Strategic tools for sustainable hydropower development

Alpine River Restoration Workshop
4th of September 2014
Zvolen, Slovak Republic

DDI Carina Mielach
Fleck S., Muhar S., Scheikl S., Schmutz S., Schinegger R. (BOKU)

Mair R. (ICPDR)  Walder C. (WWF)  Neubarth J. (e3 consult)
Hydropower – important source of renewable energy
Impacts of hydropower

Altered flow regime and interruption of river continuity

Alteration of sediment transport

Ecological impacts
Ambitious EU legislation for energy + water

RES-e
European Renewable Energy Directive 2009/28/EC

Objectives:
- to increase share of energy from renewable sources with target figures for 2020 for each state

States set national targets + decide on strategy; e.g. by targets for HP

WFD
EU Water Framework Directive 2000/60/EC

Objectives:
- good ecological status of water bodies
- No deterioration of status

Conflict of interest
Addressing the conflict of interest

How to balance?

Increase of renewable energy  Environmental objectives

Need for inter-sectoral cooperation!
4 examples addressing the conflict of interest

Sustainable Hydropower Development in the Danube Basin
Guiding Principles

HY:CON Identification of projects with high energy efficiency & least conservation concern

Measures for ensuring fish migration at transversal structures
Technical paper

Ecological prioritisation of measures to restore river and habitat continuity in the DRBD
Annex 18 of the DRBD Plan

University of Natural Resources and Life Sciences, Vienna
Department of Water, Atmosphere and Environment
Guiding Principles on Sustainable Hydropower Development

- Recommendations based on EU legislation & EU policies
- Strike for balance, represent state of the art in Europe

Guiding Principles promote

1. Set of **general principles** (inclusiveness and transparency of process, call for holistic approaches, …)
2. Technical upgrading of **existing hydropower** plants combined with ecological restoration
3. **Strategic planning** approach for **new hydropower** based on two level assessment (regional + site specific) in order to find appropriate sites in region with lowest impacts
4. **Mitigation** of negative ecological impacts
# Strategic planning approach for new hydropower development

## Two-level assessment

### Recommended list for national/regional criteria

<table>
<thead>
<tr>
<th>National/Regional criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Management</td>
<td></td>
</tr>
<tr>
<td>Hydro-electrical potential (theoretical or line Potential)</td>
<td>Product between quantity of flow and head</td>
</tr>
<tr>
<td>Environment</td>
<td></td>
</tr>
<tr>
<td>Naturalness</td>
<td>Status of river stretches/water body in relation to surrounding communities regarding hydrology, morphology and communities</td>
</tr>
<tr>
<td>Status of water body with regard to rarity and ecological value</td>
<td>Rarity of the river type, ecological status of habitats and their communities</td>
</tr>
<tr>
<td>Specific ecological structure and function of the river stretch also with regard to the whole catchment/sub-basin and in relation to ecosystem services</td>
<td>e.g. Particular habitats for sensitive/valuable species in the riverine ecology (e.g. red list species)</td>
</tr>
<tr>
<td>Conservation areas and protected sites</td>
<td>e.g. Natura 2000 areas (Birds and Habitats), UNESCO Biosphere Reserves, National, Regional</td>
</tr>
</tbody>
</table>

