Evaluation Document*. Manila: ADB.

28. For Nam Theun 2, IED highlighted several points for consideration in future hydropower investments: (i) international financial institution collaboration can yield a major developmental contribution with a high-risk project in a limited-capacity country; (ii) quality project sponsors are essential for success, but their limitations also need to be considered; (iii) a large and complex development project requires a commensurate and substantive long-term commitment; (iv) it is important to avoid overly ambitious objectives in project design; (v) overly prescriptive approaches limit the scope for adaptive management of, for example, livelihood restoration programs for project-affected people; (vi) a more inclusive approach is required for biodiversity conservation, whereby "conservation forest" is balanced with "production forest" as a source of income for affected people; and (vii) it is essential to carefully study and consider less socially and environmentally disruptive options in investment decision making in hydropower. The points (v) through (vii) are particularly relevant to environmental and social sustainability of hydropower projects, when viewed in comparison to the Erlongshan and Xiaogushan projects below (noting that these run-of-river projects provide less system benefits). ADB's engagement in the Nam Theun 2 project was long, officially beginning with project preparation technical assistance approved in 2003. ADB provided a sovereign loan, which closed in February 2011, and a nonsovereign loan to the project company, which was scheduled to close in May 2022.

29. For Song Bung 4, IED also highlighted areas for future improvement: (i) continued independent monitoring of environmental impacts, (ii) regular training on livelihood-enhancement measures, and (iii) a dam break study to understand the potential downstream impact. Additional detailed comments included:

(i.) The project environmental impact assessment (EIA) and environmental management plan (EMP) did not address dam safety and measures to enhance and monitor workers and contractors' health and safety issues in a detailed manner. The assessment of possible benefits and viability of fish ladders for migratory fish was missing. The environmental compensation flow was insufficient for fishing as a productive endeavor below the dam and only some aquatic vegetation and small fish survived in shallow pools;

(ii.) Biodiversity conservation and sustainable natural resource management did not materially meet ADB safeguard requirements;

(iii.) The project did not materially meet ADB requirements for effluent treatment and project impact on river water quality during construction;

(iv.) The occupational health and safety performance of the project was unsatisfactory because it exposed its workers and contractors to excessive health risks, resulting in at least six fatalities.

30. IED rated Erlongshan and Xiaogushan as overall *highly successful*. These projects are part of a cascade system of eight plants on the Hei He river in the PRC, which were built over a period of 25 years. These plants were also expected to be sustainable due to limited negative site-specific impacts. Both were qualified as Clean Development Mechanism (CDM) projects and secured revenue from the sale of Certified Emissions Reductions after they became operational. The Hei He river is not connected to the ocean; rather, it flows into and disappears in the southern Gobi basin. There are multiple dams and diversion structures downstream of the two hydropower plants that completely obstruct the flow of the river. The Hei He river valley is sparsely populated, so the projects were minimally disruptive to residents of the project area. The hydropower plants

were integral to retirement of coal-fired power plants in the project area, which facilitated qualification for CDM. The CDM criteria for Erlongshan[22] and Xiaogushan were quite simple at the time: a power density greater than 10 Watts per square meter of flooded area was the metric for registration as a CDM project (see Section H for more details on power density and lifecycle emissions).

C. ADB Policies and Large Hydropower Plants

31. This section provides an overview of the relevant ADB requirements for large hydropower plants under (i) ADB's Energy Policy 2021, (ii) ADB's Safeguard Policy Statement 2009 (SPS 2009) and (iii) ADB's Water Sector Directional Guide. The SPS 2009 is under review, and this section will be updated accordingly once the new Policy Statement is approved.

1. ADB 2021 Energy Policy

32. If considering a large hydropower project, the first step is to ensure conformity with the requirements set in ADB's Energy Policy 2021, approved in October 2021, as follows:

(i.) Large hydropower systems may be supported after careful consideration of their political, social, and environmental contexts.

(ii.) ADB will be selective in its support for storage hydropower plants, including pumped-storage hydro plants.

(iii.) ADB will support large hydropower schemes that have been evaluated in a robust environmental and social assessment, including an ecologically led e-flow assessment,[23] and after consideration of alternative locations and designs.

(iv.) For all hydro plants, particular attention will be paid to ensuring an eco-sensitive design, compensation for land acquisition and resettlement, and livelihood restoration in accordance with SPS 2009 as well as international good practices for large hydropower projects.

33. The ADB Energy Policy 2021 does not prohibit any specific designs or types of hydropower. Rather, it acknowledges the several technical, environmental, and social risks inherent of developing, permitting, financing, constructing, and operating large hydropower plants, which tend to have high upfront capital costs and long gestation periods, resulting in high transaction costs.

34. The statement that ADB will be selective in its support for storage hydropower plants does not mean there is a set maximum number of projects that ADB can finance per year. Each project will have to be assessed on a case-by-case basis subject to meeting technical, economic, financial, environmental and social safeguard requirements set in ADB's policies.

35. The opportunity costs associated with larger hydropower projects should be considered along with no-project option and alternative locations and designs of the project or its components,

[22] United Nations Framework Convention on Climate Change. Clean Development Mechanism. [Project 0574: Erlongshan Hydropower Project in Gansu Province]

[23] Defined by the International Finance Corporation (IFC) as the quantity, frequency, timing, and quality of water and sediment flows necessary to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems.

including, selecting the optimal hydropower plant capacity from technical, economic, environmental, and social perspective. As part of the economic analysis, project teams should also compare to feasible project alternatives from the system perspective; for example, ensuring the capacity to integrate adequate volumes of solar and wind. [24] If the large hydropower plant has multipurpose uses, these alternative locations and designs will need to take these multiple uses into consideration.

36. Furthermore, the alternatives should consider whether specific designs will qualify as climate mitigation and adaptation finance in accordance with the Common Principles of Climate Mitigation Finance and Adaptation Tracking. For example, the rehabilitation of an existing large hydropower plant augmented with floating solar photovoltaic (PV) panels in the reservoir, may be a more attractive alternative with respect to total capital costs, shorter implementation period, and reduced transaction costs (including environmental and social safeguards management costs).

2. ADB Safeguard Policy Statement 2009

37. ADB's SPS 2009[25] sets out the policy objectives, scope, and principles for three key safeguard areas:

(i.) avoid adverse impacts of projects on the environment and affected people, where possible;

(ii.) minimize, mitigate, and/or compensate for adverse project impacts on the environment and affected people when avoidance is not possible; and

(iii.) help borrowers/clients to strengthen their safeguard systems and develop the capacity to manage environmental and social risks.

38. **Environmental safeguards.** Large hydropower projects and their existing and/or associated facilities should be screened as early as possible to determine the appropriate extent and type of environmental assessment so that appropriate studies are undertaken commensurate with the significance of potential impacts and risks. If possible, large hydropower projects should be evaluated as part of a system needs assessment and robust strategic environmental and social assessment that has considered both alternative locations and designs in relation to the system needs. This assessment will need to have been informed by current and appropriate environmental and social baseline data, with particular attention paid to assessing induced and cumulative impacts on aquatic and terrestrial ecology (e.g., impacts on habitat and migratory species), affected communities and vulnerable groups.

39. Large hydropower projects are likely to be categorized as A for environment. When projects are situated in high-risk locations and their failure or malfunction may threaten the safety of communities, the borrower or client will engage qualified and experienced experts, separate from those responsible for project design and construction, to conduct a review as early as possible in project development and throughout project conceptualisation, design, construction, and commissioning.

[24] This comparison with alternatives is conducted during the economic analysis of the project as stated in ADB's Guidelines for the Economic Analysis of Projects.
[25] ADB. 2009. *ADB Safeguard Policy Statement*. Approved in June 2009. Currently under review

40. On a case-by-case basis, large hydropower projects may also be categorized as highly complex and sensitive projects (HCS), which mandates the need for establishing an independent Panel of Experts (POE)[26] and increases the frequency of monitoring reports. The HCS categorization is established in consultation with the ADB's Safeguard Division (SDSS) and endorsed by the Chief Compliance Officer (CCO). See Section D on "International Good Practices on Dam Safety" for further guidance.

41. At a project level, independent environment, social, and dam safety experts (such as lenders' technical advisors) should be involved from the start in project design and implementation, with particular attention paid (but not limited) to ensuring eco-sensitive design, such as an ecologically led e-flow assessment and the inclusion of appropriate mitigation for the blockage of fish passage by construction of the dam[27] as applicable, ecological offsets, community health and safety measures both during construction and operations, compensation for land acquisition and resettlement, and livelihood restoration.

42. The environmental assessment for each proposed project needs to identify potential direct, indirect, cumulative, and induced impacts and risks to physical, biological (with particular attention to critical and/or natural habitat, and migratory species), socioeconomic (including impacts on livelihood, health and safety, vulnerable groups, and gender issues), and physical cultural resources in the context of the project's area of influence. For large hydropower projects, a separate cumulative impact assessment should be conducted at an earlier stage (e.g., pipeline programming stage) to help address this requirement. The assessment should also consider potential transboundary impacts as defined by the SPS 2009.

