New tools for old problems

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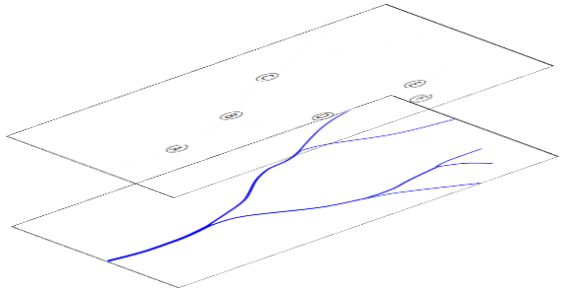
Model overview

Socio-economic goals

Input

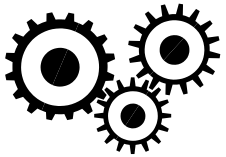
Barrier & River Data



Input

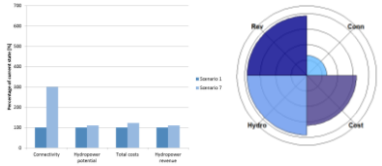
Decision Support Tool

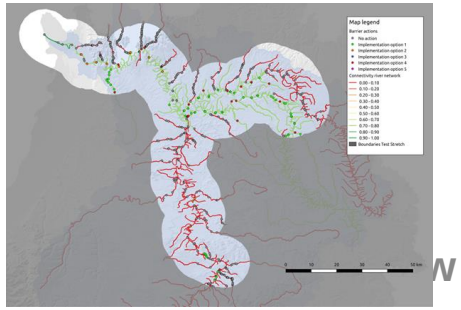
Optimisation model



Trade-offs analysis of key performance indicators (KPIs)

Optimal Solution





Output

This project has received funding from the Horizon 2020 Research and Innovation programme under grant agreement No 101062.

KPIs

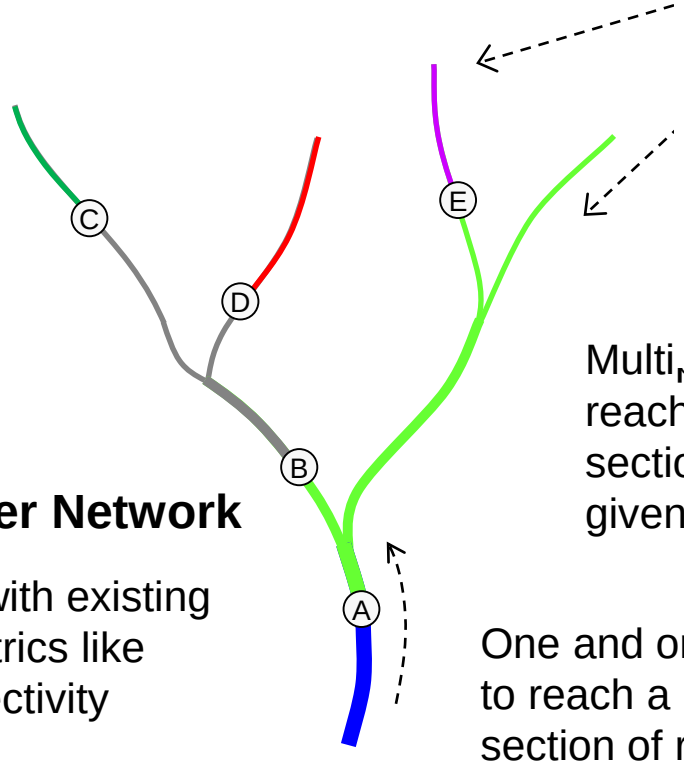
1. Maximise river connectivity (0-1 scale)
2. Maximise hydropower generation potential (kW) under medium flow conditions
3. Minimise total cost (€M) of:
   - Structural engineering works for barrier modification, mitigation, or removal
   - Annual waterborne transport of goods given low flow conditions
   - Installation / retrofitting of hydropower turbines
4. Maximise hydropower revenue (€M)

