

The drivers, research and prospects of CCS in Finnish Iron and Steel industry

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VTT Technical research centre of Finland

The largest multitechnological applied research organisation in Northern Europe

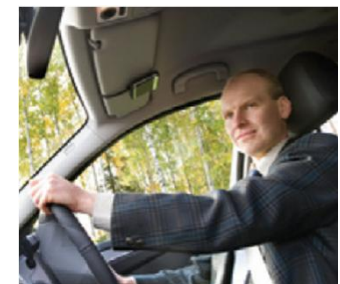
Personnel 2.818 (1.1.2010) ■ Turnover 278 M€ 2011)

Customer sectors

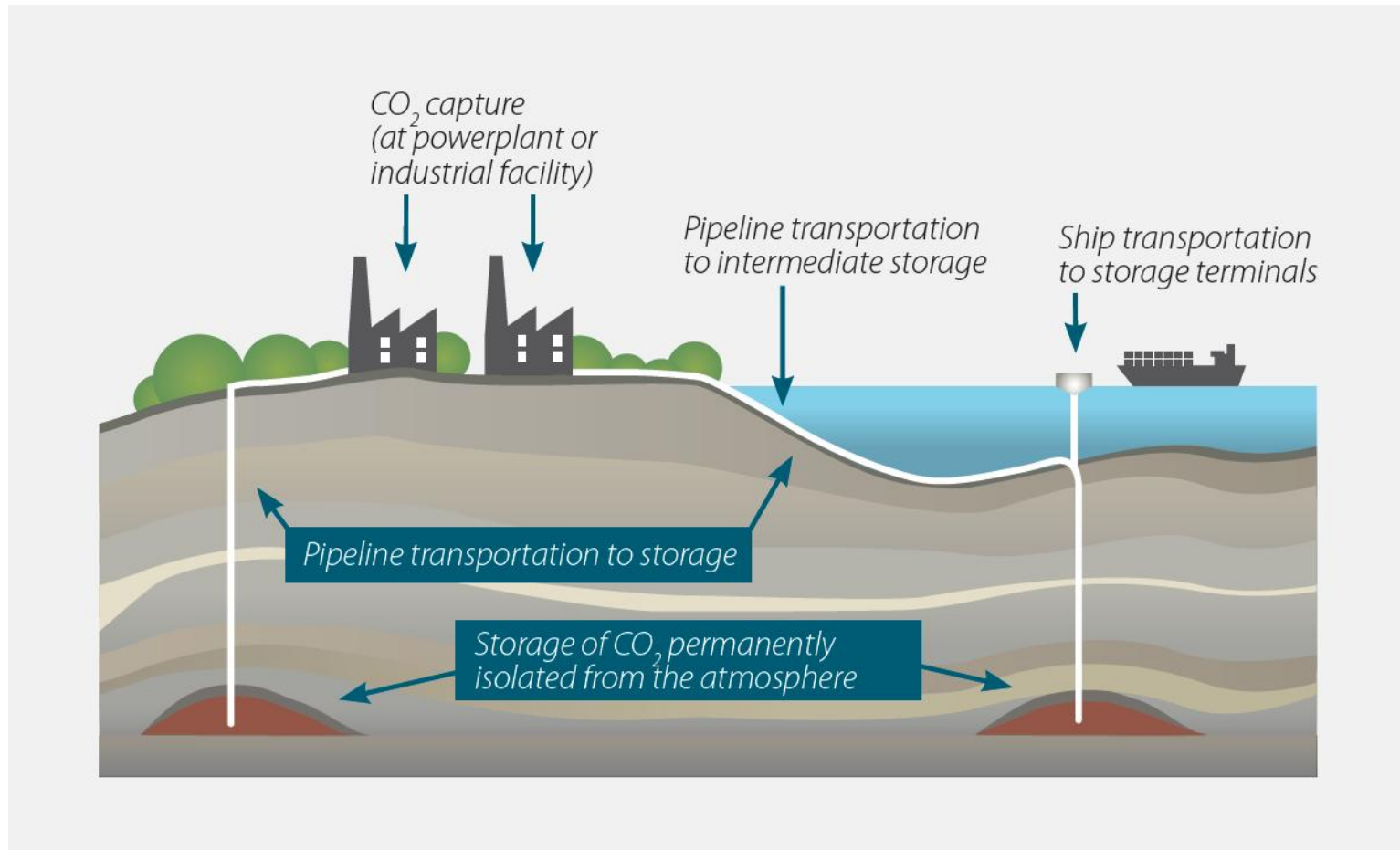
- Biotechnology, pharmaceutical and food industries
- Electronics
- Energy
- ICT
- Real estate and construction
- Machines and vehicles
- Services and logistics
- Forest industry
- Process industry and environment

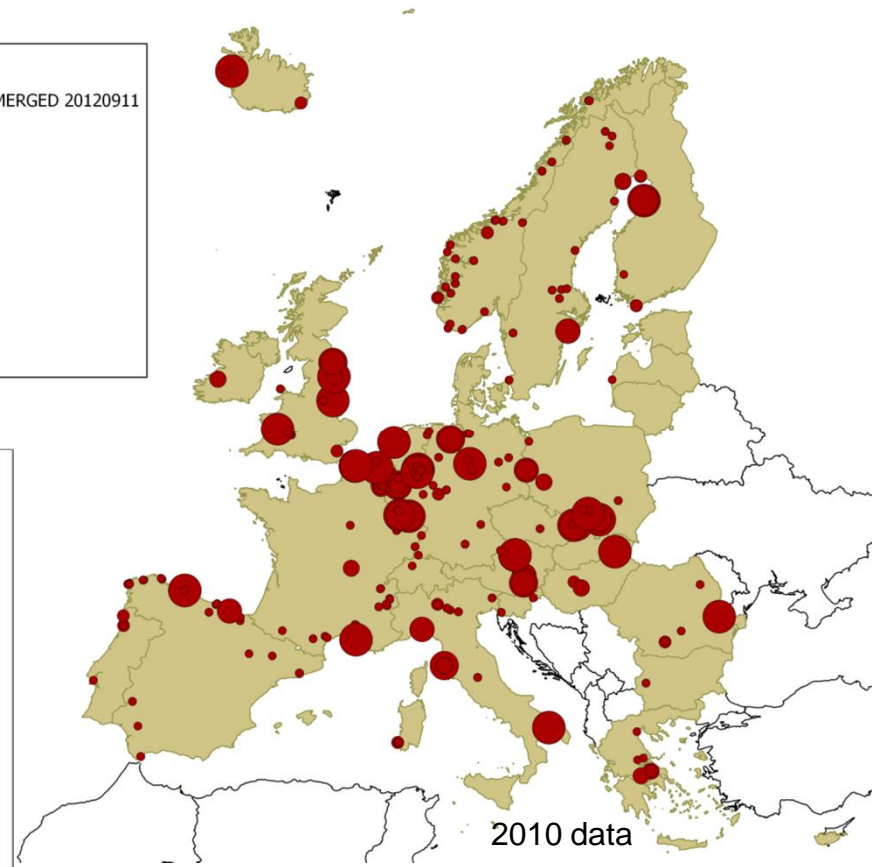
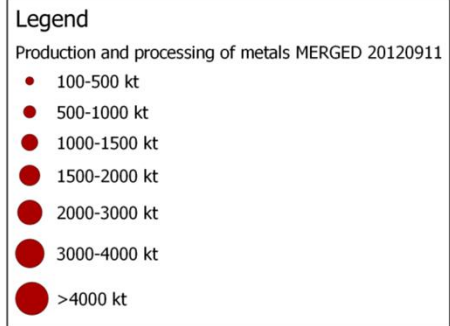
Focus areas of research