43. The project alternatives need to be evaluated related to the project's location, design, technology (including different or combination of energy producing technologies), and components and their potential environmental and social impacts and the rationale for selecting the alternative proposed be documented. The "no project" alternative should also be carefully assessed considering the global landscape and the borrower's needs.

44. The project design should avoid—and where avoidance is not possible—minimize, mitigate, and/or offset adverse impacts and enhance positive impacts by means of environmental planning and management. In case of uncertainty of the magnitude of impacts and minimization, mitigation, and/or offsetting effectiveness, precautionary approach and provisions for adaptive management should be applied.

45. An EMP, including the proposed mitigation measures, environmental monitoring and reporting requirements, related institutional or organizational arrangements, capacity development and training measures, implementation schedule, cost estimates, and performance indicators, has to be prepared as part of the EIA and incorporated in the bidding documents for the contractor. The EMP may include additional hydropower-related plans such as (but not limited to) a reservoir management plan, an e-flow implementation plan, a biodiversity management and monitoring plan, an upstream catchment management plan, a fisheries management plan, river safety management plan for peaking power operation, an emergency preparedness and response plan, stakeholder's engagement and communication plan, and statutory safety inspections and

[26] The composition of the panel is decided on a case-by-case basis, depending on the specific risks of the project. It may include environmental, social and engineering specialists.
[27] It may include fish passes, designed on the specific requirements of the migratory species present in the river. Other measures as hatcheries of "trap and haul" systems are often deemed ineffective in the long period.

safety planning. The EMP (informed by the EIA) and its key aspects (such as e-flow and fish passes) need to be incorporated as design requirements in the bidding documents.

46. Project proponents should carry out meaningful consultation[28] with affected people, ensuring women, vulnerable groups and other key stakeholders such as civil society organizations are included, and facilitate their informed participation, and involve stakeholders in the project preparation process and ensure that their views and concerns are made known to and understood by decision makers and considered. Continued consultations with stakeholders throughout project implementation as necessary to address issues related to environmental assessment are necessary. Project proponents should establish a grievance redress mechanism to receive and facilitate timely resolution of concerns raised by the affected people, vulnerable groups and civil society on project's environmental and social performance.

47. The project should disclose a draft environmental assessment (including the EMP) in a timely manner, in an accessible place and in a form and language(s) understandable to affected people and other stakeholders, as required by the SPS 2009. Their views should be included in the final disclosed EIA.

48. The project proponent should implement the EMP and monitor its effectiveness during construction, operation, and decommissioning. Document monitoring results, including the development and implementation of corrective actions, and disclose monitoring reports in a frequency commensurate with the risk (for Category A projects, biannual reports during construction are required). An independent expert, separate from the project owner and the borrower, is required to review and verify the monitoring reports for Category A projects.

49. No project should be implemented in areas of critical habitats,[29] unless (i) there are no measurable adverse impacts on the critical habitat that could impair its ability to function, (ii) there is no reduction in the population of any recognized endangered or critically endangered species, and (iii) any lesser impacts are mitigated. If a project is within a legally protected area, the project should implement additional programs to promote and enhance the conservation aims of the protected area. In an area of natural habitats, there must be no significant conversion or degradation, unless (i) alternatives are not available, (ii) a comprehensive cost-benefits analysis demonstrates that the overall benefits from the project will substantially outweigh the project costs including environmental costs, and (iii) any conversion or degradation is appropriately mitigated.

50. If the project is expected to have impacts on biodiversity, SPS 2009 requires the achievement of "no net loss of biodiversity." An early involvement of a biodiversity specialist and consultation with SDSS is recommended to identify the feasibility of such safeguards policy requirement being complied with given potential impacts.

51. Project teams should apply pollution prevention and control technologies and practices consistent with international good practices as reflected in internationally recognized standards. Adopt cleaner production processes and energy efficiency practices. Avoid pollution, or, when

[28] As defined by SPS 2009

[29] Areas with high biodiversity value, including habitat required for the survival of critically endangered or endangered species; areas having special significance for endemic or restricted-range species; sites that are critical for the survival of migratory species; areas supporting globally significant concentrations or numbers of individuals of congregatory species; areas with unique assemblages of species or that are associated with key evolutionary processes or provide key ecosystem services; and areas having biodiversity of significant social, economic, or cultural importance to local communities.

avoidance is not possible, minimize or control the intensity or load of pollutant emissions and discharges, including direct and indirect greenhouse gas (GHG) emissions (including the emissions from the reservoir), waste generation, and release of hazardous materials from their production, transportation, handling, and storage. Avoid the use of hazardous materials subject to international bans or phaseouts.

52. Project proponents should provide workers with safe and healthy working conditions and prevent accidents, injuries, and disease and establish preventive and emergency preparedness and response measures to avoid—and where avoidance is not possible—to minimize adverse impacts and risks to the health and safety of local communities.

53. Project proponents should conserve physical cultural resources and avoid destroying or damaging them by using field-based surveys that employ qualified and experienced experts during environmental assessment. Provide for the use of “chance find” [30] procedures that include a pre-approved management and conservation approach for materials that may be discovered during project implementation.

54. **Social safeguard requirements and considerations.** The most challenging social safeguards related risks and impacts of large hydropower projects result from land acquisition (LA) and land use restriction (LUR), as well as other socioeconomic (non-LA) impacts of the construction, operation and decommissioning of such projects, including impacts on indigenous peoples (IP) communities.

55. **Land acquisition and land use restriction.** The safeguards requirements of the SPS 2009 under the Involuntary Resettlement (IR) Safeguards and the Safeguard Requirements (SR) SR 2: Involuntary Resettlement may be triggered due to (i) involuntary acquisition of land from affected persons (APs) and other legal entities for the inundated reservoir area as well as powerhouse, channels and other infrastructure facilities; (ii) involuntary restriction of land use in protected areas of the catchment and in other surrounding areas of a hydropower project; (iii) loss of livelihood due to the loss of income sources resulting from LA and LUR, as well as the impairment of ecosystem services on which APs depend due to tunneling, muck deposits and landslides, and various downstream impacts, such as the impairment of surface waters, wetlands and forested land; and (iv) relocation and resettlement due to the loss of residential and business premises, as well as of essential public services.

56. The key risk and impact management tasks required includes: (i) screening and scoping of asset and livelihood losses; (ii) stakeholder engagement with APs and the establishment of a grievance mechanism throughout the project cycle; (iii) the assessment of alternative project designs and the justification of the selected option; (iv) a detailed social impact assessment for the selected design with a census and socioeconomic baseline survey and the assessment and valuation of lost assets at replacement cost; (v) planning and implementation of mitigation measures, including compensation of asset losses and/or relocation to resettlement sites or self-relocation, and/or livelihood restoration and improvement, as applicable, through land acquisition and resettlement plans (LARP); and (vi) the monitoring and evaluation of LARP implementation.

57. Before large hydropower projects are implemented, it is important to assess risks and impacts in the entire area of influence of the project, including the sites for the project facilities,

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[30] When artefacts or sites of cultural heritage are encountered by chance while undertaking excavation during construction activities, they are known as “chance finds.”

the catchment and other surrounding areas and the downstream areas impacted by project measures, as well as other existing and associated. A comprehensive and gender-sensitive social impact assessment of the asset, resource and livelihood losses of affected persons, their capacity and interests, current livelihood systems, existing human resources and the division of labor needs to be conducted. Local resource bases and markets for goods, services and labor, as well as available civil society organizations with the capacity to provide skills training and financial services must be assessed, in order to develop a viable and sustainable livelihood restoration and improvement strategy. The projects need to develop LARPs, which provide for the compensation of lost assets at replacement cost and adequate livelihood restoration measures, as well as sharing of project benefits with affected communities, and ensure the required resources for their implementation. Relocation to resettlement sites developed by the project or self-relocation by the displaced persons require comprehensive planning and implementation, ensuring timely availability of land and structures with secure tenure based on the replacement principle, as well as of other essential public infrastructure and services. Social and environmental impacts on host communities receiving the relocated displaced persons need to be assessed and mitigated as well, to prevent resource and cultural conflict. All mitigation measures are to be based on the replacement principle, which requires that in-kind replacement of land and assets offered to the displaced persons is at least equivalent in their material characteristics and use value and provided with security of tenure and advantages of location, or that cash compensation is paid at replacement cost, i.e., current actual market prices for comparable assets plus all transaction costs and without deduction for depreciation. While in areas without functioning markets for land and other assets fair market prices may not be available and alternative equivalent compensation standards may need to be negotiated between the affected persons and the project proponents, in-kind compensation through land-based resettlement should always be considered as the preferable option. The SPS 2009 requires that displaced persons without titles to land and/or formal land use rights are eligible for the compensation of all non-land assets and that vulnerability among displaced persons is addressed to ensure that adverse impacts do not fall disproportionately on vulnerable displaced persons.[31] The project management and implementation units of the borrower or client need to engage trained and experienced social safeguards specialists to carry out the management of LA and LUR and engage independent external social safeguard monitoring experts for projects with significant social impacts. For highly complex and sensitive projects, which are likely among many large hydropower projects, an independent advisory panel of social and environmental experts needs to be engaged as well. Given that large hydropower projects are likely to cause significant involuntary resettlement impacts, project proponents should consider implementing the involuntary resettlement component where feasible, and, if applicable, the Indigenous Peoples related component of the project as a stand-alone operation.

