The issue of allocation in indirect and rebound effects:

who is responsible for these effects?

Based on the case study of coal fly ash

"Is the use of fly ash a wise use?"

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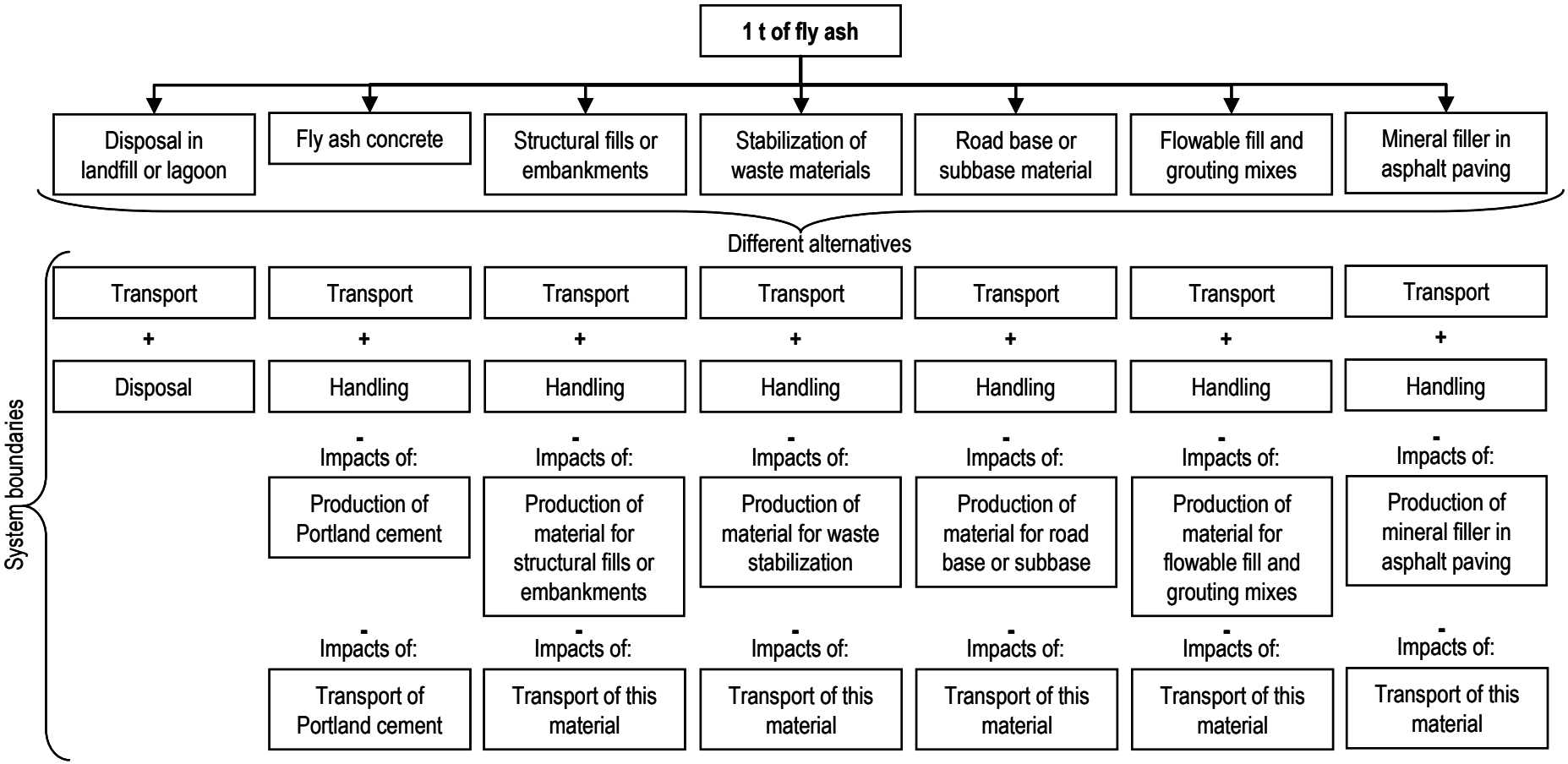
Introduction