- Applied materials
- Bio- and chemical processes
- Energy
- Information and communication technologies
- Industrial systems management
- Microtechnologies and electronics
- Services and the built environment
- Business research

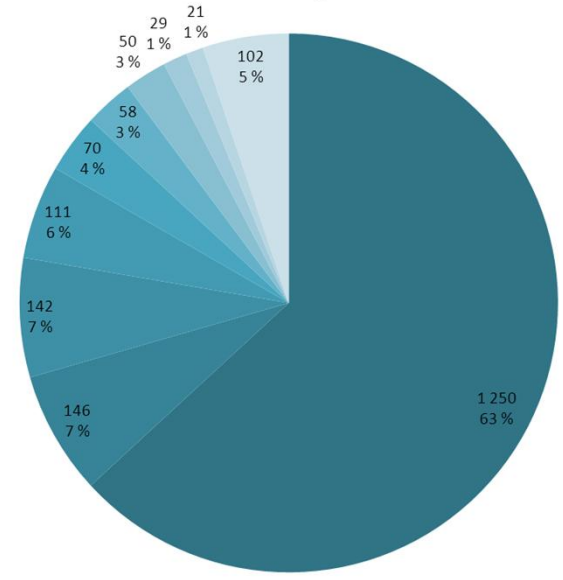


Carbon capture and storage





CO₂ emissions in EU 27 2011

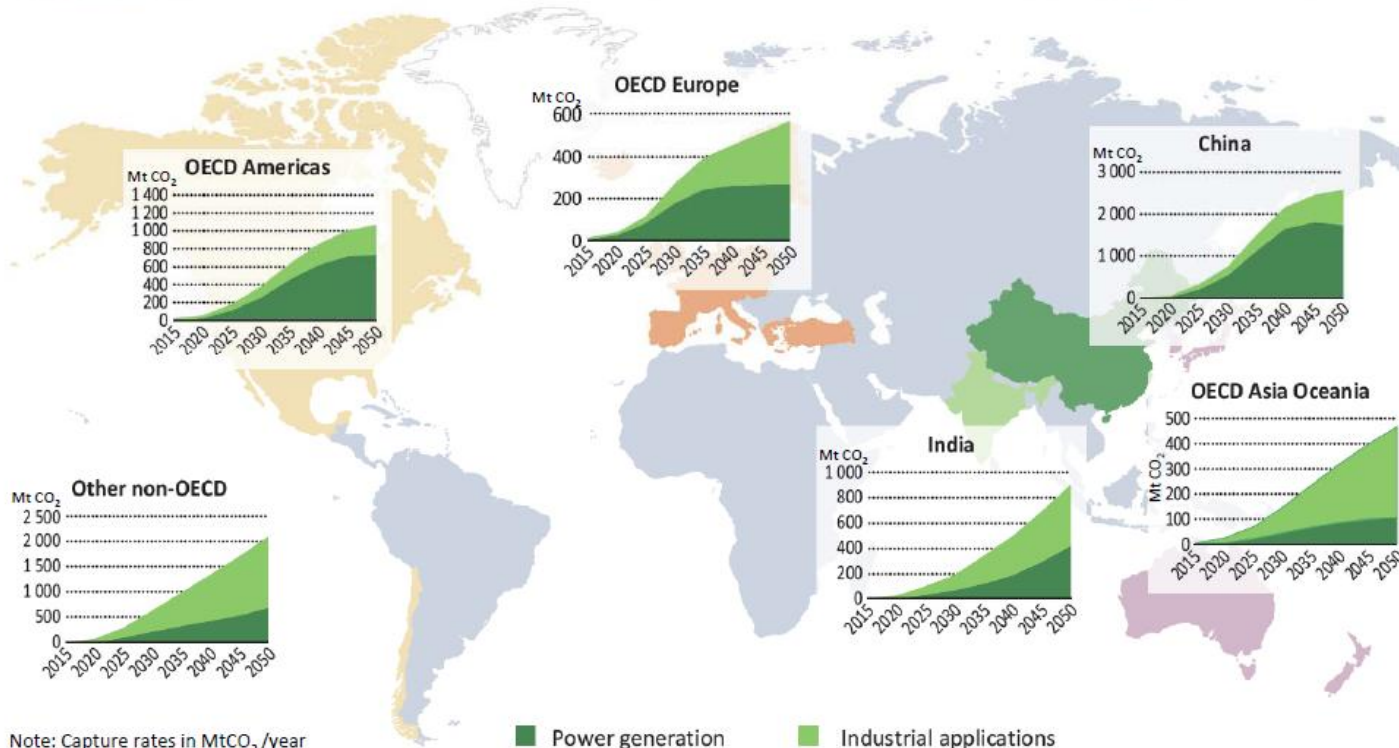


- Thermal power stations and other combustion installations
- Production of cement clinker or lime in rotary kilns or other furnaces
- Mineral oil and gas refineries
- Production of pig iron or steel including continuous casting
- Incineration of non-hazardous waste included in Directive 2000/76/EC - waste incineration
- Industrial scale production of basic organic chemicals
- Production of pulp from timber or similar fibrous materials
- Industrial scale production of basic inorganic chemicals
- Production of paper and board and other primary wood products

Source: E-PRTR

The CCS infant must grow quickly

ETP
2012



This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

NER 300 – the Next big step for CCS in Europe

- 12 July 2012 The European Commission has published interim results of the selection process under the first call for proposals of the NER300 funding programme for innovative low-carbon technologies
- Under the on-going first call, some three carbon dioxide capture and storage (CCS) demonstration projects and up to 16 innovative renewable energy sources (RES) demonstration projects could be co-funded

Candidates for award decisions

Project category	Member State	Project
Pre-combustion	UK	Don Valley Power Project
Post-combustion	PL	Belchatow CCS Project
Industrial application	NL	Green Hydrogen
Pre-combustion	UK	The Teeside CCS Project
Oxyfuel	UK	UK Oxy CCS Demo
Pre-combustion	UK	C.GEN North Killingholme Power Station
Post-combustion	IT	Zero Emission Porto Tolle
Industrial application	FR	ULCOS-BF

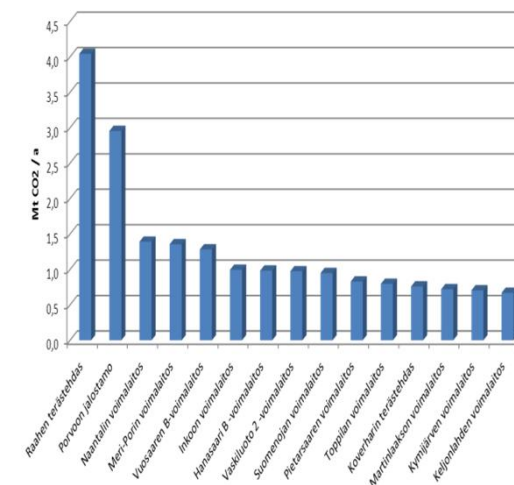
Reserve list

Project category	Member State	Project
Post-combustion	RO	Getica CCS Demo Project
Post-combustion	UK	Peterhead Gas CCS Project