Main input data

- Number and spatial position of artificial structures
- Physical and design characteristics of structures (e.g. height, elevation, installed hydropower capacity)
- Hydraulic data (e.g. low/medium flow and natural water depth)
- Barrier passability (0 to 1 scale)
- Barrier modification, mitigation, and removal options
- Cost of structural engineering works (for barrier modification, mitigation, and removal)
- Cost of hydropower installation and retrofitting
- Shipping cost curves (as a function of min. water depth)

River connectivity

Take-home message: Modelling of multithreaded river systems opens up a lot of new possibilities

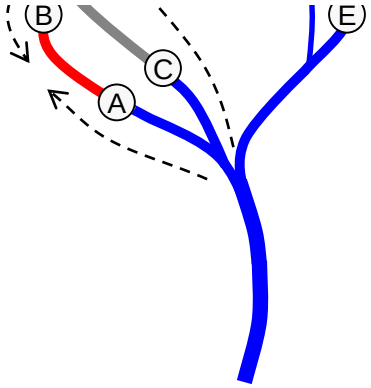


Dendritic River Network

Easy to model with existing connectivity metrics like Dendritic Connectivity Index (DCI)

One and only one way to reach a particular section of river from a given starting point

Multiple ways of reaching a particular section of river from a given starting point



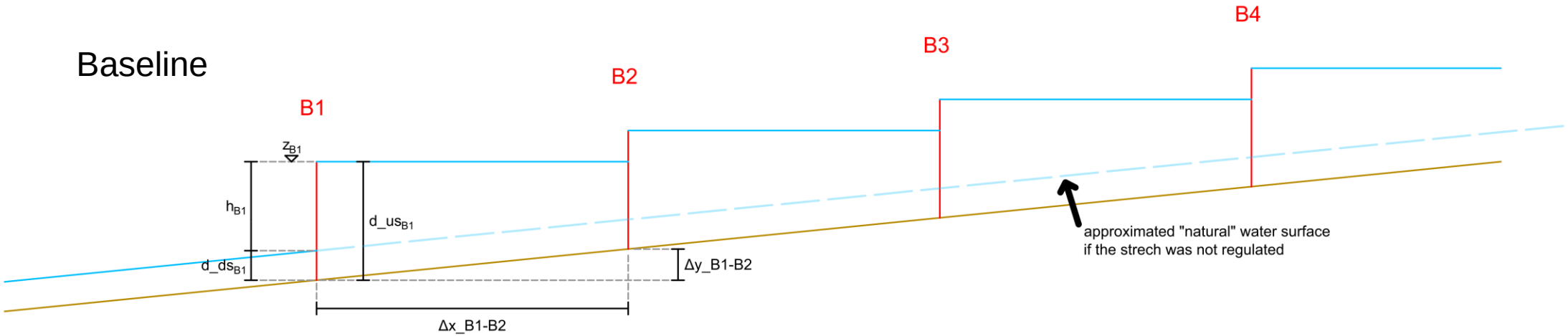
Multithreaded River Network

Difficult to model. Requires novel ways to measure connectivity.

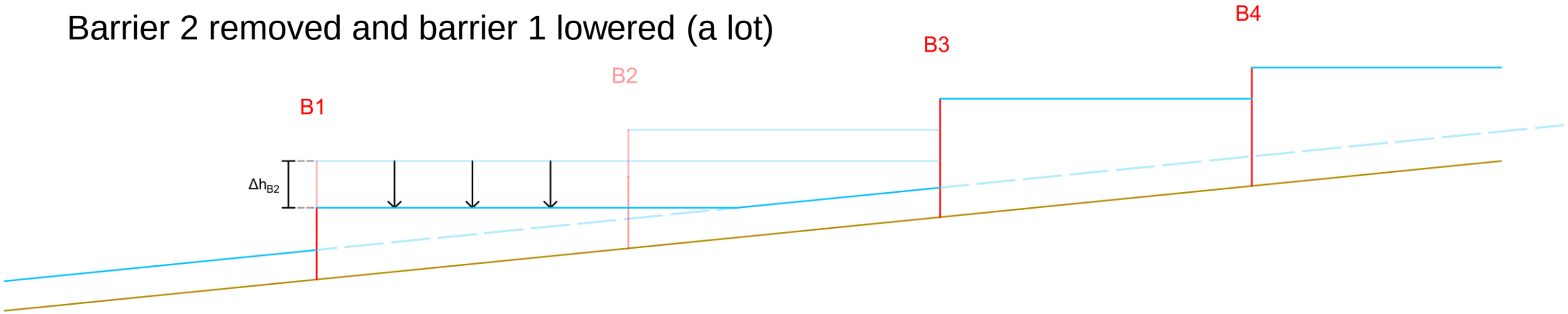
Backwater effects

Incorporating backwater effects essential for determining passability and for assessing hydropower potential

