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Sustainability counts

Characterization factors for damage to aquatic biodiversity caused by water use especially from dams used for hydropower

Sebastien Humbert^{1,2*}, Romain Maendly¹

1 University of California, Berkeley, USA

2 Quantis, Lausanne, Switzerland

*sebastien.humbert@quantis-intl.com, +41-79-754-7566

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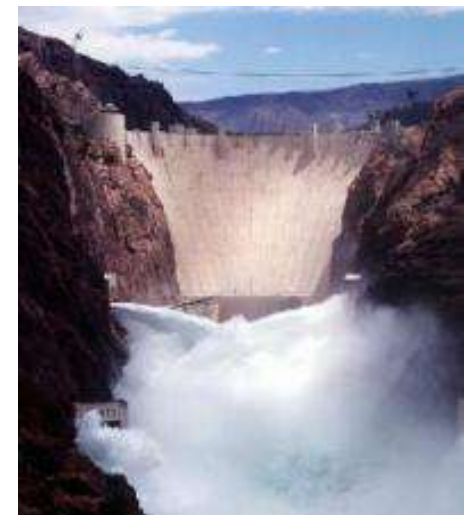
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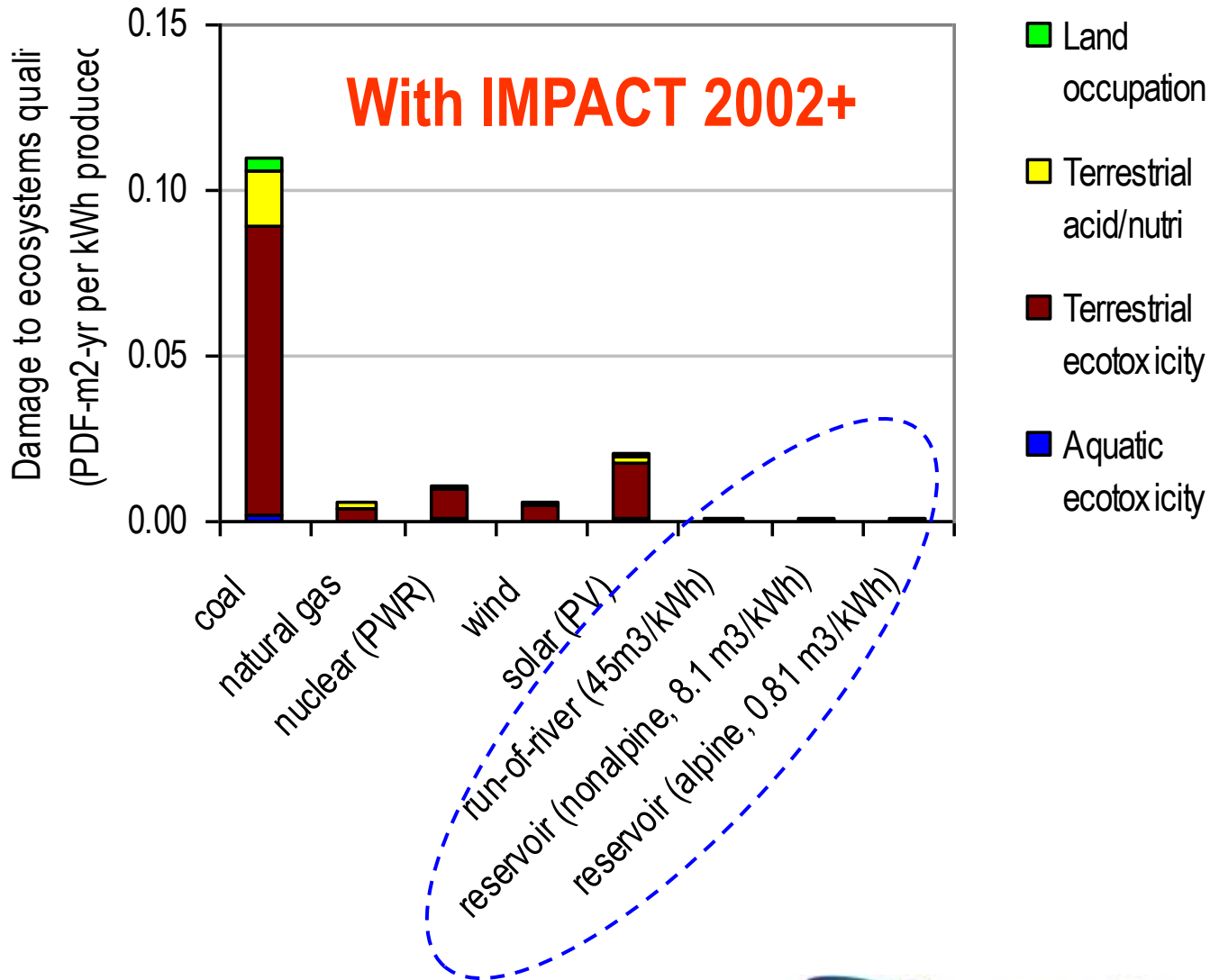
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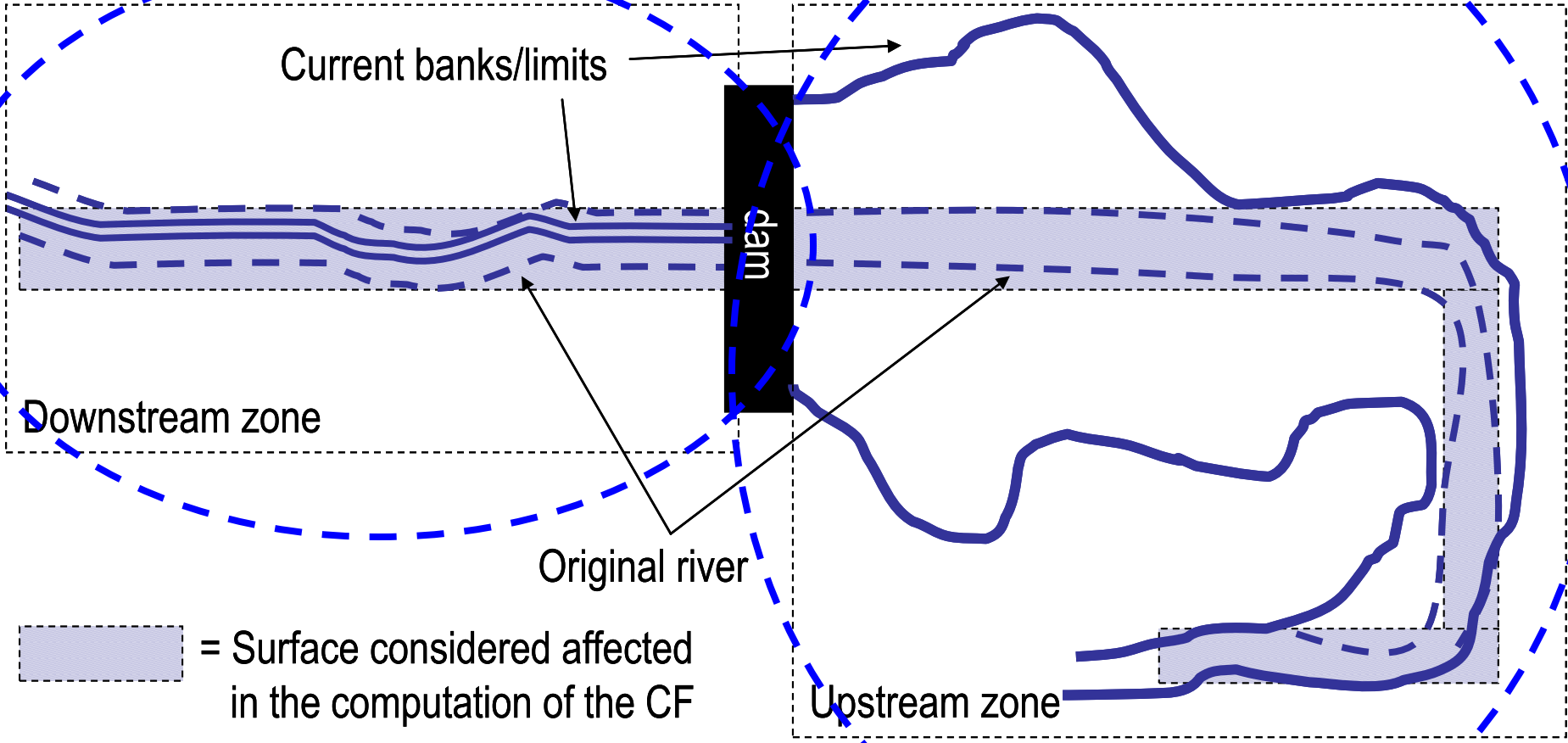
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Hydropower has less damage to ecosystems quality?



2 sub-sections



The characterization factor (CF)

*Impact score = emission or use of a resource * CF*

Fraction of species that disappears

Surface affected

$$CF = \frac{PDF * S}{Q_{water_or_electricity}}$$

[PDF*m²*yr / m³ or kWh]

Flow “under” the dam or electricity produced, per year

$$CF_{total} = \sum_i \underbrace{CF_{section_i}}_{\text{per sub-section}} = \frac{1}{Q_{total}} \sum_i (PDF_{section_i} * S_{section_i})$$

→ one can generate a unique CF (per m³ or per kWh) whatever the size of the dam the power is from

Per m³ of water

0.01 PDF·m²·yr

(0.002 – 0.1) (x50)

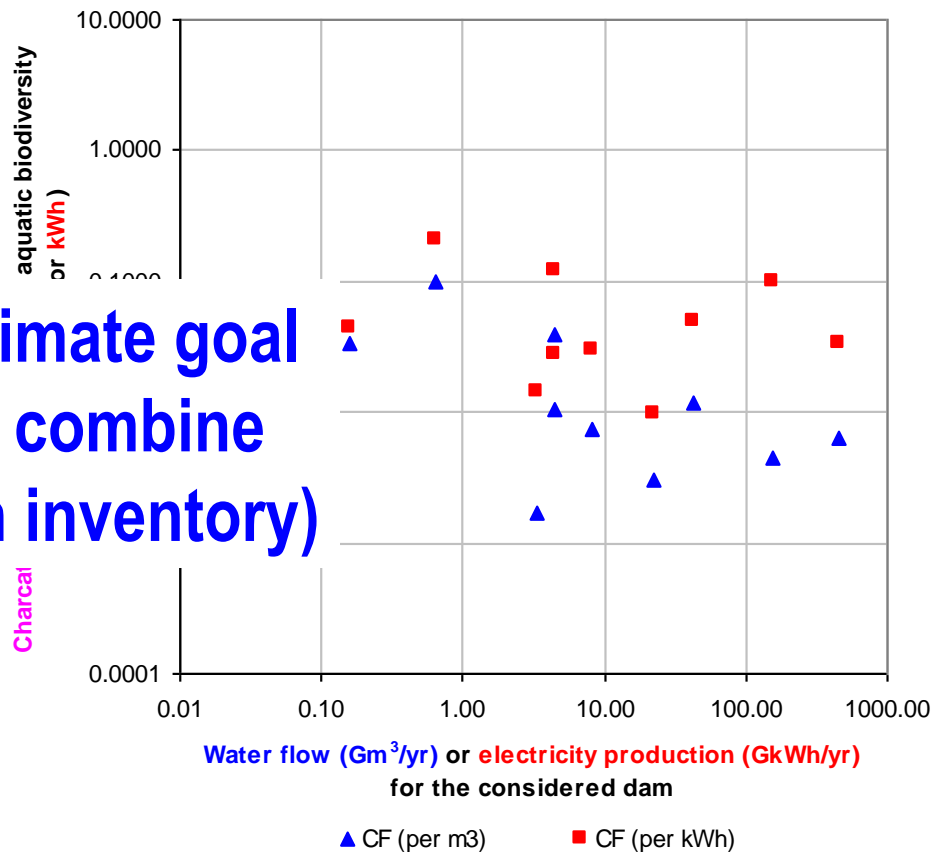
- ultimate goal
(to combine
with inventory)