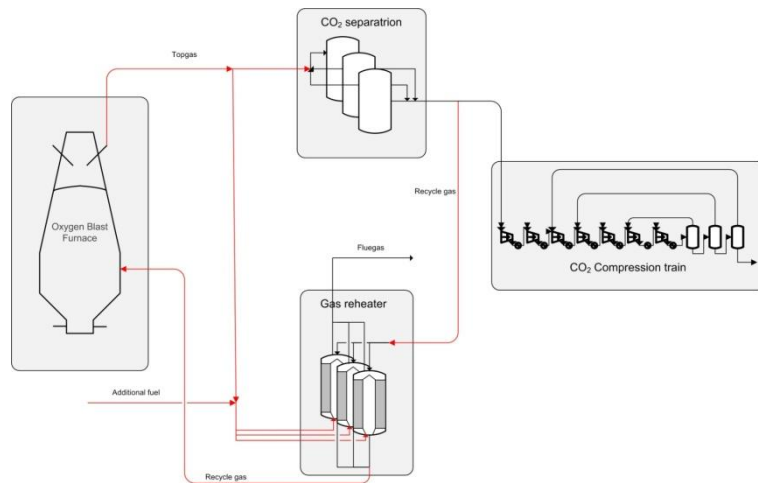
SWD(2012) 224 final

Raahe steel mill

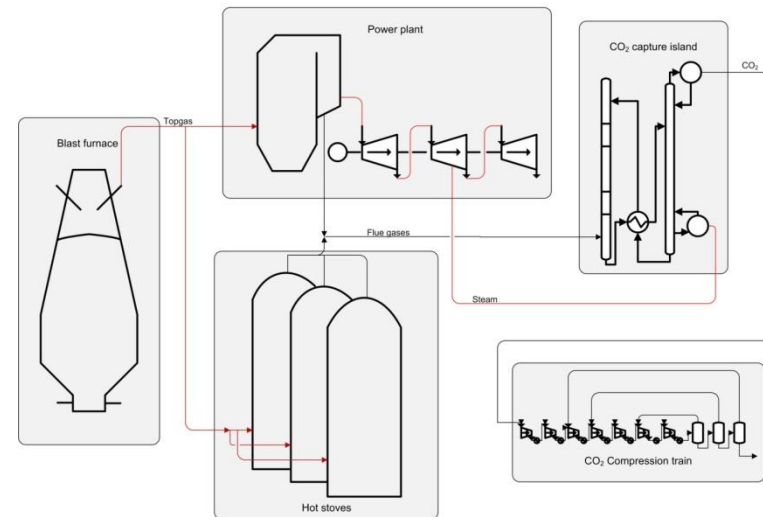
- Case study is based on Ruukki Metals Oy's Raahe steel mill that is situated on the coast of the Gulf of Bothnia
- It is the largest integrated steel mill in the Nordic countries producing hot rolled steel plates and coils.
- It is also the largest CO₂ point source in Finland emitting approximately 4 Mton / year (in 2011).



