Circular approaches to net-zero emissions in the heavy industry

Andrea Lanzini[1], Daniele Ferrario[1], Stefano Stendardo[2], Tobias Pröll[3]

[1]Politecnico di Torino, Italy

[2]ENEA – National Agency for New Technologies, Italy

[3]University of Natural Resources and Life Sciences (BOKU), Austria

Research focus

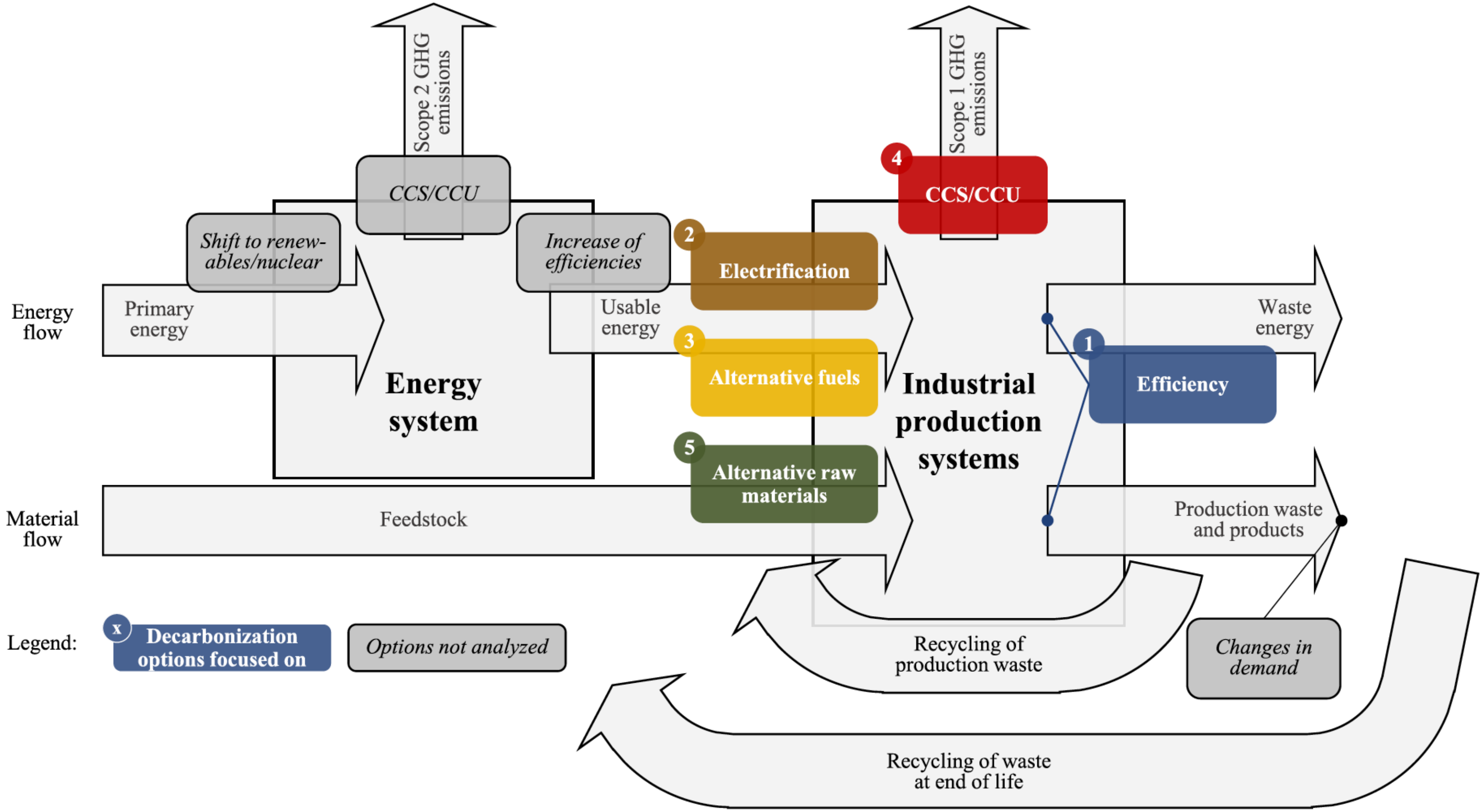
Cement and steel-making plants are the largest contributors (among industrial emitters) of CO_2 emissions – about 15% of the total amount.