Per kWh produced

0.04 PDF·m²·yr

(0.01 – 0.2) (x20)

- range smaller
- more robust



Alpine dams divert alpine rivers

Damage =
disappeared fraction of
species (PDF)
on a certain surface area (S)

With

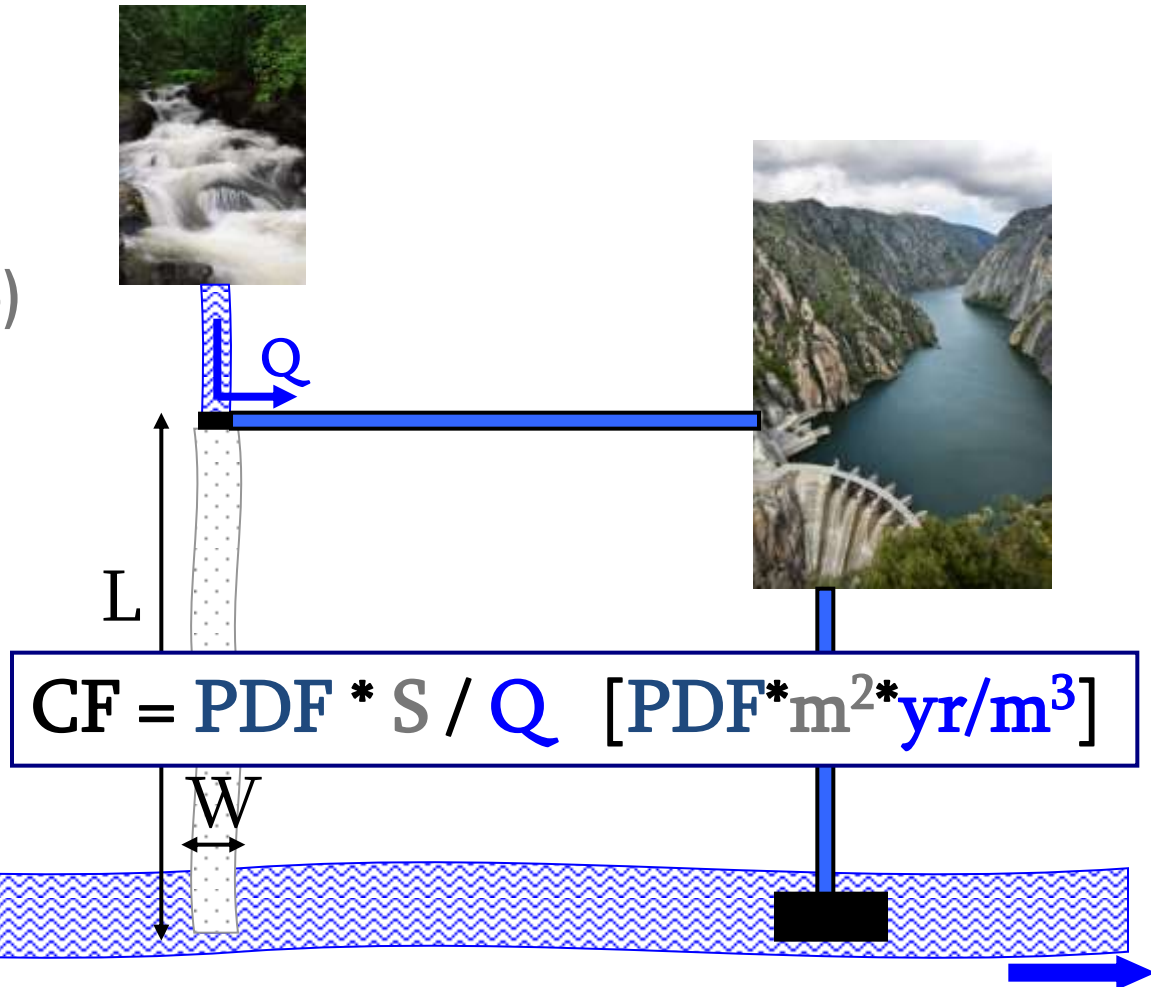
$$PDF = \sim 1 \text{ PDF}$$

$$S = L [m] * W [m]$$

This is caused by a flow Q
that is not here anymore

With

$$Q = [m^3/yr]$$



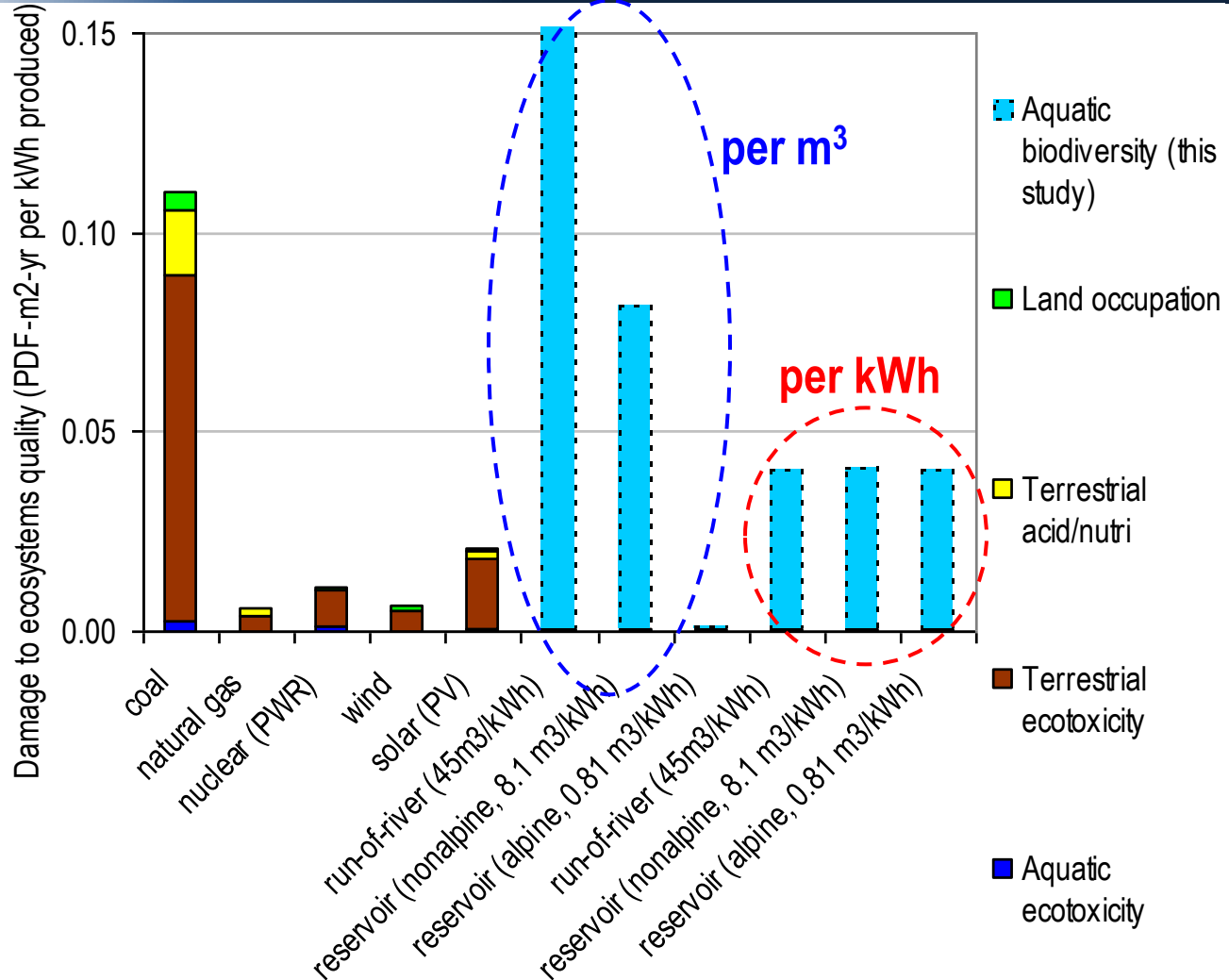
Input parameters for alpine dams

| ID | L [m] | W [m] | Q [m ³ /s] | CF [PDF·m ² ·yr/m ³] |
|----|-------|-------|-----------------------|---|
| 1 | 10000 | 2 | 1 | 0.0006 |
| 2 | 5000 | 1 | 0.1 | 0.002 |
| 3 | 20000 | 1 | 0.5 | 0.001 |
| 4 | 40000 | 3 | 3 | 0.001 |

Geomean CF = 0.001 PDF·m²·yr/m³ (0.0006-0.002)

Weighted average (using Q as weights) CF = 0.001 PDF·m²·yr/m³

Aquatic biodiversity appears not negligible





Thank you for your interest!

→ *Poster*

Questions ?