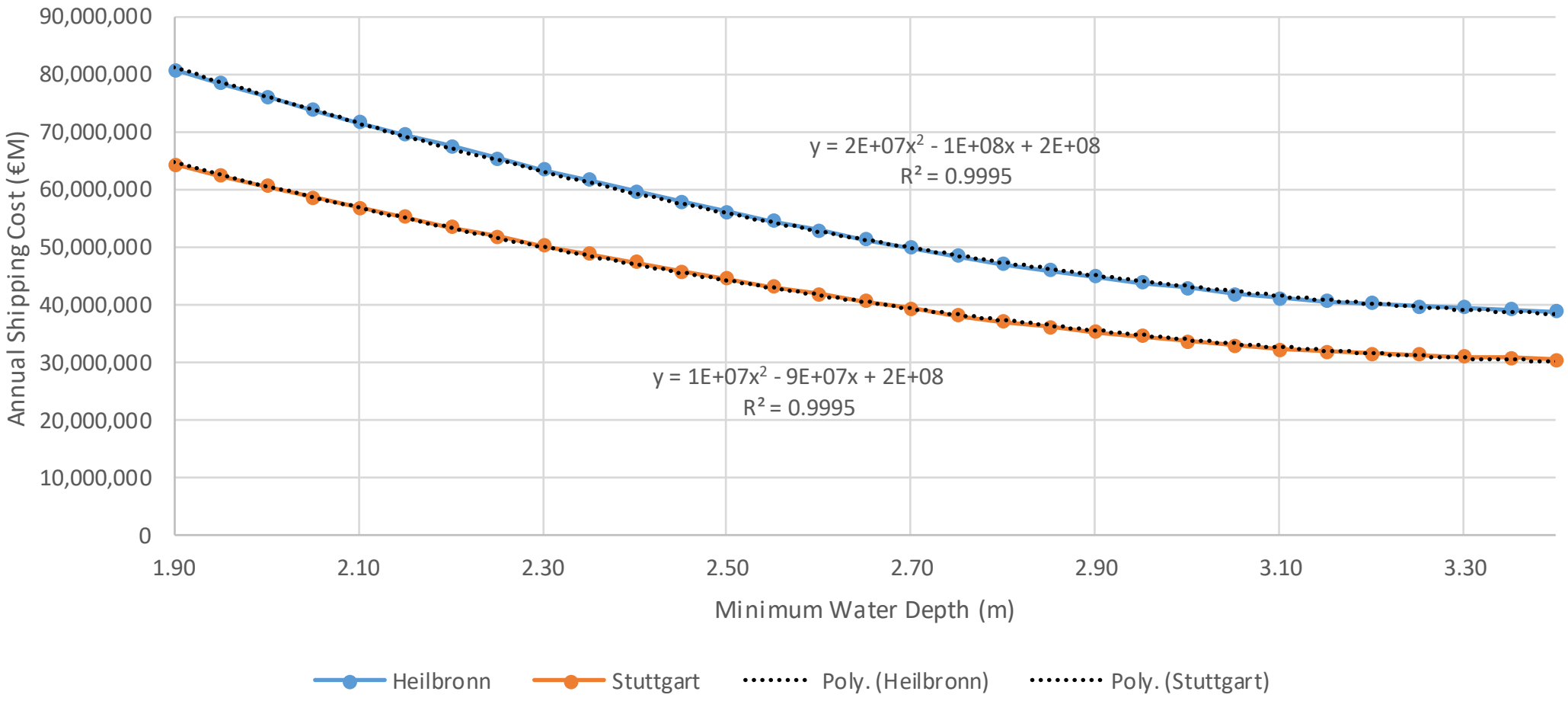
Baseline