We investigated the role of carbon capture and carbon removal technologies to reach from reduced up to zero emissions in such plants. The conversion and upgrading of captured CO_2 to a fuel has been addressed too.

The focus of this presentation is on the cement industry (*BAT technology*; *EU setting*)

A *cradle-to-gate* approach is used to calculate and present carbon balances of the analysed net-zero configurations.

Main topics in heavy-industry decarbonization



P. Tautorat, *Directions of innovation for the decarbonization of cement and steel production – A topic modeling-based analysis*, Journal of Cleaner Production 407 (2023) 137055

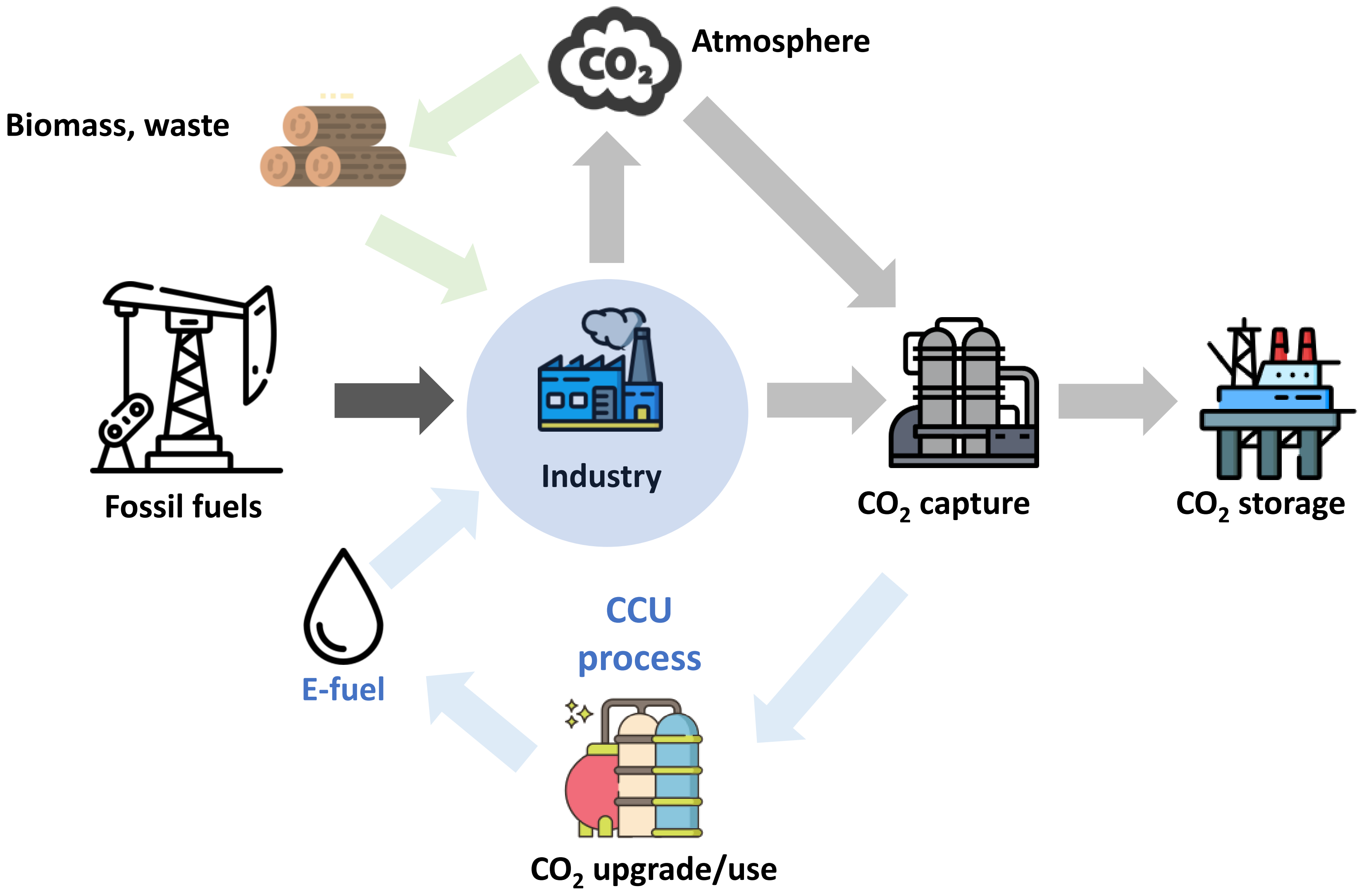
Key findings

Cement plants: fuel switch is energy-efficient and cost-effective for reducing CO_2 emissions. The combination of fuel switch to waste solid fuel (RFD) and CCS can lead to a net-zero plant. DAC is needed (in addition to CCS) to reach net-zero when using coal or NG as a fuel.

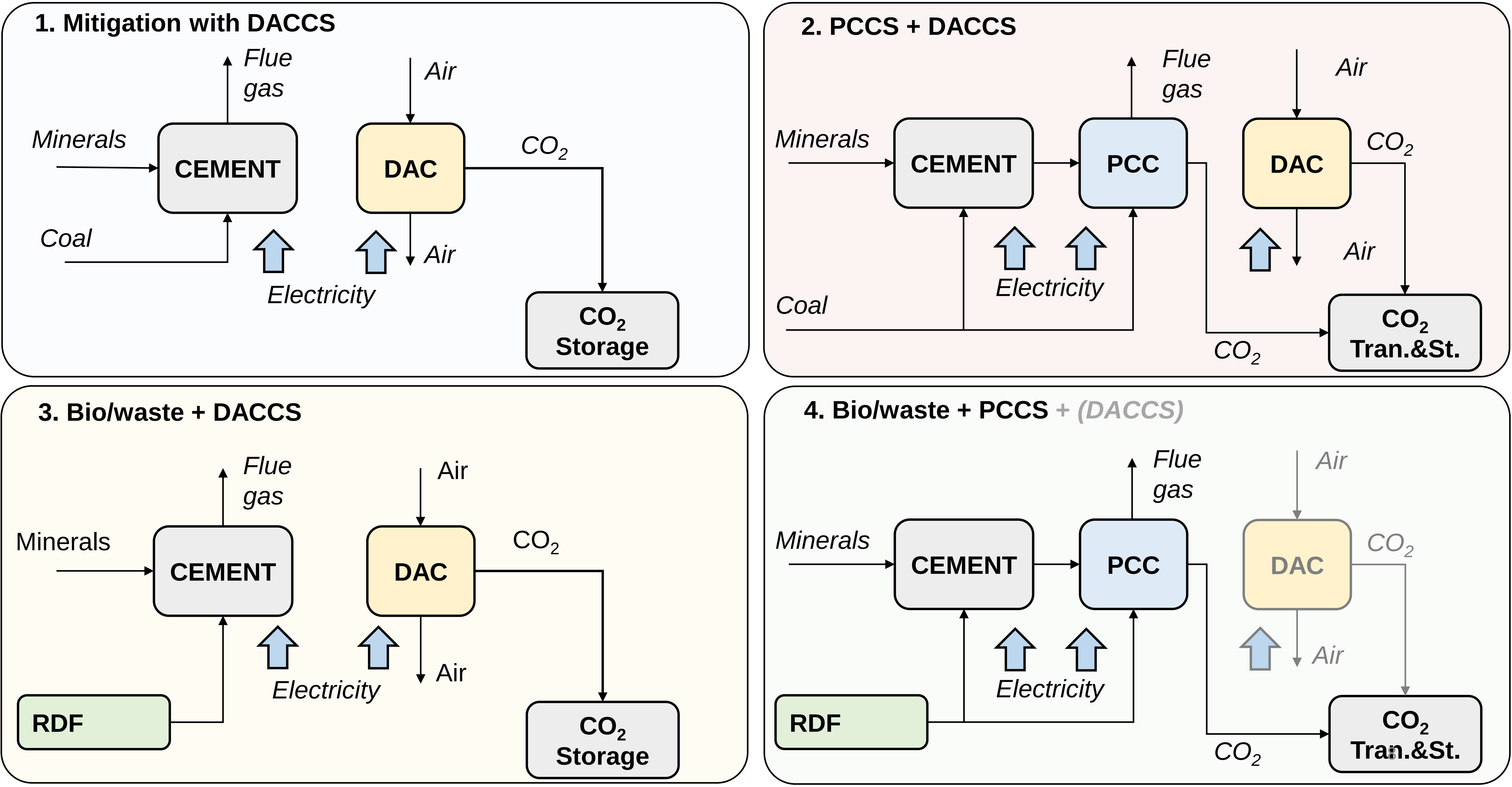
CO_2 conversion to *e-fuels* is viable. However, on-site need is generally limited.