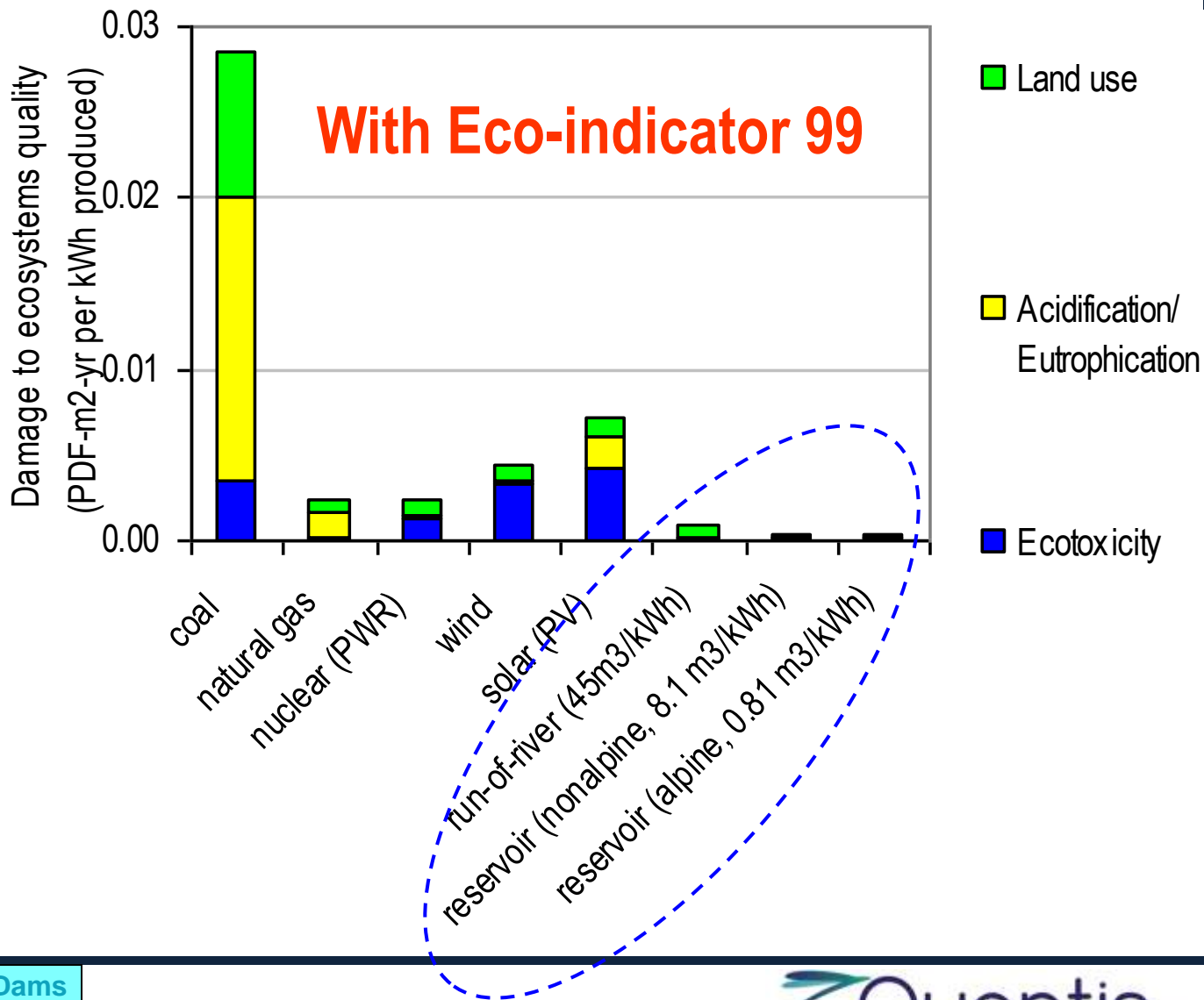
Thanks to Manuele Margni for his precious feedbacks

Maendly and Humbert (2009) "Characterization factors for damage to aquatic biodiversity caused by water use" in process

Problem statement

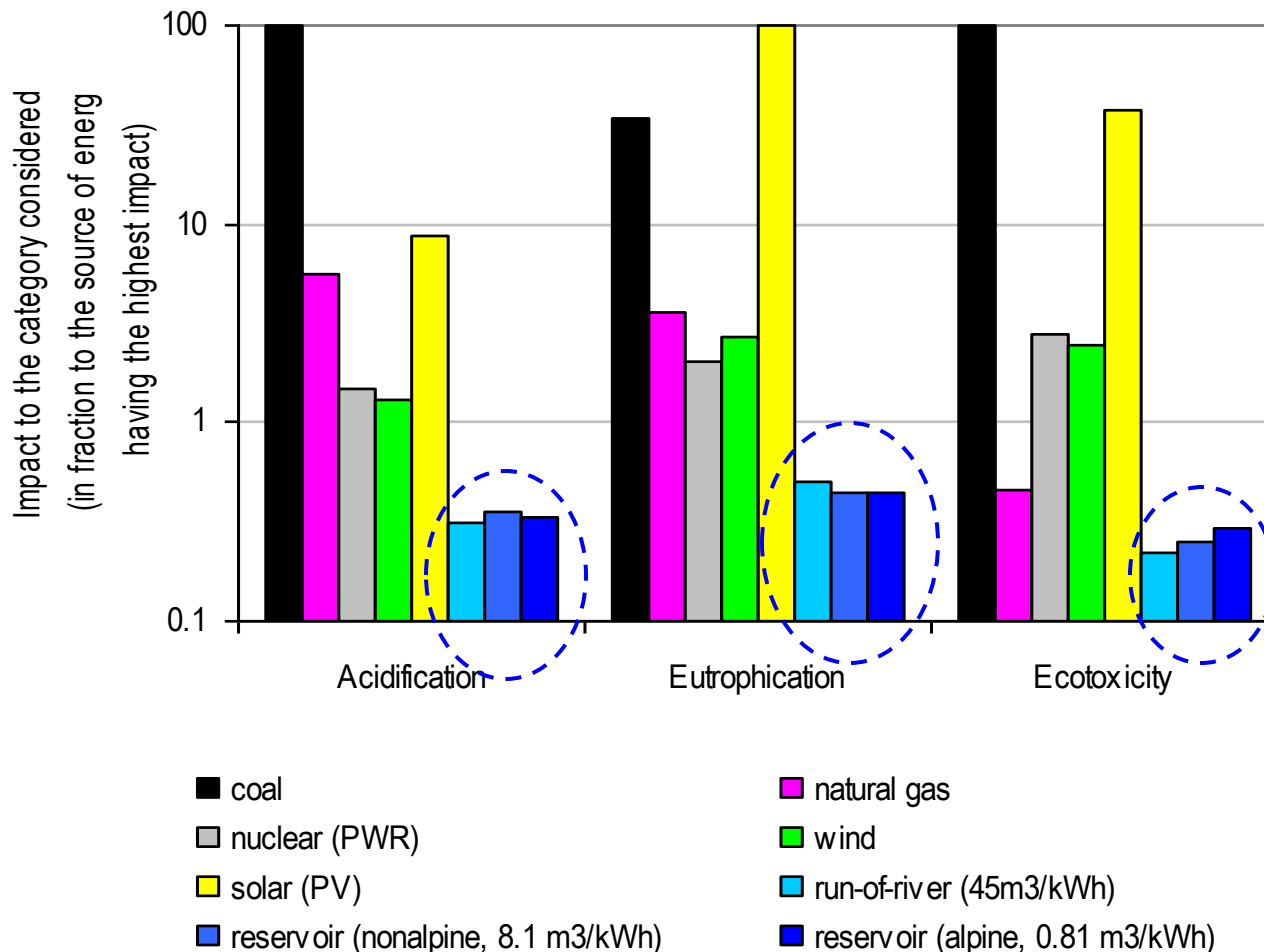
- LCA tend to systematically show **hydropower** more environmentally friendly than other alternatives to produce electricity
- Can be intuitive for CO₂,
 - Though dams in tropical regions can emit high amount of CH₄
- Using traditional LCIA methodologies, even **damage to ecosystems quality** appears lower for dams than for fossil fuel based power plants

Hydropower has less damage to ecosystems quality?



Hydropower has less damage to ecosystems quality?

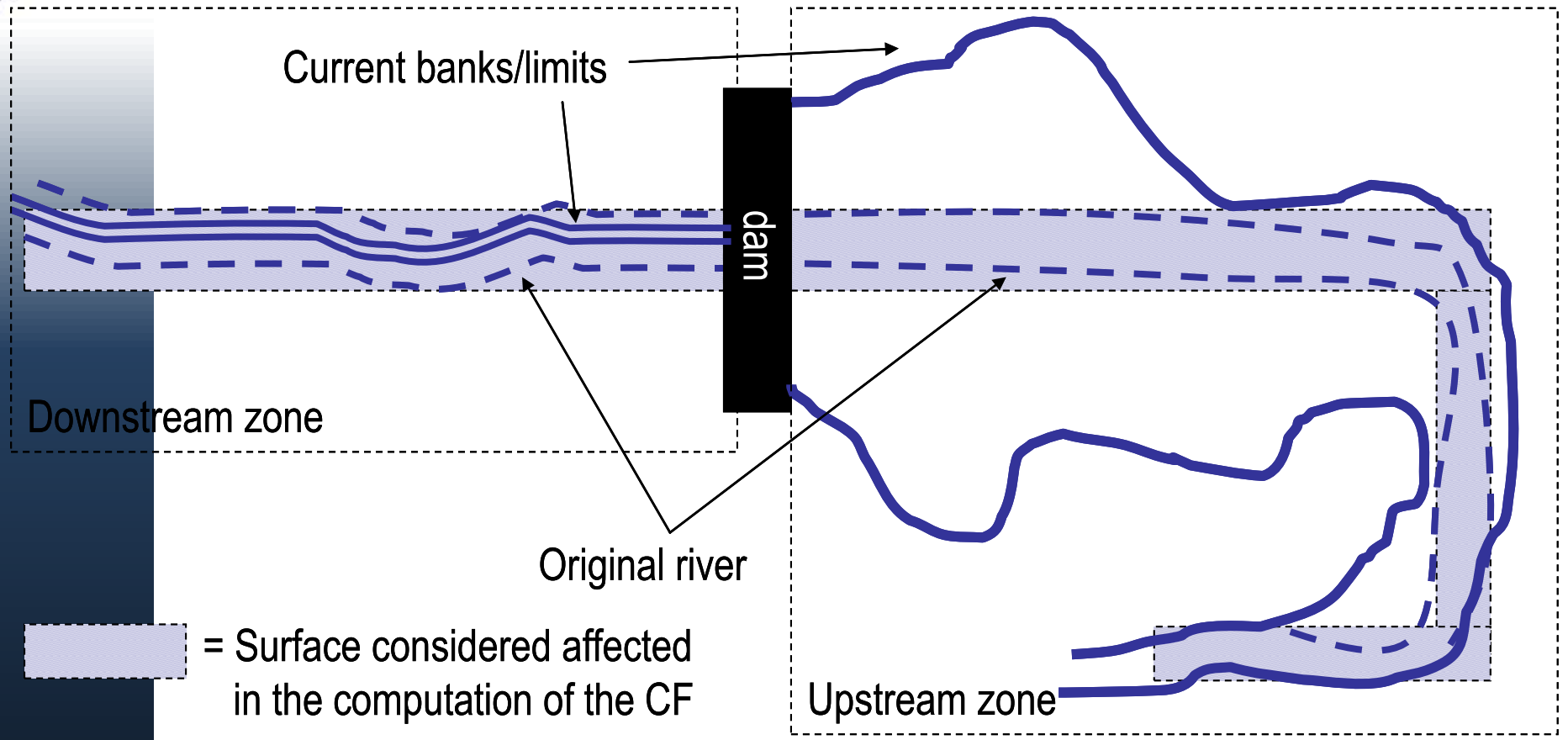
With TRACI (midpoint)