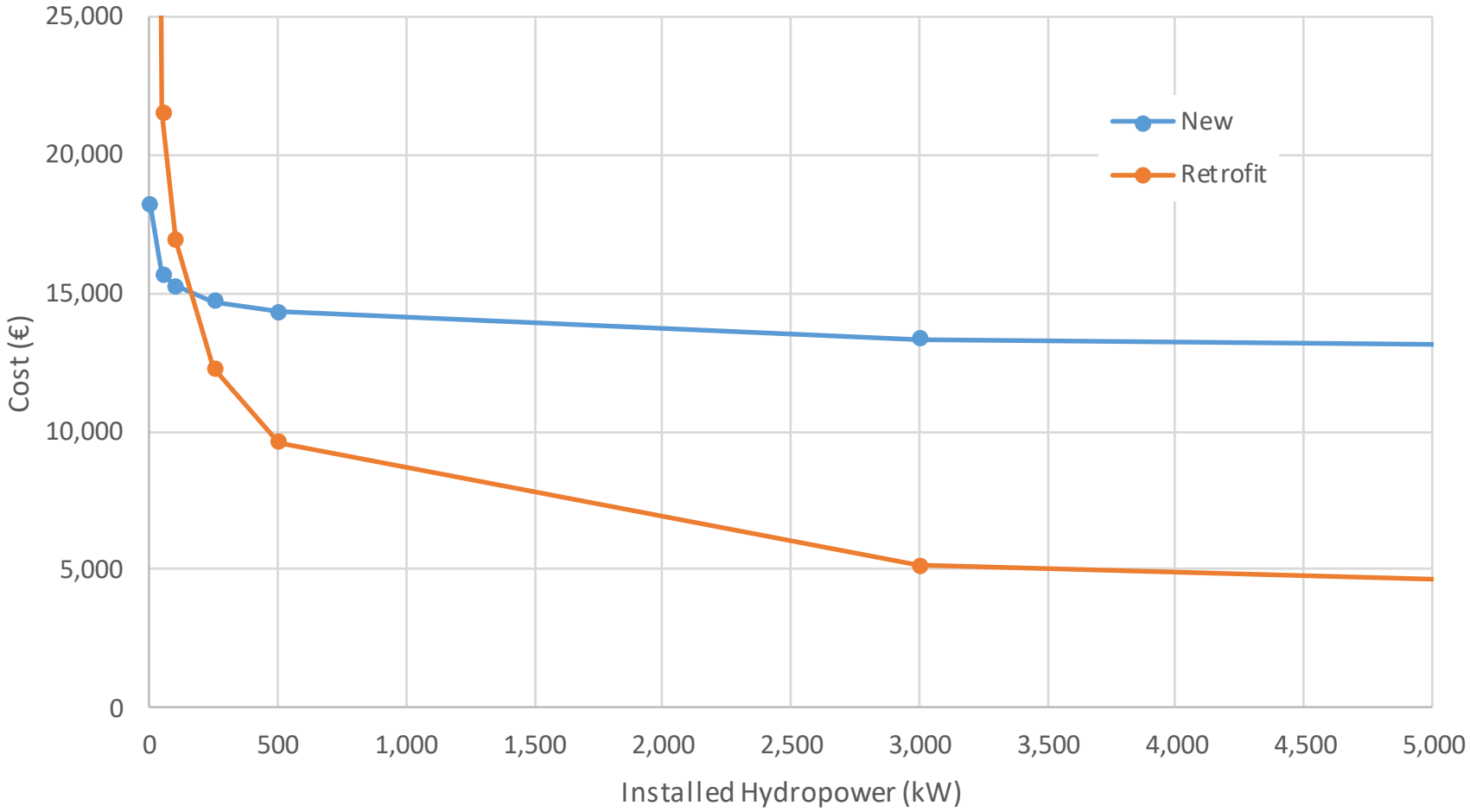
Barrier 2 removed and barrier 1 lowered (a lot)