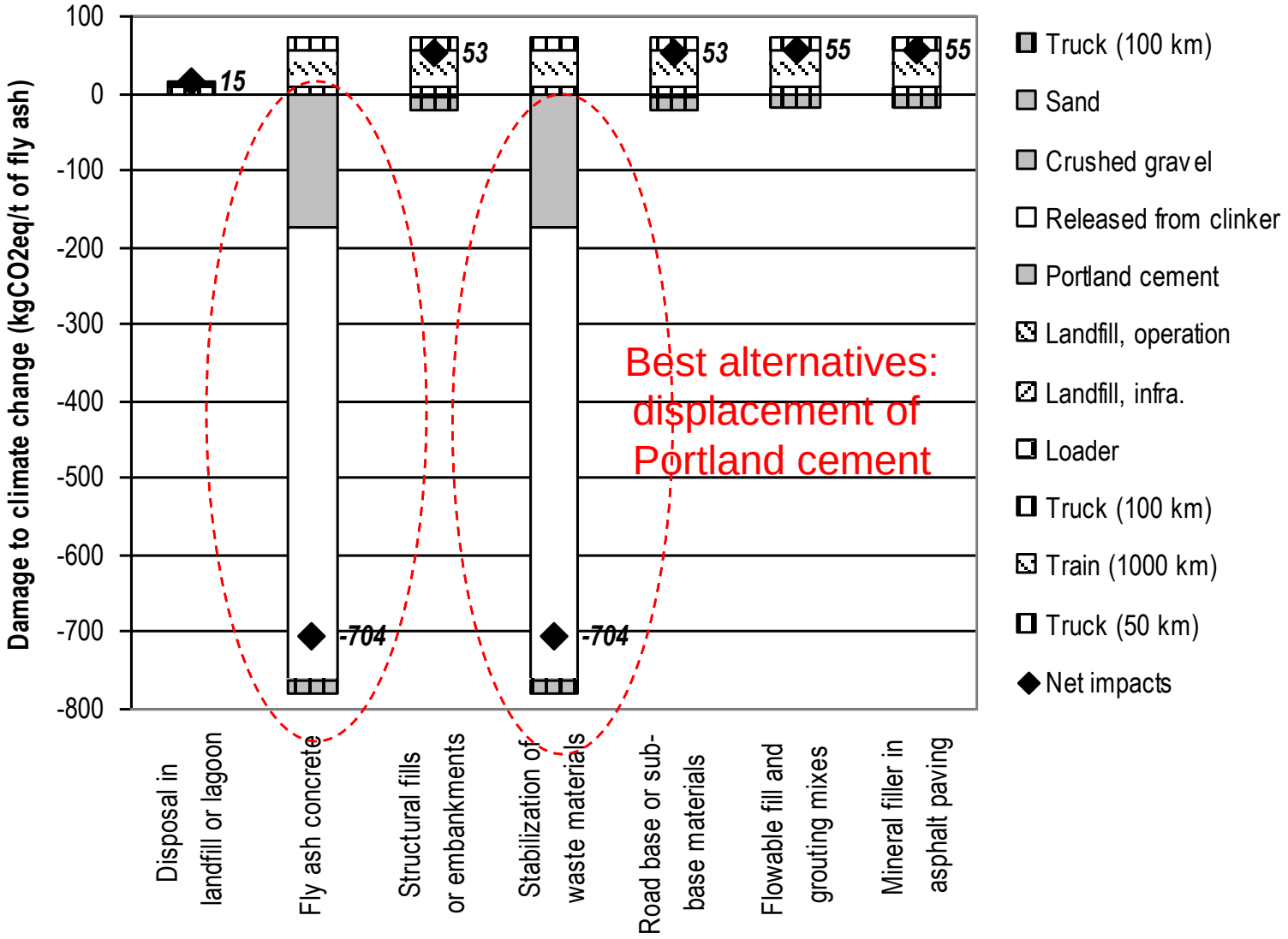
- Fly ash is a fine powder recovered from coal-fired power plants
- 2006: more than 70 million metric tons produced
- Traditionally dumped in landfills or lagoons
- Can be used in civil engineering work
  - Landfill or lagoons,
  - **Cement production and/or concrete products**,
    - Substitution on a 1:1 ratio, but within a certain fraction of the total amount of binder needed (in general between 20% and 50%)
  - Structural fills or embankments,
  - Stabilization of waste materials,
  - Road base or subbase materials,
  - Flowable fill and grouting mixes, and
  - Mineral filler in asphalt paving.