Process integration of CCS to the steel mill

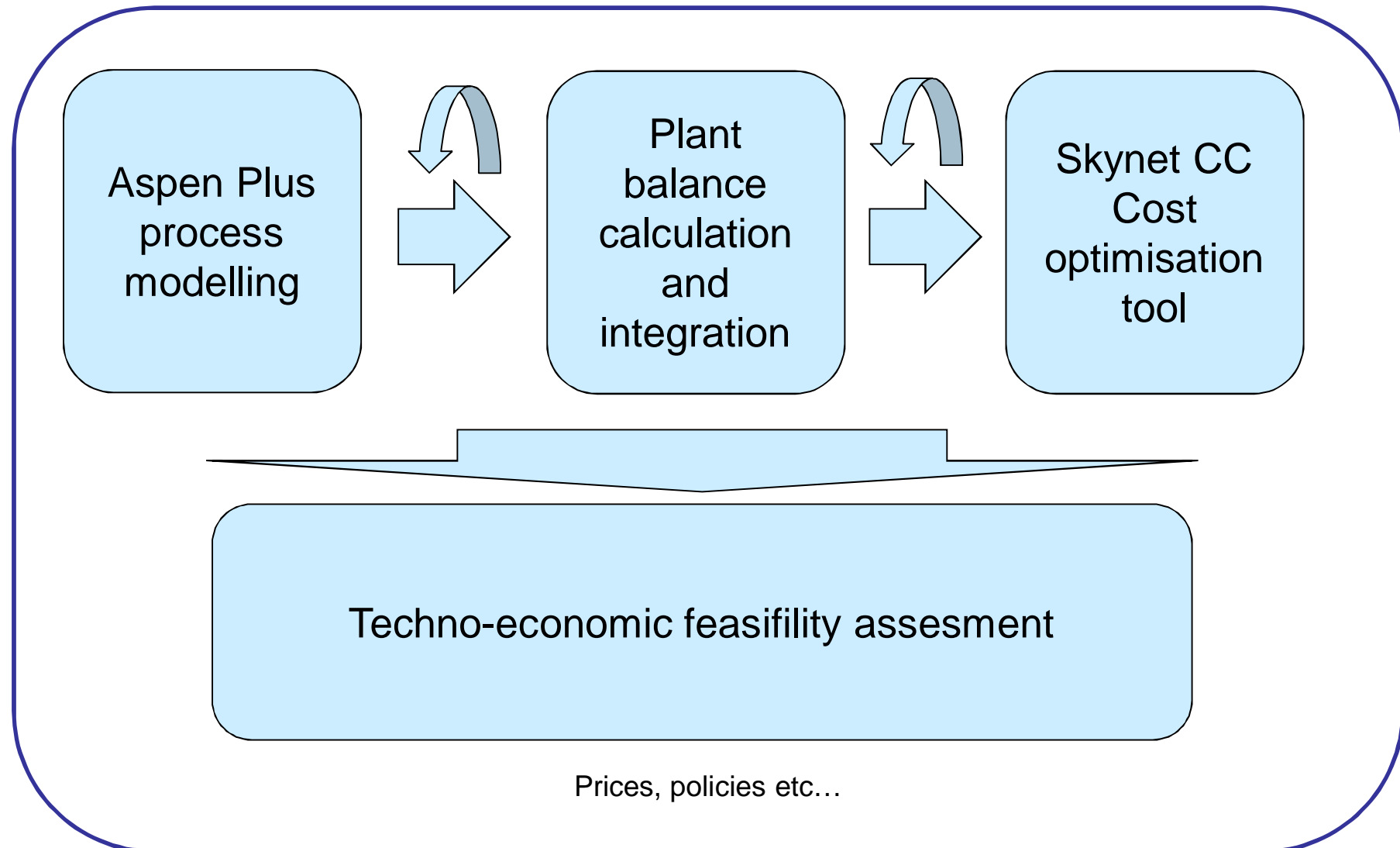


Post combustion carbon capture

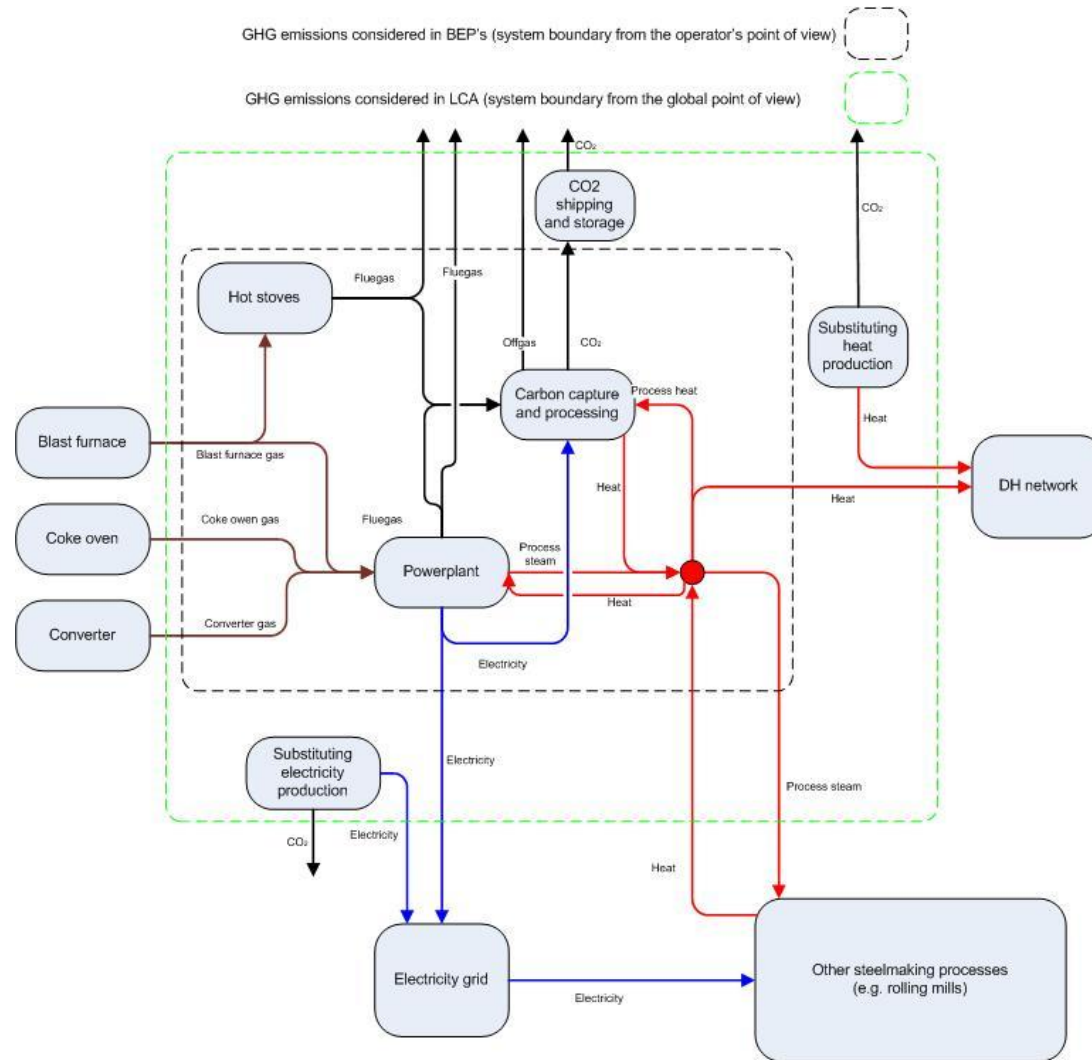


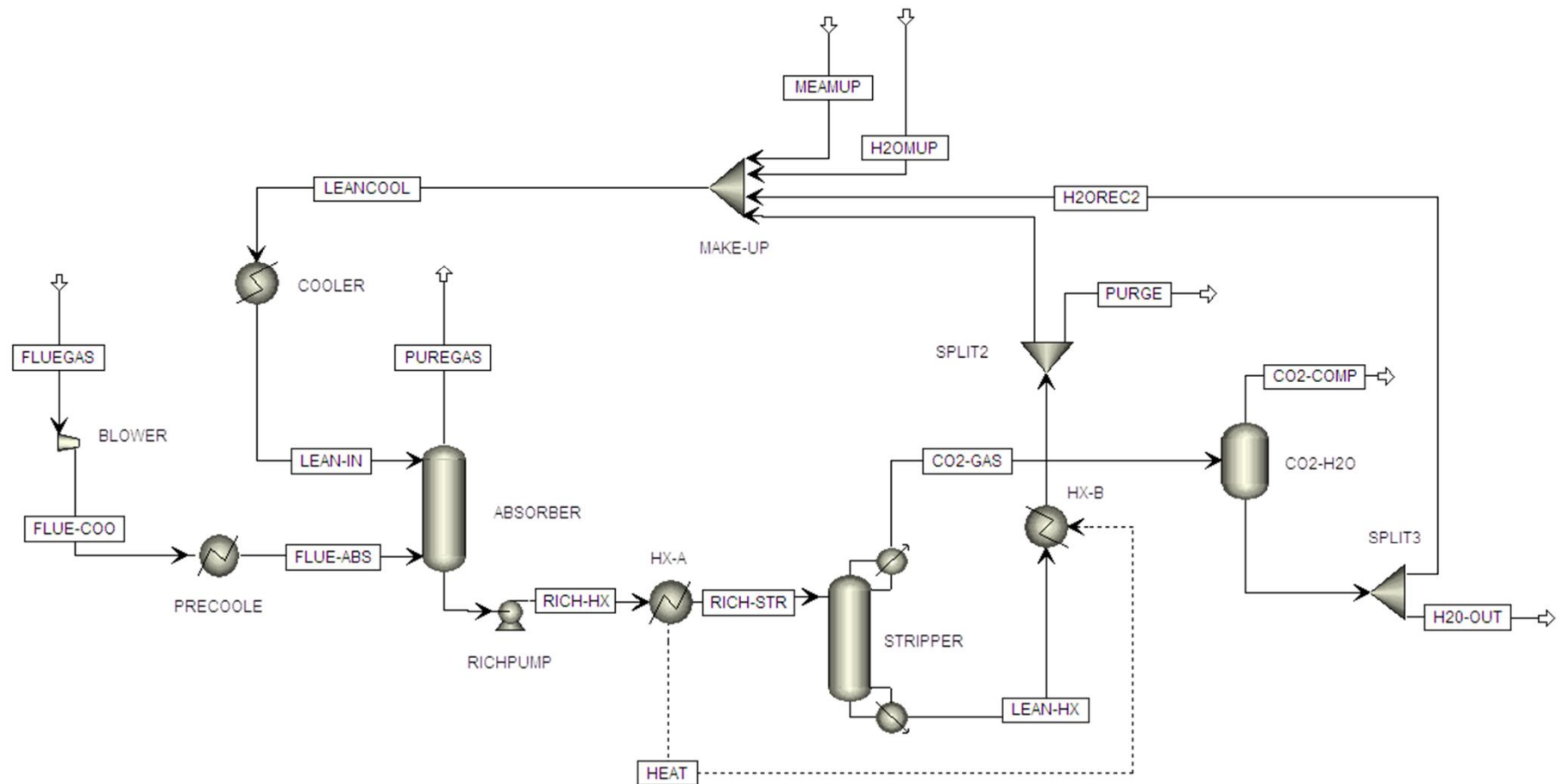
Oxygen blast furnace with carbon capture

