



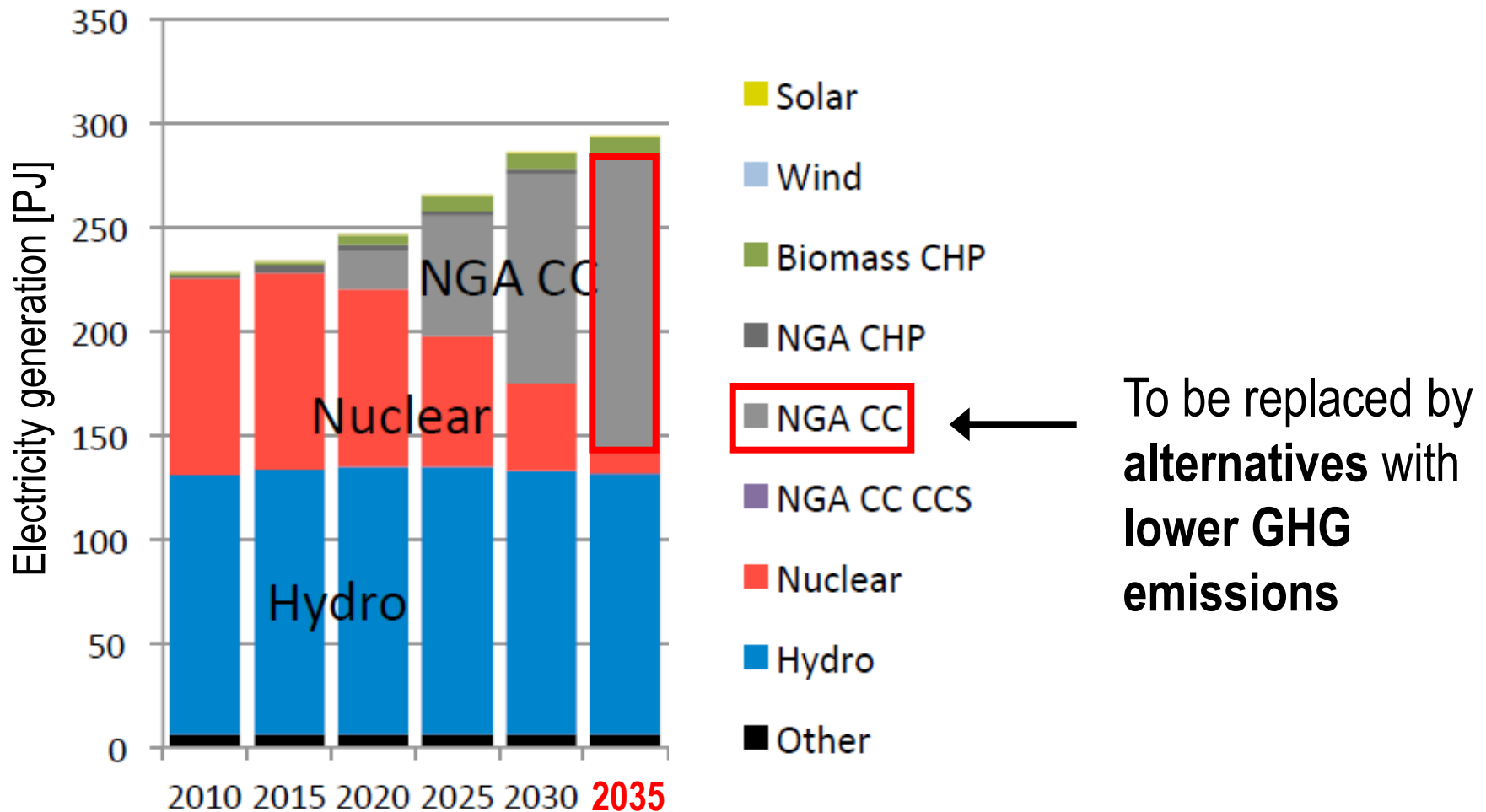
Wir schaffen Wissen – heute für morgen

Reducing the carbon footprint of the Swiss power sector: How to fill the gap?

Christian Bauer, P. Eckle, K. Volkart, W. Schenler

Paul Scherrer Institut, Laboratory for Energy Systems Analysis

Reference scenario: CO₂ reduction in the Swiss power sector



Research question to be answered

Given (a) certain preference profile(s):

Which will be the preferred options for CO₂ reduction in the Swiss power sector in the future?