Problem & Objective

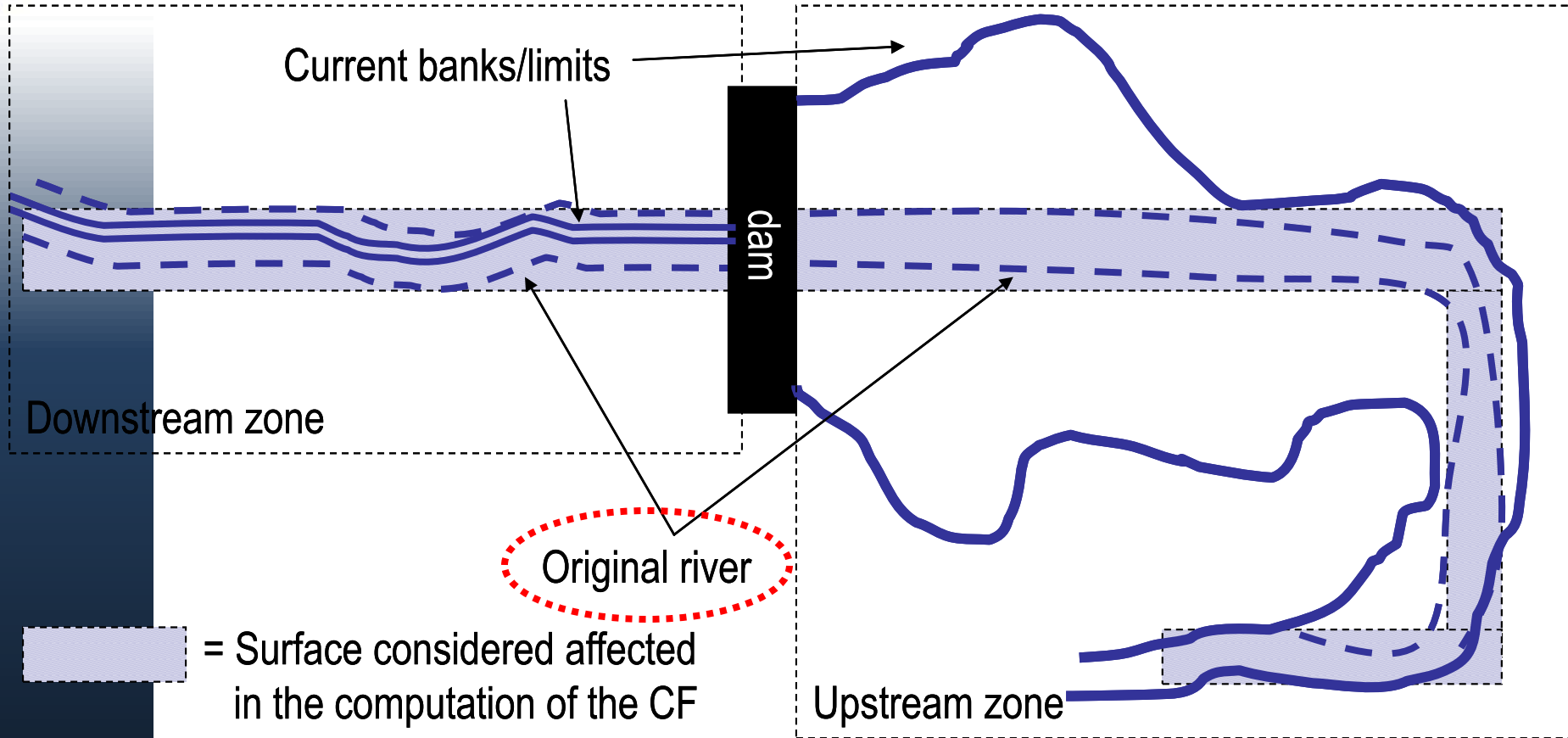
- No impact category to account for **aquatic biodiversity loss** due to a change in the ecosystems caused by dams
 - *No impact category* → *no impact.... !?*
- Our goal:
 - Try to **capture** this **damage** in a comprehensive and **usable way** with current LCA approach
- **Empirical approach**, using observation of **reduction in biodiversity** in the river between before and after the **construction of dams**

The model



 = Surface considered affected in the computation of the CF

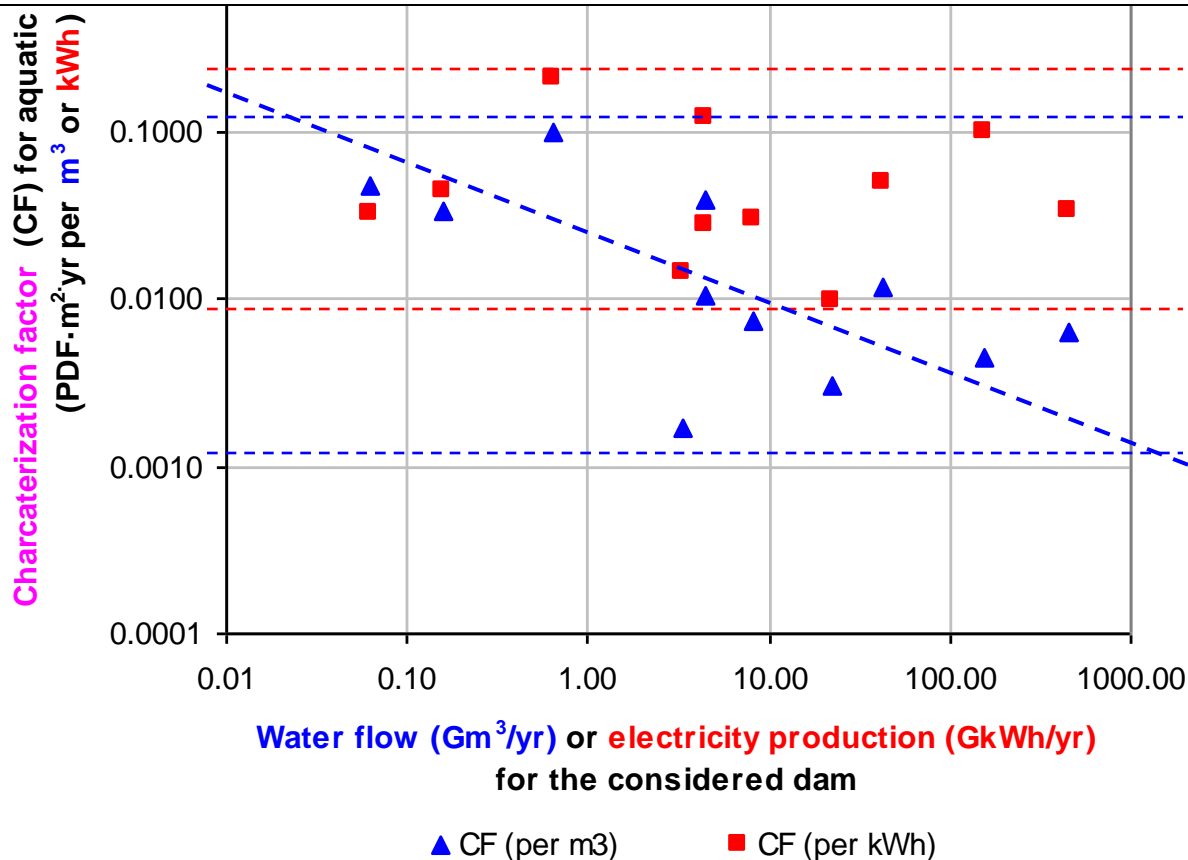
The model



Our goal: capture the damage on the original system

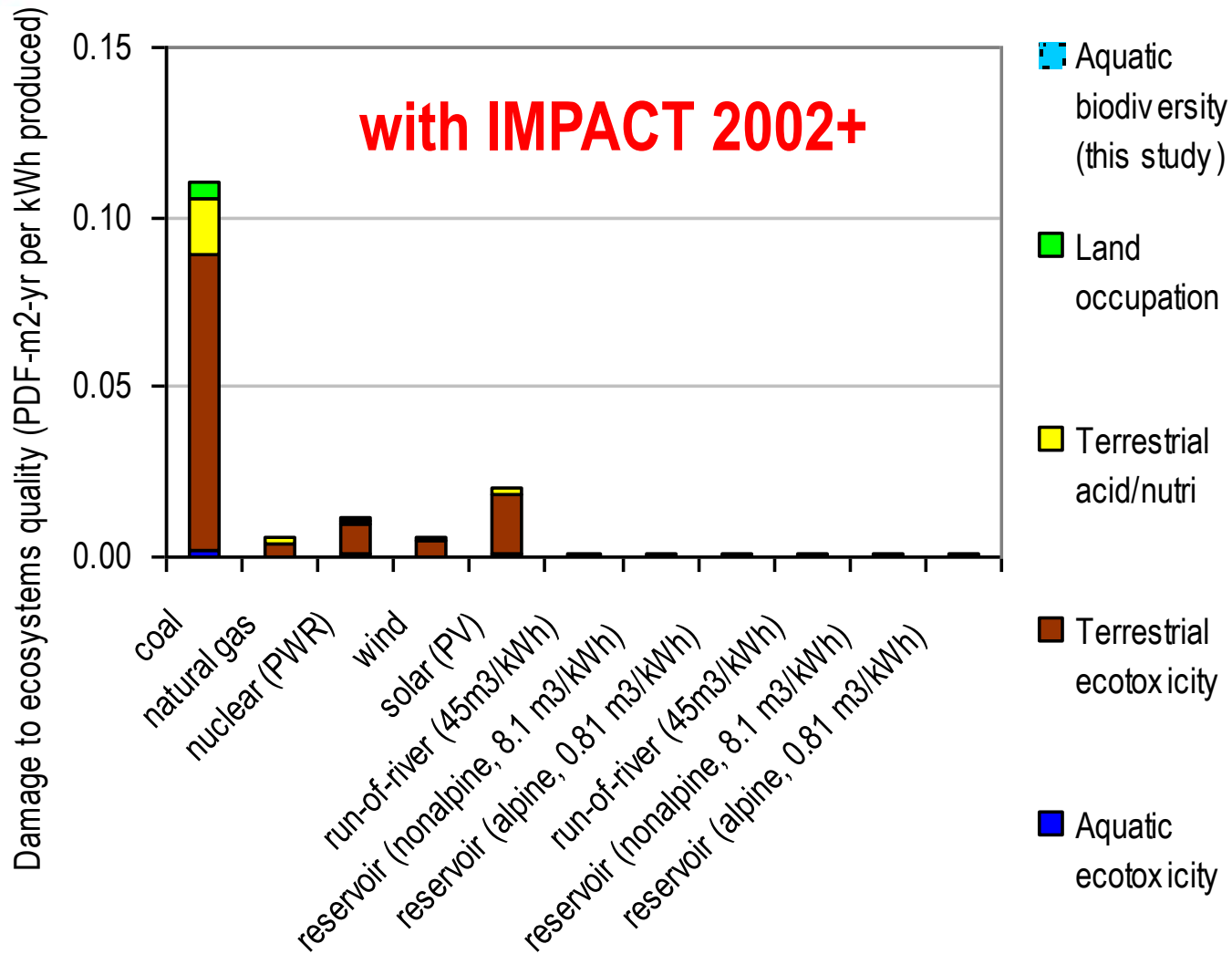
CF independent of the size!