Steel making plants: the capture cost of CO_2 in cement plants is generally lower than cement plants because of their larger size (in terms of processed/captured CO_2). In terms of specific energy consumption, the energy cost of capture of both cement and steel plants is comparable.

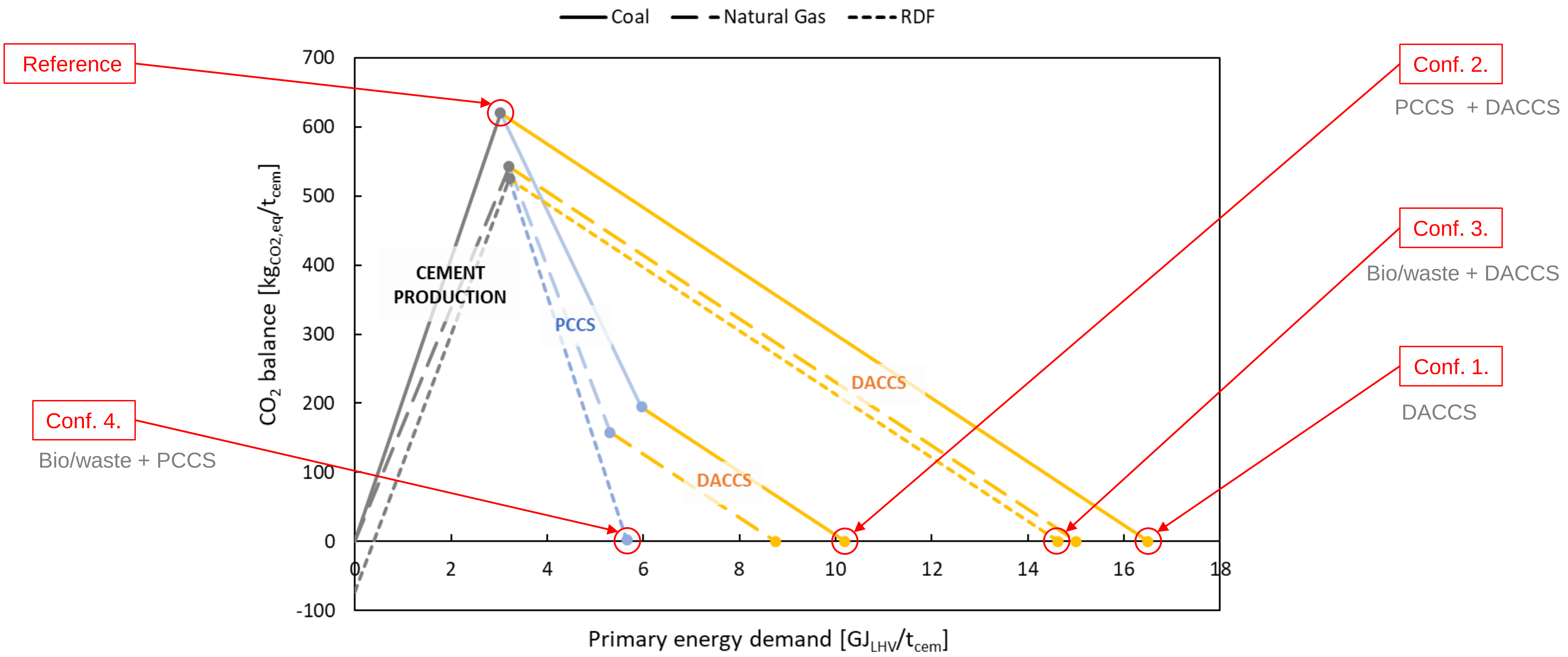
Circular approach to net-zero industry



Net-zero options for the cement industry with carbon capture and removal technologies:



Net-zero options for the cement plant

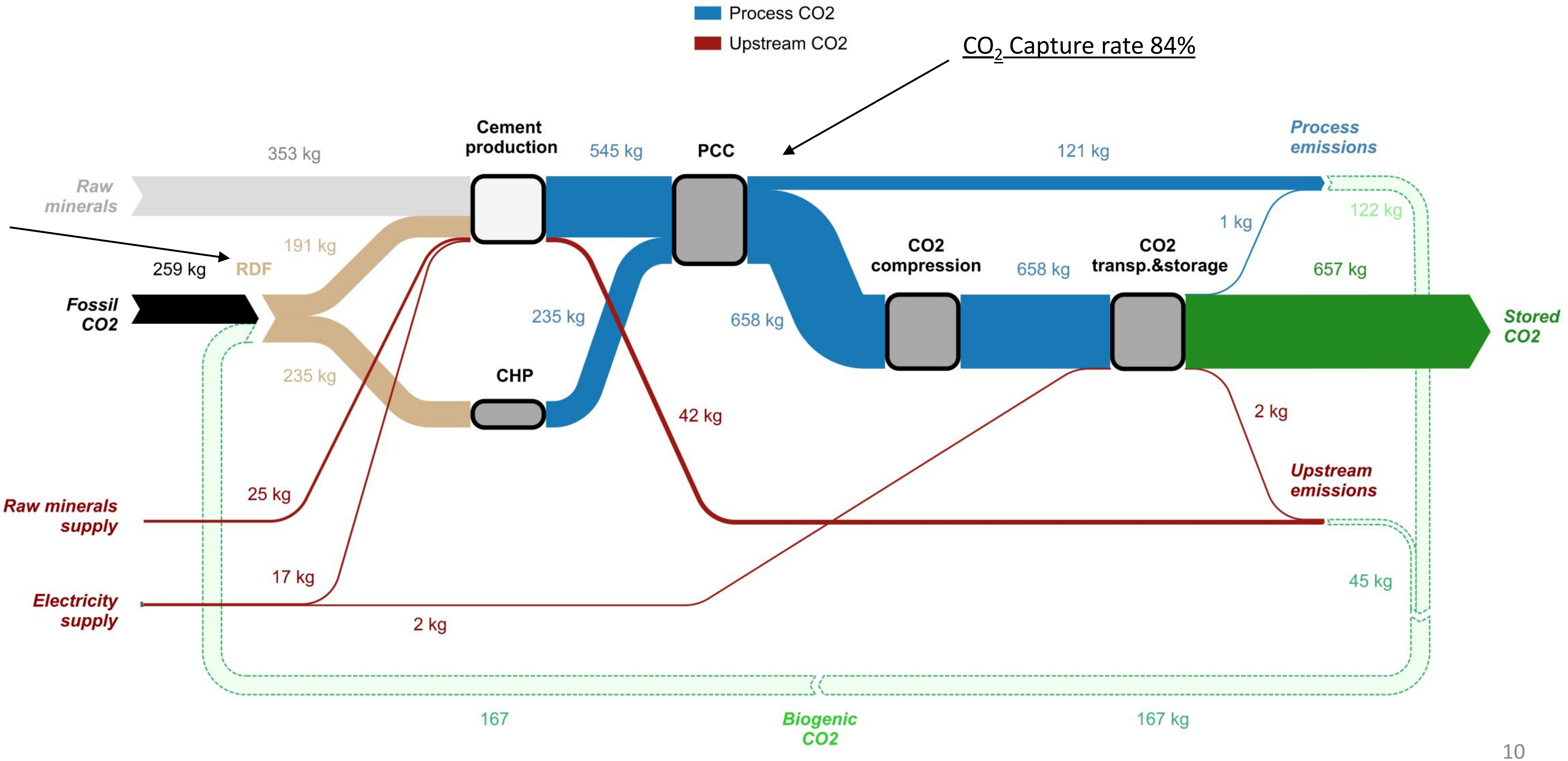


DACCS = Direct Air Capture with Carbon Storage; PCCS = Post Combustion Carbon Capture and Storage; RDF = Refuse Derived Fuel