Reference year 2035

Comparing different alternatives according to multiple criteria

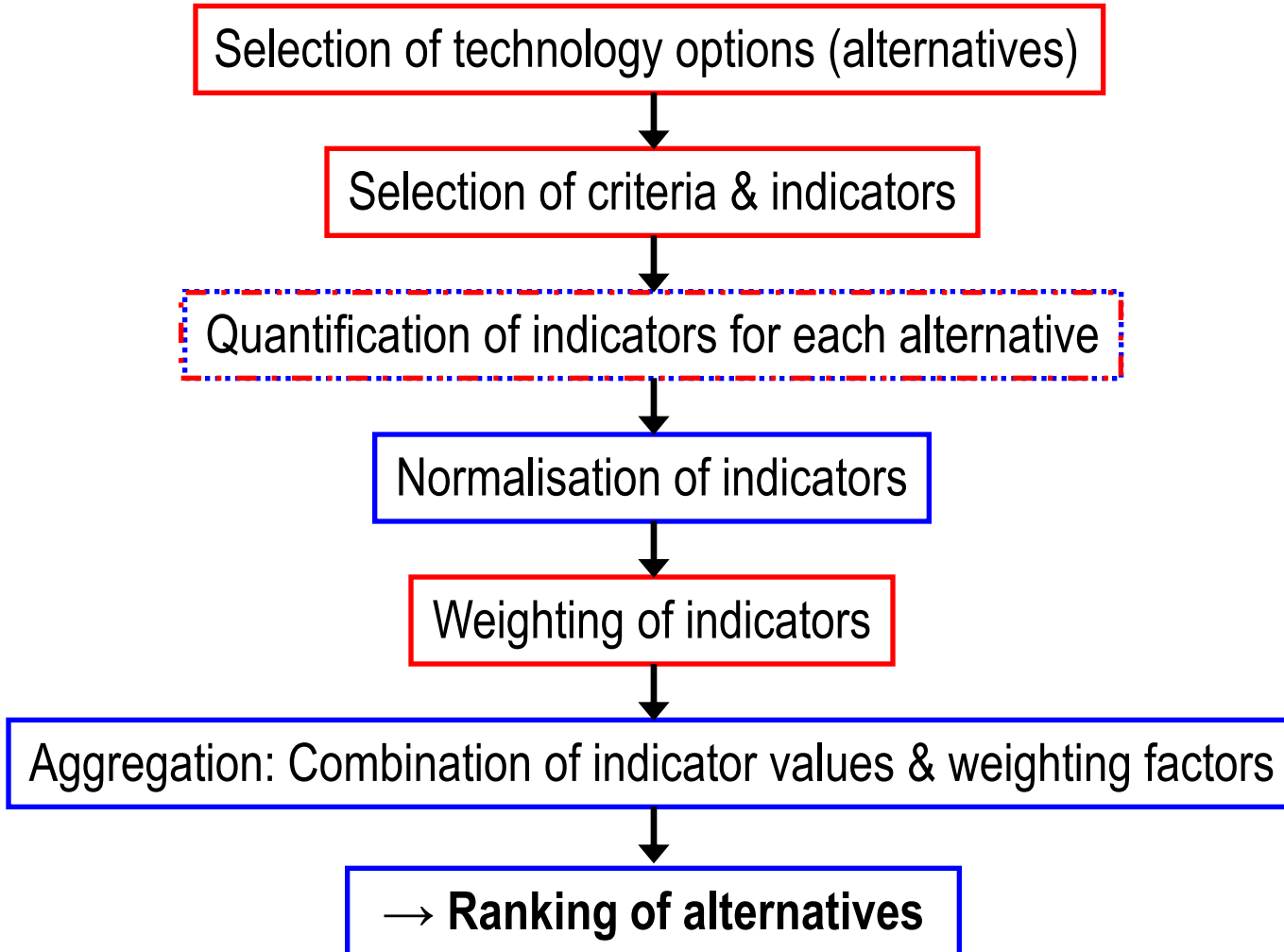
Method

Multi-Criteria Decision Analysis (MCDA)

- Comparing various electricity generation technologies
- Taking into account environmental, economic & social evaluation criteria
- Allowing stakeholder interaction by considering individual weighting of criteria/indicators
- using the weighted sum approach

MCDA: How does it work?

Goal: CO₂ reduction in the power sector



Alternatives for CO₂ reduction in the Swiss power sector

- **Hydro:** reservoir & run-of river
- **Photovoltaic:** mc- & a-Si, roof-top
- **Wind:** onshore & offshore (import)
- **Geothermal:** Enhanced geothermal system
- **Wood:** with & w/o CCS (**sustainable forestry**)
- **Biogas:** from organic waste
- **Nuclear:** EPR
- **Natural Gas CC:** with CCS
- **Hard coal & lignite:** with CCS (import)
- **Solar thermal** (import)

Differing generation potentials need to be considered in conclusions!

online MCDA tool

<http://www.mightymcda.net>

Selection of indicators

Four main categories:

- Environment
- Economy
- Society
- Security of supply

Selection of indicators

Environment – based on LCIA

- fossil energy demand (CED) [MJ/t CO₂ avd.]
- nuclear energy demand (CED) [MJ/t CO₂ avd.]
- metal depletion (ReCiPe) [kg Fe-eq/t CO₂ avd.]
- ecosystem quality (ReCiPe) [species*a/t CO₂ avd.]
- GHG emissions (IPCC 2007 + biog. CO₂) [kg CO₂-eq/t CO₂ avd.]

Economy

- CO₂ avoidance costs [CHF/t CO₂ avd.]
- capital costs (investments) [CHF NPV]
- fuel sensitivity [share of fuel costs]
- marginal avoidance costs [marginal CHF/t CO₂ avd.]