→ **per kWh** appears more 'robust' than **per m³** of water

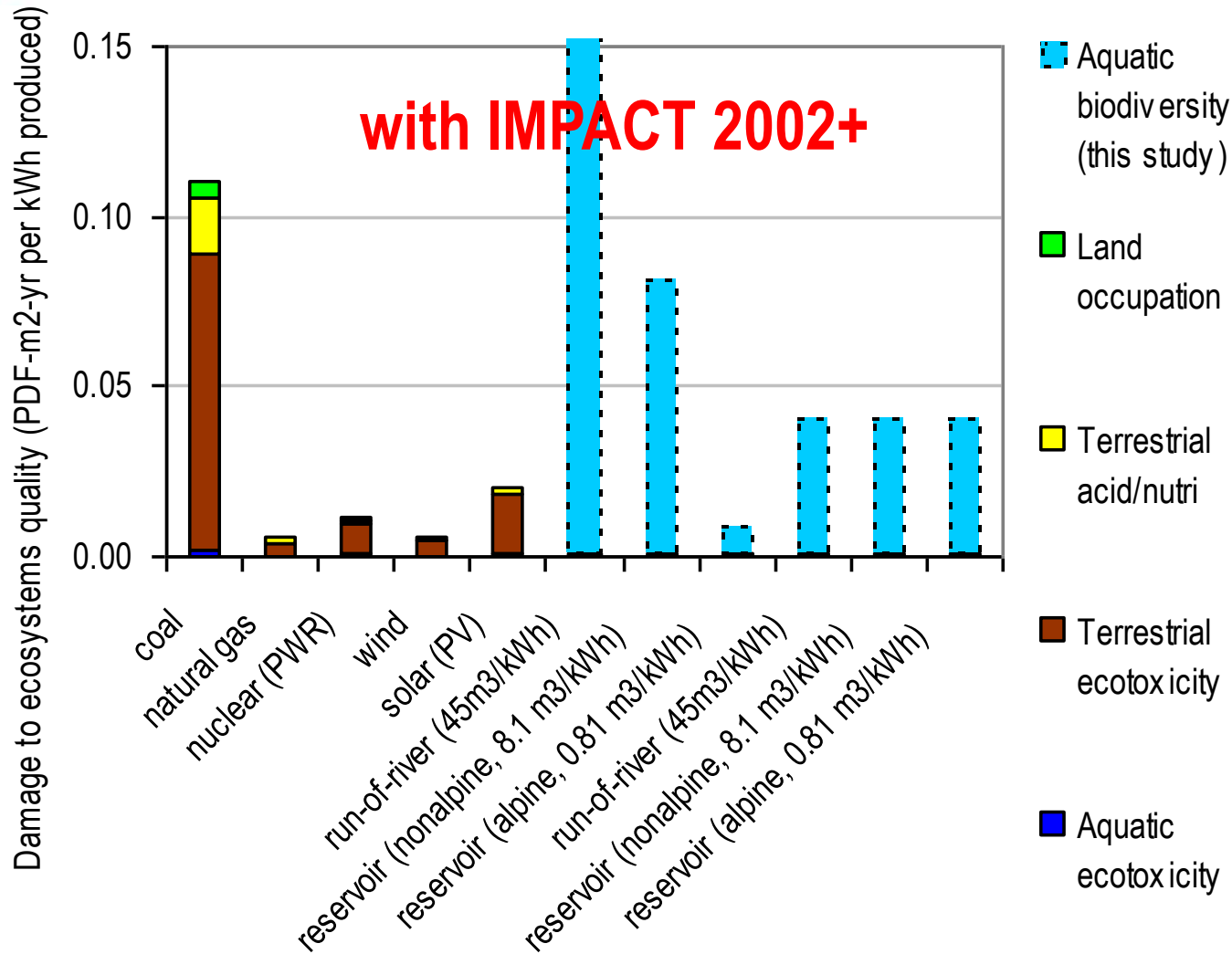


reduction statistically significant?

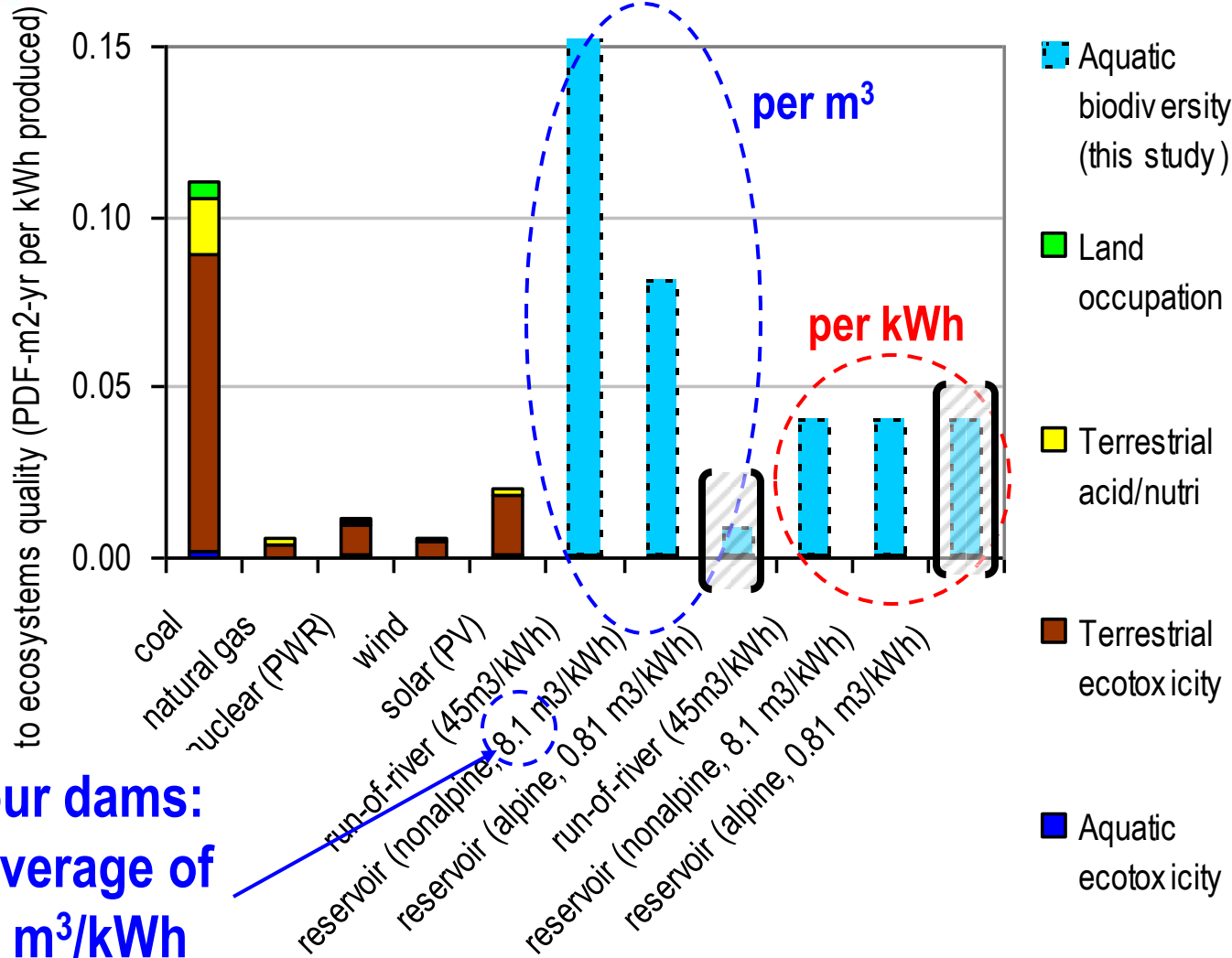
Back to original results



Aquatic biodiversity appears not negligible



Aquatic biodiversity appears not negligible



Alpine dams seem to have lower damage than non-alpine dams

- Non-alpine dams: $CF = 0.01 \text{ PDF} \cdot \text{m}^2 \cdot \text{yr} / \text{m}^3_{\text{water turbined}}$
 - 8 to 45 m^3/kWh
- Alpine dams: $CF = 0.001 \text{ PDF} \cdot \text{m}^2 \cdot \text{yr} / \text{m}^3_{\text{water turbined}}$
 - 0.8 m^3/kWh
- 1 kWh: non-alpine $\approx 0.08\text{-}0.5 \text{ PDF} \cdot \text{m}^2 \cdot \text{yr}$; alpine $\approx 0.0008 \text{ PDF} \cdot \text{m}^2 \cdot \text{yr}$
- Electricity from alpine dams seems to have 100x lower damage to aquatic biodiversity than electricity from non-alpine dams
 - Assume that the two aquatic ecosystems have the same value on a per m^3 basis
 - Once the ecosystem is destroyed (i.e., 100% of the water diverted), the PDF cannot go above 1
 - No consideration for impact on surrounding terrestrial ecosystems
 - Less area affected, on a per m^3 used, when diverted from alpine zone than from plain zone
 - 1 m^3 of water used to produce electricity is 10x more efficient when used in an alpine dam than in a non-alpine dam

Conclusions

- Framework suggested to account for **damage to aquatic biodiversity** from **water use**
 - focus on **hydropower**
- When expressed per kWh produced, damage to aquatic biodiversity appears **independent from the size of the dam**
 - Less clear when expressed per m³ of water use
 - Further research needed
- **CF, per kWh produced**, directly usable with current LCA approach, to capture the **magnitude of the damage to aquatic biodiversity** associated with **hydropower**

Further work

- Need to understand better the relation between **amount of water** use and impact
- Need to evaluate benefits from increase in **aquatic ecosystem** (reservoir) vs decrease in **terrestrial ecosystem** (loss of some land and original banks)
- Framework suggested valid for **other type of water use**
 - Irrigation dams (→ per m³ water used or retained?)
 - Flooding control dams (→ per m³ retained?)
 - Rivers' correction (→ per m² of river corrected?)

