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Commission

The Green Collection

# Aligning Hydropower proposals to the Green Deal

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**The Green Collection: A series of short notes providing information to help align selected infrastructure projects to the European Green Deal.**

This collection provides basic information on the environmental, climate, biodiversity and disaster risk reduction aspects of selected types of infrastructure projects. It aims at equipping colleagues dealing with such projects in headquarters and European Union Delegations to better address their alignment to the Green Deal.

## Hydropower fundamentals

Hydropower production (HPP) is the use of falling or fast-running water that passes through a turbine to generate electricity. It mostly uses an elevation difference of water<sup>1</sup> created by a dam or a diversion structure (see Annex below for more details on types of HPP facilities). The power generating capacity depends on the amount of water, its flow velocity and the difference in height. Instantaneous power production capacity is expressed in kilo-, mega- or gigawatts. Since turbines depend on water inflow they cannot always run at maximum capacity<sup>2</sup>. Therefore, the average yearly energy production is usually expressed in annual amounts of **gigawatt-hours** (or kilowatt- / megawatt-hours), based on monthly average water inflows. Distinction is made between large (> 100MW), medium (15-100 MW), small (1-15 MW), and even mini, micro and pico-hydropower<sup>3</sup>.

## Benefits of hydropower



**Renewable:** Hydropower is a renewable source of energy.



**Low carbon emissions:** only wind and nuclear emit less GHGs, even though emissions from deep tropical reservoirs can be significant (see below).

<sup>1</sup> Often referred to as 'head', which in its simplest form is the difference in height in water levels at the intake and at the outlet of the hydropower facility.

<sup>2</sup> Due to freezing at high altitudes, small HP is often not operational in winter, when demand is typically higher.

<sup>3</sup> Indicative thresholds which may differ by country and can have legal implications, for example as a threshold for ESIA requirement.



**Water use and co-benefits:** water used for hydropower generation remains available for downstream uses. Facilities with dam and storage reservoir can provide co-benefits for flood and drought control (climate adaptation and disaster risk reduction), irrigation, public and industrial water supply, recreation, fisheries, ecosystems, also in a transboundary context.



**Grid stability and flexibility:** by being able to instantly adjust its production, hydropower is the ideal load-frequency compensator for irregular solar and wind power, in order to balance electricity supply and demand. Pumped storage HPP systems provide additional flexibility, in particular to absorb surplus of production from renewable sources (provided the generation capacity of the facility is higher than the demand).

## Potential negative impacts of hydropower on environment and climate

Potential negative impacts of hydropower to be considered, and if possible avoided, mitigated or compensated:

- **Effect on ecosystem, river hydrology and ecological connectivity:** dams create barriers to aquatic organisms depending on upstream and downstream areas for survival; lengthy reservoirs create barriers to migration of large mammals; storage reservoirs and water transfer to other river basins (inter-basin transfers) have multiple and serious consequences for downstream water users and ecosystems. Construction works unsettle the river-bed, change or destroy habitats and disturb aquatic life. Fish passes and other techniques to mitigate or compensate damage are only partially effective. In hot, dry areas, reservoirs may lose water through evaporation.
- **Location:** Downstream dams in the main river channel are more damaging than dams in upstream river branches. Several dams located in different branches of the same river are far more damaging than a cascade of dams in one branch (yet, see also below under Cumulative impacts), if other branches remain untouched and free-flowing. River basin-wide analysis should be applied to find optimal locations, preferably through Strategic Environmental Assessment (SEA) or cumulative impact assessment.
- **Greenhouse gas emissions:** newly built tropical storage reservoirs where biomass is not removed before flooding may, in its first decade of operation, produce more CO<sub>2</sub> than carbon-based electricity<sup>4</sup>. Deep anoxic reservoirs also produce methane, a stronger GHG gas. Reservoirs built on wetlands and peatlands can also have a strong impact on GHG emissions. Please note: to claim a Rio Marker for climate change mitigation net emission reduction should be demonstrated<sup>5</sup>. Most development banks nowadays require developers to implement a biomass removal plan as part of their Environmental Management and Monitoring Plan.
- **Climate vulnerability:** hydropower is considered highly vulnerable to climate change<sup>6</sup> as it is directly related to precipitation patterns, behaviour of snow-caps and glaciers, and resulting changes in (timing of) river flows. This affects both the capacity to produce electricity and the safety of dams, for example when flood gates or spillways can no longer safely evacuate increasing river discharges.
- **Sediments:** reservoirs are a sediment trap and get filled up. Upstream erosion of hillsides thus affects the lifetime of a reservoir (and forest/nature protection and revegetation are effective tools to combat soil erosion). The consequence of the reservoir filling up with sediments is a downstream lack of sediments leading to increased erosion of river banks and coastal zones, and reduced productivity of seasonally flooded areas and coastal waters.
- **Eutrophication:** inflows of sediments and polluted water (e.g. untreated sewage, industrial wastewater, agricultural runoff) can result in eutrophication of the reservoir (excess of nutrients), leading to algal bloom and proliferation of water weeds, and in turn leading to reduced oxygen content and fish mortality. Water weeds can interfere with turbines and other activities on the reservoir. The effects are strongest at high temperatures (tropics, lowlands).
- **Cumulative impacts of “below ESIA (or EIA?) threshold” dams:** mini-hydropower dams are often “invisible” for ESIA (below threshold), yet potentially very damaging, particularly when constructed in cascade. Formally, an ESIA should be done for the entire cascade, but this usually is effectively avoided by investors, by taking a one-by-one approach. A river basin management plan, and dialogue or a well-designed permit, may avoid this, informed by a basin-wide assessment of all existing and planned interventions and water uses/users, through SEA or cumulative impact assessment.
- **Bad water management,** exacerbated by weak legislation and/or improper implementation may encourage hydropower developers to ignore essential instruments, such as adequate environmental flows (e-flows) and/or availability of fish passes, to sustain good ecological status of the fluvial ecosystem<sup>8</sup>. Water allocation which fails to consider uses beyond power generation, such as irrigation, ecosystems and transboundary uses, may result in unfair water sharing between upstream and downstream communities and across sectors and seasons.