Shipping cost curves



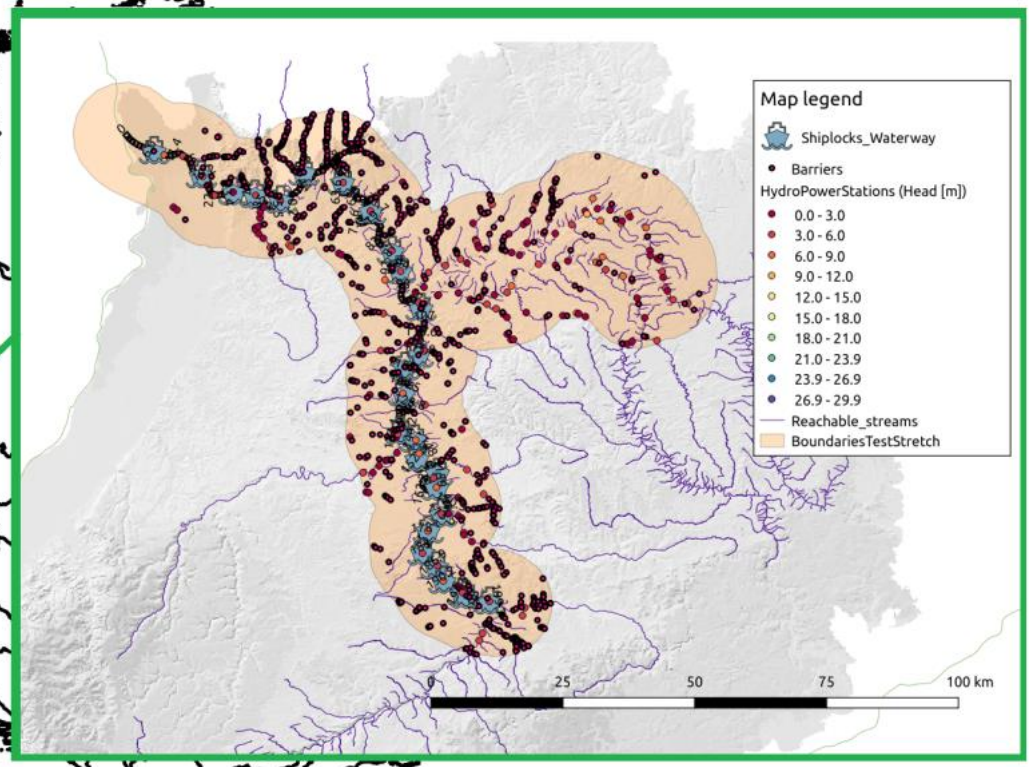
Hydropower unit installation cost



Neckar River catchment

Neckar Database

- 4,069km of river
- 1069 weirs, dams, and culverts and 27 shipping locks
- Installed hydropower capacity at existing hydropower plants
- Med. flow estimates
- Low / medium / natural water depth estimates
- Shipping cost data
  - Fleet make-up
  - Cross-port distances and shipping volumes
  - Shipping cost equations as functions of: max. eff. draft, travel distance, laden vs. unladen returns