58. **Indigenous peoples.** Large hydropower projects planned and implemented in locations where IP communities live and carry out livelihood activities may affect these even more severely than other displaced persons and, in addition to the same LA and LUR related assessment and mitigation measures required under SR 2 and indicated above, would trigger the SPS 2009 requirements of the IPs Safeguards and SR 3: Indigenous Peoples. The proponents of

[31] Defined in the SPS 2009 as displaced persons with incomes below the poverty line, the landless, the elderly, women and children, and IPs, and those without legal title to land.

hydropower projects are required to undertake a full EIA and the preparation of mitigation plans that (i) identify measures to avoid, minimize, mitigate, or compensate for any adverse project impacts; (ii) specify measures to ensure that IPs receive culturally appropriate benefits; and (iii) include culturally appropriate grievance procedures, monitoring and evaluation arrangements, as well as a budget and time-bound actions for implementing the planned measures. Due to the special vulnerability of most IPs, the SPS 2009 requires obtaining the consent of IP communities in the form of broad community support (BCS) for a project that involves the physical displacement of IPs and/or the commercial development of natural resources within the customary lands under use by IPs. Physical displacement and the loss of livelihoods or of the cultural, ceremonial, or spiritual uses of resources that define the identity and community of IPs would require the preparation of combined Indigenous Peoples and Land Acquisition Plans, which clearly demonstrate and verify with documentary evidence how the BCS of affected IP communities was obtained. The borrower or client needs to engage trained and experienced social safeguards specialists with anthropological expertise to carry out the management of IP safeguards and ensure meaningful consultation and full participation of IP communities and consideration of their knowledge and interests in the planning and implementation of the project and all required mitigation measures. Unimpeded access to a culturally appropriate and gender inclusive grievance mechanism needs to be ensured. However, if a hydropower and dam project planned in locations where IP communities live and carry out livelihood activities is unable to obtain BCS, the project will not be able to proceed.

59. **Dam safety.** ADB considers dam safety in its safeguard policies with requirements provided in Appendix 1 of the SPS 2009 under the heading “Community Health and Safety.” There are general requirements for projects, including for borrowers or clients to “identify and assess the risks to, and potential impacts on, safety of affected communities, during the design, construction, operation and decommissioning of the project, and will establish preventive measures and plans to address them in a manner commensurate with the identified risks and impacts.” The focus on risks is particularly important and includes exposure to both accidental and natural hazards including floods, earthquakes, landslides and glacial lake outburst floods (GLOF), taking into consideration all climate change scenarios.

60. The SPS 2009 further requires the borrower/client “to inform affected communities of significant potential hazards in a culturally appropriate manner” and be prepared to respond to accidental and emergency situations, including preparation of “response planning document(s) that address the training, resources, responsibilities, communications, procedures, and other aspects required to respond effectively to emergencies associated with project hazards.” The statement requires that “appropriate information about emergency preparedness and response activities, resources, and responsibilities will be disclosed to affected communities.”

61. A specific reference is made to “structural elements or components, such as dams, tailings dams, or ash ponds,” in high-risk locations where the safety of the community is threatened. It requires that the “borrower/client will engage qualified and experienced experts, separate from those responsible for project design and construction, to conduct a risk assessment as early as possible in project development and throughout project design, construction and commissioning.” Note that this does not limit the coverage of the SPS 2009 to the conventional definition of large dams and can include any structure that is deemed to be high risk including temporary coffer dams.

3. ADB Water Sector Directional Guide

62. The ADB's Water Policy 2001 and the Water Operational Plan 2011 do not cover hydropower specifically. However, the Water Sector Directional Guide (WSDG)[32] contains the following provisions related to hydropower:

(i.) Hydropower is seeing a resurgence and will be promoted further to complement wind and solar and to provide back-up capacity, reservoir storage, and grid stability to balance the intermittent production of solar and wind. This supporting role of hydropower will produce greater diurnal variability of river flows as projects switch on and off rapidly to stabilize grid voltage, leading to impacts for communities and ecosystems downstream. Such interconnectivity strengthens the argument for more coordinated planning and operation of electricity and water resource systems to seek mutual benefits and mitigate impacts.

(ii.) Hydropower projects contribute toward national climate mitigation and adaptation, and renewable energy targets although, as with other projects that change a river's hydrology, they can have a wide range of social and environmental impacts. ADB will consider supporting the construction of new dams and hydropower projects where they emerge from a comprehensive planning and options assessment process as the most appropriate intervention and, for transboundary projects, fit within a framework of regional cooperation. Knowledge of impact avoidance and mitigation measures related to dam projects has advanced considerably and international good practices will be applied in line with ADB's safeguards. Existing dams provide a large asset base in many countries and there is scope for upgrading and remodeling them to increase output and to meet changing demands and societal needs. More efficient turbines, dam raising, reservoir re-operation and environmental releases provide potential solutions to raise productivity and mitigate impacts while reducing the need for new projects. Close coordination with water regulators is needed early in the planning and contract negotiation processes of private sector hydropower concessions to ensure coherence between power purchase provisions and river flow thresholds, including meeting the needs of downstream users and the environment.

D. Compendium of International Good Practices on Hydropower

63. The aim of this section is to provide a compendium of international good practices for large hydropower projects that can be used by ADB staff and project teams for the planning, design, and development of projects in large hydropower plants (new or modernization). This section is limited to providing recommendations and references to international good practices and does not constitute ADB requirements. For ADB requirements for large hydropower projects refer to Section C on ADB's Policies.

64. For reference, as stated in ADB's Energy Policy 2021:

[32] ADB. 2022. *ADB Water Sector Directional Guide – Water-Secure and Resilient Asia and Pacific*. Approved in November 2022.

(i.) “ADB will support large hydropower schemes that have been evaluated in a robust environmental and social assessment, including an ecologically led e-flow assessment, and after consideration of alternative locations and designs.”

(ii.) “For all hydropower plants, particular attention will be paid to ensuring an eco-sensitive design, compensation for land acquisition and resettlement, and livelihood restoration in accordance with SPS 2009 as well as international good practices for large hydropower projects.”

65. The term “good practice” can be understood as a practice which has (i) successfully addressed or resolved technical, environmental, social or other issues as a result of design and/or mitigation measures; (ii) delivered socioeconomic, environmental, social and/or other benefits as a result of hydropower development.

66. The compendium of international good practices for large hydropower projects, by alphabetical order, include:

(i.) International Finance Corporation (IFC) – Good Practice Note: Environmental, Health, and Safety Approaches for Hydropower Projects (2018): addresses environment, health and safety aspects of all types of hydropower and covers industry-specific impacts and management, as well as performance indicators and monitoring.

(ii.) IFC – Good Practice Handbook on Environmental Flows for Hydropower Projects (2018): provides guidance to practitioners on determining a project's environmental flow commitments through assessment of impacts on downstream river ecosystems and people.

(iii.) IFC – Hydroelectric Power – A Guide for Developers and Investors (2015): aims to assist all players in hydropower development, covering site selection, plant design, permitting/licensing, financing, contracting and commissioning, and explains key issues and typical responses.

(iv.) International Association of Impact Assessment – Strategic Environmental Assessment for Renewable Energy (under development)

(v.) International Commission on Large Dams (ICOLD) Bulletins:

i. Bulletin 72 - Selecting Seismic Parameters for Large Dams (1989)

ii. Bulletin 130 - Risk Assessment in Dam Safety Management (2005)

iii. Bulletin 154 - Dam Safety Management: Operational Phase of the Dam Life Cycle (2017)

iv. Bulletin 99 - Statistical Analysis of Dam Failures (2019)

v. Bulletin 140 - Mathematical Modelling of Sediment Transport and Deposition in Reservoirs - Guidelines and Case Studies (2021)

vi. Bulletin 175 - Dam Safety Management: Pre-operational Phases of the Dam Life Cycle (2021)

(vi.) International Energy Agency (IEA) – Technology Collaboration Programme on Hydropower – Good Practices: provides working group ('Annex') reports on approximately 25 topics relating to hydropower activities. Recent publications include: Annex XV Maintenance Works and Decision-Making for Hydro Facilities and Annex XIV Management Models for Hydropower Cascade Reservoirs.

(vii.) International Forum on Pumped Storage Hydropower – Working Paper on Sustainability of Pumped Storage Hydropower (2021): takes a system needs approach to energy storage and flexibility solutions to support electricity systems with large amounts of variable renewable energy sources, through system-level strategic assessment, options assessment and project optimization.

(viii.) International Hydropower Association (IHA) – Better Hydro – Compendium of Case Studies (2017): presents examples of excellence in specific aspects of sustainable hydropower development, covering 34 case studies based on Hydropower Sustainability Assessment Protocol assessments.

(ix.) IHA – Hydropower Sector Climate Resilience Guide (2019): addresses how best to access, use and interpret climate change modelling and observed climate data in the context of hydropower design and asset management., with an approach developed jointly with the European Bank for Reconstruction and Development and the World Bank Group.

(x.) IHA – Hydropower Sustainability Assurance System (2021): describes the governance and quality control mechanisms, and provides the key process elements of the Hydropower Sustainability Standard Certification Scheme.