... today, only one
point to be discussed!



point to be
discussed
-SAVE
THE PLANET

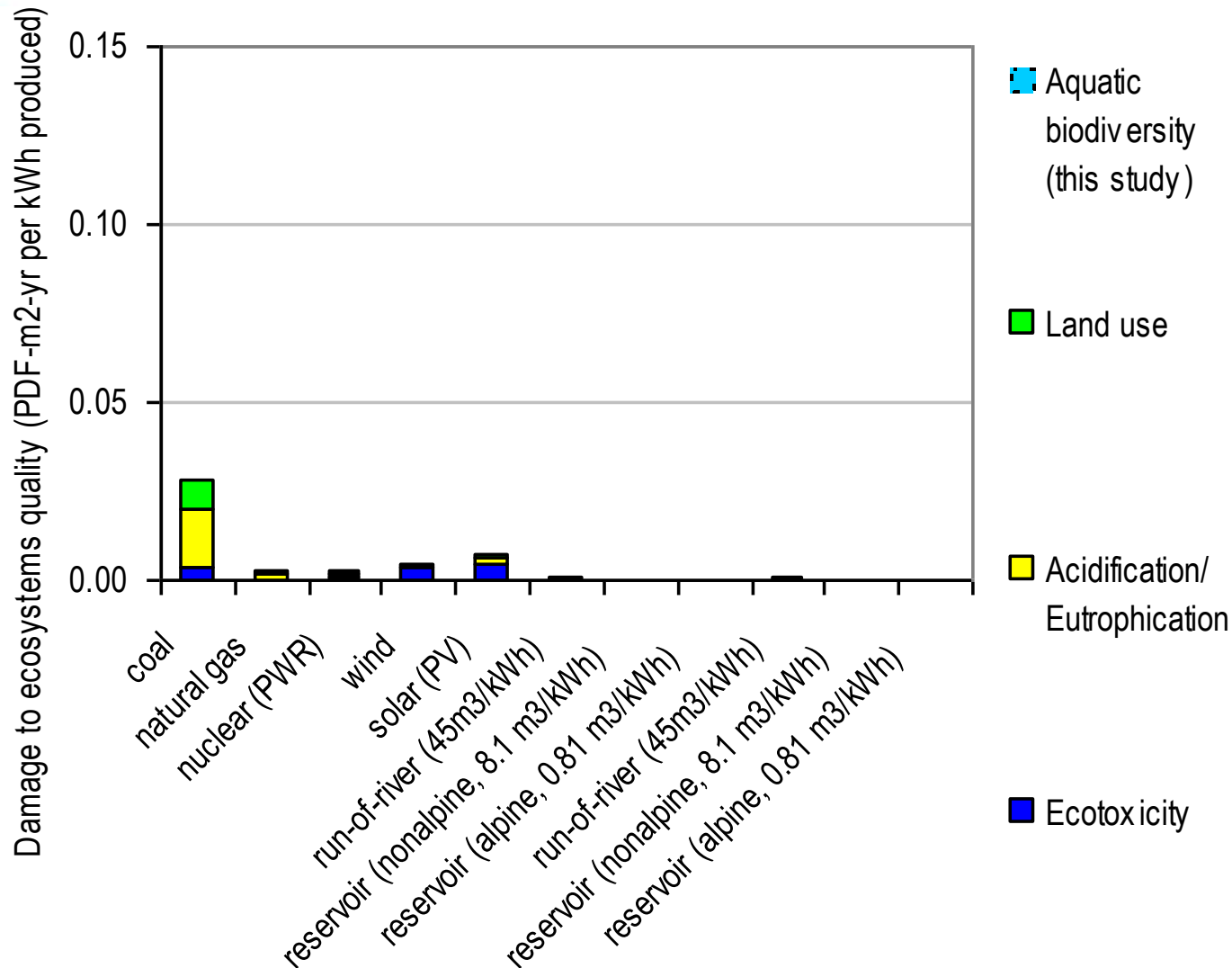
MIX & REMIX

... AUJOURD'HUI, UN SEUL
POINT À L'ORDRE DU JOUR !

