Making hydropower more sustainable: Environmental flows and other measures

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Introduction: Water-Energy Nexus and Sustainable Hydropower
The Water & Energy Nexus and Ecosystems

- Generating energy requires water, and vice-versa
- Water management affects, and is affected by, energy planning
- Many developments in last decade:
  - Accelerated construction of dams for hydro, flood-control, water supply
  - "Rush for renewables" – hydro as "clean", low carbon solution
  - Growing populations; growing demands for food, water, energy
Sustainable Hydropower, what is it?

WILL THEY EVER GET IT DAM RIGHT?

YOU TELL ME...!
Sustainable Hydropower, what is it?

The mitigation hierarchy

**Mantra:**
Avoid, minimize, mitigate, and only then compensate!
1. A preventive approach: Avoidance of impacts and risks
1. Avoid – Why? How?

Avoidance

= measures taken to avoid impacts from outset (e.g. siting of dams, timing of works)
= often easiest, cheapest and most effective way of reducing potential impacts
NB: requires biodiversity assessment in early stages

Scoping stage:

1. Needs assessment
   • What energy current and future needs in the country/region?
   • Is there a need for additional infrastructure? What about existing dams?

2. Alternative options assessment
   • What sound, feasible options for energy generation in the region?
   • Is importing energy from elsewhere an option?
   • Doing a cost-benefit analysis, incl, env. and social factors
   • In case of existing dams, what options for refurbishing/retrofitting?

NB: Dam = large costly investment, many impacts, infrastructure to remain in place for long time !!!
1. Avoid – Integrated River Basin Planning

Conservation Plan

- Headwater habitat
- Floodplain fishery
- Priority conservation river segment / High Conservation Value Area

Hydropower Plan

- Existing dam
- Proposed dam

Source: TNC
1. Avoid – Integrated River Basin Planning

Lack of integrated planning

- Projects in areas of conservation concern with high mitigation requirements
- Dam operations constrained by environmental flow requirements

Source: TNC
1. Avoid – Integrated River Basin Planning

- Locate additional dams on already developed segment and eliminate conflicting dam
- Operations of total cascade is less constrained by environmental flow requirements
- Modify downstream dam operations to re-regulate flows to improve flow regime in flood-plain conservation area
- Locate alternative conservation segment with similar ecosystem values
- Locate areas of conflict
  - Existing dam
  - Proposed dam
  - Priority conservation river segment

Evaluate Results:
- Similar ecosystem values?
- Similar hydropower outputs?

Source: TNC
1. Avoid – Prioritisation of Conservation Areas
2. Minimisation and Mitigation of adverse impacts and risks
2. Minimize/Mitigate – How?

The right dam in the right place operated in the right way...
- dam design (structure, equipment)
- dam operations

Minimisation = measures taken to reduce duration, intensity and/or extent of impacts that cannot be completely avoided. Effective minimisation can eliminate some negative impacts.
2. Minimize/Mitigate – How?

Dam Design: Structure and equipment

- Use **best available techniques** and **state-of-the-art technology**
- Build **fish passages/ladders**
- Enhance/enlargen **water-release structures** for e-flows (e.g. Jindabyne Dam in Australia)
- Add **bypass tunnels and bottom outlets** to allow sediment transport
- Install **fish-friendly turbines** to reduce mortality
- Install **special water intake towers** for variable water temperature (e.g. Berg River dam, South Africa)
2. Minimize/Mitigate – Fish-friendly equipment

**CONVENTIONAL TURBINES**
- Fish may strike gates or be wedged in gaps
- Fish may be pinched between the blades and the wall
- Fish may be caught in turbulence

**IMPROVED TURBINE DESIGN**
- Redesigned gates with rounded edges & fewer gaps
- Curved walls reduce places where fish may be pinched
- Blade, hub and outlet designs work together to reduce turbulence
2. Minimize/Mitigate – Fish passages
2. Minimize/Mitigate – Water Intake Tower

Intake tower for level-specific water withdrawal

- Water intake (drinking water)
- Bottom outlet
2. Minimize/Mitigate – How?

Dam Operations

- **Apply best practices/standards**, incl. for dam safety (e.g. IFI safeguards, etc.)
- **Design and implement e-flows** (volume, timing, temperature, sediments)
- Facilitate and **coordinate for multi-purpose use** and IWRM
- **Build capacity** of plant managers and staff
- Consider the **changing climate** and impacts on dam operations!
2. Minimize/Mitigate – Environmental Flows

“Environmental flows” ≠ natural flows
= quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems.

Basic Approaches to setting Eflow Standards

- Minimum flow thresholds
  – Annual or seasonal minimum flow levels to not be undercut

- Variation percentage of natural flow
  – Bands of allowable alterations from the natural flow regime (sustainability boundaries)

- Systematic construction of a modified flow regime
  – Specification of flow elements representing well defined features of the flow regime intended to achieve particular ecological, geomorphological, water quality, social or other objectives in the modified system
2. Minimize/Mitigate – Environmental Flows

Diagram: Natural Flow Pattern

- Day of Year
- River Flow
- Natural Low Flows
- Natural High Flows
- Natural Flood
2. Minimize/Mitigate – Environmental Flows

NATURAL FLOW PATTERN

River Flow

Day of Year

Natural Flood

Natural High Flows

Natural Low Flows

Fish have adequate oxygen and can move up- or downstream to feed

Riparian vegetation sustained by shallow ground water table

Insects feed on organic material carried downstream

Birds supported by healthy riparian vegetation and aquatic prey
2. Minimize/Mitigate – Environmental Flows

Natural Flood

- Fish are able to feed and spawn in floodplain areas
- Riparian plant seeds germinate on flood-deposited sediments
- Insects emerge from water to complete their lifecycle
- Wading birds and waterfowl feed on fish and plants in shallow flooded areas
2. Minimize/Mitigate – Environmental Flows

1. Retain flood magnitude, to scour channel and vegetation, recharge river banks and floodplains
2. Maintain baseflow and thus aquatic habitat in dry season
3. Retain spring flushing flow as cue to life cycles
4. Vary baseflow in wet season, but with removal of some floods
2. Minimize/Mitigate – Environmental Flows

- Moderate Level of Ecological Protection: 
  +/- 11-20% from natural

- High Level of Ecological Protection: 
  +/- 0-10% from natural

Natural flows (undepleted and unregulated)

Increasing Ecological Risk

Increasing Ecological Risk
2. Minimize/Mitigate – Environmental Flows

Environmental Flow Implementation – Key Steps:

1. Fully engage stakeholders in every aspect of e-flow assessment and decision-making.

2. Identify opportunities for e-flow integration at a regional scale.

3. Define e-flow needs using a holistic approach, utilizing the best available knowledge and tools.

4. Assess e-flow needs before designing the dam’s structural features (‘form follows function’ concept).

5. For existing dams, seek to integrate e-flow needs and implement opportunistically.

6. Be clear about desired outcomes and necessary measures, and monitor outcomes and re-adjust during implementation.
Thank you for your attention!

For further info, please contact: angela.klauschen@gwp.org or visit: www.gwp.org