<sup>4</sup> See the [Technical annex to the final report on EU taxonomy](#) (2020, p. 224-228)

<sup>5</sup> The G-res model ([IHA, 2010](#)) is the commonly used model to estimate the net change in GHG emissions attributable to the creation of a specific reservoir. Outcomes on carbon emissions are fairly reliable but on methane it is at best a good guesstimate. It includes the often-forgotten GHG-emissions of construction works (cement!).

<sup>6</sup> [IPCC Sixth Assessment Report – IPCC](#)

<sup>7</sup> Environmental Impact Assessment (EIA) is the commonly used term in national environmental legislation; financial institutions often refer to Environmental and Social Impact Assessment (ESIA).

<sup>8</sup> [EU Water Framework Directive \(WFD\) 2000/60/EC](#), requires that planning, development, and operation of such hydropower schemes guarantee a “good” ecological status of the river under exploitation.

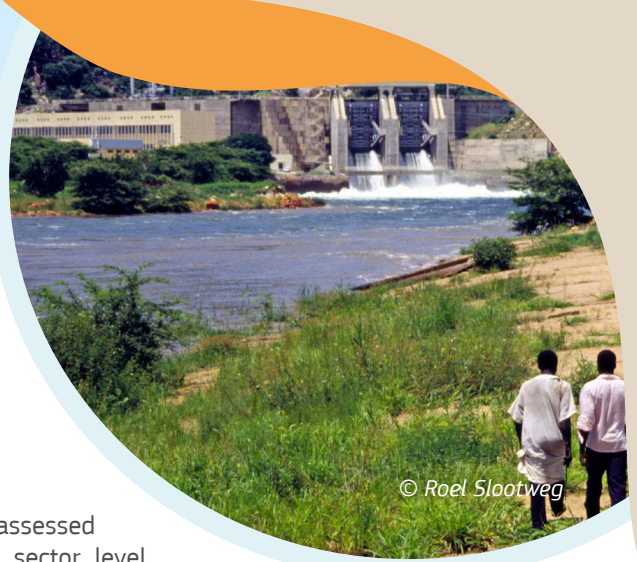
- **Other issues:** forced displacement, loss of agricultural land and livelihoods; accidents; construction of access roads, transmission lines, quarries, transfer tunnels/canal/pipes, dumping of spoil; dam safety (earthquakes, floods, landslides). Dams in international river basins can create transboundary impacts.

## What needs to be checked before approving an HPP proposal

The contribution of hydropower for the green energy future has to be assessed within a strategic planning framework at river basin and at energy sector level, including cumulative effects of and impacts on other water users and uses (such as irrigation, water supply, riverine and coastal fisheries, navigation, nature conservation, recreation as well as other HPPs, including transboundary aspects). Water uses (including for the environment) during times of water shortages first need to be defined and then prioritised. Different water use scenarios to maximise water use outcomes should be considered before entering into specific investments. The incorporation of SEA in the workflow is therefore necessary (and required by European directives in EU Member States and countries moving towards EU standards).

Against this background, the following documents should be available when dealing with a request for funding of hydropower. If they are not available, they should be requested and quality-assessed before moving forward.