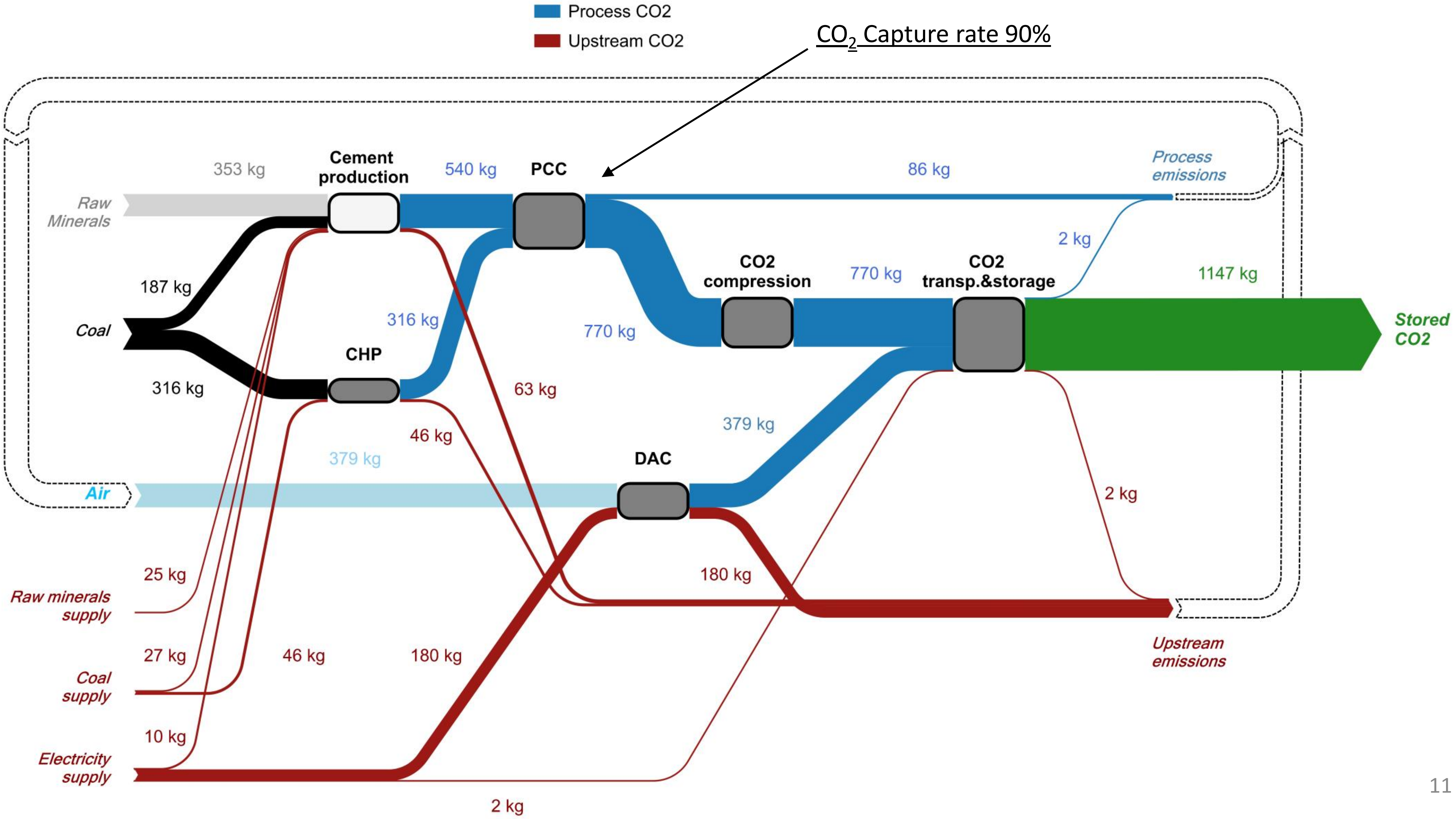
Carbon balance: switch to waste fuel + CCS