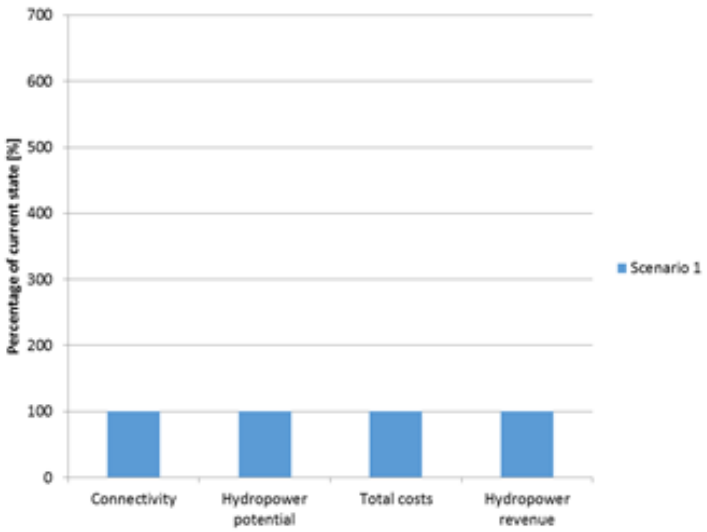
Planning options

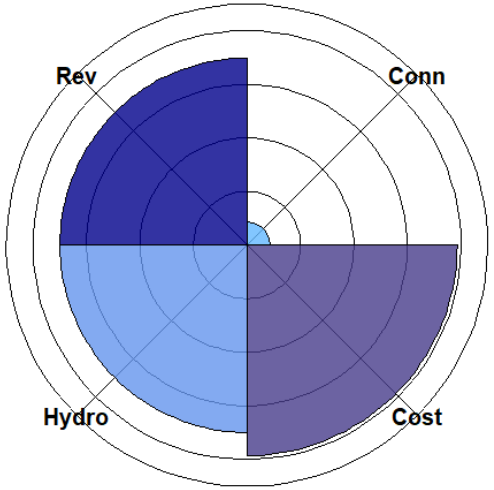
- Do nothing
- Install fish pass if none currently (dams and weirs only)
- On main Neckar
  - Raise head 0.5m to (i) increase hydropower potential; (ii) raise water depth upstream to reduce the cost of shipping; (iii) possibly increase passability of barriers upstream; or (iv) any combination thereof.
  - Lower head 0.5m to increase fish passability
- Off main Neckar
  - Remove completely to increase fish passability
  - Culvert replacement to increase fish passability

Planning scenarios

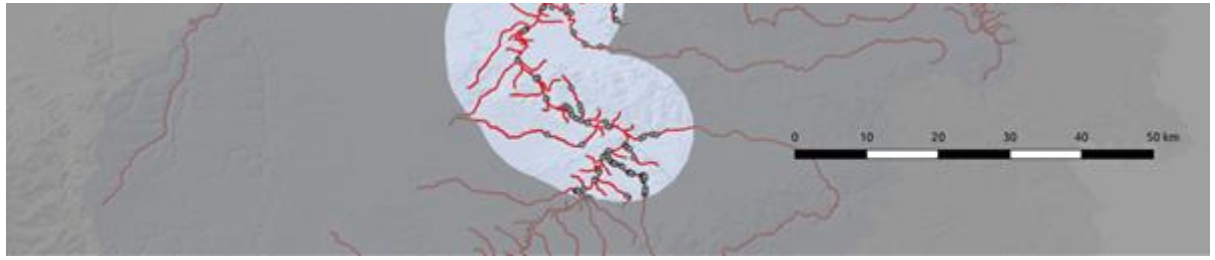
No.	Scenario
1	Current situation
2	Maximise connectivity
3	Maximise hydropower
4	Minimise cost given: i) no decrease in connectivity and ii) no decrease in hydropower
5	Minimise cost given: i) no decrease in connectivity and ii) a 10% increase in hydropower
6	Minimise cost given: i) a 200% increase in connectivity and ii) no decrease in hydropower
7	Minimise cost given: i) a 200% increase in connectivity and ii) a 10% increase in hydropower
8	Minimise cost given: i) a 400% increase in connectivity and ii) a 10% decrease in hydropower
9	Minimise cost given: i) a 400% increase in connectivity and ii) no decrease in hydropower
10	Minimise cost given: i) a 400% increase in connectivity and ii) 10% increase in hydropower

Current situation





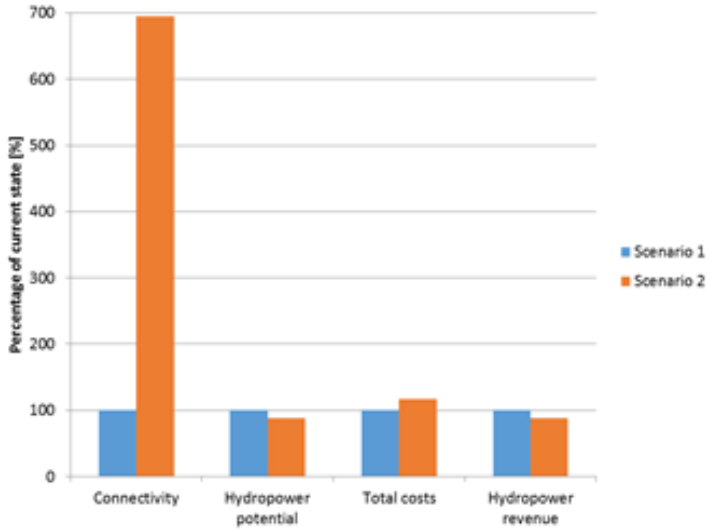
Take-home message: Like most places across Europe, the Neckar has been heavily impacted by barriers

