Environmental assessment of a 25 MWe fossil-fired supercritical CO_2 cycle

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Project sCO_2-Flex

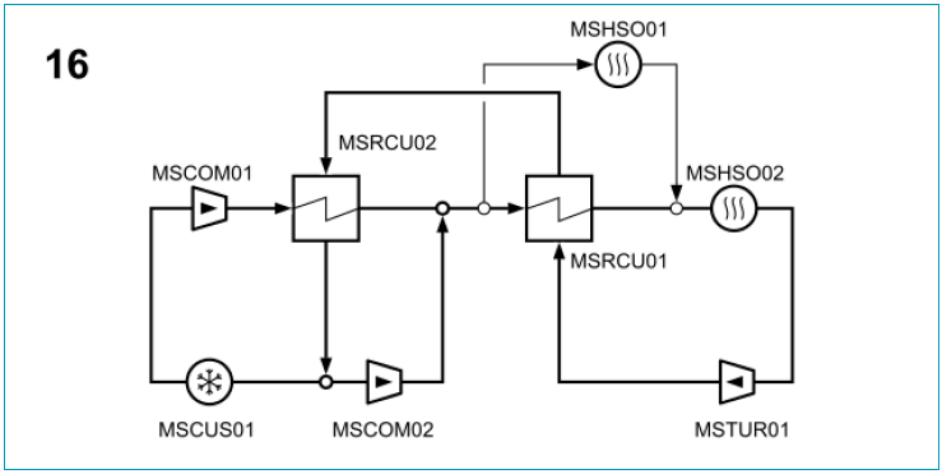
EU-funded project (5,6 M€) aimed at designing and assessing a 25 MWe fossil-fired cycle:

- Consortium members from 5 countries
- From January 1st 2018 to June 30th 2021
- Materials / equipment testing
- Main technical objectives:
  - Higher efficiency and flexibility
  - Better economics
  - Lower environmental footprint

Cycle developed in sCO_2-Flex

Recompression cycle with hot recuperator bypass :

- T_{max} = 620°C
- T_{min} = 33°C
- P_{max} = 250 bars
- P_{min} = 81 bars
- W_{raw} = 25 MW_e



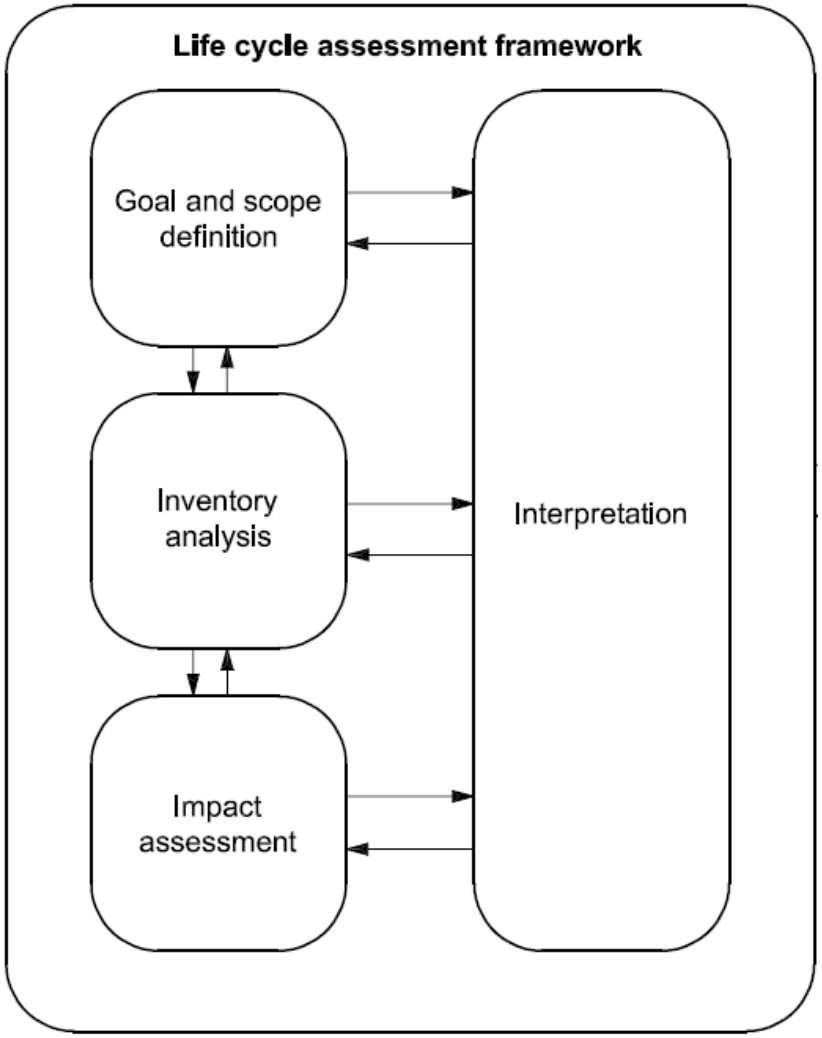
Assumption	Value	Unit
Cycle raw efficiency	42.3	%
Boiler LHV efficiency	92.5	%
Yearly number of startups	30	-
Energy penalty for a startup	20	MWhth
Overall auxiliary consumption & losses	1720	kWe

