Can the legal requirements be met by hydro power plants?

Rita Keuneke

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Legal requirements for surface waters

- EU Water Framework Directive (EU-WFD)
  - Good ecological status
  - Good ecological potential

<table>
<thead>
<tr>
<th>Biological quality elements</th>
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<tbody>
<tr>
<td>Phytoplankton</td>
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<tr>
<td>Macrophytes and phytobenthos</td>
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<tr>
<td>Benthic invertebrate fauna</td>
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<tr>
<td>Fish fauna</td>
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<table>
<thead>
<tr>
<th>Hydromorphological quality elements</th>
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<tr>
<td>Hydrological regime</td>
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<tr>
<td>River continuity</td>
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<tr>
<td>Morphology</td>
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<thead>
<tr>
<th>Physico-chemical quality elements</th>
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<tbody>
<tr>
<td>General conditions</td>
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<tr>
<td>Specific synthetic pollutants</td>
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<td>Specific non-synthetic pollutants</td>
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</tbody>
</table>
Legal requirements (Ger)

- German Federal Water Act – Wasserhaushaltsgesetz (WHG 2009)
  
  - § 33 Minimum flow conditions
    Sufficient flow according to the aims of the management plans
  
  - § 34 River continuity
    Sustaining or reinstatement of river continuity by appropriate facilities and operating methods
  
  - § 35 Use of hydro power
    Appropriate measures to protect fish population
Minimum flow conditions at diversion hydro power plants (HPP)

Example plant
- Design flow: 12 m³/s
- Power output: 130 kW
- Annual generation: 754,000 kWh/a

Q_{min} = 0.3 - 0.5 of average minimum flow
- Minimum flow: 2 m³/s
- Annual generation: 646,000 kWh/a
- approx. 14 % less
River continuity

- Construction of upstream migration facilities
Protection of fish population

- Fish protection and downstream migration facilities
  - Horizontal protection screens (10 to 15 mm clear width of bars)
    \[ Q_a \leq 50 \text{ m}^3/\text{s} \text{ per screen element} \]
  - Vertical protection screen (10 to 15 mm clear width of bars)
    \[ Q_a \leq 30 \text{ m}^3/\text{s} \text{ per screen element} \]
  - Appropriate bypasses
Economical view

Example HPP

- Annual gains: approx. 50,000 €/a
- Min. flow conditions: 10 to 15% of annual gains
- Value of plant at 4% interest rate and a remaining term of 20 years:
  \[0.9 \times 50,000 \text{ €/a} \times 13.6 = 680,000 \text{ €}\]
- Construction costs of upstream migration facilities
- Construction costs of fish protection and downstream migration facilities
- Total costs of measures: 830,000 €

⇒ Funding necessary
Feed-in tariff (Ger)


<table>
<thead>
<tr>
<th>$P_{EEG}$ up to</th>
<th>Feed-in tariff ct/kWh</th>
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<tbody>
<tr>
<td>500 kW</td>
<td>12,40</td>
</tr>
<tr>
<td>2 MW</td>
<td>8,17</td>
</tr>
<tr>
<td>5 MW</td>
<td>6,25</td>
</tr>
<tr>
<td>10 MW</td>
<td>5,48</td>
</tr>
<tr>
<td>20 MW</td>
<td>5,29</td>
</tr>
<tr>
<td>50 MW</td>
<td>4,24</td>
</tr>
<tr>
<td>ab 50 MW</td>
<td>3,47</td>
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</table>

- Requirement
  - Increase of power capacity (technical measures)
  - Upgrading measures which require authorisation (ecological measures)
Reimbursement (Ger)

Electricity production costs

![Bar chart showing electricity production costs for various capacities (100 kW, 200 kW, 500 kW, 1 MW, 2 MW, 5 MW) with different cases (Lower limit case, average, Upper limit case, Feed-in tariff) and costs per kWh.](chart.png)
Number and annual generation of HPP in Germany (in 2013)

- Number of plants:
  - P < 1 MW: 94%
  - P >= 1 MW: 6%

- Annual generation:
  - P < 1 MW: 14%
  - P >= 1 MW: 86%
Fish protection at large HPP (Q >> 100 m³/s): No state of technology

- Protection screens
  - Unrealisable
- Fish friendly turbines
  - Lack of practical experience
- Eel friendly operation
  - Species-specific
Conclusion

Can the legal requirements be met by hydropower plants?

- Small HPP: uneconomical
- Large HPP: lack of adequate technology
Thank you for your attention

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