(xi.) IHA – Hydropower Sustainability Guidelines on Good International Industry Practice (2018): defines the processes and outcomes that constitute good international industry practice. Performance against the guidelines can be measured through two complementary tools: the Hydropower Sustainability Assessment Protocol and the Hydropower Sustainability Environmental, Social, and Governance Gap Analysis Tool.

(xii.) IHA – Hydropower Sustainability Standard (2021): using a rating system, the standard certifies hydropower performance at stages of preparation, development and operation against internationally recognized levels of good practices.

(xiii.) World Bank Group – Extending the Life of Reservoirs – Sustainable Sediment Management for Dams and Run-of-River Hydropower (2016): provides guidance on adopting sediment management practices for hydropower and dam projects, with a focus on techniques addressing uncertainties related to future climate changes, and how uncertainty over future hydrological patterns may be addressed.

(xiv.) World Bank Group – Good Dams and Bad Dams: Environmental Criteria for Site Selection of Hydroelectric Projects (November 2003): addresses hydropower reservoirs, with a simple methodology for comparing proposed project sites in terms of their expected negative environmental impacts, and relating these to power generation benefits; it also summarizes environmental mitigation options.

(xv.) World Bank Group – Good Practice Note on Dam Safety (2020): provides guidance on using a risk management approach to dam safety requirements; it includes six technical notes on: hydrological risk, geotechnical risk, seismic risk, small dam safety, potential failure mode analysis, and portfolio risk assessment using risk index. It also provides sample frameworks of dam safety plans, as well as sample terms of reference for panel of experts for new dam safety review and safety assessment for existing dams.

(xvi.) World Bank Group – Using the Hydropower Sustainability Tools in World Bank Group Client Countries – Lessons Learned and Recommendations (2020): focusing on environmental, social, and governance topics, the Hydropower Sustainability Tools are deliberately aligned with World Bank Group frameworks, providing opportunities for the tools to be used as a complement to World Bank Group standards, including to help clients meet World Bank Group requirements and support World Bank Group staff in their due diligence and supervision.

67. Figure 1 provides an illustration of several of the relevant elements to consider in planning, designing, developing and operating a large hydropower project. Associated to each element are international good practices for consideration by project teams and which are covered in the references above from IFC, ICOLD, IHA and World Bank.

68. The project teams can select which elements are most relevant and applicable to the project in accordance with their expert judgment and in line with ADB’s Policies (Section C). The

compendium will be further updated based on recommendations from ADB staff and as new international good practices are introduced by leading international organizations.

69. When considering large hydropower projects, project teams should look at the level of risk and potential positive or negative impact in each of these elements. The higher the risk level, the higher the likelihood of extensive due diligence and effort from both ADB and the client, particularly in project design and implementation input.

70. For example, at an early stage, a large hydropower plant can be perceived as being of high risk, if it requires the displacement of vulnerable communities including IPs or is in: (i) an area with known complex geology, seismic risk, landslide history, critical and protected habitat; (ii) a country with a history of dam safety risks from a technical and/or operational perspective; (iii) a major international waterway. In these cases, ADB will need to dedicate sufficient resources to conduct extensive due diligence during project design and implementation.

71. In the design phase, the priority should be to ensure the most sustainable approach is selected in terms of resource use and shared benefits. If and whenever possible, project teams should be involved in early project preparation including in the assessment of alternative locations and designs based on economic, environmental and social impacts and risks.

72. Large hydropower projects can take a long time from planning stage, to design, construction and operation. Project teams are highly encouraged to follow international good practices and consider designs that are inherently sustainable and amenable to ownership participation by affected communities.

Figure 1: International Hydropower Association Hydropower Sustainability Guidelines on Good International Industry Practice

Source: International Hydropower Association. 2020. [Hydropower Sustainability Guidelines.](#)

1. International Good Practices on Dam Safety

73. This section is limited to providing recommendations and references to international good practices on dam safety and does not constitute ADB requirements.

74. Dam safety is intended to secure the water and services for which the dam was developed, as well as to protect and ensure the resilience of downstream communities, assets, and infrastructure. Dam safety and infrastructure safety is a key element of high importance for MDBs, for both new and modernisation of large hydropower projects (i.e., legacy issues).

75. Despite safety provisions, dam breaks and other accidents do happen with an overall serious incident rate historically of 1% globally. [33] Recent incidents in Asia and the Pacific include the Larji Hydropower Dam (2014) in India, the Krel 2 Dam (2013 and 2014) in Viet Nam, the Xe Pian Xe Namnoy Dam (2018) in Lao PDR, Swar Chaung Dam (2018) in Myanmar, the Sardoba Dam (2020) in Uzbekistan, and the Rishiganga Hydropower Dam in India (2021). The consequences of failure can be devastating as demonstrated by the collapse of the Xe Pian Xe Namnoy saddle dam in Lao PDR where the World Bank reported 140 casualties and there were estimates of 14,000 people displaced. Impacts can also be transboundary as in the case of Sardoba Dam where floodwaters reached downstream Kazakhstan.

76. Dam failure modes are dependent on the location, dam design and the materials used. Modes include structural failure of the dam body or appurtenant structures (e.g., saddle dams, coffer dams, etc.); overtopping of the dam structure due to gate failure, blockage or insufficient spillway capacity; seepage causing internal erosion in embankment dams; foundation failure or settlement. Most failures involve newly-built dams, occurring during first impounding or in the first years after commissioning. Limited monitoring constrains the ability to detect early signs of a problem and to take mitigating actions. Possible causes behind these failure mechanisms include insufficient investigation or design, poor construction quality, lack of maintenance, seismic activity, landslides, extreme floods, and flood waves caused by glacial lake outbursts. Loss of life and damage to property can also be caused by mis-operation of reservoir releases, e.g., the lack of prior notification of abnormal flow releases to downstream communities.

77. Safety issues need to be addressed for all dams and their appurtenant structures based on the level of risk they present. Recently, there has been a trend toward adopting an explicit risk-informed approach to dam safety that aligns the extent of safety provisions with an assessment of the risks and consequences of failure for downstream communities, property, livelihoods and the environment. This is clearly a more targeted approach, but also more complex and requires new skills. As the application of risk-based approaches is relatively new, a combination of risk-based and more conventional standards-based approaches has often been adopted.

78. Risk management approaches typically include (i) risk analysis; (ii) risk assessments; (iii) decision making for risk control and reduction measures; and (iv) monitoring and evaluation, including a robust feedback loop. [34] The extent of climate change impacts such as frequency and intensity of extreme flows and occurrence of landslides should be assessed early through climate and disaster risk screening tools. Project teams can refer to the Hydropower Sector Climate Resilience Guide listed in the Section D on Compendium of International Good Practices.

79. The extent and nature of risks will inform application of safety provisions including adoption of design guidance in respect of return periods of floods, earthquake resistant design, etc; scope and frequency of reviews by an independent panel of experts; preparation of a range of dam safety plans (including construction supervision and quality assurance, instrumentation plan, operation and maintenance plan, and emergency response and preparedness plan); prequalification of contractors; and periodic safety inspections after completion.

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[33] International Commission on Large Dams – Definition of Large Dams.
[34] World Bank. 2020. Good Practice Note on Dam Safety.

80. The World Bank's Operational Directive on Dam Safety was adopted in 1977, revised in 2001 and in 2013.[35] In 2018, following a safeguards review, dam safety provisions were incorporated into Environmental and Social Standard on Community Health and Safety (ESS4) with a dedicated annex on safety of dams and an accompanying Guidance Note. Annex 1 of the Standard notes that 'the risks associated with a dam are design and situation specific, and will vary depending on structural components, socioeconomic factors and the environment within which the dam is being constructed and will "operate" with application "proportionate to the size, complexity and potential risk of the dam". The overarching requirement of ESS4 for new dams is that: "The Borrower will engage experienced and competent professionals for the supervision of the design and construction of new dams, and require the owner of the dam to adopt and implement dam safety measures during the design, bid tendering, construction, operation, and maintenance of the dam and associated works."

81. Under the World Bank's Directive, large dams[36] require:

(i.) reviews by an independent panel of experts of the investigation, design, and construction of the dam and the start of operations;

(ii.) preparation and implementation of dam safety plans for:

a. construction supervision and quality assurance;

b. instrumentation;

c. operation and maintenance; and

d. emergency preparedness;

(iii.) prequalification of bidders during procurement and bid tendering; and

(iv.) periodic safety inspections of the dam after completion, and on implementation of measures required to address safety deficiencies.

82. In 2020, the World Bank published a Good Practice Note on dam safety covering new and existing dams (large and small). Model Terms of Reference for the independent panel are given in Appendix 5 of the Good Practice Note for new dams and in Appendix 6 for existing dams. The Note provides extensive guidance on application of risk-based approaches and on procedural matters. Annex H gives a Standard Project Preparation Data Table for Projects with Dams that is a valuable template for consideration by ADB's project teams.

83. For large dams, the World Bank requires an independent panel of experts, which consists of three or more experts, appointed by the borrower and acceptable to the World Bank, with expertise in relevant technical fields.[37] The primary purpose of the panel is to review and advise the borrower on matters relevant to dam safety and other critical aspects of the dam. Typically, the borrower will extend the Panel's composition to cover other aspects beyond dam safety such as technical design, river diversions and power facilities. The panel can be contracted as early as

[35] World Bank. 2001. OP 4.37 – Safety of Dams.