Methodology

This study followed, whenever possible, the guidelines provided by standards ISO-14040 and 14044 on LCA.

It is however not, properly speaking, an LCA, as full LCAs involve a critical review by a specialized cabinet.

The study was performed with OpenLCA v1.10, using the database EcoInvent v3.6



Scope of study (1/2)

Reference unit: **average kWh delivered to the Czech grid** (the boiler being designed for fuel used in Czech Republic)

	Reference plant (EcoInvent 3.6)	sCO_2-Flex plant	Unit
Dispatch strategy	5800	5000	hr/yr (full-load equivalent)
Plant lifetime	26	30	years
Plant yearly efficiency	0,333	0,364	-
Plant net output at full load	> 250	23,3	MW_e

Scope of study (2/2)

Phases of the plant's lifetime:

- Construction (data for the cycle taken from project partners, generic data from EcoInvent database for the other equipments)
- Fuel supply chain (coal mining, preparation and transportation)
- Operation (coal combustion, flue gas and ash treatment)

Impact categories selected:

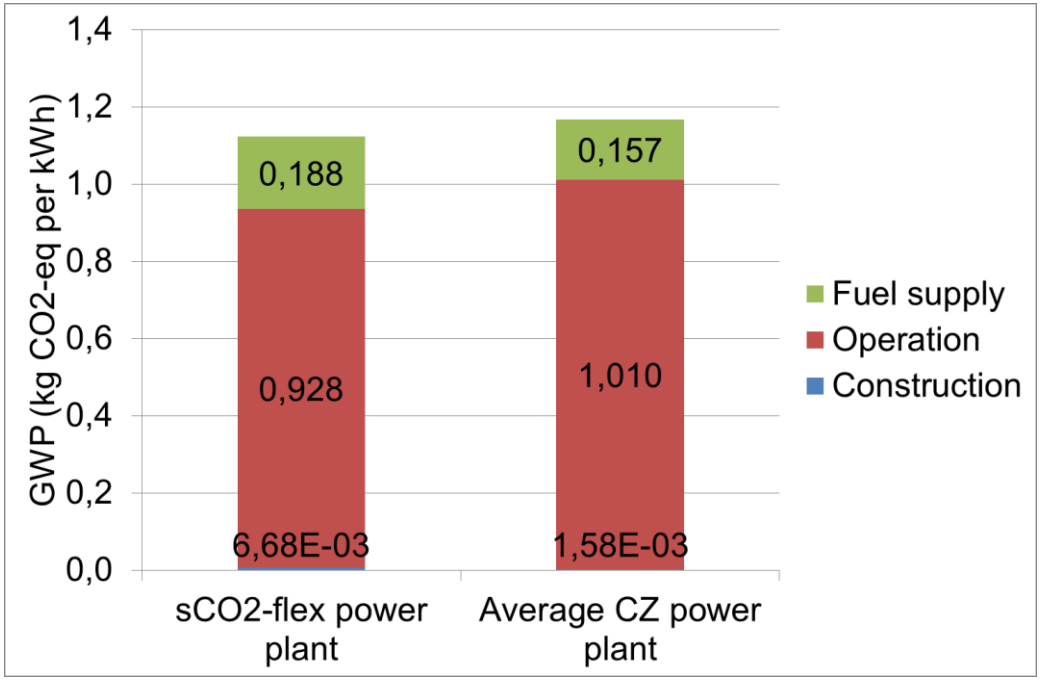
- Global Warming Potential at 100 years (GWP) : kg CO_2 equivalent
- Abiotic Depletion Potential (ADP) : kg Sb equivalent

Results: GWP

As expected, the majority of the plant's impact comes from the operation phase.

sCO_2-Flex plant's impact is overall lower.

