Sustainable development of hydropower – tools and methods

Atle Harby, CEDREN
Dams

- Migration barrier
- Loss of connectivity
- Less access
- Loss of biodiversity
Degraded habitat in bypassed sections
Change in downstream flow regime
Landscape effect
Impacts on wildlife
Greenhouse gas emission control
Resettlement
Mitigation

Fishstockings

Fishways

Physical constructions
Flow and the environment

environment

flow
Flow and the environment
Variation important!

Stable low flow

Flood

Foto: SINTEF

Foto: NTNU
Alternatives

- Investigate status
- Compare to other rivers
- Guess
- Model

![Graph showing water flow and area comparison](image)
### Methods and models

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*please note that the exact position of boxes may vary from the point of view and by case*
More complex systems
Mesohabitat classification

ArcMap digitised mesohabitats overlayed topographic maps

flow direction
Hydraulic models for rivers

- **HEC-RAS**
  - Well known and widely used
  - 1-D suitable also for long reaches

- **MIKE 11**
  - Well known and widely used
  - 1-D and 2-D suitable also for long reaches
  - Expensive

- **RIVER 2D**
  - Robus, but not as well known or widely used as HEC-RAS or MIKE 11

- **SSIIM**
  - 3D including sediment transport
  - Widely in research use
Rapid changes in flow → stranding risk
Lake and reservoir models

- CE-QUAL-W2 calculates physical and ecological variables as a function of climate, flow and load.
- Results: Current velocity, temperature, ice, oxygen content, particle concentrations, chemistry, bacteria, sediments, algal growth, etc.
- 2-D model with user defined time steps.
- CE-QUAL-W2 is well suited for simulations in long and narrow lakes and reservoirs, as well as rivers, estuaries and fjords.

Freeware from EPA
Widely applied in Norway.
Biological and ecological models in running waters

- Functional relationships
- Correlations
- Habitat models
- Population models
Seasonal requirements

- Natural
- Regulated

Flow (m³/s)

- Egg survival, winter habitat
- Smolt migration
- Maintain geomorphology
- Fry displacement?
- Habitat
- Attract spawners
- Spawning

- 1. jan.
- 1. feb.
- 1. mar.
- 1. apr.
- 1. mai.
- 1. jun.
- 1. jul.
- 1. aug.
- 1. sep.
- 1. okt.
- 1. nov.
- 1. des.

CEDREN
Centre for Environmental Design of Renewable Energy
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.

From Richter, adapted from Tharme & King.
....thank you for your attention!