LCA of fly ash

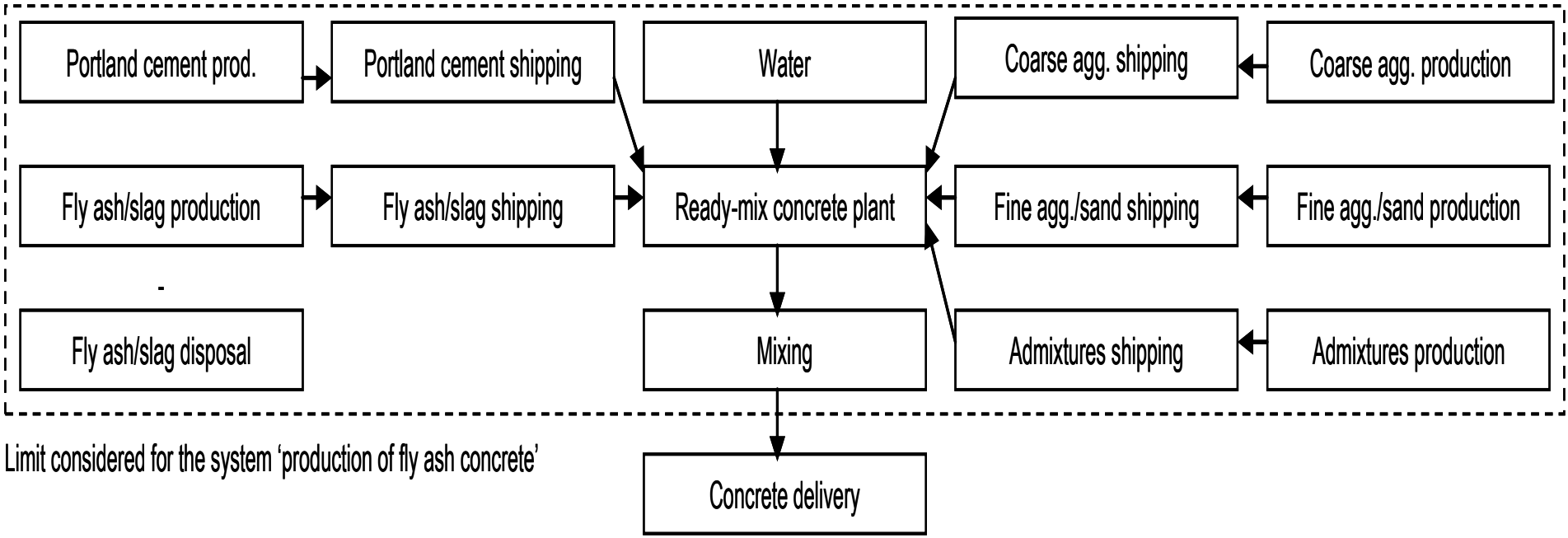


LCA of fly ash disposal

considering fly ash a waste, i.e., no impacts allocation

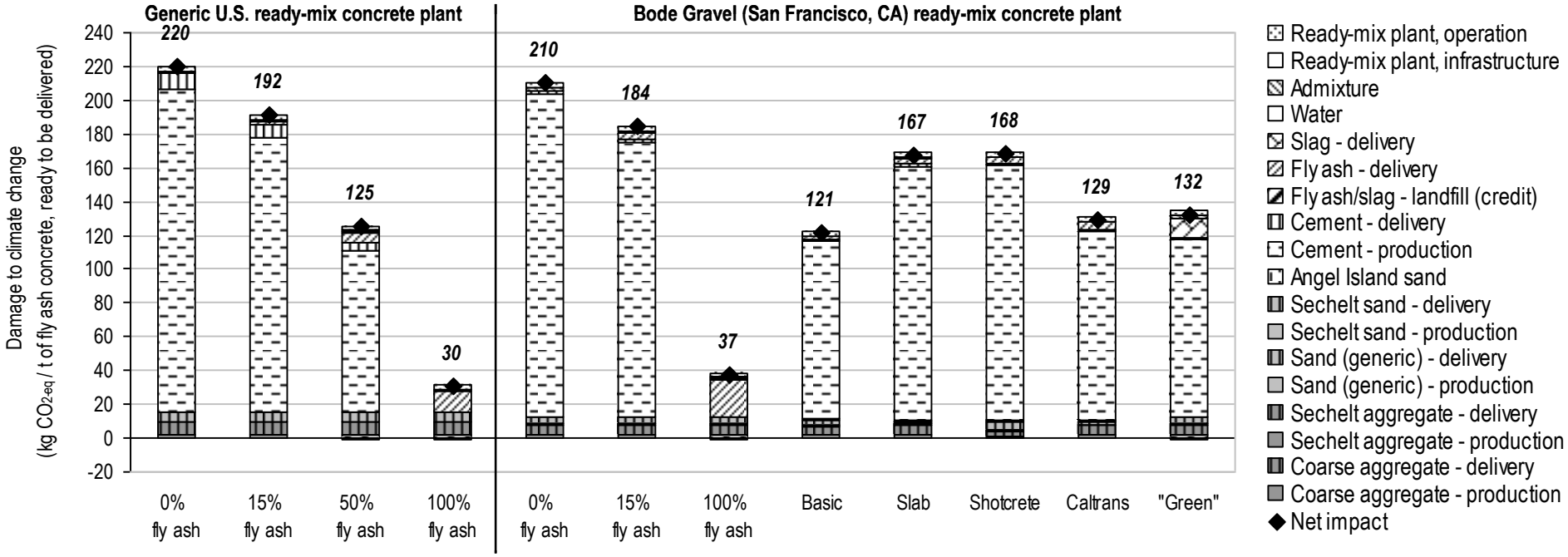


LCA of fly ash concrete



LCA of fly ash concrete

considering fly ash a waste, i.e., no impacts allocation

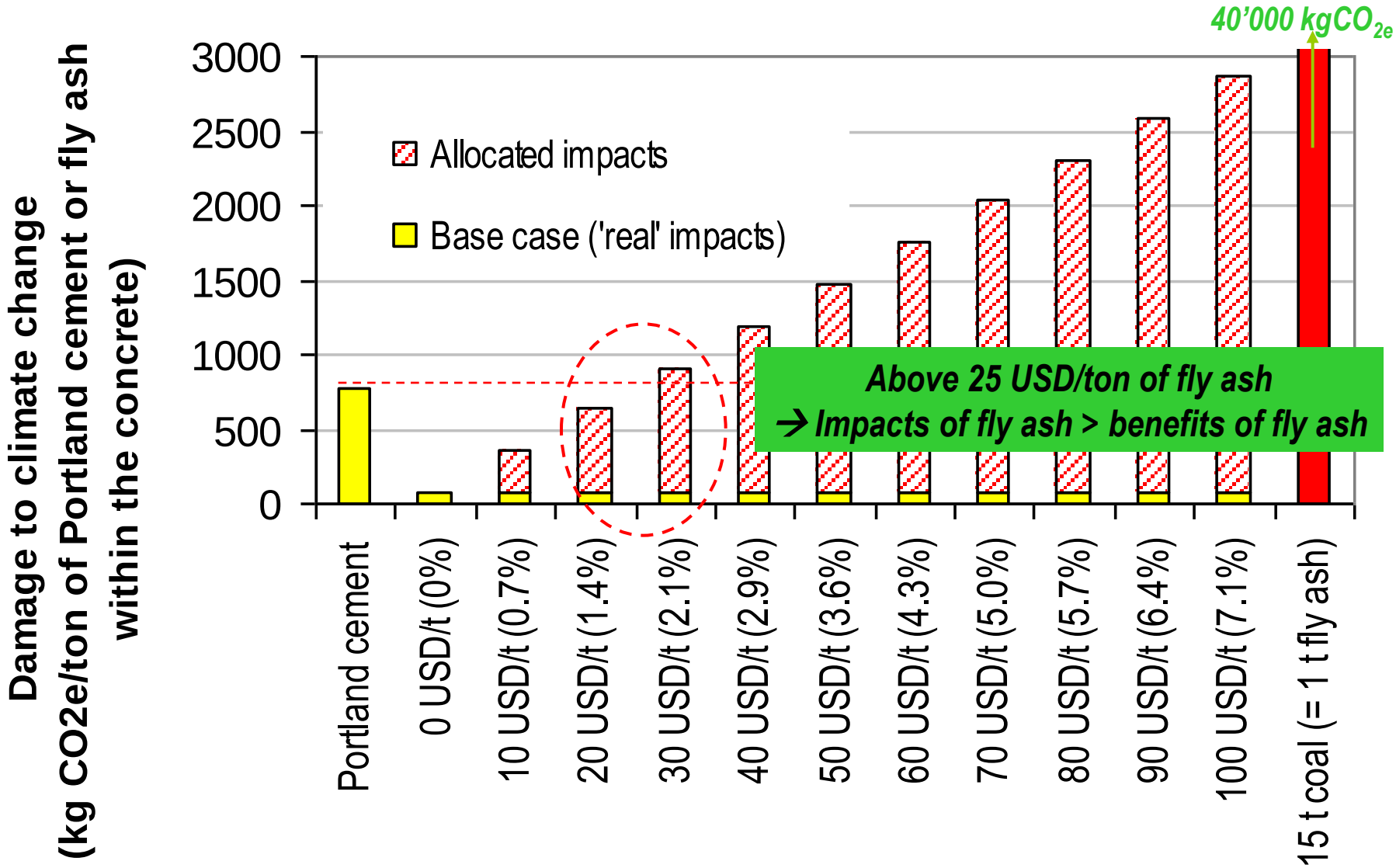


Allocation of some impacts to the fly ash

- 0.07 ton of fly ash produced / ton of coal burned
  - 15 ton of coal/ton of fly ash
- 2’400 kWh / ton of coal
  - 35’000 kWh / ton of fly ash produced
- 0.04 USD / kWh
  - Income from electricity production: **96** USD / ton of coal burned
- 20 USD / ton fly ash
  - Income from fly ash production: 20 x 0.07 ton fly ash / ton coal burned = **1.4** USD ton of coal due to fly ash
- More than **1%** of the impacts of coal burning!

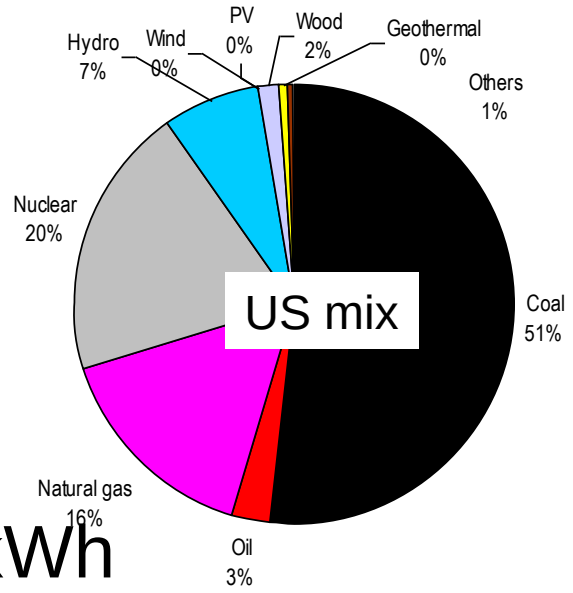
LCA of fly ash concrete