Selection of indicators

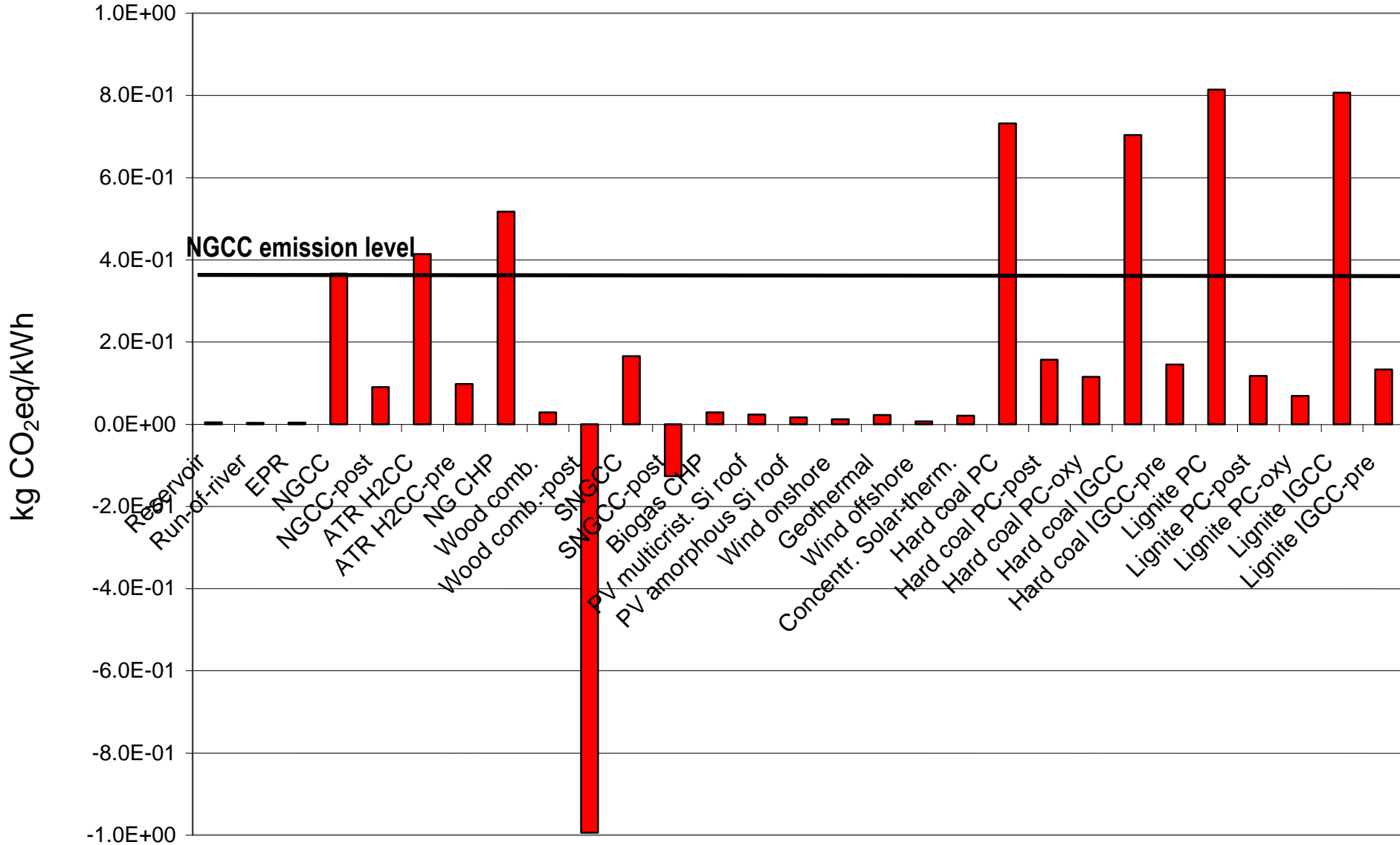
Society

- conflict potential [ordinal scale]
- direct employment [person*a/t CO₂ avd.]
- impacts on human health (ReCiPe) [DALY/t CO₂ avd.]
- expected fatalities (severe accidents) [fatalities/t CO₂ avd.]
- max. number of fatalities (severe accidents) [max. fatalities/accident]
- waste: chemical & radioactive (LCI results) [m³/t CO₂ avd.]