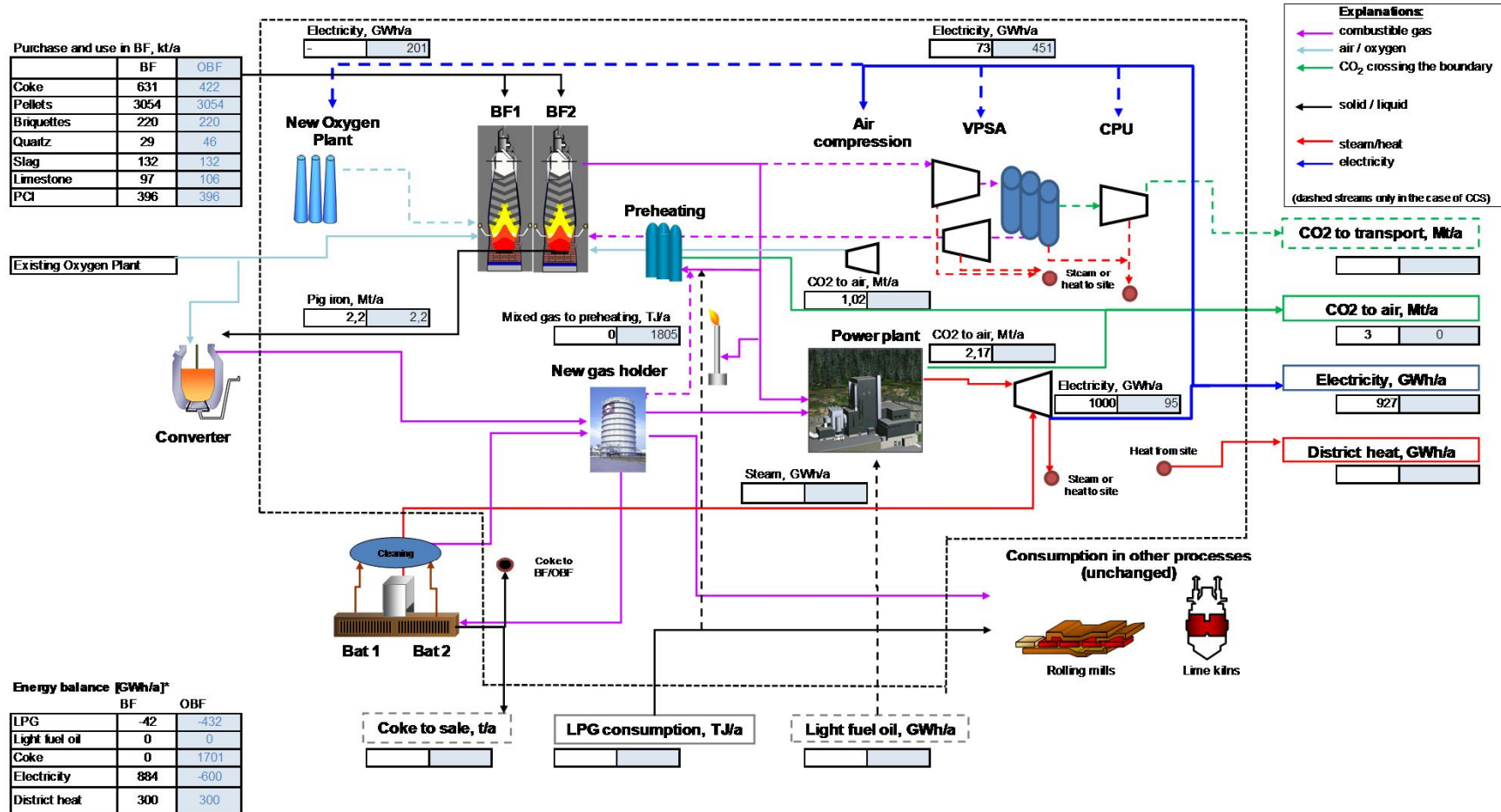
Methodology



Boundaries of evaluation





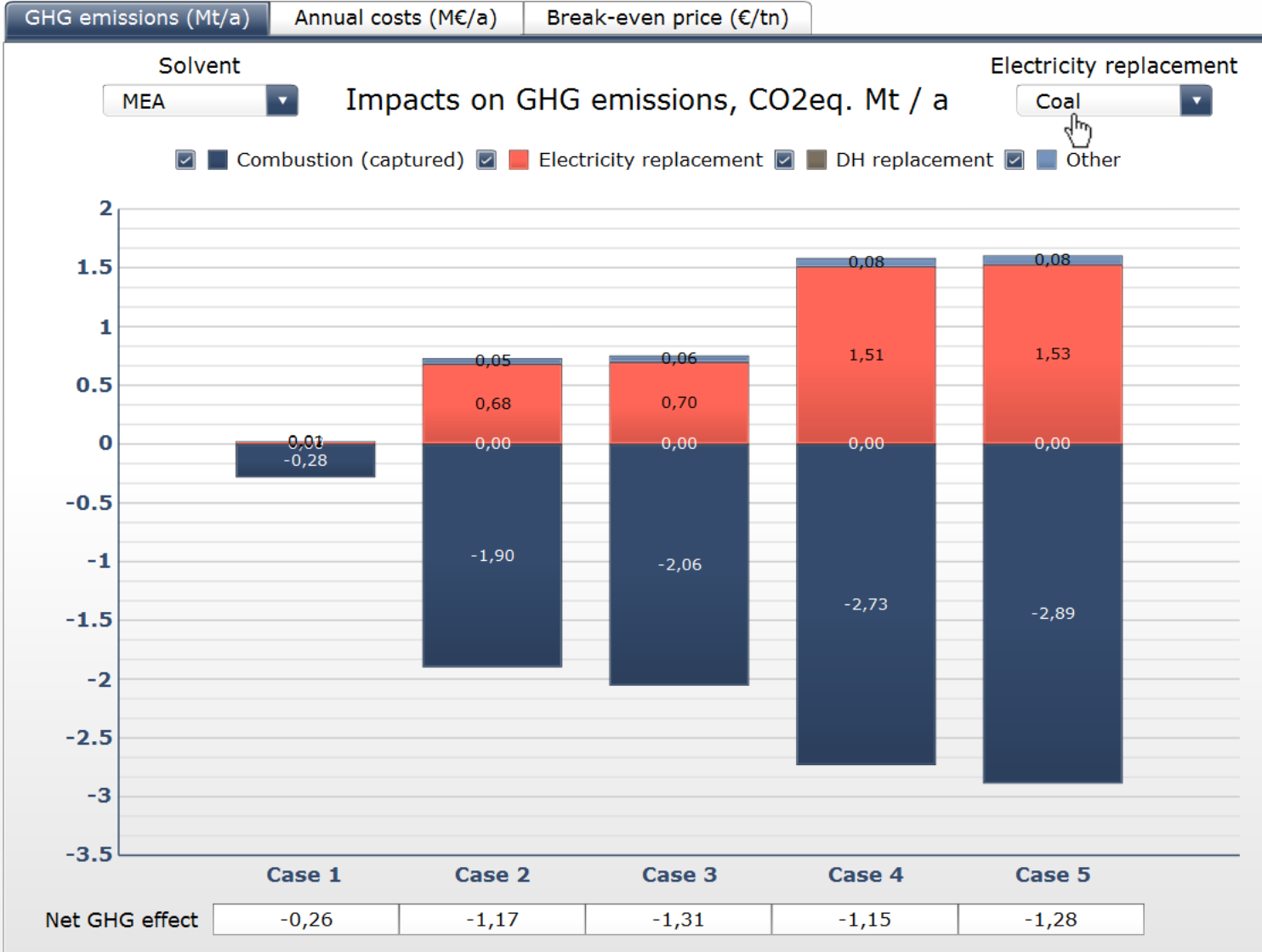


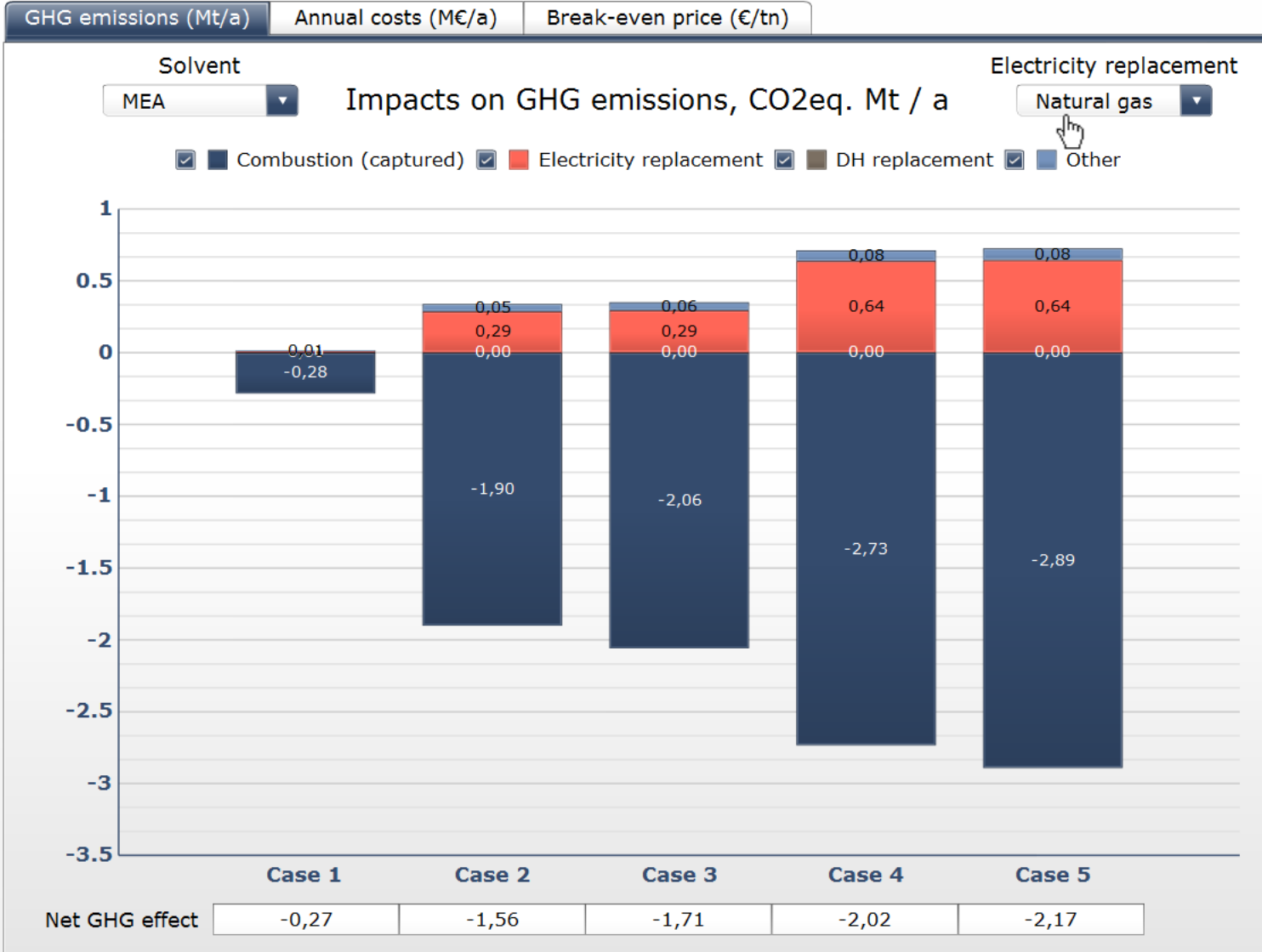
Explanations:

- ← combustible gas
- ← air / oxygen
- ← CO₂ crossing the boundary
- ← solid / liquid
- ← steam/heat
- ← electricity

(dashed streams only in the case of CCS)







GHG emissions (Mt/a)

Annual costs (M€/a)