### Recommended list for project-specific criteria

<table>
<thead>
<tr>
<th>Project-specific criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Management</td>
<td></td>
</tr>
<tr>
<td>Hydropower plant size</td>
<td>Installed capacity</td>
</tr>
<tr>
<td>Hydropower plant type</td>
<td>e.g. run-of-river, diversion, storage, pumped storage</td>
</tr>
<tr>
<td>Security of supply</td>
<td>Production and supply of energy (Auto supply)</td>
</tr>
<tr>
<td>Quality of supply</td>
<td>Production characteristics – base load/ peak load (storage option, pumping storage)</td>
</tr>
<tr>
<td>Contribution to climate protection</td>
<td>Lower CO2 emissions of the energy mix</td>
</tr>
<tr>
<td>Technical efficiency</td>
<td>Grid connection, potential use, size of plants</td>
</tr>
<tr>
<td>Environment and water management</td>
<td>Longitudinal/lateral/vertical connectivity, impacts on habitats and biota taking into account already existing impacts</td>
</tr>
<tr>
<td>Flood control</td>
<td>Protection of sites at flood risk; alteration of flow regime</td>
</tr>
<tr>
<td>Irrigation</td>
<td>Positive or negative effects on water availability for irrigation</td>
</tr>
<tr>
<td>Sediment management</td>
<td>Reservoir siltation, bedload transport, sediment contamination, plant design</td>
</tr>
<tr>
<td>Surface and groundwater quantity</td>
<td>Infiltration and evaporation, minimum ecological flow</td>
</tr>
<tr>
<td>Surface and groundwater quality</td>
<td>Nutrients, persistent organic substances, hazardous substances, thermal effects</td>
</tr>
<tr>
<td>Drinking water supply</td>
<td>Positive or negative effects on quality and service security</td>
</tr>
<tr>
<td>Bank protection and restoration</td>
<td>Flood erosion banks</td>
</tr>
<tr>
<td>Fisheries</td>
<td>Ensuring natural reproduction and fish migration across dams and residual water stretches</td>
</tr>
<tr>
<td>Effects of climate change</td>
<td>Changes in flow regime and impacts on economic feasibility of projects</td>
</tr>
<tr>
<td>Effects on water bodies already restored</td>
<td>Water bodies restored by public money should not be affected again</td>
</tr>
<tr>
<td>Socio-economic criteria</td>
<td>Compliance with local regulations</td>
</tr>
<tr>
<td>Conformity with local spatial planning</td>
<td>Access, energy grids, etc.</td>
</tr>
<tr>
<td>Necessity of further infrastructure for construction and operation</td>
<td>Access, energy grids, etc.</td>
</tr>
<tr>
<td>Regional economic effects</td>
<td>Taxes, income for the public; investments in local economy, induced employment</td>
</tr>
<tr>
<td>Recreation, tourism</td>
<td>Potential positive and negative effects on tourism</td>
</tr>
<tr>
<td>Other socio-political considerations</td>
<td>depending on the local situation</td>
</tr>
</tbody>
</table>
Strategic planning for new hydropower
National/Regional level assessment

**Suitability**

**Step One**
Is hydropower development possible according to existing national or regional legislation/agreements?*

- no → Exclusion*
- yes → 

**Step Two**

**Energy management**
- FAVOURABLE for hydropower development
- LESS-FAVOURABLE for hydropower development
- NON-FAVOURABLE for hydropower development

**Environment/landscape**
- Generally considered as possible
- Possible under specific circumstances
- Possible in exceptional cases”

<table>
<thead>
<tr>
<th>Energy Management</th>
<th>Hydro-electrical Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment and Landscape</td>
<td></td>
</tr>
<tr>
<td>low</td>
<td>medium</td>
</tr>
<tr>
<td>low</td>
<td>medium</td>
</tr>
<tr>
<td>low</td>
<td>medium</td>
</tr>
</tbody>
</table>
Austrian Water Catalogue (AWC)

- Published by the Austrian Ministry of Life (2012)
- Defines important assessment criteria
  - Energy
  - Ecology
  - Project specific/ water-management related criteria

AWC does not include an approach on how to combine the criteria to an overall assessment

**HY:CON** ➔ **Instrument for identifying projects with high energy efficiency & least conservation concern** based on economic & ecological criteria
Identification of Conservation needs based on ecological criteria

8 groups out of > 40 conservation criteria

- Ecological status
- Hydro-morphological status
- Key habitats (e.g. lake outflow, rare river types…)
- Key species (e.g. *Hucho hucho*, *Margaritifera margaritifera*)
- Floodplain forests
- Protected sites with strict restrictions (e.g. national park)
- Other protected sites (e.g. protected landscapes)
- Free flowing sections and migration corridor of medium-distant migrating fish species