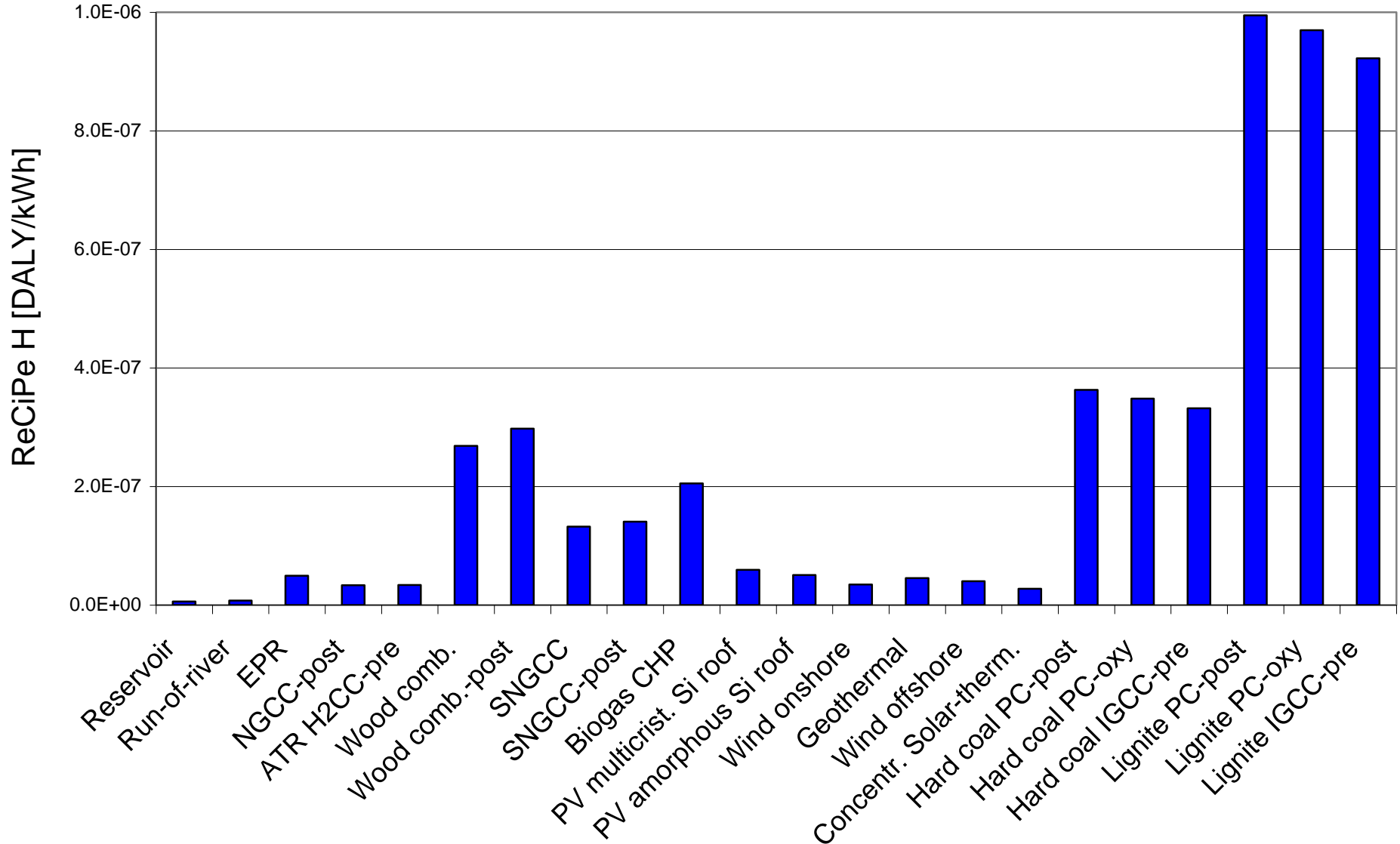
Security of supply

- share of domestic supply [ordinal scale]
- diversity of resources [ordinal scale]
- reliability [ordinal scale]