[36] World Bank defines large dams as 15 meters or more in height. Dams that are between 10 and 15 meters in height are treated as large dams if they present special design complexities. Dams under 10 meters in height are treated as large dams if they are expected to become large dams during the operation of the facility.

[37] The number, professional breadth, technical expertise, and experience of panel members are appropriate to the size, complexity, and hazard potential of the dam under consideration. For high-hazard dams, in particular, the panel members should be internationally known experts in their field.

start of project design and preparation. World Bank will send an observer to the panel meetings and a copy of meeting report is sent to the World Bank.[38]

84. Further, each country typically follows a national approach to dam safety whether covered by bespoke legislation or as a section of other sector related laws. Some may make reference to international guidance provided by professional organizations as described above. In countries where ADB has a recent history of support to dam projects, the regulatory frameworks and institutional capacities for planning, design and implementation are well known and provide the basis for discussion on the need for capacity development. For other countries, a capacity needs assessment may be needed as part of the appraisal process. So far, only a relatively small number of countries, mostly in more advanced economies, have adopted a risk-based approach. In many of ADB's DMCs, this transition will require considerable level of support. Project teams are highly encouraged to consider and engage an independent panel of experts for large hydropower projects as early as possible in the design process and preparation including in the assessment of alternatives.

E. Paris Agreement Alignment and Large Hydropower Plants

85. Climate change mitigation and adaptation measures are becoming increasingly urgent in Asia and the Pacific region. The Paris Agreement sets the goal of holding the increase in global average temperature to well below 2°C above pre-industrial levels and pursuing efforts towards limiting it to 1.5°C, and calls on all countries to undertake ambitious efforts to support global peaking of GHG emissions as soon as possible. [39]

86. To this end, MDBs have developed approaches to align operations with the goals of the Paris Agreement based on six building blocks (BB1-BB6)[40]. The ADB PAA Guidance Note[41] provides guidance to ADB staff and project teams on alignment with Mitigation Goals (BB1) and alignment with Adaptation and Climate-Resilient Operations (BB2).

87. The assessment of PAA can be done in parallel with conformity with the requirements in the ADB's Energy Policy 2021 and SPS 2009.

88. In accordance with the ADB PAA Guidance Note, there are two eligible operation types in the universally aligned list for BB1, of relevance for new and existing large hydropower projects, which are:

(i.) Run-of-the-river hydropower with negligible lifecycle GHG emissions (See Section H below on lifecycle GHG emission calculations).

(ii.) Rehabilitation and desilting of existing hydropower plants including maintenance of the catchment area (for example, a forest management plan). Rehabilitation includes works on water holding capacity of the dam and works to pipes and/or turbines to increase productivity and bring additional grid stabilization benefits and

[38] World Bank, 2001. OP 4.37 – Safety of Dams.
[39] The principles and guidance will be further refined and expanded as the building blocks road-testing progresses. ADB's internal Paris Alignment Working Group, and MDBs will regularly discuss alignment/non-alignment of projects to transparently address inconsistencies and to harmonize and improve the approach over time.
[40] BB1 and BB2 Technical Note - Joint MDB Assessment Framework for Paris Alignment for Direct Investment Operations (working draft as of November 2021)
[41] Guidance Note on Implementing Operations' Alignment with the Paris Agreement at ADB. Version 1.7. Approved on 6 October 2022 (internal document)

for pumped storage. It also includes large hydropower rehabilitation as well as rehabilitation of pumped storage basins. It does not include any projects that increase water surface and inundated areas.

89. Based on these, all new large hydropower plants with reservoir and/or pumped storage as well as run-of-the-river hydropower which do not fall under (i) and modernization projects which do not fall under (ii), such as hydropower expansion projects that lead to larger capacity and reservoir volume, will have to be assessed against BB1 specific criteria as indicated in the ADB PAA Guidance Note.

90. Unlike natural gas operations and waste-to-energy projects, the application of BB1 criteria of the PAA Guidance Note should be relatively simple noting that large hydropower still qualifies as renewable energy and in most cases as low-carbon energy resource compared to fossil fuels.

91. In addition, hydropower is typically included as a mitigation measure in Nationally Determined Contributions (NDCs) and long-term decarbonization strategies (LTS) of several DMCs. Hydropower is still one of the lowest cost renewable energy resources available today and is considered an important element of global decarbonization pathways such as the IEA's Net-Zero by 2050 Scenario.

92. Large hydropower projects are typically not perceived as stranded assets. However, questions regarding asset stranding and physical risks, require a comprehensive assessment by project teams under BB1 criteria 5 and BB2. Current climate change patterns and models show there is a high probability of (i) droughts combined with glacier thinning and retreat, reduced precipitation which might decrease average water flows; and (ii) extreme floods combined with landslides and high sediment load. All of these will be detrimental for the operation of large hydropower plants leading to asset stranding and lower lifetime of the dam. Climate resilience and adaptation measures will need to be an essential part of new and existing large hydropower plants.

93. The next section provides some examples of possible climate resilience and adaptation measures that can be considered by projects teams for large hydropower projects, and of relevance for BB2 criteria of the ADB PAA Guidance Note. These measures are also likely to be eligible for climate adaptation finance accounting under the MDB's Joint Methodology for Tracking Climate Change Adaptation Finance.[42]

F. Climate Resilience and Adaptation Measures for Large Hydropower Plants

94. There is a need to plan and design projects, covering both new and existing large hydropower plants, with climate resilience as one of their core elements to ensure these deliver the expected economic and financial benefits during the expected lifetime of the plant. A hydropower project needs to be managed in coordination with other socioeconomic and water sector uses (e.g., water supply and irrigation), even more so due to the expected increase in drought and floods risks in the future.

95. Climate change can have detrimental impacts on a range of processes that can directly influence the hydropower plant's operations. Climate change will potentially alter meteorological, hydrological, geotechnical, glacial and geomorphological processes, and the nature and

[42] Joint methodology for tracking climate change adaptation finance. November 2022.

magnitude of such changes cannot always be projected with high confidence. A climate-resilient hydropower plant is one that can absorb the potential impacts brought by climate change through improved design, construction and operation. A hydropower project which does not take into account climate risks will also increase risks to the environment and safety of local communities.

96. Accordingly, hydropower plants need to be designed for the 21st century with advanced digital technologies, more efficient and faster dispatching turbines to respond to different water flows and complement the increasing uptake of variable renewable energy (e.g., solar and wind power).

97. Characteristically, hydropower projects are capital-intensive, long-lasting, relatively difficult to retrofit (high lock-in) and present significant risks to surrounding communities and environment if under- or poorly designed. Therefore, it is essential to have a detailed and comprehensive climate risk assessment for large hydropower projects at an early stage of project design and preparation.

98. Under BB2 (Adaptation and Climate-Resilient Operations) of the PAA Guidance Note, specifically for large hydropower projects, the project teams will be expected to undertake the following three steps:

(i.) identifying and assessing physical climate risk,

(ii.) addressing physical climate risk and climate resilience, and

(iii.) assessment of inconsistency with the national/broad context for climate resilience

99. As articulated in ADB's climate risk management framework,[43] ADB conducts climate risk and adaptation assessments (CRA) for all projects determined to be at medium or high risk from the impacts of climate change, which will include most or all large hydropower projects. The climate risk management process should encompass (i) climate risk screening at concept stage, (ii) comprehensive climate risk and adaptation assessment as required during project preparation, including (iii) a technical and economic evaluation of adaptation options, (iv) identification of adaptation options, and (v) monitoring and reporting of the level of risk, and climate risk mitigation actions.

100. Examples of comprehensive CRAs for hydropower projects include the Nam Ngiep 1 and Balakot hydropower projects. These two CRAs emphasized and quantified (to the extent possible) (i) performance risks, (ii) risks to reservoir life, (iii) safety risks, (iv) environmental risks, and (v) secondary risks from climate change, which include changing frequency of hillslope failure and landslides. Managing these risks requires interventions during the design, operations and maintenance phases of the infrastructure lifecycle. These interventions are potentially costly and need to be based on robust science comparable in methodology and accuracy with the original design calculations. Furthermore, these two CRAs assessed changes in catchment hydrology, assets and sensitivity to climate change, impacts of climate change on operations and integrity, economic implications of climate change impacts and recommended adaptation priorities. The adaptation measures proposed included, for example, water quality (e.g. aeration), watershed restoration (e.g., sediment conservation, reforestation, dredging), spillage (e.g., increased

[43] ADB. 2014. *Climate Risk Management in ADB Projects*. Manila.

frequency of maintenance), overtopping (e.g., flood buffer, early warning systems), among many others.

101. Once the climate risk and vulnerability context (BB2 Criterion 1) is completed based on the CRA, the project team should consider climate resilience measures to address the physical climate risks (BB2 Criterion 2). The list of climate resilience and adaptation measures can be extensive as mentioned in the previous point for Nam Ngiep 1 and Balakot hydropower projects.