The fuel supply phase is however not negligible, due to a coal of moderate LHV.

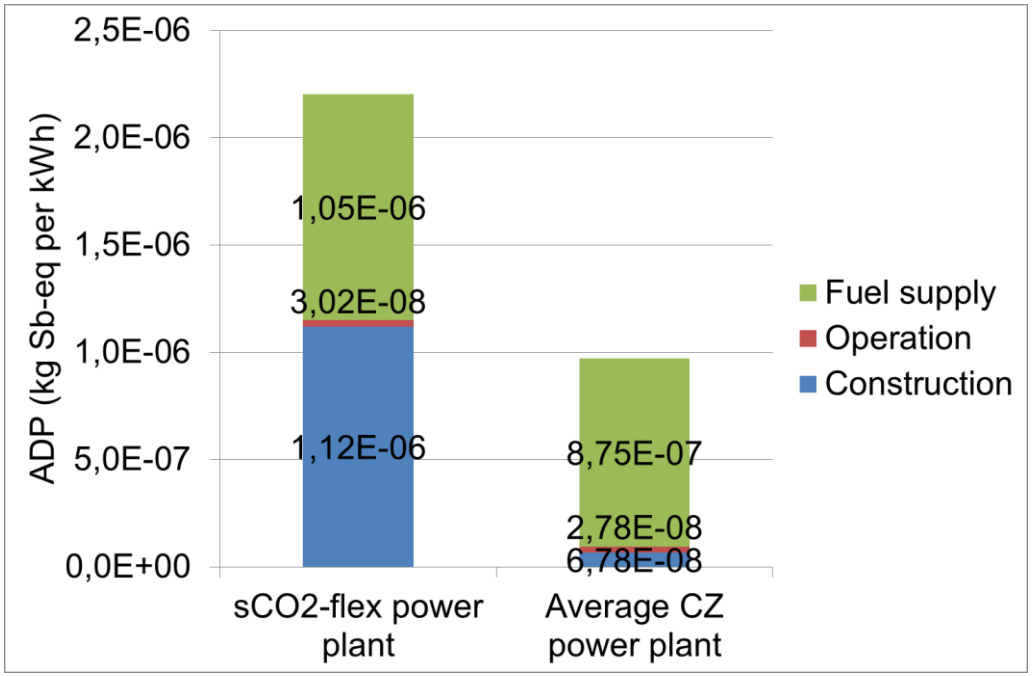


Results: ADP (1/3)

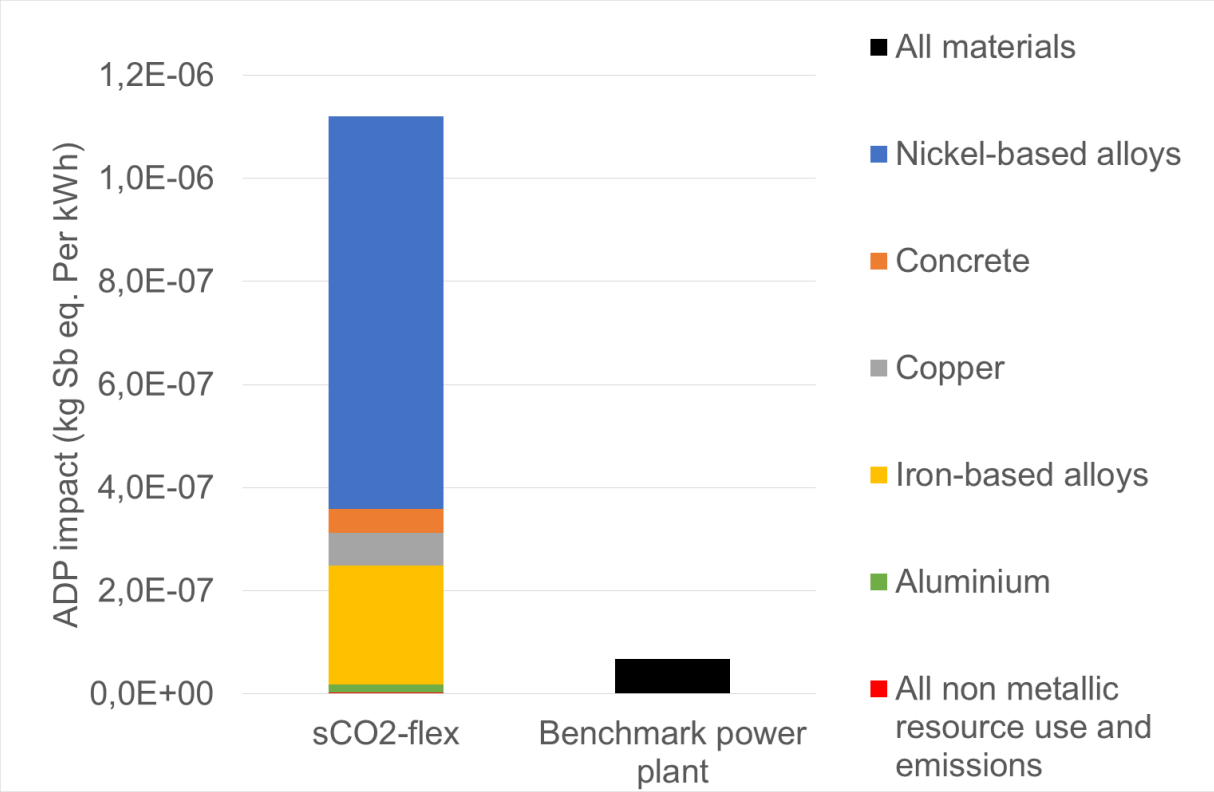
Higher impact on that indicator.