- **River basin management plan (RBMP)** and the position of hydropower in the plan; preferably supported by a **Strategic Environmental Assessment (SEA)** of this plan, looking from an integrated water resources management (IWRM) perspective at cumulative impacts of all planned and existing interventions in the basin (so not only power generation, and including alternative water uses and options), taking into account expected consequences of climate change on river hydrology. The RBMP must have government ownership and be prepared in consultation with all key stakeholders and water users. Institutional capacity must be in place to implement and update the plan.
- **National energy policy** explaining the role of hydropower in the national energy mix; preferably supported by an SEA to assess the consequences of alternative energy scenarios, including their climate change mitigation and adaptation potential. When upgrading existing HP facilities, their potential role in providing grid stability in combination with wind and solar power generation should be addressed.
- **Climate change risk assessment (CRA):** HPP facilities depend on availability of water and extreme hydrological events have an impact on dam safety, both of which are governed by climatic variables. The long lifetime of HPP investments makes a climate risk and vulnerability assessment an absolute requirement, including its consequences for dam design, HPP productivity, cost-benefit analysis, impact assessment, disaster risk reduction measures and operational procedures. CRA can be part of the ESIA (see next).
- **Environmental and Social Impact Assessment (ESIA):** it identifies potential consequences and proposes measures to avoid and/or mitigate the negative impacts and compensate those suffering from them. It is advised to ask for the ToR of the ESIA, to verify that all relevant issues are considered. It should include an assessment of the alignment of the project to the Nationally Determined Contributions (NDC) to the Paris Agreement and to the National Biodiversity Strategy and Action Plan (NBSAP). ESIA is designed to inform decision making, so make sure it provides the needed information. Development consent should not be granted before an ESIA has been satisfactorily completed and the necessary impact mitigation measures defined and validated.
- **Environmental and Social Management Plan (ESMP)<sup>9</sup>:** should be one of the products stemming from the ESIA, specifying the impact mitigation measures, responsibilities for their implementation and monitoring and verification mechanisms. The ESMP must be integrated in the contractual documents and in the HPP project's monitoring & evaluation system.
- **Operational rules** for the dam, hydropower facility and reservoir use. Verify that the following issues are addressed: maintenance of downstream ecosystems and ecosystem services through environmental flows; the potential of the reservoir for other uses (irrigation, fisheries, recreation, navigation, etc.); and measures to maintain the ecological connectivity between upstream and downstream river sections (provision for fish passages / ladders / elevators, with proven effectiveness); sound institutions in place to implement and adapt rules, as needed. Dams must be maintained in good operating condition and reservoirs managed safely<sup>10</sup>.
- **Identify opportunities for biodiversity objectives:** the European Green Deal invites all sectors to go beyond the principle of 'doing no harm', and think in terms of how a sector can contribute to environmental objectives. HPP provides opportunities for investments in biodiversity conservation and restoration, going beyond mitigation or compensation<sup>11</sup>.



<sup>9</sup> Similar to EIA and ESIA, EMP and ESMP are used interchangeably.

<sup>10</sup> See: [World Bank ESS4 Annex 1 on Dam Safety](#)

<sup>11</sup> See QuickTips on [Working with nature](#) and its [energy sector annex](#).

Nature conservation and ecosystem management may provide solutions for some of the problems encountered by dam operators, such as upstream water storage and flow regulation, or control of landslides, erosion and sediment inflow. Measures such as afforestation and pasture management may cost a fraction of construction and operational cost, if biodiversity is pro-actively considered as a project objective.

## Annexes

### Useful references

EIB (2019) [Environmental, Climate and Social Guidelines on Hydropower Development](#)

International Hydropower Association (2010): [GHG Measurement Guidelines for Freshwater Reservoirs](#)

World Bank (2003). [Good Dams and Bad Dams: Environmental Criteria for Site Selection of Hydroelectric Projects](#)

World Commission on Dams (2000). [Dams and Development: A New Framework for Decision-Making](#)

For Western Balkans: [Sustainable Hydropower \(wbif.eu\)](#)

### Main types of hydropower<sup>12</sup>

**Run-of-the-river (RoR):** the force of the river flow is used to generate electricity. It usually works with a low weir across (a part of) the river leading the water to a turbine. It has no storage reservoir, so power production depends on the available water flow. It has less ability to provide power on demand which obviously fluctuates with seasonality of water flows. Small RoR facilities are among the most affordable renewable energy sources that can be developed in low-income countries, with low construction and maintenance costs and short construction times.

**Run-of-the-river with water diversion:** a weir across (part of) the river leads water into a diversion channel (or pipe / tunnel) bringing the water to a lower lying powerhouse; the water may re-join the main river, so the facility has no influence on the hydrology of the downstream river section, or is diverted into another (lower lying) river basin, thus affecting the hydrology of two river basins. Ranging from mini to large hydropower facilities.

**Run-of-the-river with dam:** a dam creates difference in water height with larger potential for power generation; the reservoir behind the dam is not large enough to store water for prolonged periods. Power production depends on the available water flow. Ranging from small to very large HPP (the term 'run-of-the-river' is sometimes used to downplay potential impacts).

**Dam with storage reservoir:** to store water for periods of low river flow (seasonal storage) or even for years of lower flows (over-annual storage), potentially combined with water supply for public or industrial uses, flood control, gravity flow irrigation systems, recreation. It has the best capability to respond to changes in electricity demand.

**Pumped storage is a special reservoir case:** an upper and a lower reservoir with turbines and pumps (or reversible turbines) in between; with high electricity demand the turbines produce electricity from the upper reservoir; in times of oversupply of solar, wind, or nuclear electricity water is pumped from the lower into the high reservoir to "store" energy.

**HPP cascade:** in a river valley the same water can be used more than once for power generation if the river has sufficient gradient. Several dams are built 'in cascade'. In the extreme case the tail end of the lower reservoir (where the water enters the reservoir) reaches the dam toe of the higher facility.

### Contact

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<sup>12</sup> See also: <https://www.energy.gov/eere/water/types-hydropower-plants>