102. Below are some examples of possible technical measures for large hydropower projects for consideration by project teams. Communication, awareness and capacity building on climate change and adaptation measures are not covered below but are equally important. The list can be expanded over time based on project teams experience and new international case studies. ADB has prepared a climate adaptation options database with further list of good practices for climate-resilient infrastructure design for large hydropower projects.

103. **Water storage management.** Water storage management can be considered as climate adaptation measure since it buffers both ends of the extremes (e.g., high flows from floods are attenuated and low flows from droughts are compensated). Depending on its multipurpose use, project teams should assess how the hydropower plant might help manage water flows, particularly during extreme events and monsoon seasons, and therefore address potential climate risks.

104. **Watershed planning and management.** Watershed planning and management including land and reservoir management can help improve the climate resilience of a large hydropower plant, particularly in reservoirs with multiple purposes. Coordination between all relevant entities and users of reservoir are critical to allow for optimal management of water resources throughout the year, factoring potential droughts and floods. Afforestation or reforestation of the watershed, especially on highly erosive slopes, can help improve water retention, and reduce landslides and sediment load. Other adaptive measures might include increased landslide protection measures to reduce sediment load as well as other climate change risks on the hydropower plant and associated facilities.

105. **Smart and digital technologies.** Water flows can be better managed if reservoir inflows are accurately estimated through upstream catchment sensors for precipitation and river discharge, in conjunction with other tools such as satellite imagery and rainfall-runoff modeling.

106. Large hydropower projects are designed factoring long-term historical hydrological data and projections. However, climate change is impacting precipitation and water flow patterns, due to more frequent and extreme droughts and floods. Seasonal variation in monsoon patterns, increased snow melt, glacier thinning and retreat will further impact water flows and sediment load. To reduce uncertainty, several hydropower projects are now making use of automated, smart and digital technologies for data collection and monitoring such as climate stations, sediment and stream gauging stations, meteorological and satellite data to determine and optimize the daily, weekly and even monthly operations of the hydropower plants using computer algorithms. These technologies are also being used for early warning systems. Geographic information systems and satellite imagery can be useful to determine any changes in land cover and land use over time as well as to understand snow and glacier melt patterns. These technologies are especially relevant for large hydropower plants with reservoirs, and which provide multiple or competing services such fresh water supply, recreation and/or irrigation for

agriculture. It is important to keep in mind that hydropower plants with reservoir can also be useful infrastructure for flood and drought management.

107. **Design, structural, and operational measures.** The design and structural measures can cover the electro-mechanical, hydromechanical, and dam structure itself but also the associated facilities such as access roads, river diversion works, powerhouse, and electrical equipment. Regarding dam structure, additional construction joints and new concrete mix designs, which are more resilient to flow and temperature variations, could be considered. For associated facilities, the location of the powerhouse and respective flood mitigation measures such as spillways, which discharge downstream of the powerhouse and transmission lines, should be suited to extreme weather patterns and landslides. Arrangements for sediment management should be designed and dimensioned for potentially larger volumes of sediment transport and deposition.

108. The use of efficient turbines across a wide operating range can allow for optimal operation during different rates of discharge and quick dispatch and/or shutdown in response to early warning systems and emergency response during extreme weather and landslides. These can be combined with fast reacting spillway gates to route the flood water over the dam without damaging its structure. Flexible generation equipment also allows for greater uptake of variable renewable energy sources through quick adjustment of dispatch or as energy storage if it is a hydropower pumped storage plant.

109. There are also operational measures that can be considered to allow for increased flood storage buffer and flood evacuation capacity by reviewing operating rules, monthly reservoir operating rule curves and early warning system guidelines. With increasing frequency of floods, sediment management is becoming more relevant for both new and existing hydropower projects. Greater floods will bring higher sediment load which affects lifetime and operational flexibility of the hydropower plant.

110. **Floating solar PV modules.** Climate change will lead to higher temperatures and an increase in the frequency of droughts in certain regions. These factors can decrease water flows as well as increase the rate of evaporation of a large hydropower plant with reservoir. Ways are being explored to reduce evaporation including the potential side-benefit of installing solar PV panels.

111. Floating solar PV panels on the reservoir can take advantage of the cooling effect of the water surface which is beneficial for the operation of solar PV (compared to ground mounted solar PV). The floating solar PV panels should be carefully located and moored to ensure these do not damage the dam during strong winds, floods and other extreme weather events. Floating solar PV can also support the optimal operation of the hydropower plant by compensating during periods of drought and when solar irradiation is higher and can make use of the existing electricity transmission infrastructure connected to the hydropower plant.

G. Common Principles for Climate Mitigation Finance Tracking

112. The Common Principles for Climate Mitigation Finance Tracking are developed jointly by the MDBs.[44] These principles consist of a set of definitions and guidelines and a list of eligible

[44] The principles and guidance will be further refined and expanded as the building blocks road-testing progresses. ADB's internal Paris Alignment Working Group, and MDBs will regularly discuss alignment/non-alignment of projects

activities that allow for consistent accounting and reporting of financial flows for climate change mitigation finance. The principles were updated in October 2021 to better reflect the context of the Paris Agreement.

113. An activity can be classified as climate change mitigation where the activity, by avoiding or reducing GHG emissions or increasing GHG sequestration, contributes substantially to the stabilization of GHG concentrations in the atmosphere at a level which prevents dangerous anthropogenic interference with the climate system consistent with the long-term temperature goal of the Paris Agreement.

114. The Common Principles for Climate Mitigation Finance Tracking are designed for use in ex-ante assessments and focus on the type of activity to be executed, not on its purpose, the origin of the financial resources, or its actual mitigation impact.

115. For the purpose of this guidance note, the Common Principles for Climate Mitigation Finance Tracking are optional but highly recommended. A large hydropower project that meets the Common Principles for Climate Mitigation Finance Tracking requirements will contribute substantially to ADB's climate finance targets.

116. If a large hydropower project is eligible under the Common Principles for Climate Mitigation Finance Tracking, it does not mean it is Paris-Aligned and vice-versa.

117. The Common Principles for Climate Mitigation Finance Tracking, under the renewable energy generation category, state the following guidance which could be applicable to large hydropower projects, particularly if with reservoir:

(i.) Analysis of GHG should take account of material lifecycle sources, such as where scope 3 emissions[45] or scope 1 emissions during construction are expected to be material.

(ii.) Examination of material lifecycle sources is typically relevant for reservoir hydropower.

(iii.) Direct land-use changes should be included in the lifecycle GHG emissions analysis if they are deemed to make a material difference, and indirect land-use changes should also be considered where they are feasible to assess and expected to be material.

118. Based on these, subject to the project team's expert assessment, and to ensure that any large hydropower project is eligible for climate mitigation finance, the project team will need to consider assessment of lifecycle GHG emissions. The next section provides guidance on how to determine lifecycle GHG emissions of large hydropower plants.

119. Large hydropower projects are also likely to be eligible for climate adaptation finance under the MDBs Joint methodology for tracking climate change adaptation finance.[46] Project

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to transparently address inconsistencies and to harmonize and improve the approach over time. Common Principles for Climate Change Mitigation Tracking. Version 3. 18 October 2021

[45] Scope 1 emissions are direct GHG emissions from the sources that are affected by the investment project and that are owned or controlled by the investee. Scope 2 emissions are indirect GHG emissions from energy sources not owned or controlled by the investee but directly utilized by the investment project. This includes emissions associated with electricity, heating or cooling purchased for the investee activities. Scope 3 emissions are other indirect GHG emissions from sources that are upstream or downstream of a value chain and not owned or controlled by the investee. For further details, refer to the International Financial Institutions Guideline for a Harmonised Approach to Greenhouse Gas Accounting.

[46] Joint methodology for tracking climate change adaptation finance. November 2022.

teams should refer to the section above on Climate Resilience and Adaptation Measures for Large Hydropower Plants and consult with the Climate Change and Disaster Risk Management Division (SDCD) team for guidance on eligibility for climate adaptation.

H. Lifecycle Greenhouse Gas Emissions

120. The lifecycle GHG emissions of hydropower plants depend on the change in biogenic emissions resulting from land use change (terrestrial to aquatic, through reservoir inundation), as well as emissions relating to the project's construction. Absolute construction emissions will be influenced by the design and material volumes (excavations, embankments, concrete, and steel). Reservoir emissions will be influenced by the change in the biogenic emission relative to the pre-project condition in the watershed. The net impact of inundation will depend on several factors, including the pre-project land cover and land use, GHG stock from the watershed feeding the reservoir, reservoir characteristics, meteorological conditions and operational/hydro-dynamic aspects, amongst many others.

121. Tools exist to estimate both types of emissions as described below. These emissions can be aggregated in the form of carbon dioxide equivalent. This requires using the Intergovernmental Panel on Climate Change (IPCC) 100-year global warming potential (GWP) of other GHGs, especially methane. The result is annualized across the expected life of the asset (normally 100 years), providing an emission rate per year. In turn, these 'absolute emissions' can be allocated to the annual production of hydropower generation, proving 'activity level emissions' per kWh.

122. As indicated in Sections F and G, the assessment of lifecycle GHG emissions of large hydropower plants is essential to determine:

(i.) If a large run-of-the-river hydropower plant has negligible lifecycle GHG emissions to qualify as universally aligned under the PAA guidance note.