The main difference occurs in the plant construction phase, due to the small size of the plant and the high amount of Ni-based alloys in the boiler.

The fuel supply phase is still higher, probably still due to poor fuel quality.

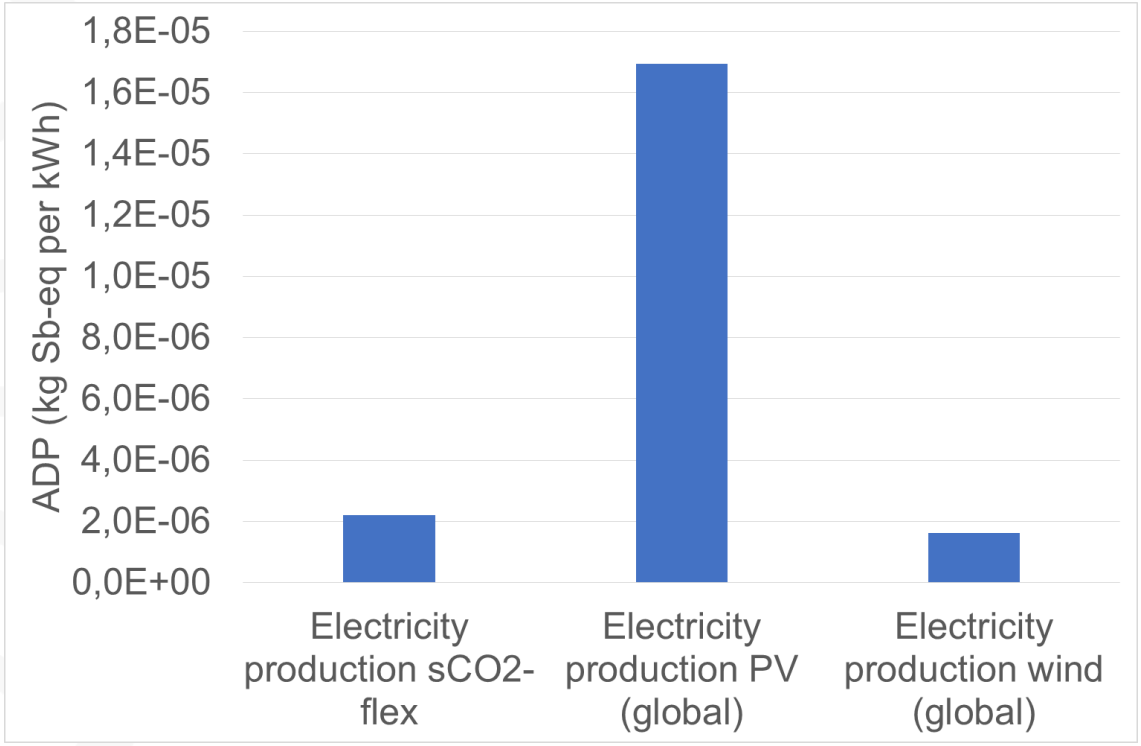


Results: ADP (2/3)
Construction phase



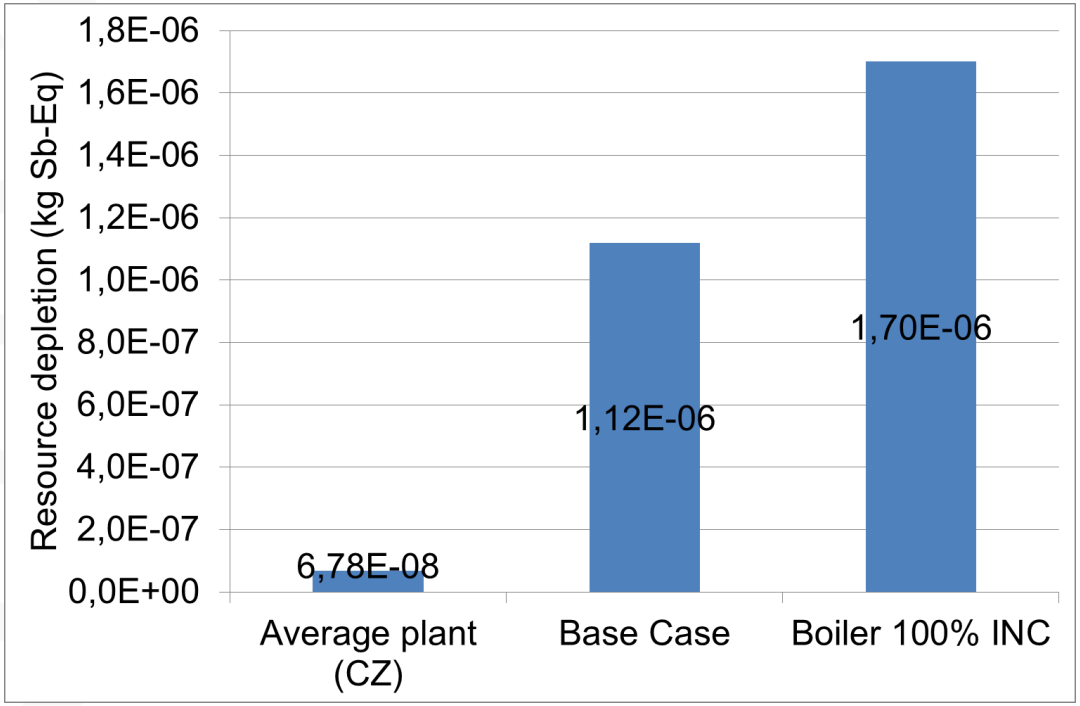