6 different conservation scenarios

Exclusion criteria

Criterion with highest rating defined group rating

Group ratings were averaged to overall rating

Results divided into 4 equally distributed groups
(very high / high / medium / low)
# Hydropower attractiveness based on energy economic criteria

## Scoring 0-5

<table>
<thead>
<tr>
<th>Group</th>
<th>Criteria</th>
<th>HP type</th>
<th>Overall weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic attractiveness</td>
<td>Specific investment costs €/kWh, €/kW</td>
<td>run-of-river, storage pumped-storage</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Security of supply</td>
<td>Annual production (GWh/a)</td>
<td>all</td>
<td>17%</td>
</tr>
<tr>
<td>Quality of supply</td>
<td>Production characteristic</td>
<td>run-of-river</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Installed capacity (MW)</td>
<td>storage, pumped-storage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Storage duration (h)</td>
<td>storage, pumped-storage</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td>Pump storage</td>
<td>storage, pumped-storage</td>
<td></td>
</tr>
<tr>
<td>Climate protection</td>
<td>CO₂ avoidance (ktCO₂eq. p.a.)</td>
<td>all</td>
<td>17%</td>
</tr>
<tr>
<td></td>
<td>Renewables support</td>
<td>all</td>
<td></td>
</tr>
</tbody>
</table>
The HY:CON approach
(national scale: rivers, catchment area >10 km²)
HY:CON results – combined evaluation

Abandonment of projects economic rating <2.5 reduces
- projects from 102 to 54 \(-47\%\)
- MW from 4,742 to 4632 \(-2.3\%\)
- GWh/a from 4304 to 3805 \(-12\%\)

Conservation needs

<table>
<thead>
<tr>
<th>HPP type</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>V. high</th>
<th>Exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other HPPs</td>
<td>29</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>65</td>
</tr>
<tr>
<td>HPP</td>
<td>44</td>
<td>39</td>
<td>19</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

04.09.2012
Mitigation measures: Continuity restoration

Long-term goal: continuity restoration at all barriers

- construction of fish passes
- transformation of weirs to ramps
- removal of barrier

High number of barriers ↔ limited resources

Where to start to obtain the highest ecological benefit?

Prioritisation approach!
Mitigation measures: Prioritisation index

- **Migratory habitat**: higher priority to barriers in habitat of long-distant migrants
- **Location of barrier**: higher priority to barrier in or close to the Danube
- **Reconnected habitat length**: higher priority to barrier reconnecting long habitat stretches
- **Protected site (Natura2000)**: higher priority to barrier in/ close to Natura2000 sites
Mitigation measures: Prioritisation index

Legend

Long. Continuum Interruptions

Prioritisation Index
- utmost priority (PI >13)
- very high priority (PI 10 - 12)
- high priority (PI 7 - 9)
- medium priority (PI 4 - 6)
- low priority (PI 1 - 3)
- excluded (PI = 0)

Rivers (>4000 km²)

Presence of migratory species
- Head waters
- Medium-distance-migrants
- Long-distance-migrants

2009-10-07 (version 6)
Conclusions

- A high number of projects is in conflict with conservation needs
- Many small projects are implemented which contribute only a little to the RES-e Directive but jeopardize the aims of the WFD
- Well processed data and transparent results are required for decision making
- Further HP development plans have to base on a large scale assessment, integrating conservation needs & energy economics
- If HPPs are realized, ecological mitigation measures, e.g. fish passes, need to be considered
- Investments need to be assigned strategically to allow most efficient restoration process
University of Natural Resources and Life Sciences, Vienna

Department of Water, Atmosphere and Environment

Institute of Hydrobiology and Aquatic Ecosystem Management

DDI Carina Mielach

Max Emanuel-Straße 17, A-1180 Wien
Tel.: +43 1 47654-5202, Fax: +43 1 47654-5217
carina.mielach@boku.ac.at, www.boku.ac.at