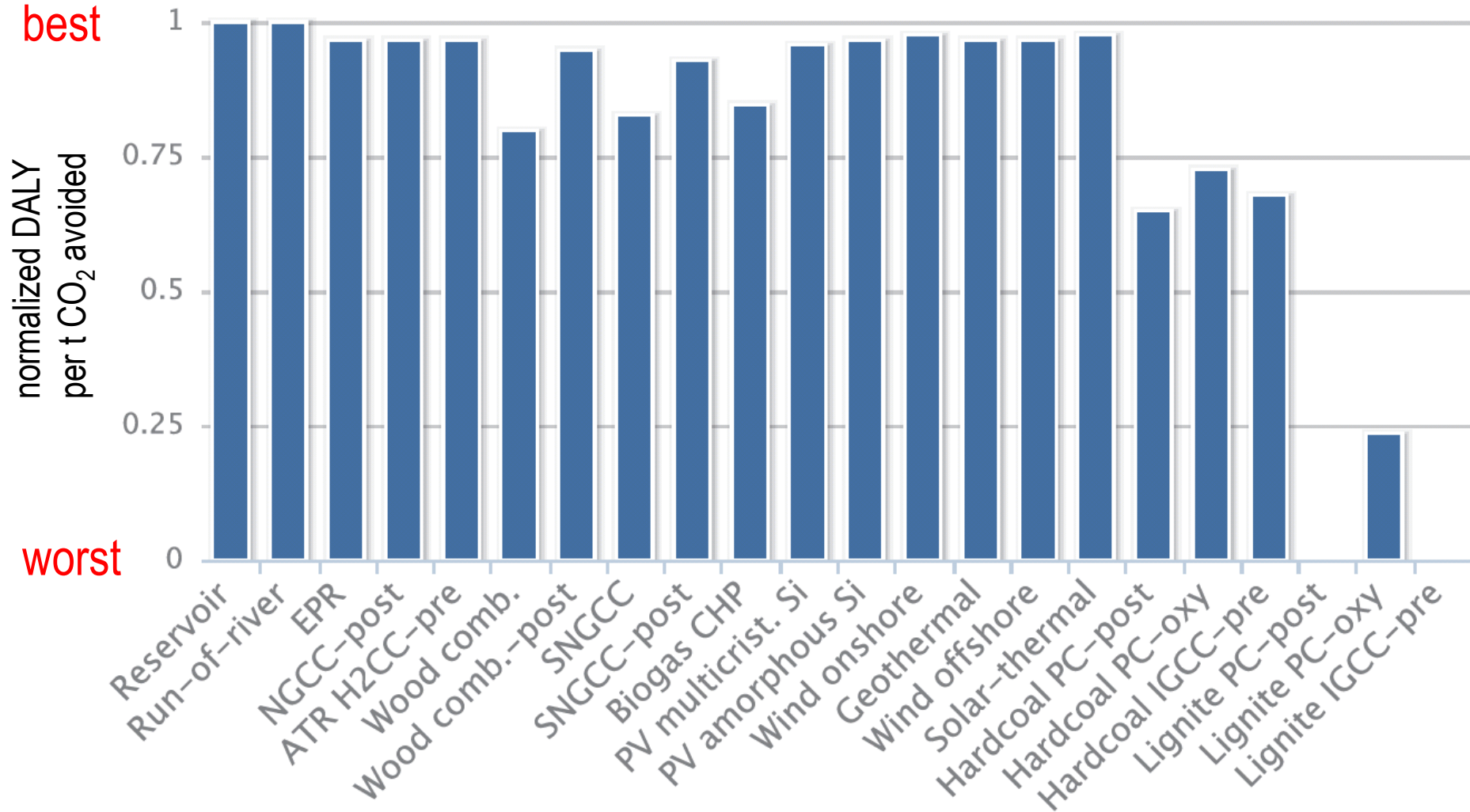
GHG emissions from electricity generation (preliminary)



Example: impacts on human health (ReCiPe H) (preliminary)



Example: impacts on human health (ReCiPe H) (preliminary)