Break-even price (€/tn)

Change in annual costs and income, M€/a

Solvent: MEA

Electricity, €/MWh 80

EUA, €/tn 50

Investment sensitivity factor 0%

- Electricity
- District heat
- CO2 allowances
- CO2 transport&storage
- Other OPEX
- CAPEX



Total, M€/a

Case 1	Case 2	Case 3	Case 4	Case 5
10	31	32	77	77

GHG emissions (Mt/a)

Annual costs (M€/a)

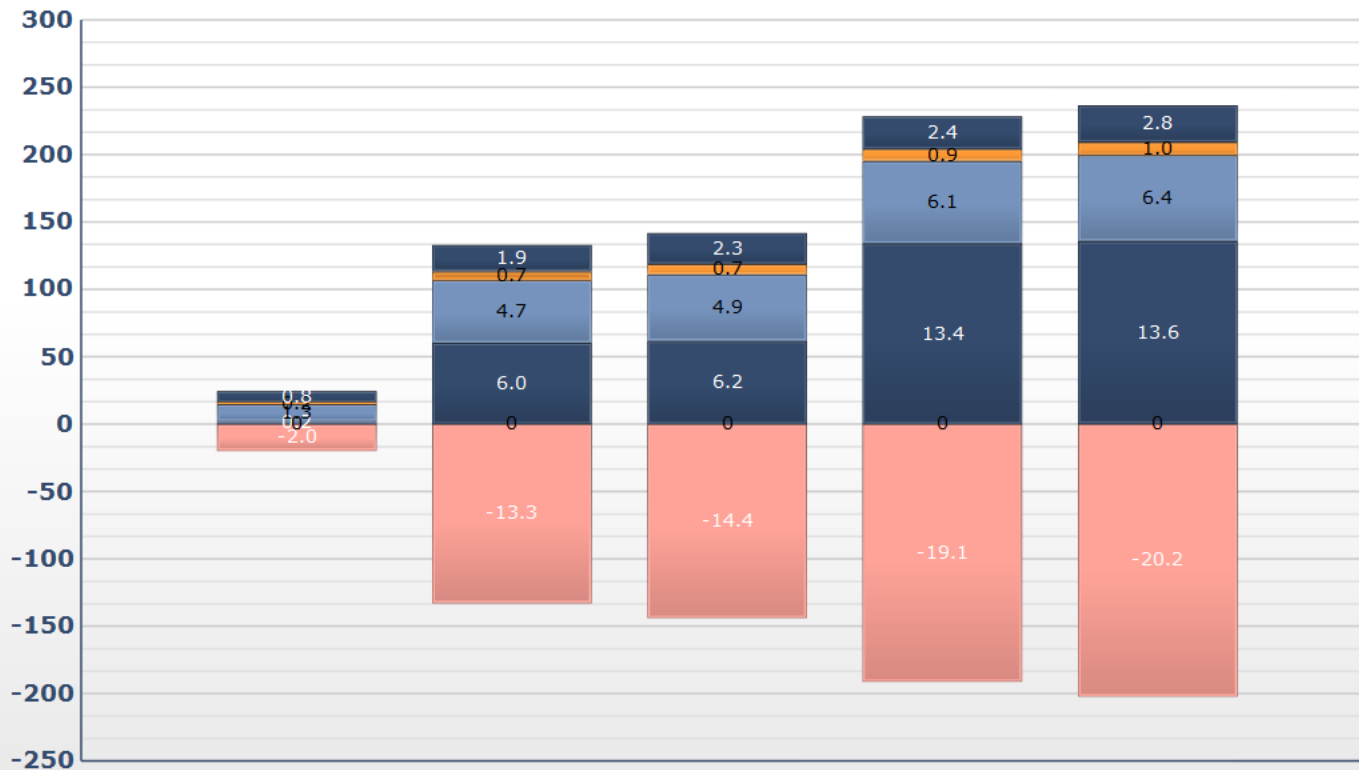
Break-even price (€/tn)