Biogenic carbon 40%

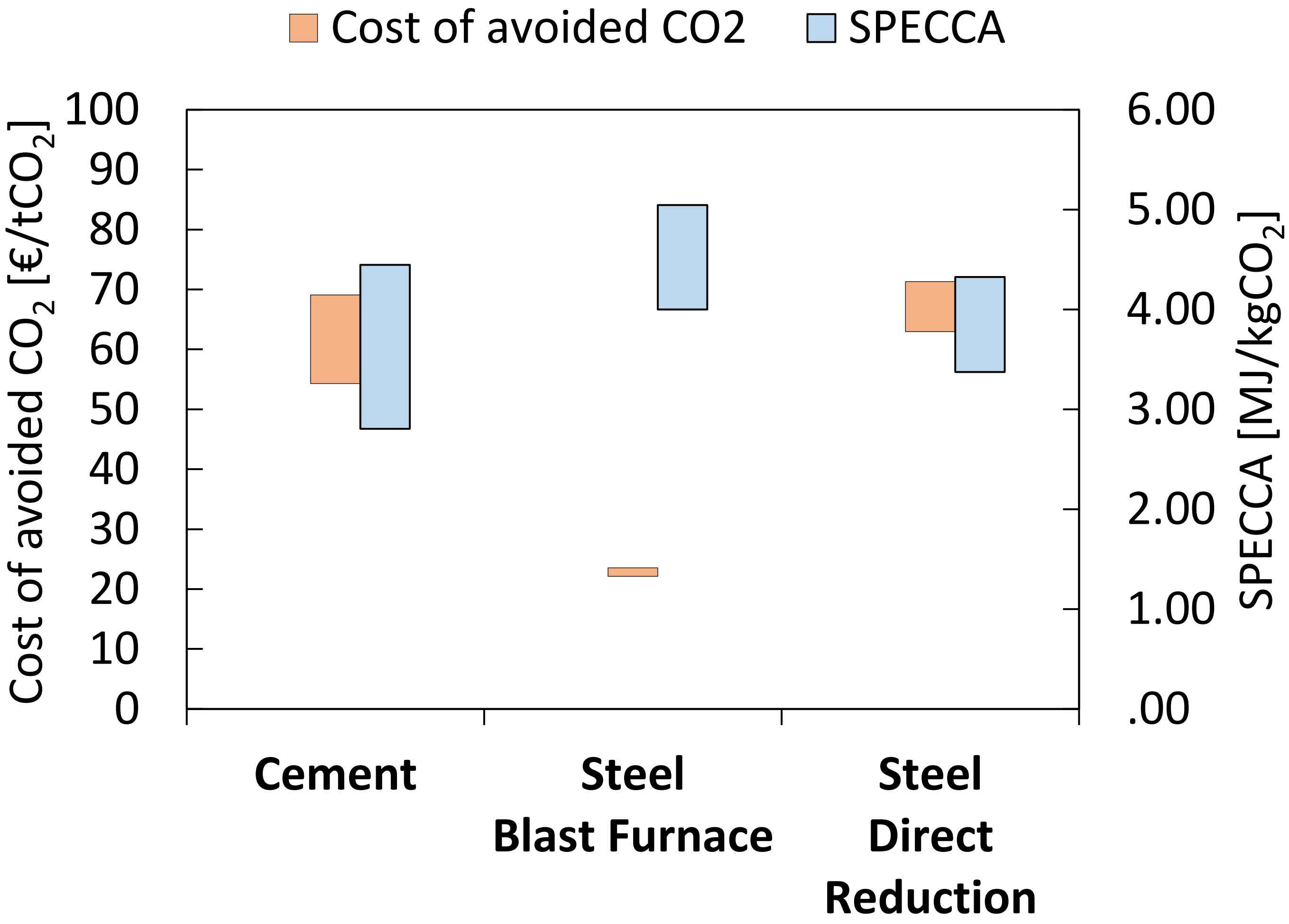
CO_2 Capture rate 84%



Carbon balance: CCS+DAC



Decarbonization cost



Captured CO_2: 2,000 t_{CO2}/d 28,000 t_{CO2}/d 3,000 t_{CO2}/d

Contact:

andrea.lanzini@polito.it

Politecnico di Torino, Energy Department

Additional references:

Carbon Footprint of Cement Plants Integrated With the Calcium Looping CO_2 Capture Process, https://doi.org/10.3389/frsus.2022.809231

Calcium looping in the steel industry: GHG emissions and energy demand, https://doi.org/10.1016/j.ijggc.2023.103893

Solar-driven calcium looping system for carbon capture in cement plants: Process modelling and energy analysis, https://dx.doi.org/10.1016/j.jclepro.2023.136367