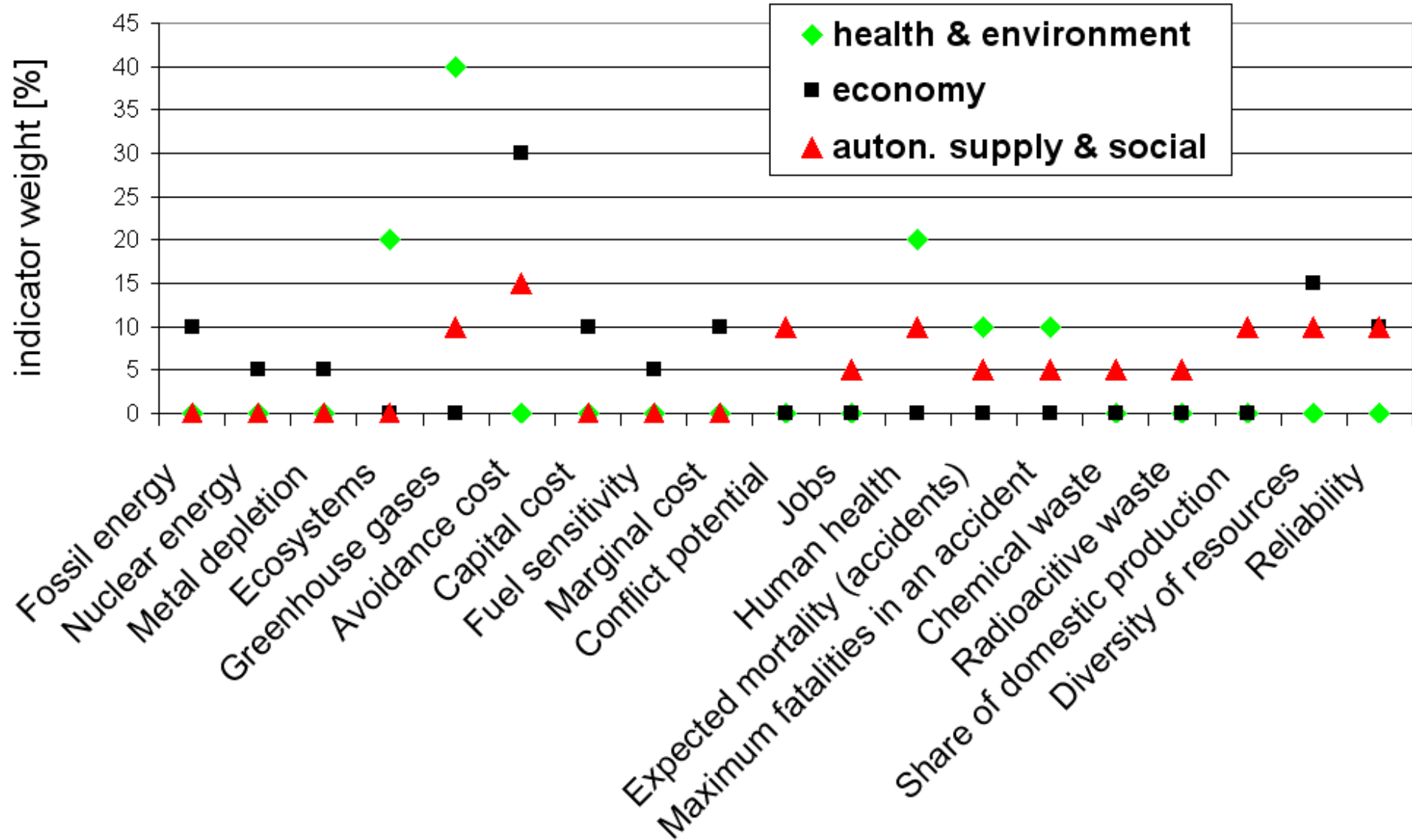


Weighting of indicators

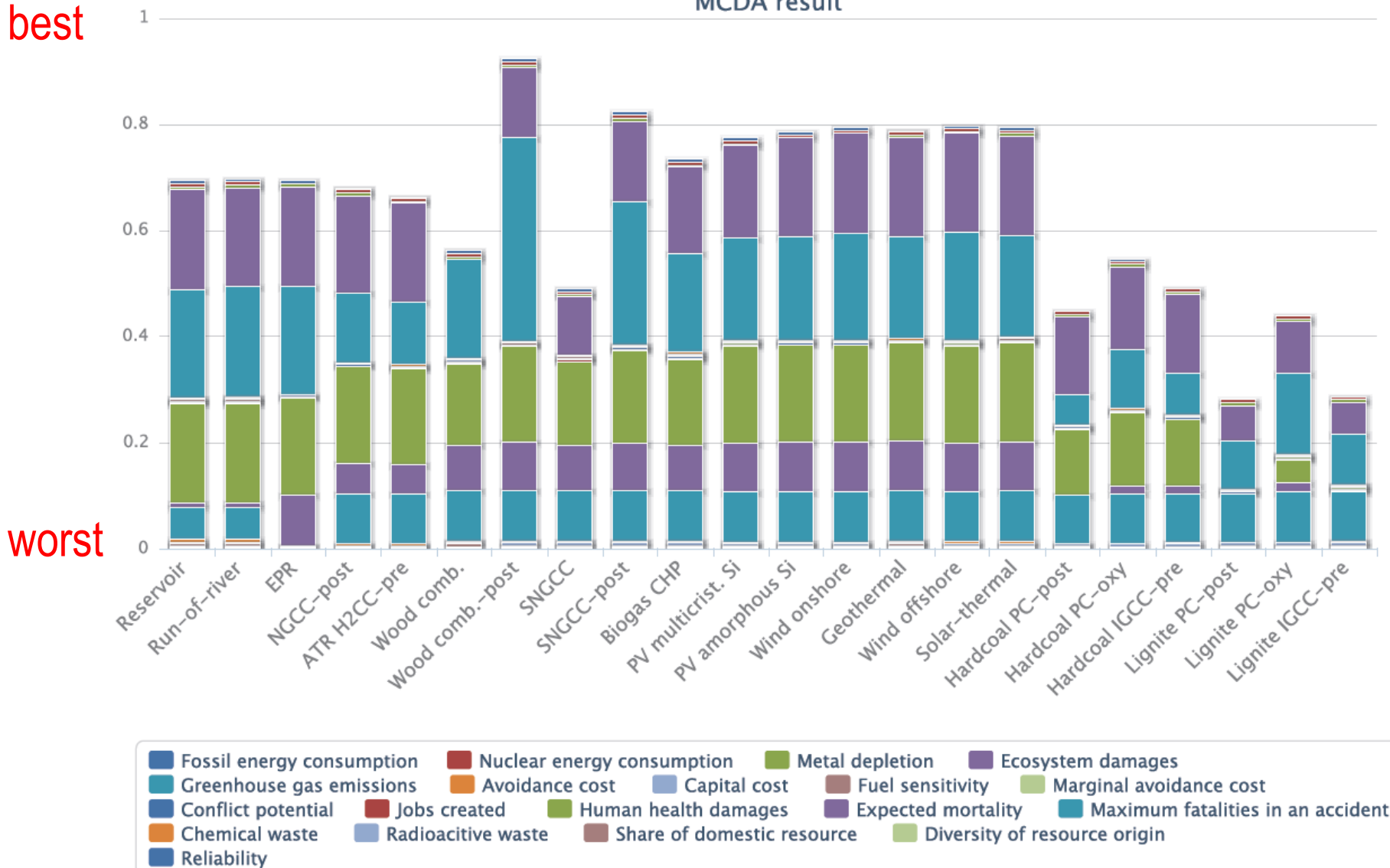
Stakeholder profiles (exemplary)