Change in annual costs and income, M€/a

Solvent: MEA

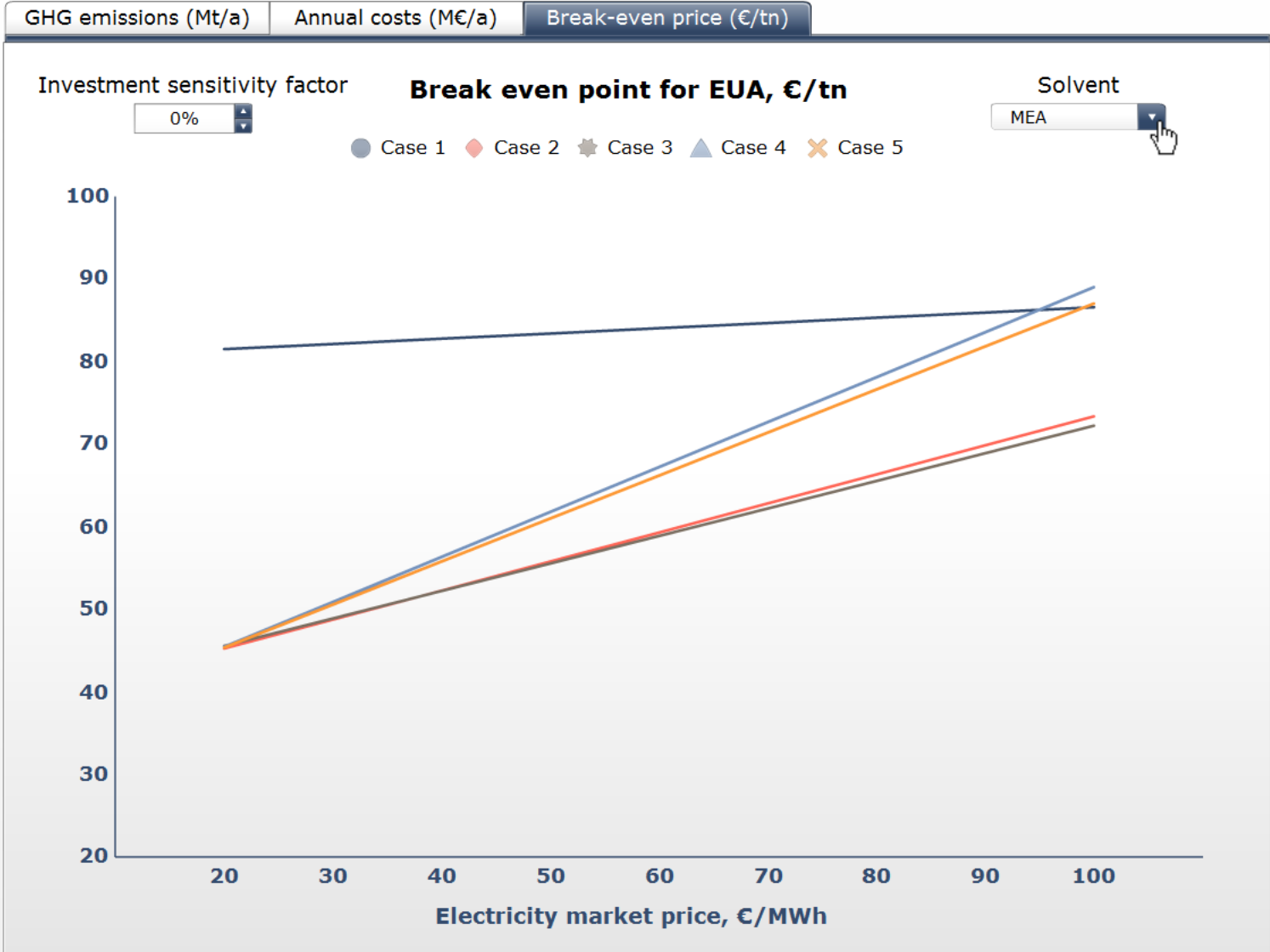
Electricity, €/MWh 90
 EUA, €/tn 70
 Investment sensitivity factor 0%

- Electricity
- District heat
- CO2 allowances
- CO2 transport&storage
- Other OPEX
- CAPEX



Total, M€/a

Case 1	Case 2	Case 3	Case 4	Case 5
5	0	-2	37	34



GHG emissions (Mt/a)

Annual costs (M€/a)

Break-even price (€/tn)