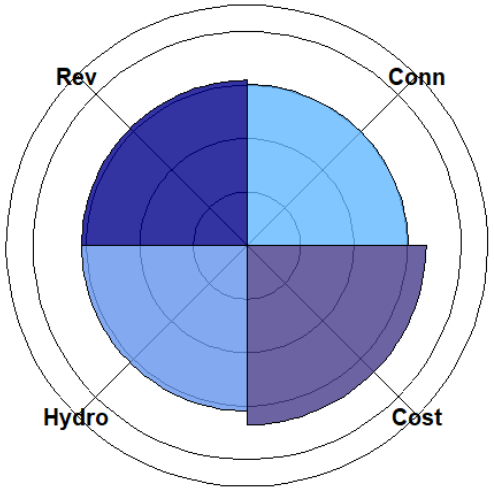


Observations:

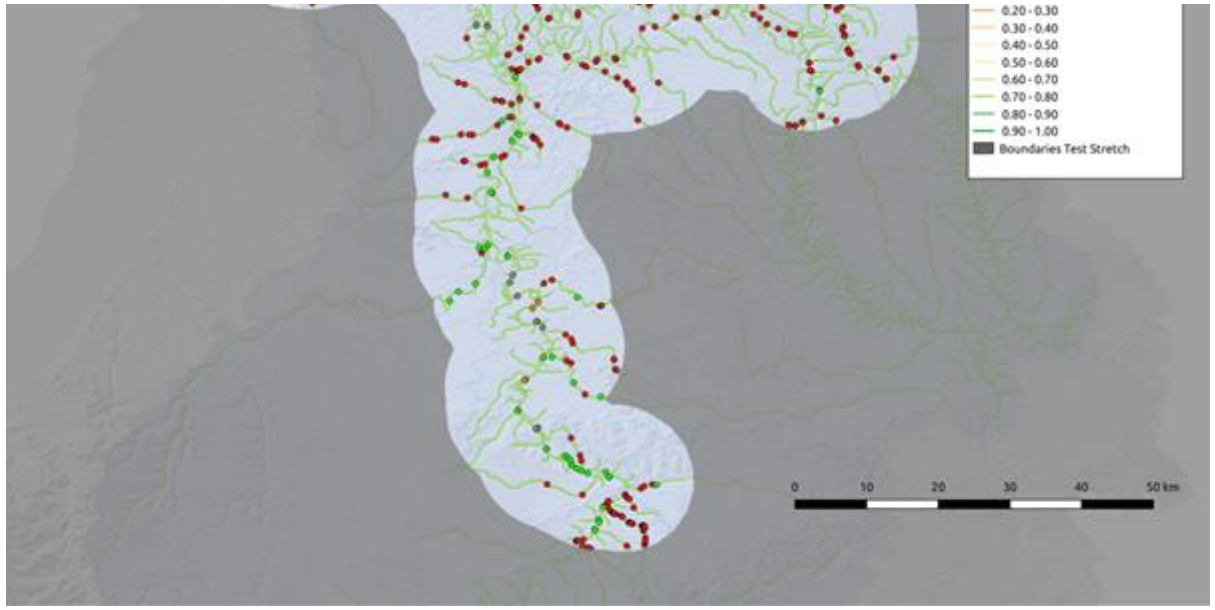
- Current connectivity in the Neckar is deficient.
- Most well-connected river sections along the main Neckar because of existing fish passes and semi-passable locks.