1. focus on **health & environment**
2. focus on **economy**
3. focus on **autonomous electricity supply & social** factors

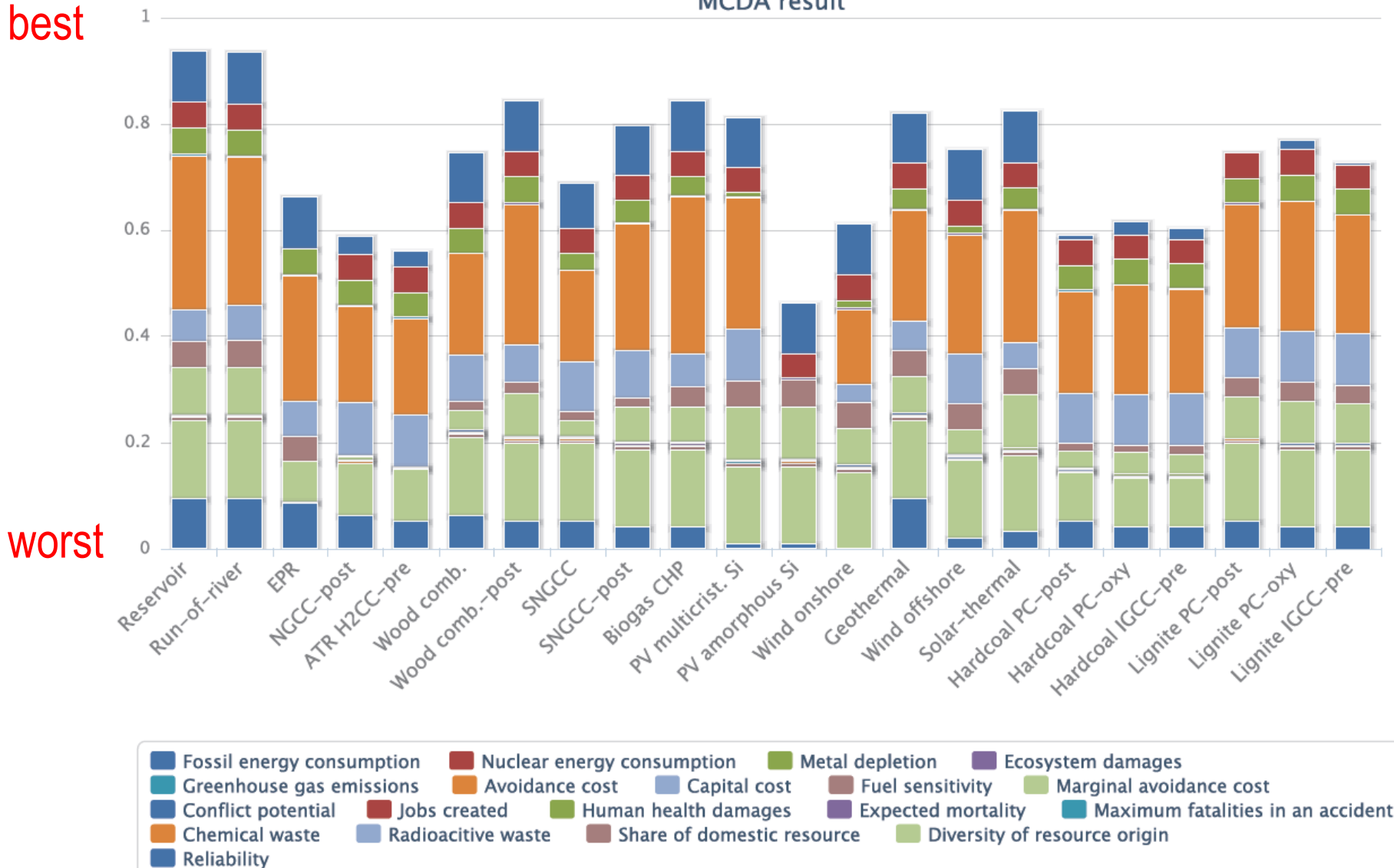
Weighting of indicators: 3 profiles



MCDA results (preliminary): profile health & environment



MCDA results (preliminary): profile economy



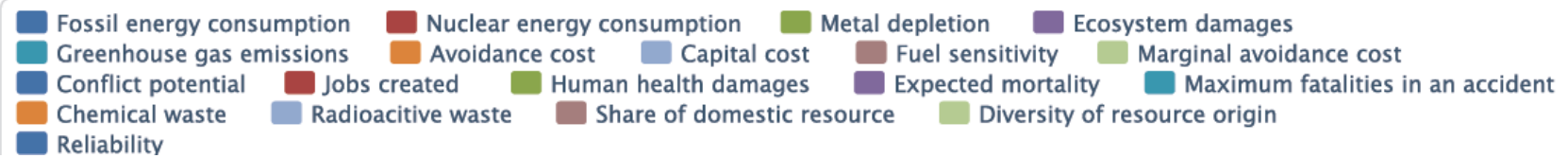
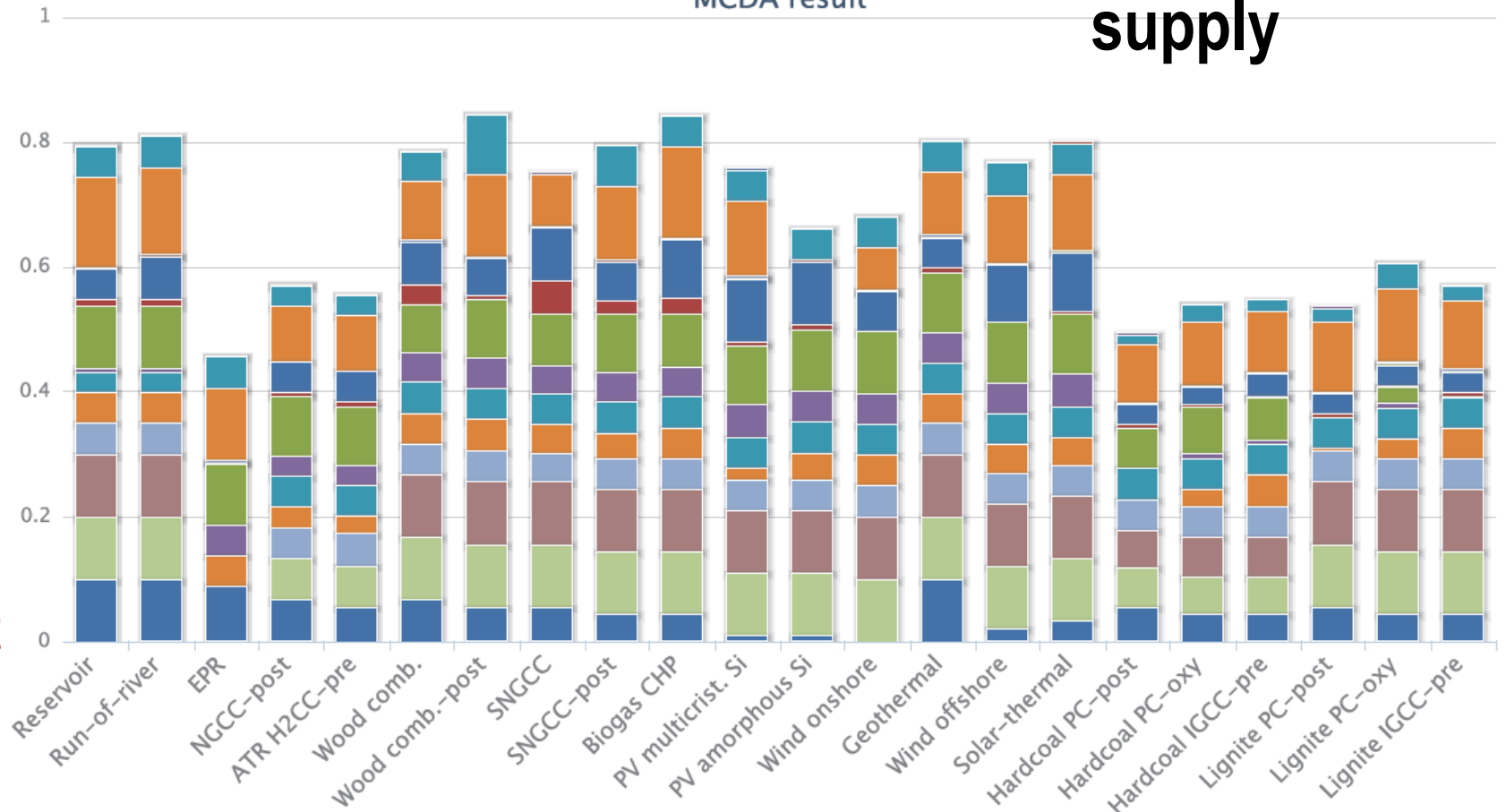
MCDA results (preliminary): profile social & autonomous supply

best

MCDA result

supply

worst



Summary & Conclusions

- **MCDA tool** allows a transparent & interactive evaluation of technology options
 - Considering stakeholder preference profiles & a comprehensive set of evaluation criteria/indicators
 - Showing pros & cons of each alternative

- **Preliminary MCDA results** for CO₂ reduction in the Swiss power sector
 - Hydro shows in general a good performance (BUT: very limited potential)
 - Decentralized renewables tend to perform better than fossil power with CCS
 - Biomass combustion with CCS turns out to be a good option
 - Limited potentials of renewables to be considered → NGCC with CCS

Outlook

- Generation of final indicator results
- Extension to **further economic sectors** with high potential for CO₂ reduction: residential, industry, mobility
- Consideration of efficiency measures
- Implementation of **stakeholder interaction**:
→integration of real preference profiles

Thanks for your attention!

More information:

christian.bauer@psi.ch; kathrin.volkart@psi.ch
<http://gabe.web.psi.ch/>

Research carried out within the project „CARMA“:

<http://www.carma.ethz.ch/>