The use of noble (especially Ni-based) alloys in the boiler causes the impact of the construction phase to increase dramatically.

Results: ADP (3/3)
Comparison with renewables



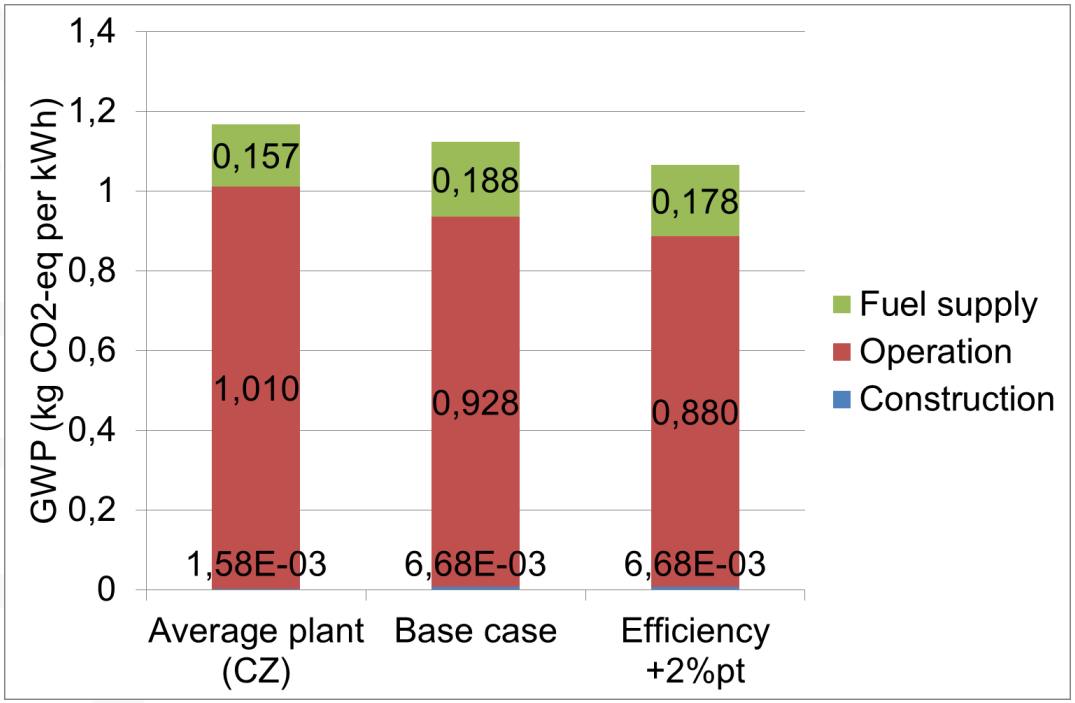
Resource depletion is usually more linked to renewables. sCO_2-Flex plant is still better than PV on that account, but worse than wind power.