Investment sensitivity factor

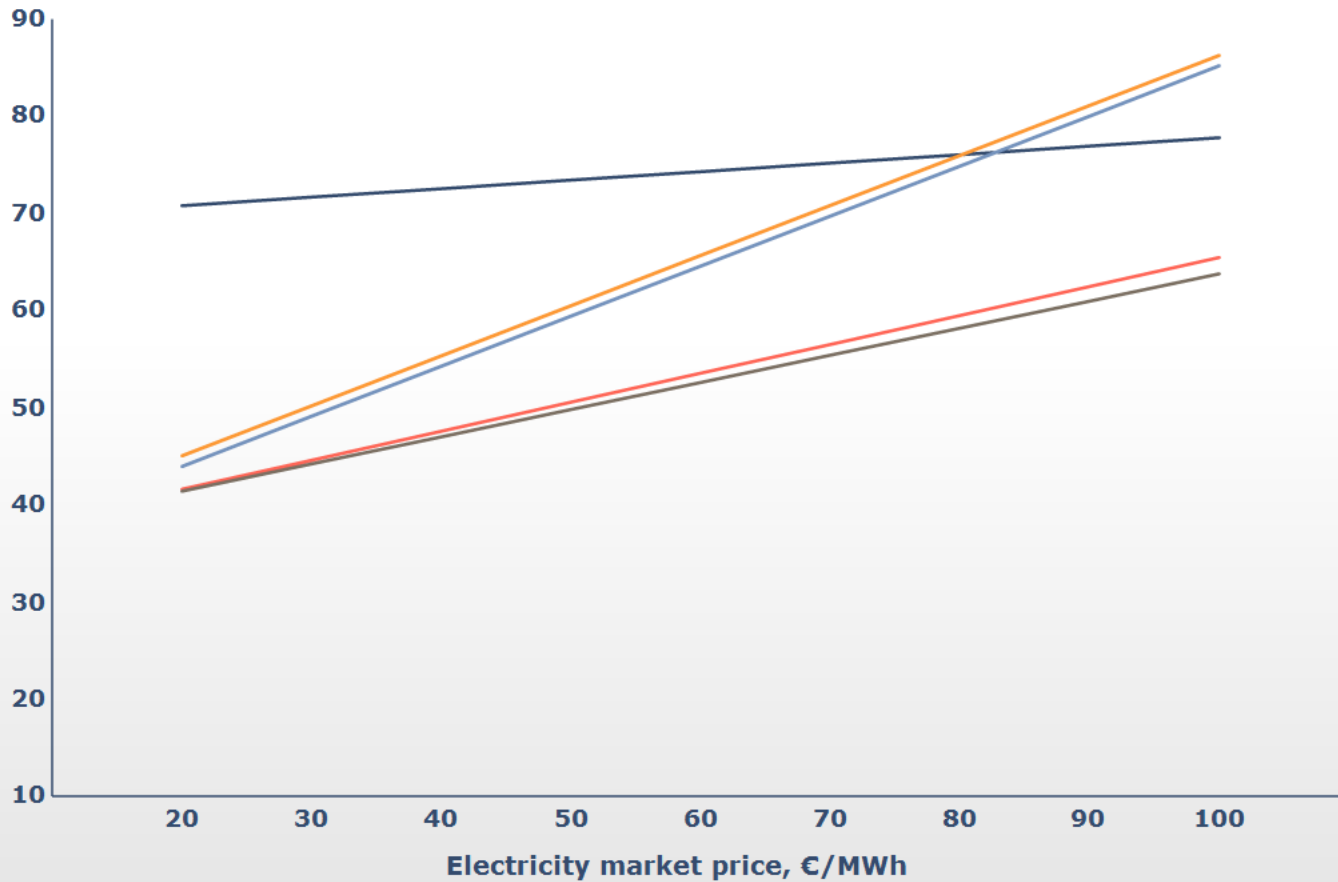
0%

Break even point for EUA, €/tn

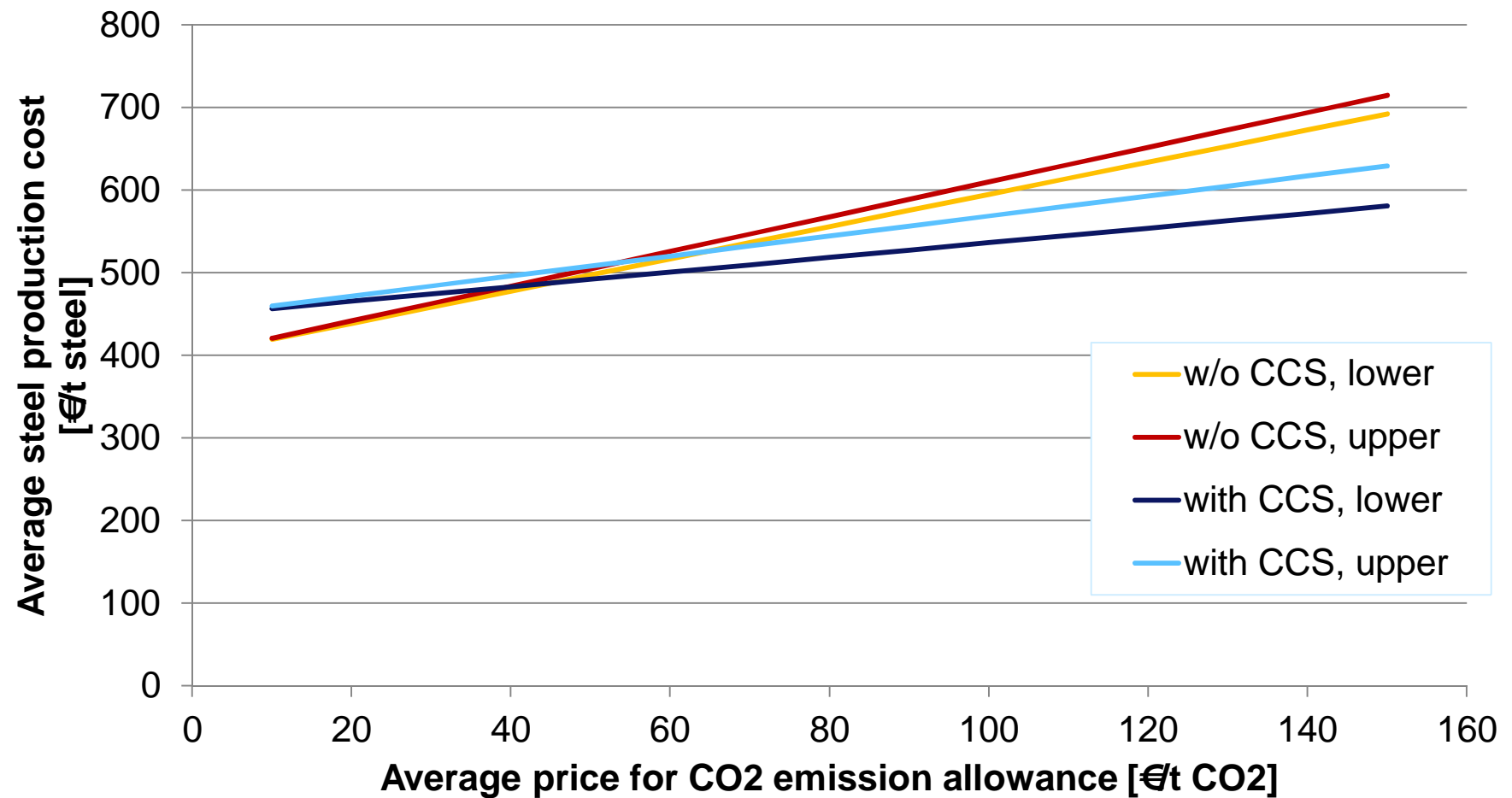
Solvent

80 °C

● Case 1 ◆ Case 2 ★ Case 3 ▲ Case 4 ✕ Case 5



Effect of carbon prices to the production cost of steel



Conclusions

- Possibility of significant CO₂ reductions with CCS
 - Also other options, such as bio reductants and energy efficiency, but with limitations
- Post combustion capture process
 - Smaller amounts (in the range of 0.3 Mt CO₂/a), with very low operational costs, due to the waste heat available at the site of the steel mill
 - Avoided CO₂ emissions and the costs strongly effected by electricity production
58– 78 €/t CO₂ (with electricity prices in the range of 80 - 150 €/MWh)
84 – 114 €/t CO₂ Globally avoided (replacing electricity coal)
- Oxygen blast furnace
 - From net electricity producer to net electricity user,
 - Decreased coke utilisation enables selling of coke
 - Increased LPG utilisation
- Even if CCS would become more feasible than (over the operation without CCS) in the steel industry with realistically assumed future EUA prices, the production costs of steel would rise drastically in the EU member states



Business from technology

Thank you for your attention!

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More information:

http://www.cleen.fi/en/program_overviews/ccsp_carbon_capture_and_storage_program

<http://www.vtt.fi/proj/ccsfinland/>