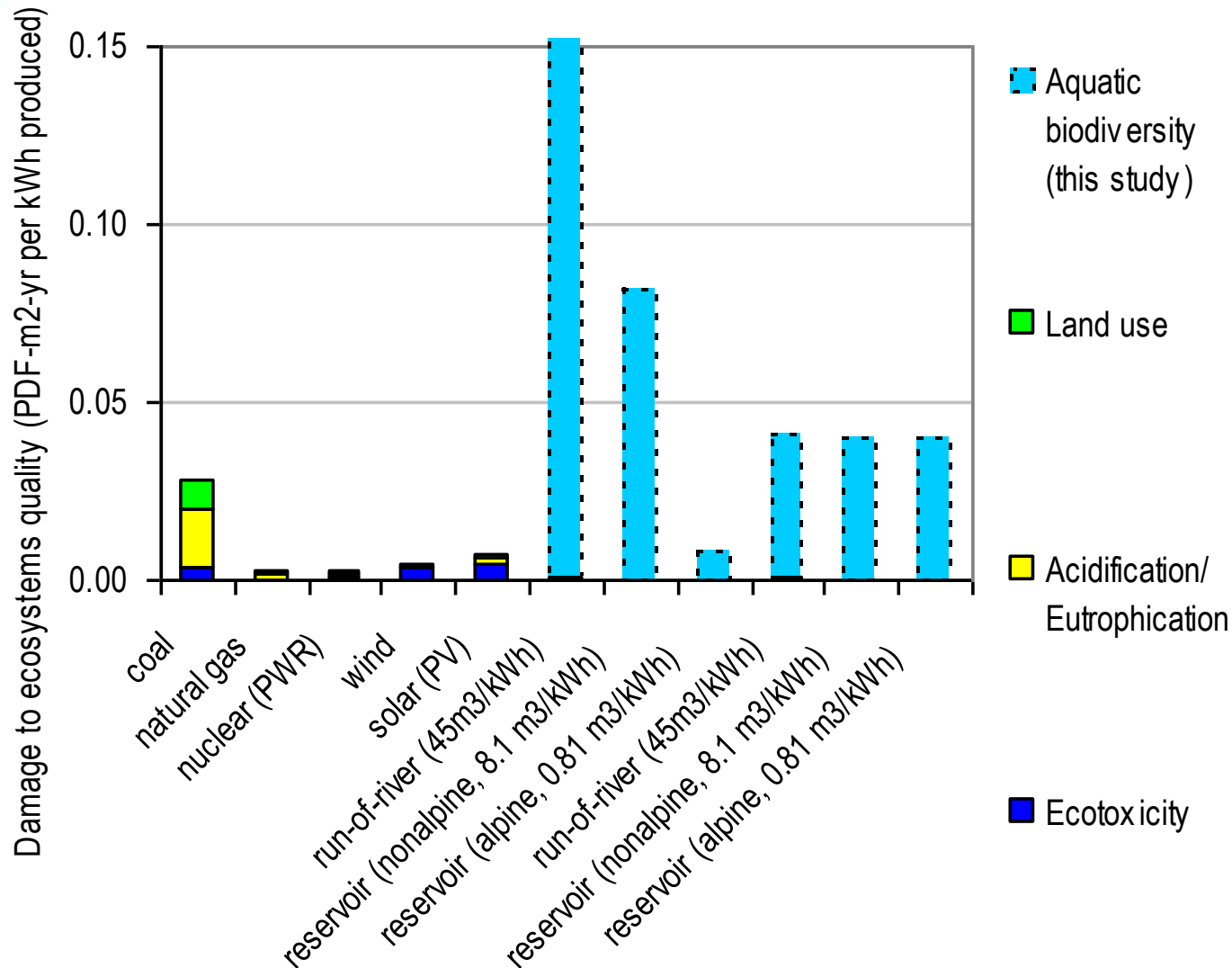


MIX & REMIX

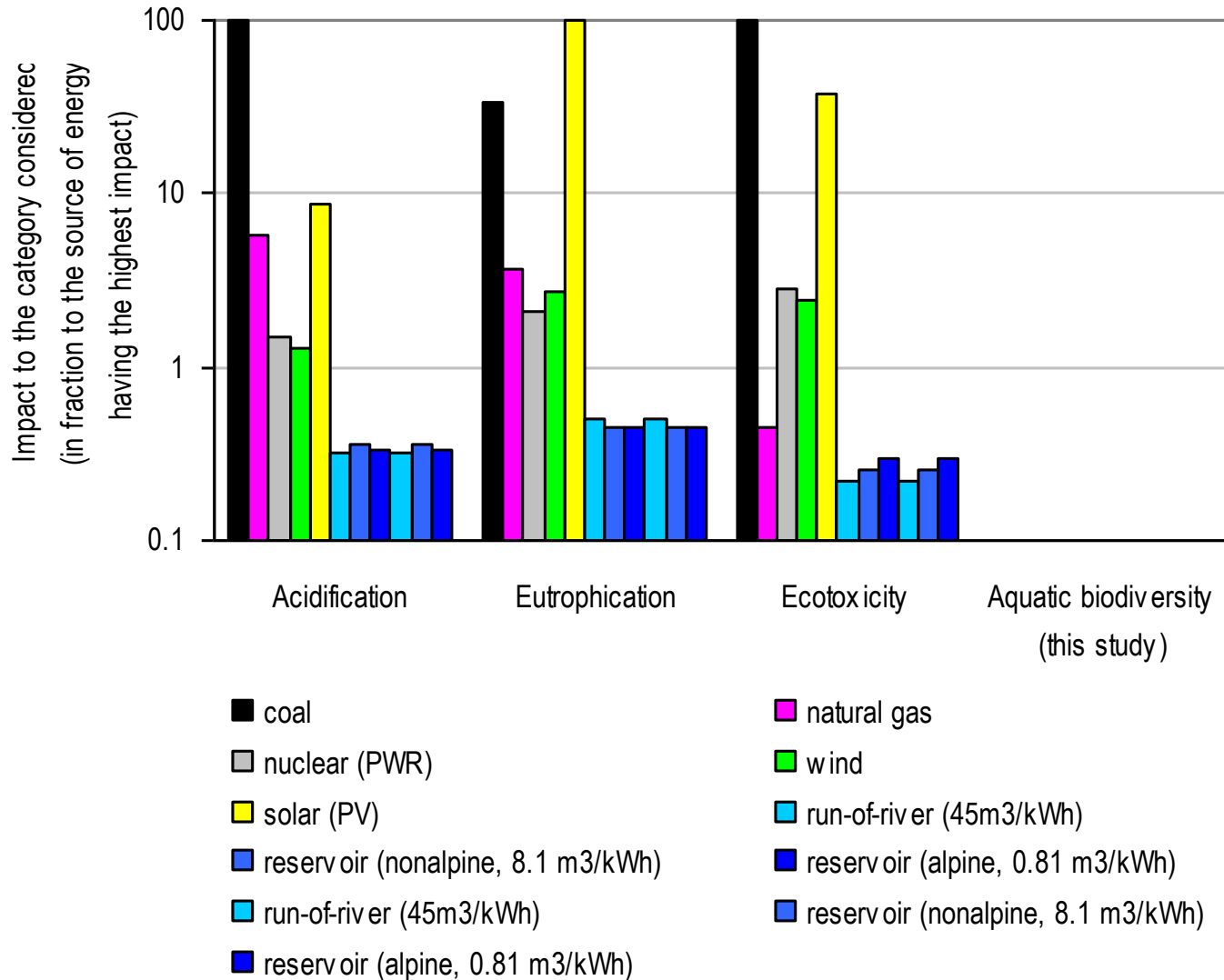
Same observations with Eco-indicator 99



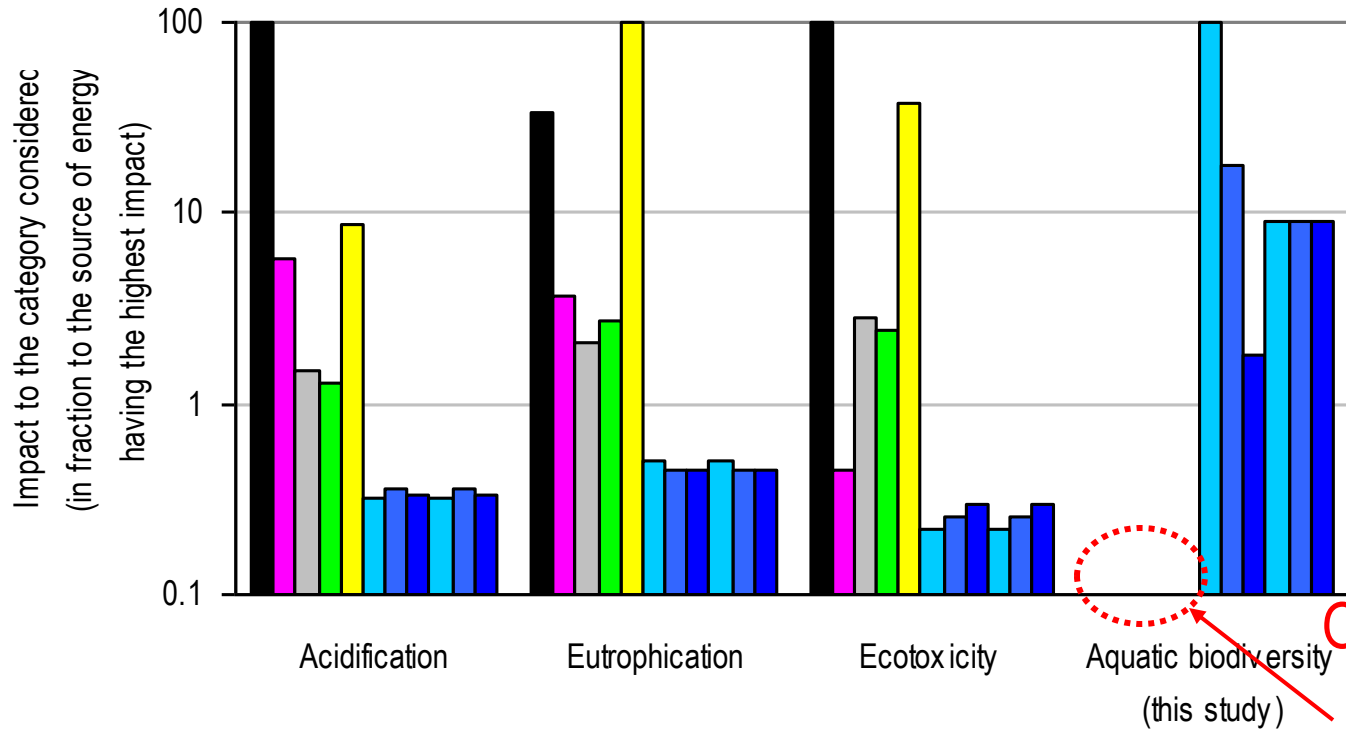
Same observations with Eco-indicator 99



With TRACI (midpoint LCIA)



More complicated with midpoint LCIA



- coal
- natural gas
- nuclear (PWR)
- wind
- solar (PV)
- run-of-river (45m3/kWh)
- reservoir (nonalpine, 8.1 m3/kWh)
- reservoir (alpine, 0.81 m3/kWh)
- run-of-river (45m3/kWh)
- reservoir (nonalpine, 8.1 m3/kWh)
- reservoir (alpine, 0.81 m3/kWh)

Other processes do not have direct impact on aquatic biodiversity



Do you have any questions?

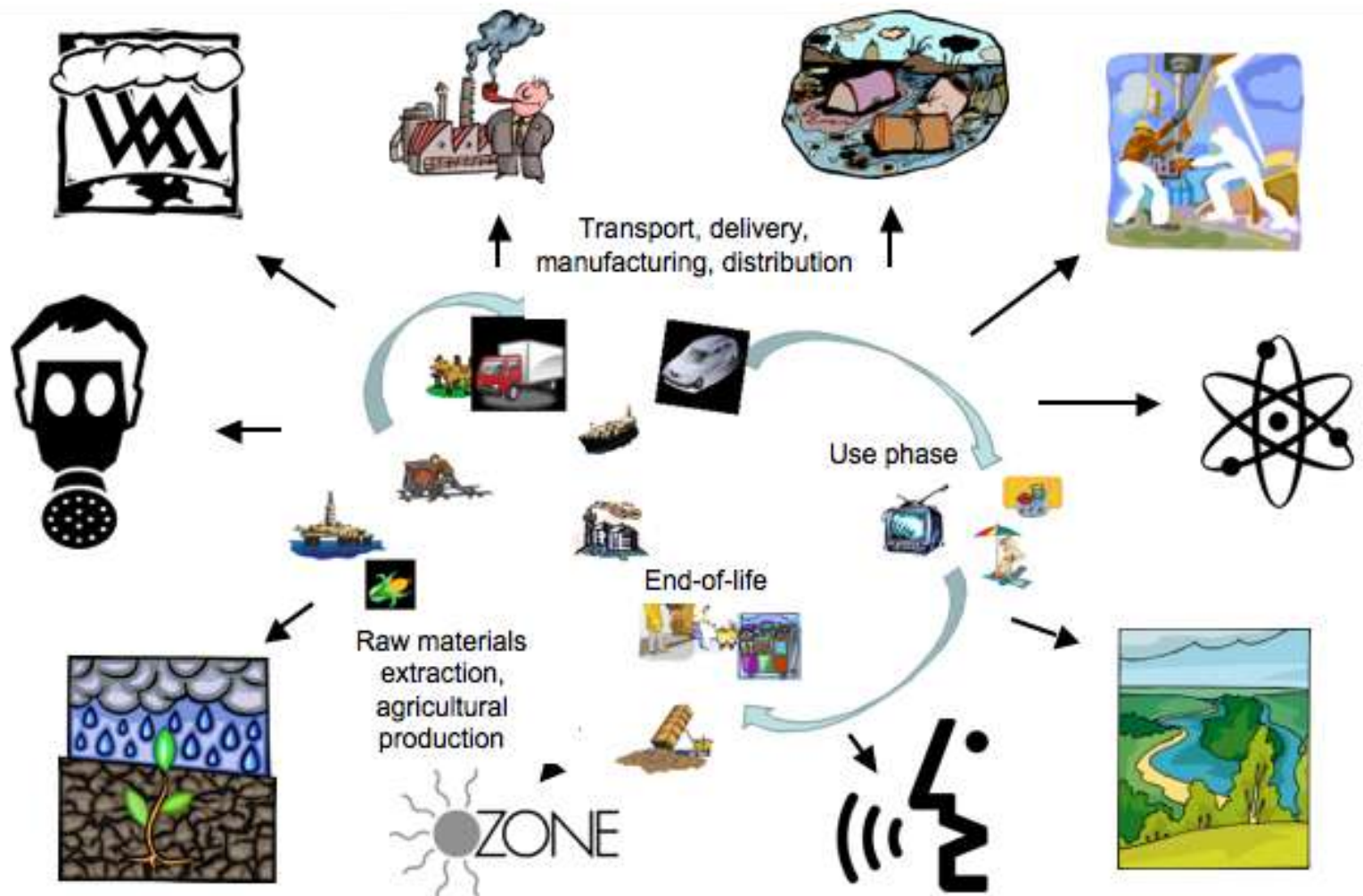


Additional slides of the study

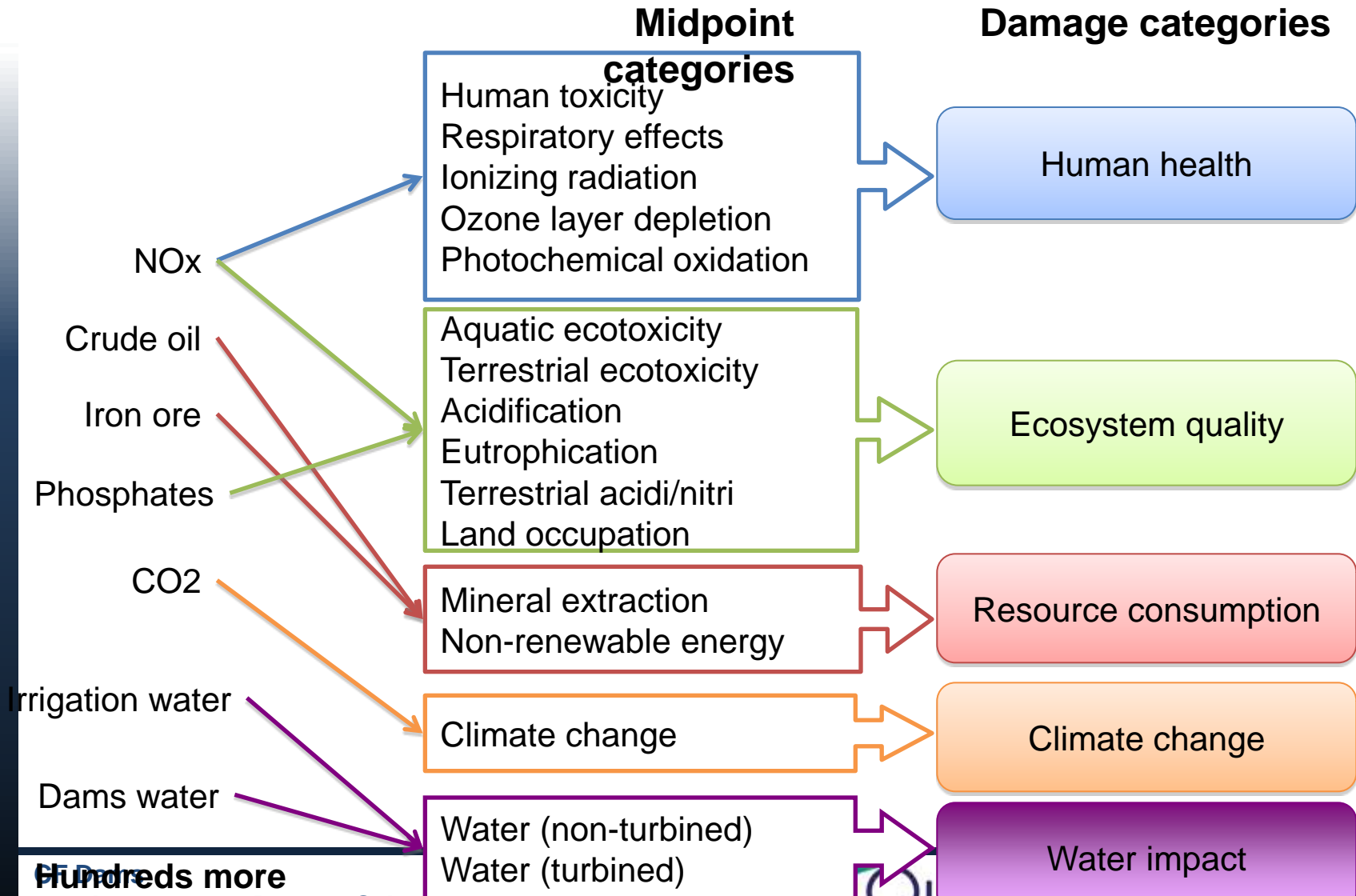


Supporting info of LCA

The life cycle perspective (life cycle stages and impacts)