Sensitivity study: Ni-based alloys



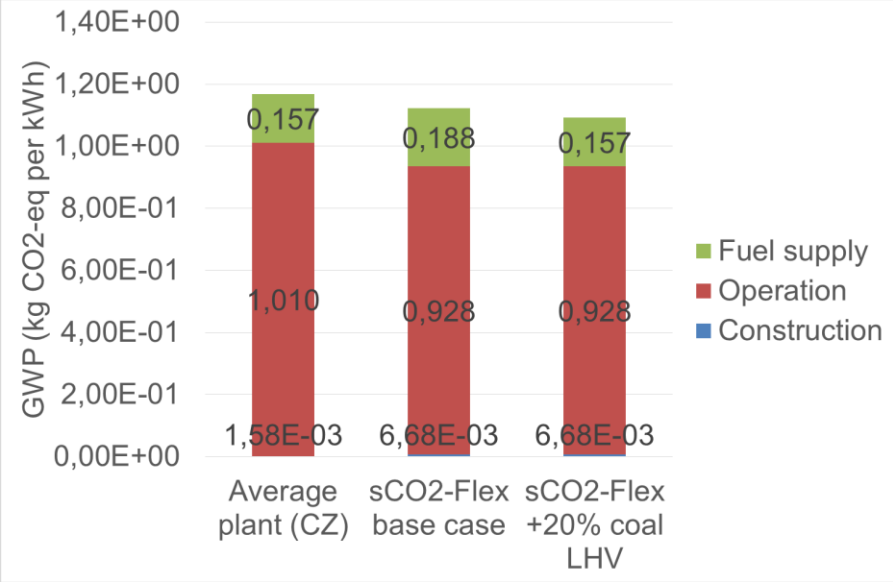
The share of INC 617 in the boiler has a significant influence on the plant's environmental footprint → care is required when raising the maximum temperature / pressure

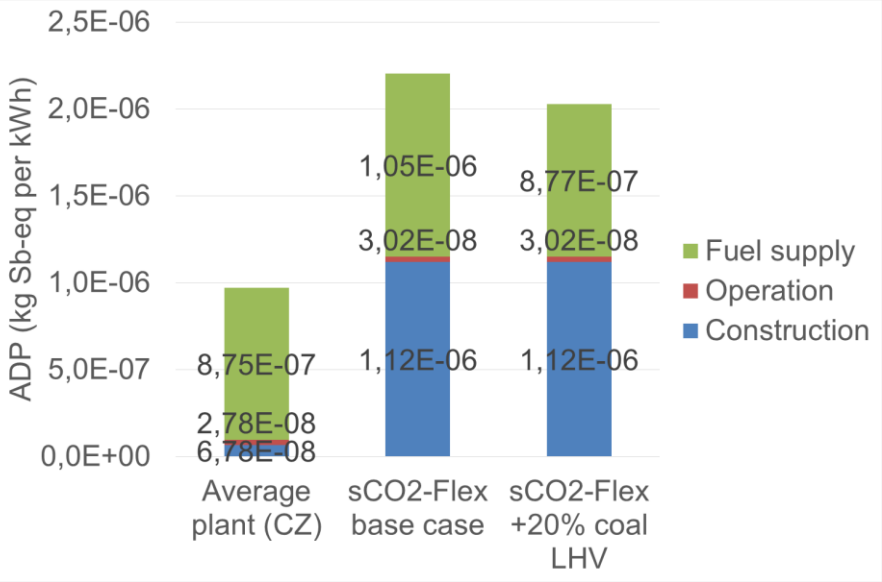
Sensitivity study: efficiency



Gains in efficiency (for instance when scaling up or raising the maximum temperature) will result in savings in GHG emissions

Sensitivity study: fuel LHV





Higher LHV → lower fuel consumption in mass → lower environmental impact (all else being equal)

Conclusion

sCO_2 plants can be expected to bring improvements on GHG emissions.