(ii.) If a large hydropower plant has low lifecycle GHG emissions to be eligible for climate mitigation finance.

123. This section applies only to the calculation of lifecycle GHG emissions of large hydropower plants and is not for the purpose of the project's economic analysis.

124. If the reservoir of the hydropower plant has multiple purposes (e.g., irrigation, fisheries, water supply), the lifecycle GHG emissions will need to be allocated accordingly based on relative importance of the different services (see Annex 2). If the large hydropower plant has a high lifecycle GHG emissions, this will need to be carefully assessed by the project teams to avoid misallocation.

1. Reference Values for Lifecycle GHG Emissions of Hydropower Plants

125. To date, MDBs have not defined what is meant by negligible and low lifecycle GHG emissions for hydropower projects. The IPCC states that hydropower has a median GHG emission intensity of 24 grams (g) of carbon dioxide (CO_2) equivalent per kilowatt-hour (kWh). This value is consistent with analysis from the IHA covering almost 500 reservoir measurement campaigns and which takes into account lifecycle GHG emissions.[47]

[47] IHA. Fact Sheets - Hydropower's Carbon Footprint

126. For the purpose of this guidance note, a large hydropower plant can be considered as with negligible or low lifecycle GHG emissions if it meets one of the two reference values below:

(i.) European Union Sustainable Finance Taxonomy – **lifecycle GHG emissions of lower than 100 gCO_2 equivalent per kWh**[48] OR

(ii.) Climate Bond Initiative (CBI) - **lifecycle GHG emissions[49] of lower than 50 gCO_2 equivalent per kWh for hydropower plants in operation during 2020 or after and less than 100 gCO_2 equivalent per kWh for hydropower plants in operation pre-2020**.[50] The CBI threshold will be relevant for project teams supporting issuance of climate bonds related to the project including for the refinancing of existing hydropower plants. Alternatively, CBI also accepts the use of power density thresholds, however, the PAA guidance note and the Common Principles for Climate Mitigation Finance Tracking do not currently recognize the use of power density thresholds.

127. Power density is the installed capacity of hydropower plant, measured in watts (W) divided by the surface area of the reservoir, measured in squared meter (m^2).[51] This metric is also useful to give an indication because considerable efforts will be required to determine the lifecycle GHG emissions through site-specific data acquisition and modeling. Prior to considering a large hydropower project, including modernization of existing hydropower plants, project teams can use power density (W/m^2) as a simple proxy to indicate the likelihood of a new or existing large hydropower plant having lifecycle GHG emissions above 50 or 100 (gCO_2) equivalent per kWh.

128. For example, under the United Nations Framework Convention on Climate Change's (UNFCCC) Clean Development Mechanism, large hydropower plants with power density less than or equal to 10 W/m^2 are deemed to have an emission factor of 90 gCO_2 equivalent per kWh for project reservoir emissions.[52] This is similar to the values considered by CBI for automatic eligibility for climate bond standard, of power density above 5 W/m^2 for hydropower plants operation pre-2020 and 10 W/m^2 for hydropower plants operations during 2020 or after.[53] Consequently, site-specific analysis is being encouraged for all new projects, particularly for projects with a power density of less than 10 W/m^2.

129. Based on the IHA G-Res Database, comprising lifecycle GHG emissions of more than 200 reservoirs, large hydropower plants with power density below 5 W/m^2 have a higher probability of having lifecycle GHG emissions above 100 gCO_2 equivalent per kWh as shown in Figure 2. Project teams should take this metric into consideration when deciding on whether to proceed with a new or existing hydropower plant project and for allocating sufficient resources for lifecycle GHG assessments. If the large hydropower plant has multiple purposes, the lifecycle GHG emissions will need to be allocated accordingly.

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[48] European Commission. About the EU Taxonomy Compass

[49] Note that CBI excludes emissions from the construction and end of life in determining the lifecycle GHG emissions of hydropower

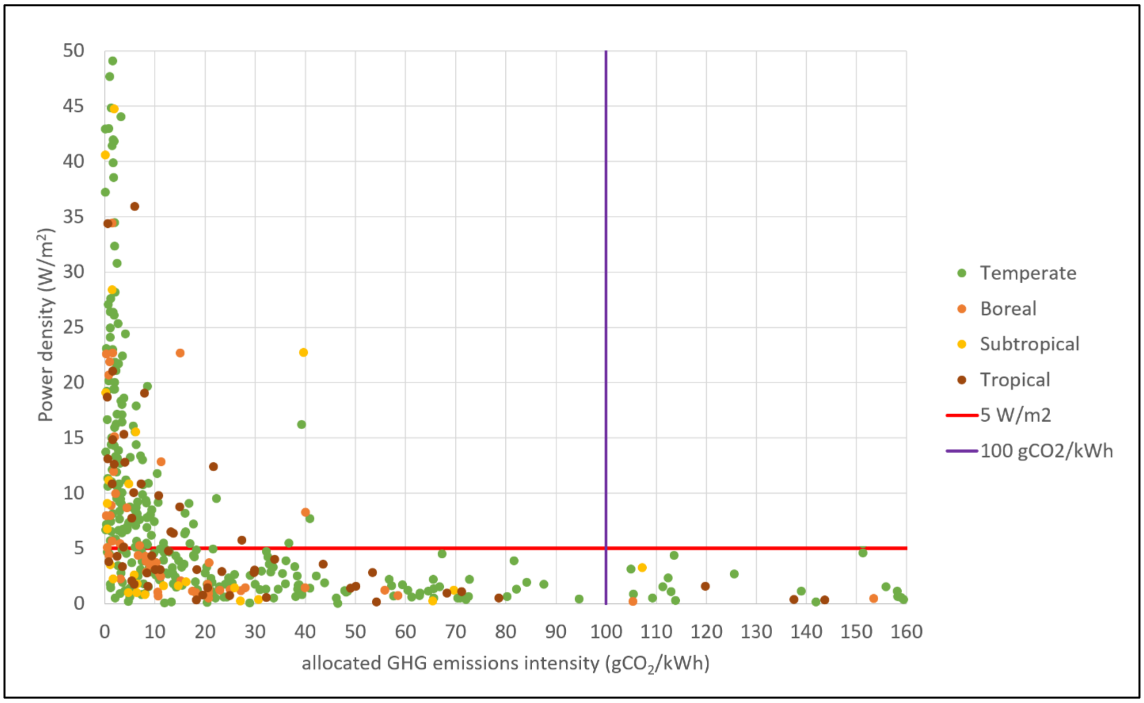
[50] CBI. The Hydropower Criteria – Climate Bonds Standards

[51] CBI, 2021. Hydropower Criteria – Development of Eligibility Criteria for the Climate Bonds Standard & Certification Scheme. Background Paper. March 2021 – Version 1.0.

[52] Clean Development Mechanism – Executive Board. Annex 5 – Thresholds and criteria for the eligibility of hydroelectric power plants with reservoirs as CDM project activities.

[53] CBI. 2021. Introduction to the Hydropower Criteria. Climate Bonds Standards. March 2021.

Figure 2 – Power Density and Lifecycle Greenhouse Gas Emission Intensity by Climate Zone for Existing Hydropower Plants in the IHA G-Res Database



gCO_2/kWh = grams of carbon dioxide equivalent per kilowatt-hour.
Source: CBI. 2021. Hydropower Criteria – Development of Eligibility Criteria for the Climate Bonds Standard & Certification Scheme. Background Paper. March 2021 – Version 1.0.

2. Tools for Calculation of Lifecycle GHG Emissions of Hydropower Plants

130. For the calculation of lifecycle GHG emissions for large hydropower plants, the project teams can choose between the following three options:

(i.) Internationally recognized tools (e.g. G-Res Tool),

(ii.) On-site specific assessments, or

(iii.) National guidance or tools for measurement of lifecycle GHG emissions for large hydropower projects (if available).

131. For internationally recognized tools, the G-Res Tool should be considered by project teams. For on-site specific assessments, the IEA Hydro Framework provides guidelines for the quantitative analysis of net GHG emissions from reservoirs[54]. The large amount of data required for calculation of lifecycle GHG emissions should be factored in the planning and allocation of resources by project teams. In most cases, using existing internationally recognized tools is likely to be a less expensive than full on-site specific assessments.

132. Annex 2 includes further information on the G-Res Tool.

[54] IEA Technology Collaboration Programme on Hydropower. Task XII: Hydropower & the Environment Task 1: Managing the Carbon Balance of Freshwater Reservoirs (2007-Present).