Maximise connectivity





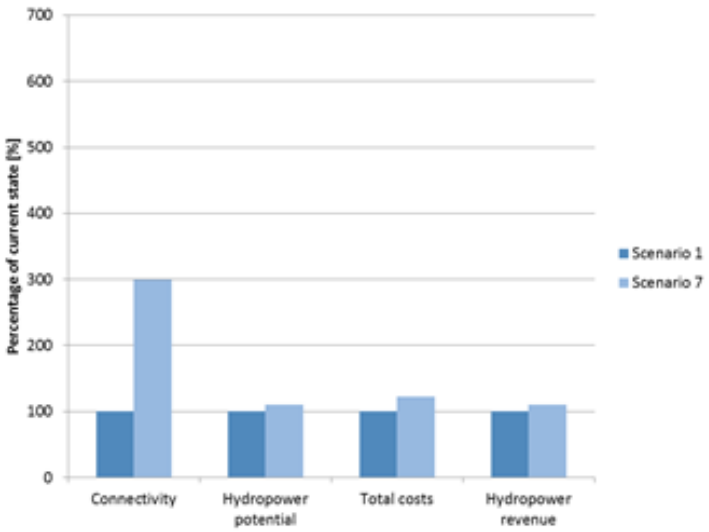
Take-home message: There's no free lunch!

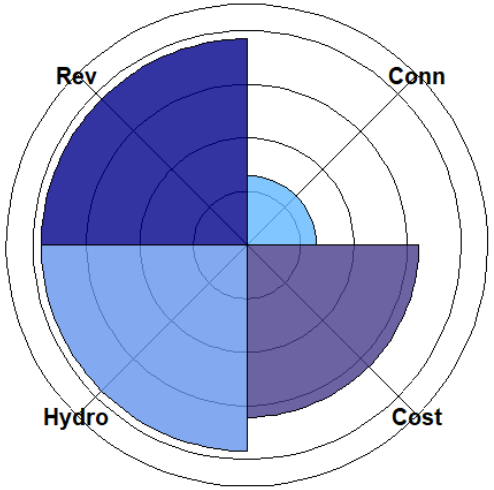


Observations:

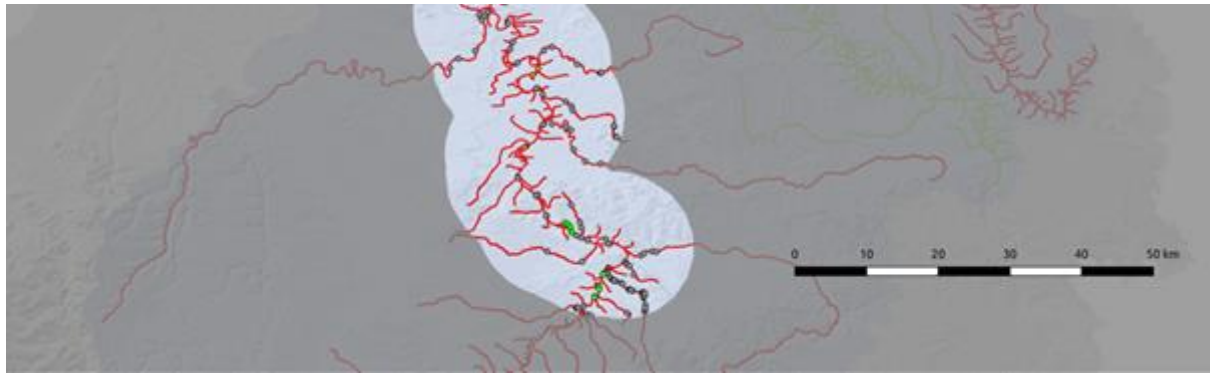
- Possible to increase connectivity considerably.
- High project cost, but partly offset by lower shipping cost.
- Hydropower potential and revenue both reduced.

+200% conn. & +10% hydropower





Take-home message: Still no free lunch, but maybe possible to find a happy tradeoff



Observations:

- Much better connectivity along main Neckar and main tributaries (still low in minor tributaries).
- Increased hydropower potential/revenue (10%).
- Total cost 22% higher but only a 3.7% dec. in net benefit.

THANK YOU LET IT FLOW

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