Work is still needed to mitigate the higher impact on abiotic resource depletion, especially in order to minimize the share of Ni-based alloys in the boiler.

The overall environmental impact of such a plant should benefit from a scale-up (25 MW_e raw considered in the present study).

Thank you!
Any question ?

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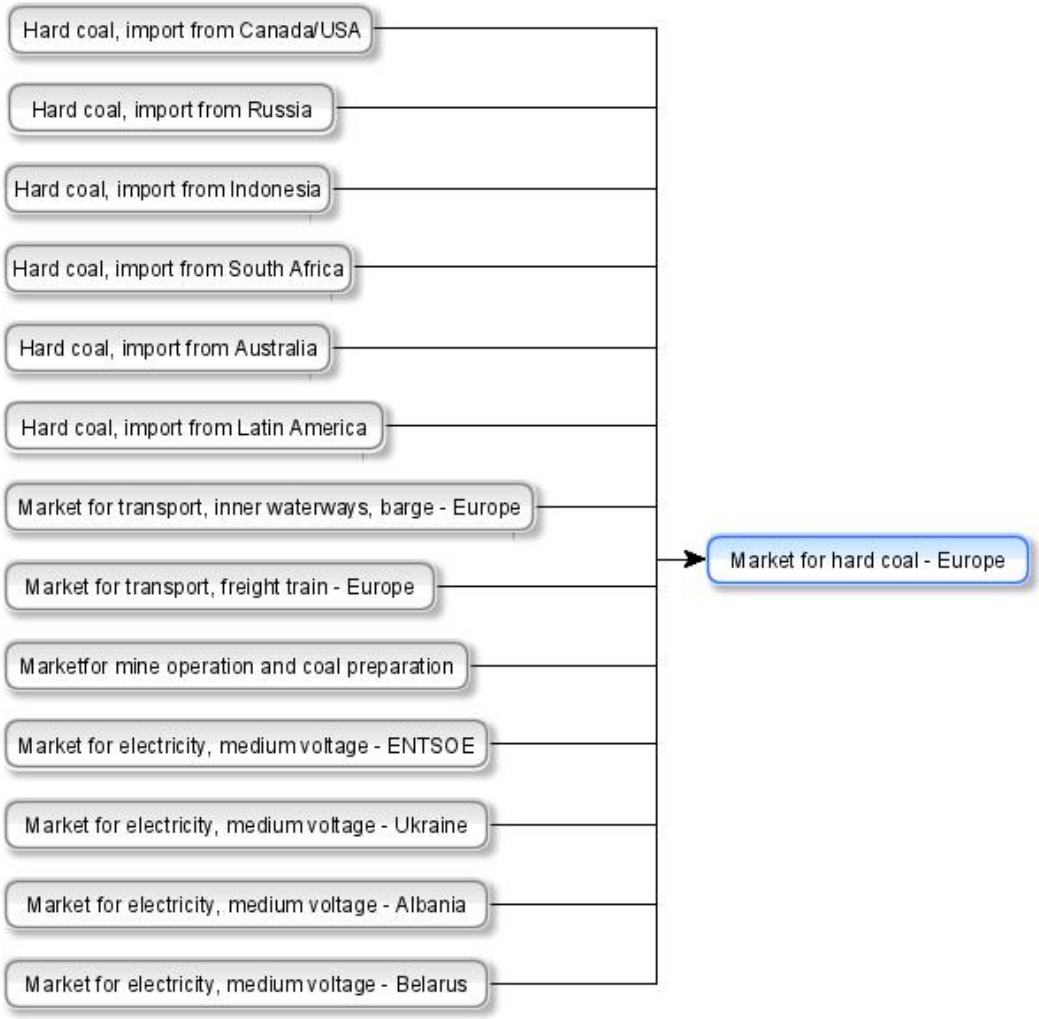
Model: construction

Model: Fuel supply



Model: plant operation