Annex 1: ADB Hydropower Portfolio (2002–2021)

ADB Large Hydropower Projects from 2002 to 2021

Year	Loan No.	Project	Capacity (MW)	Country	Sovereign / Nonsovereign	ADB Funding ($ million)
2002	1922	Hebei Zhanghewan Pumped Storage Project [Upper reservoir installed above existing hydropower plant.]	1,000 MW (4 x 250 MW)	PRC	Sovereign	144.00
2003	2032	Gansu Clean Energy Development Project (Xiaogushan Hydropower Plant)	98 MW (upgraded to 102 MW)	PRC	Sovereign	35.00
2005	2162	Greater Mekong Subregion: Nam Theun 2 Hydroelectric Project	1,070 MW	Lao PDR	Sovereign	20.00
2005	7210/ 2161	Greater Mekong Subregion: Nam Theun 2 Hydroelectric Project			Nonsovereign	100.00
2005	2198	New Bong Escape Hydropower Project, Laraib Energy Limited [Retrofit of large dam] Safeguards BCC	84 MW	Pakistan	Nonsovereign	37.30
2006	2296	Gansu Heihe Rural Hydropower Development Investment Program – MFF (Tranche 1: Erlongshan 50.5 MW; Tranche 2: Dagushan 65 MW)	115.5 MW	PRC	Sovereign	50.00
2008	2461/ 2596/ 2687/ 2914	Himachal Pradesh Clean Energy Development Investment Program – MFF (Tranche 1-2: 111 MW; Tranche 3: 100 MW; Tranche 4: 450 MW)	661 MW	India	Sovereign	800.00
2008	2429	Song Bung 4 Hydropower Safeguards A	156 MW	Viet Nam	Sovereign	196.00
2008	9128 (grant	Development of Mini Hydropower Plants in Badakhshan and Bamiyan Provinces 4 sites, each 0.5 MW Safeguards CCC [Project cancelled in 2014]		Afghanistan	Sovereign	12.00
2008	2463/ 2464/ 3034	Green Power Development	114 MW	Bhutan	Sovereign	119.00
2011	7339/ 2792	Patrind Hydropower Project Star Hydro Power Limited Safeguards AAC	147 MW	Pakistan	Nonsovereign	97.00
2011	2818/ 2819	Greater Mekong Subregion Nam Ngum 3 Hydropower Project	290 MW	Lao PDR	Sovereign	115.12
2011	7341/ 2799	Nam Ngum 3 Power Company Project	440 MW	Lao PDR	Nonsovereign	350.00
2012	2869	Power Sector Rehabilitation Project	No additional MW	Kyrgyz Republic	Sovereign	15.00
2013	0376 (grant)	Golovnaya 240 MW Hydropower Plant Rehabilitation Project Increase of generation output	Increase from	Tajikistan	Sovereign	136.00

Year	Loan No.	Project	Capacity (MW)	Country	Sovereign / Nonsovereign	ADB Funding ($ million)
		Safeguards BBC	240 MW to 252 MW			
2013	2990/ 2991	Tanahu Hydropower Project Multiple cofinanciers Safeguards AAA	140 MW	Nepal	Sovereign	150.00
2013	2996	Sevan-Hradza Cascade Hydropower Rehabilitation Project Safeguards BCC	[Capacity not reported]	Armenia	Nonsovereign	25.00
2013	7386	NSL Renewable Power Private Limited (Hydro and Wind Power Development Project) Safeguards ABC	100 MW	India	Nonsovereign	17.76
2014	7407/ 3130	Adjaristsqali Hydropower Project Cofinancing with IFC Safeguards AAC	185 MW	Georgia	Nonsovereign	90.00
2014	7414	Nam Ngiep 1 Power Company Limited (Nam Ngiep 1 Hydropower Project) Loan 3153 $49.78 M Loan 3154 THB 3025 M Loan 66 (B Loan) $71.33 Safeguards AAA	290 MW	Lao PDR	Nonsovereign	221.00
2014	3121	Toktogul Rehabilitation Phase 2 Project	120 MW	Kyrgyz Republic	Sovereign	110.00
2014	0421 (Grant 3225/ 3226	Second Green Power Development Project Cofinanced with India (State Bank of India and Ex-Im Bank) Safeguards ABC	118 MW	Bhutan	Sovereign	25.25 70.00 25.25
2015	3253	Gulpur Hydropower Project [Mira Power Limited] Safeguards AAC	102 MW	Pakistan	Nonsovereign	65.00
2016	0494 (Grant) 3422 8306	Toktogul Rehabilitation Phase 3 project Cofinancing with Eurasian Development Bank Safeguards BCC	120 MW	Kyrgyz Republic	Sovereign	50.00 60.00 100.00
2016	3476	Access to Clean Energy Investment Program [RBL] 1000 Micro-hydro plants in off-grid villages of Khyber Pakhtunkhwa province	[capacity not reported]	Pakistan	Sovereign	325.00
2017		Lower Kopili (Assam Power Sector MFF Tranche 3) Safeguards AAA	120 MW	India	Sovereign	231.00
2019	0643 (Grant) 3778	Uch Kurgan Hydropower Plant Modernization Project Rehabilitation of 4 x 45 MW units with up to 20% capacity increase Safeguards BCC	36 MW (20% increase on 180 MW existing capacity)	Kyrgyz Republic	Sovereign	40.00 60.00
2019	0665 (Grant) 3828 Loan	Tina River Cofinanced with World Bank, Green Climate Fund and others Safeguards AAC	15 MW	Solomon Islands	Sovereign	12.00 (G) 18.00 (COL)

Year	Loan No.	Project	Capacity (MW)	Country	Sovereign / Nonsovereign	ADB Funding ($ million)
						175.5
2019	3834	Sustainable Hydropower Project 3 “small” run of river plants: 6 MW in Rabat, 8 MW in Chappasuy, 10 MW in Tamshusu, + 3 mini-/micro plants totaling 1 MW Safeguards ABC	25 MW	Uzbekistan	Sovereign	60.00
2019	3781 8355	Upper Trishuli 1 Cofinancing with Canadian Fund for the Private Sector in Asia II with IFC, Asian Infrastructure Investment Bank (AIIB) and others Safeguards AAA	216 MW	Nepal	Nonsovereign	30.00 30.00
2021	4057 8397	Balakot Hydropower Development Project – cofinancing with AIIB Safeguards AAC	300 MW	Pakistan	Sovereign	300.00 250.00
		Total Sovereign	3443 MW			3,658.87
		Total NonSovereign	1480 MW			925.76
		Nam Theun 2 – Sovereign	1070 MW			20.00
		Nam Theun 2 – NonSovereign				100.00
		Total Capacity	5993 MW			
					TOTAL FINANCING ($ million)	**4,704.63**

Lao PDR = Lao People’s Democratic Republic, MW = megawatt, PRC = People’s Republic of China.
Source: Asian Development Bank

Annex 2 – About G-Res Tool

1. The International Hydropower Association (IHA), with collaboration from the UNESCO Chair for Global Environment Change, launched the G-Res Tool in 2017. The G-Res Tool is a web-based tool, that allows the estimation of the net change in greenhouse gas (GHG) emissions attributable to the introduction of a reservoir in a landscape for approximation of the construction emissions, and for the allocation of emissions in the case of multipurpose projects. Estimates can be carried out for an existing or planned project.[1] The G-Res Tool can be used for all types of hydropower, including run-of-river projects.

2. As with any lifecycle GHG emissions tools, the G-Res Tool has its advantages and disadvantages and limitations. However, it is typically recognized of one of the best available tools today to estimate the lifecycle GHG emissions for large hydropower plants. The G-Res Tool builds on a conceptual framework developed by the University of Quebec at Montreal, the Norwegian Foundation for Scientific and Industrial Research and the Natural Resources Institute of Finland. It uses a series of models based on over 500 published empirical measurements form more than 200 reservoirs worldwide. It was also developed with support from leading international organizations including World Bank Group.[2] The tool is maintained by the University of Quebec at Montreal, Canada.

3. For the analysis of reservoirs, the G-Res Tool distinguishes between four biogenic GHG emission pathways: diffusive carbon dioxide (CO_2) emissions as well as diffusive, bubbling and degassing methane (CH4) emissions. It also integrates the GHG balance of the landscape prior to the project and takes account of displaced emissions (where natural emissions that would have occurred regardless of the presence of the reservoir are displaced at the surface of the reservoir). It estimates the net impact of introducing a reservoir into a catchment over the complete lifetime of a reservoir (using 100 years as the default value for a lifetime). It also accounts for the emissions from the reservoir surface resulting from human activity occurring within or outside the reservoir, which are unrelated to the creation of the reservoir itself. In addition, it includes a module to estimate emissions associated with the construction phase of the dam. It also includes a method for apportioning the net GHG footprint among the services that the reservoir provides.

4. The project teams should ensure all lifecycle GHG emissions are considered when applying the G-Res Tool.

5. The G-Res Tool has been used on pumped storage projects, where the upper and lower reservoirs are treated as independent water bodies. However, the characteristics of pumped storage lend themselves to low biogenic emissions per unit of service. This is because of the very high elevation (head) between the upper and lower reservoirs (normally more than 300 meters), therefore requiring small volumes of water relative to the installed capacity (that is, a high power density is likely, much greater than 10 watts per square meter [W/m^2]). Emissions results can be allocated to the electricity returned to the grid (carbon dioxide equivalent [CO_2e] grams per kilowatt-hour [kWh]); an alternative is to allocate the emissions to the units of electricity exchanged with the grid (totaling storage charging and discharging, again in CO_2e grams per kWh).

[1] IHA. G-Res Tool
[2] IHA. G-Res Tool – Partners and Supporters

6. Further technical information, user guides, costs for assessment and training on G-Res Tool are available on the G-Res website (https://g-res.hydropower.org). For any questions, please contact the Energy Sector Group of the Sustainable Development and Climate Change Department.