economic allocation of parts of the impacts



Influence on the electricity production market

- Coal is the most CO_{2e} emitting fuel within the electricity mix
  - Coal: 1'120 gCO_{2e}/kWh
  - Natural gas: 680 gCO_{2e}/kWh
  - Nuclear: 13 gCO_{2e}/kWh
  - Hydro: 9 gCO_{2e}/kWh
  - Renewable: 9 gCO_{2e}/kWh
  - Average US mix: 730 gCO_{2e}/kWh
  - Average US mix without coal: 300 gCO_{2e}/kWh



- If coal competitivity increases → increase in C intensity of average mix

Benefits from fly ash vs impacts from increased coal competitivity

- Benefits from Portland cement production reduction if all the fly ash is used to substitute Portland cement
  - 72 Mt PC/yr * 760 kg CO2e/t PC = 55 MtCO2e

- US electricity production
  - Total: 4.1E+12 kWh/yr (780 gCO_{2e}/kWh)
  - From coal: 2.1E+12 kWh/yr (1'120 gCO_{2e}/kWh)
  - Not from coal: 2.1E+12 kWh/yr (300 gCO_{2e}/kWh)

- Additional damage from U.S. coal-based electricity compared to U.S. mix without coal, on a per kWh basis: 820 gCO_{2e}/kWh

- Number of coal kWh so that the extra damage from coal-based electricity equal damage from Portland cement displacement
  - 6.7E+10 kWh/yr

- This represents: 3.2% of US coal electricity production

Conclusions

- Use of fly ash is only beneficial if considered a waste and not a co-product

  < ~25 USD/t of fly ash paid to the power plant

  Or

  Does not increase US coal production by more than 3.2% from its 'normal' evolution if fly ash were not used economically

- Economical models need to be applied to verify if the economic allocation, resp. the increase of competitivity of the coal industry, is valid in the case of fly ash, and if so, what are the correlations

Thank you for your attention!

point to be discussed

-SAVE THE PLANET