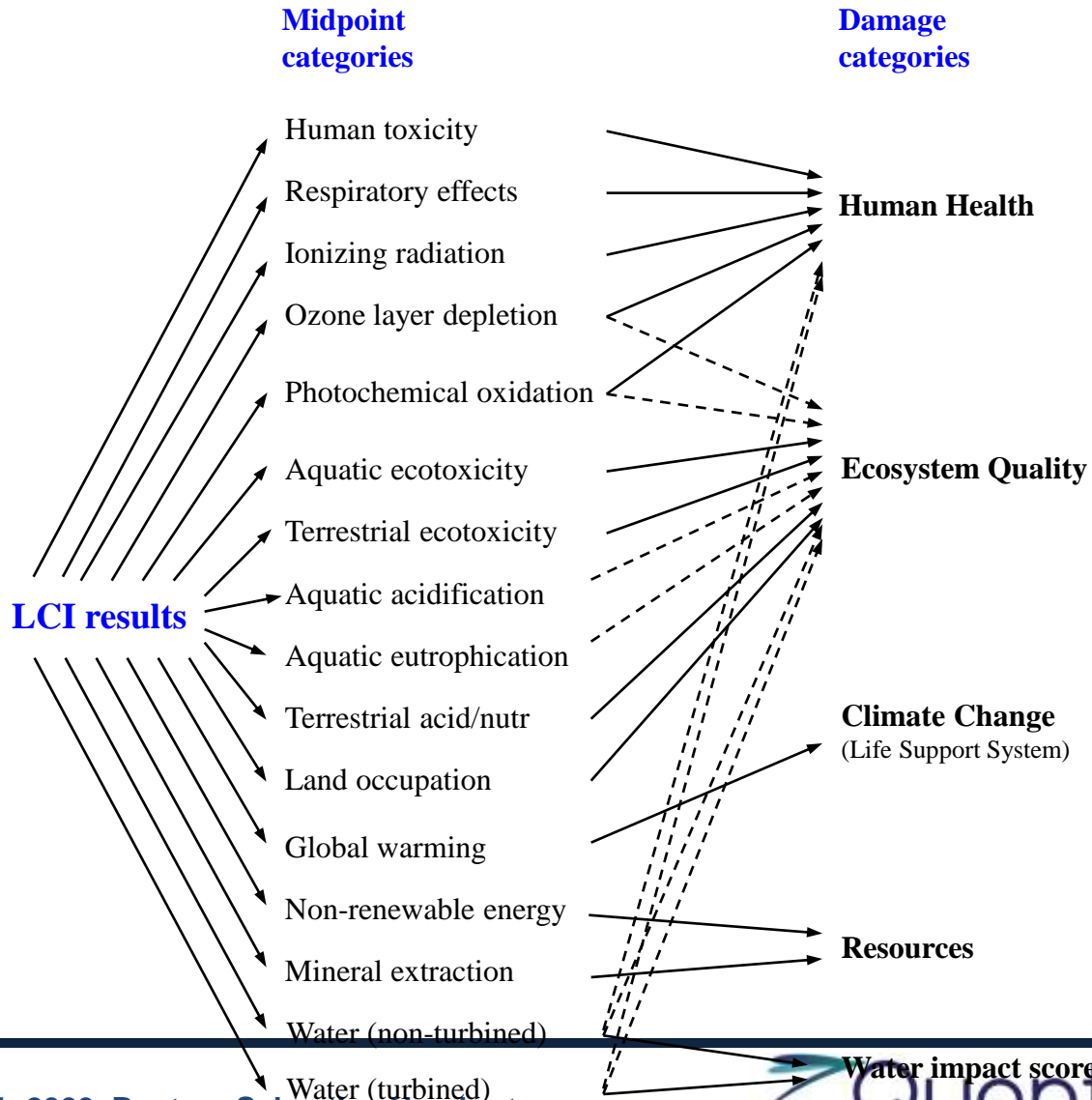
IMPACT 2002+ (Jolliet et al. 2003)



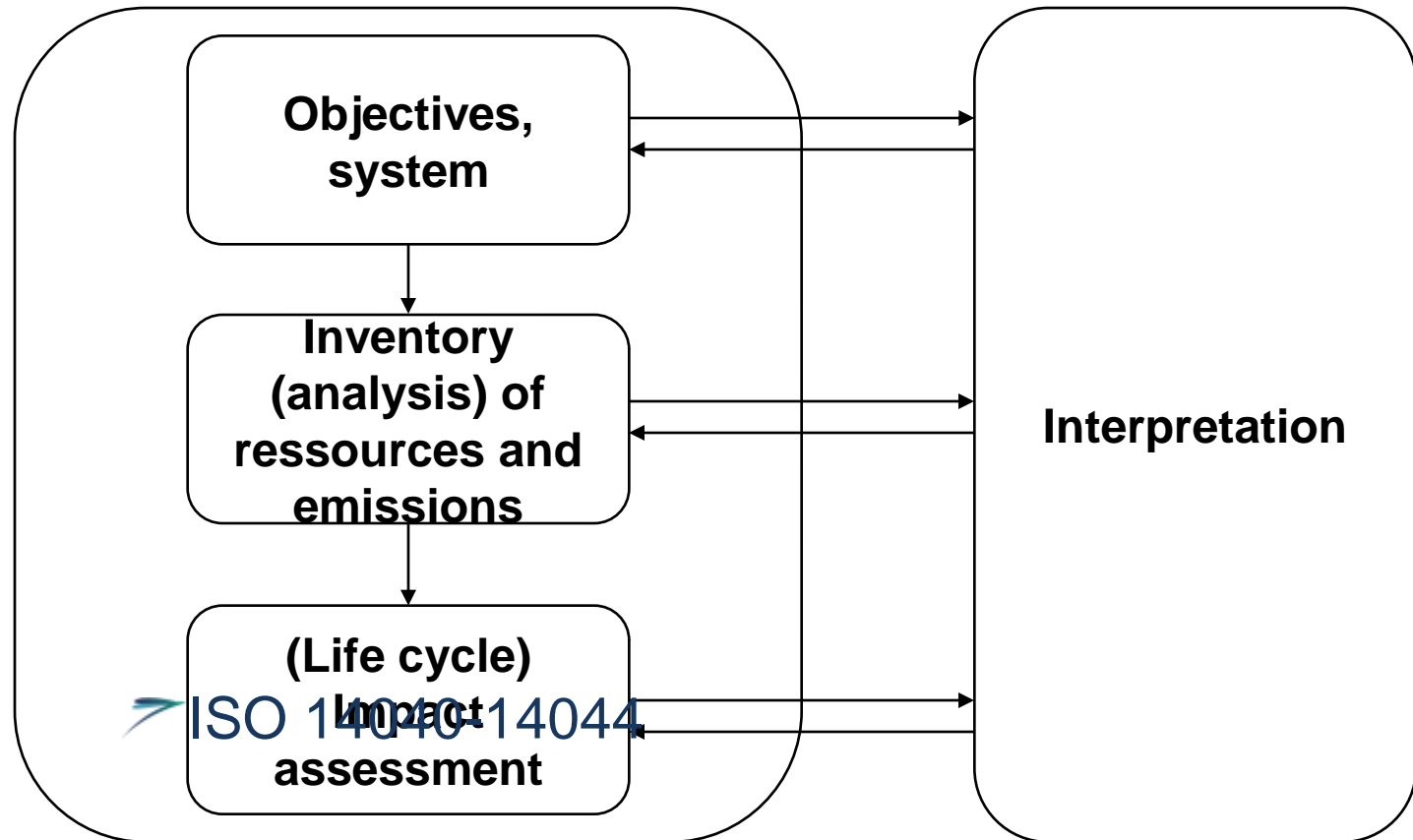
Hundreds more

October 01, 2009, Boston, Sebastien Humbert

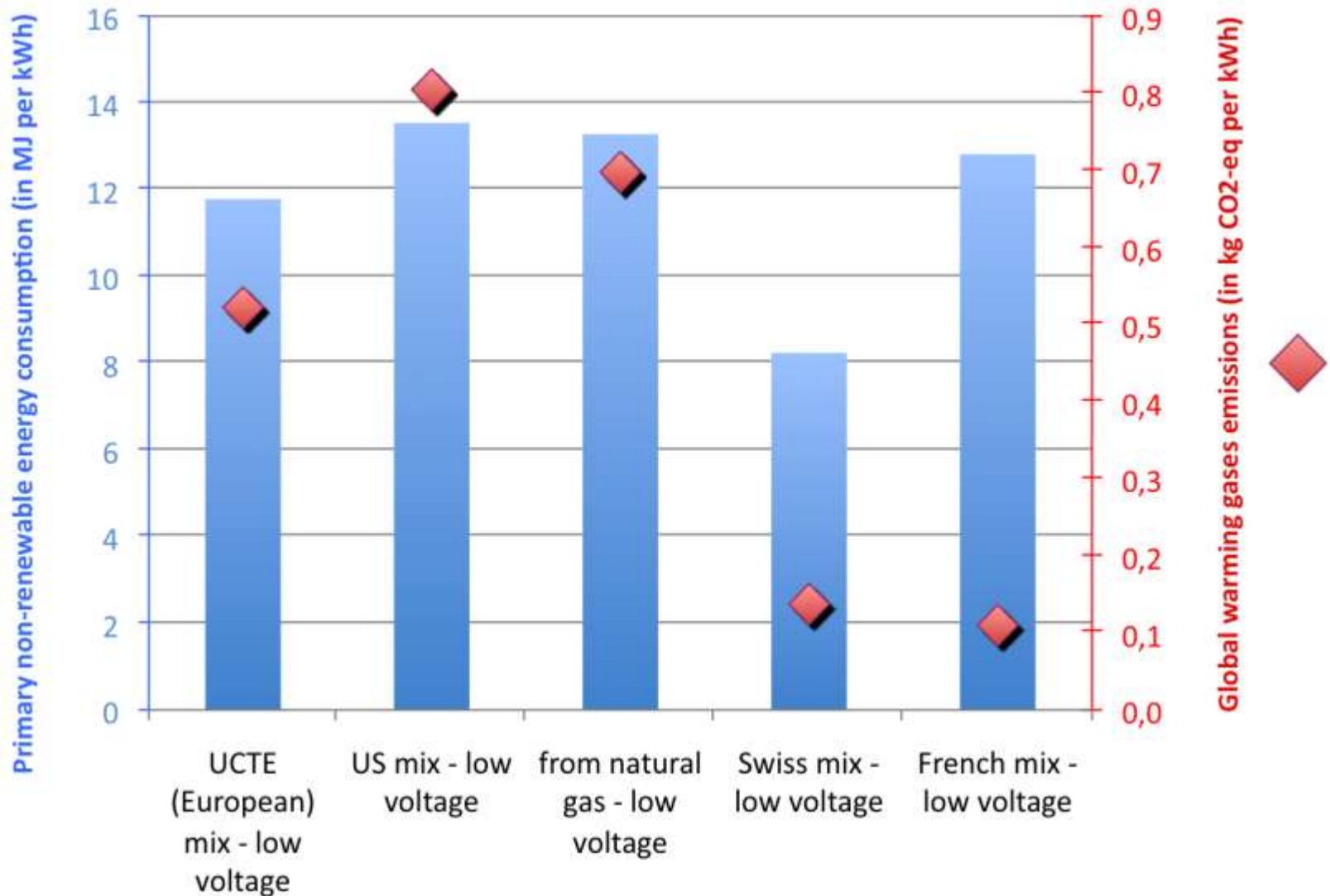
IMPACT 2002+ (Jolliet et al. 2003)



Life Cycle Assessment (LCA)



Electricity mix



Modeling transport

