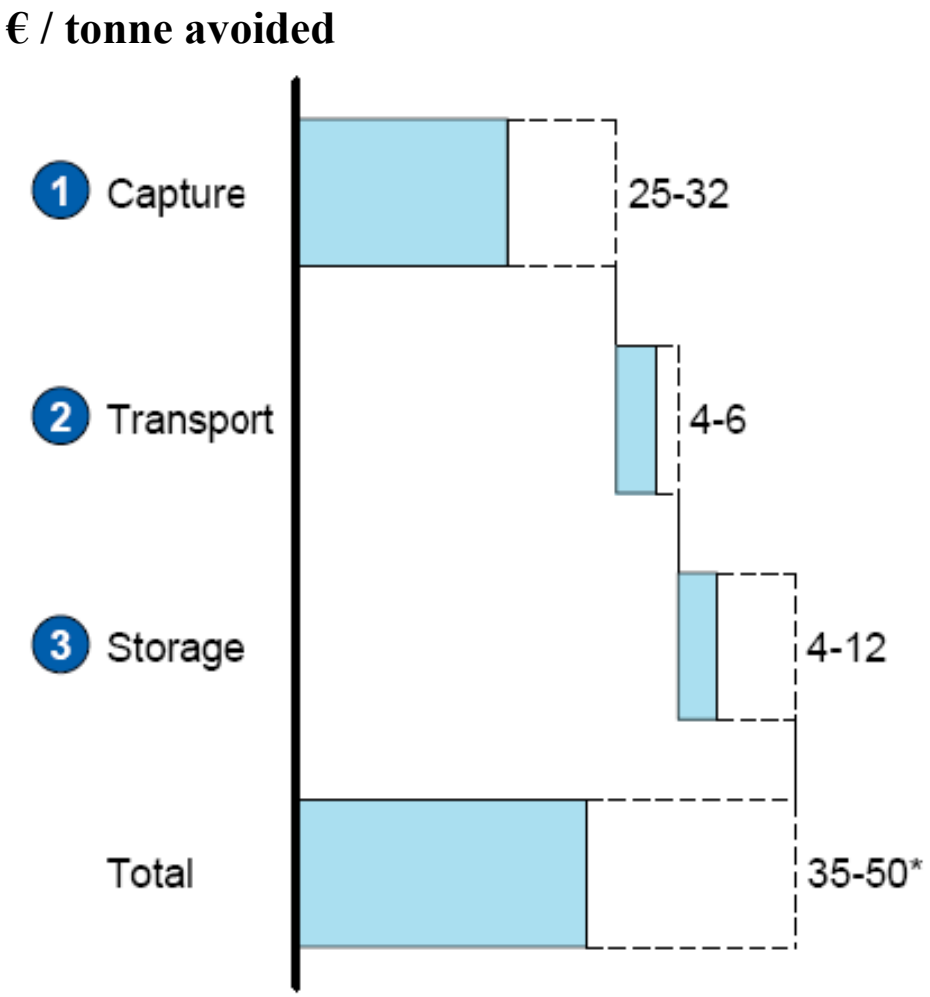
BECCS applied in existing industries

Bio-energy, CCS and BECCS:
Options for Indonesia
Jakarta, Indonesia,
21-22 September 2012

Stefan Grönkvist

Royal Institute of
Technology, KTH

Costs in the CCS chain (coal condensing power)



Assumption

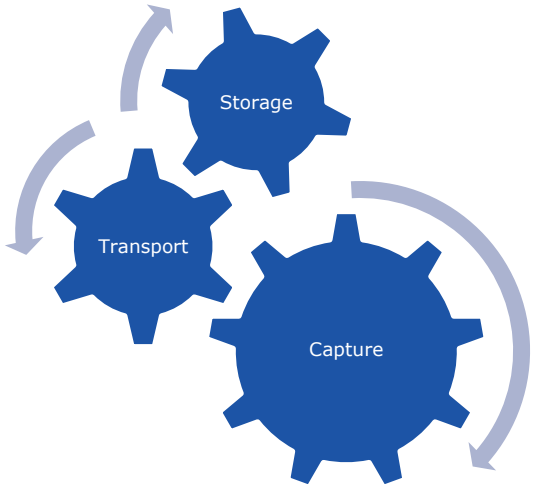
- CO_2 capture rate of 90-92%
- CCS efficiency penalty of 7-12% points
- Same utilization as non-CCS plant (86%)
- CO_2 compression at capture site

- Transport through onshore/offshore pipeline network of 200/300 km in supercritical state with no intermediate booster station
- Use of carbon steel (assumed sufficiently dry CO_2)

- Injection depth of 1,500 m in supercritical state
- Use of carbon steel (assumed sufficiently dry CO_2)
- Vertical well for onshore/ directional for offshore

Source: McKinsey & Company, 2008

Deductions from most estimates of costs in the CCS chain



- The most costly link in the CCS chain is likely to be carbon capture

- Reduced costs for carbon capture will have an impact on the competiveness of CCS as a method for the abatement of GHG emissions

Low hanging fruits for carbon capture

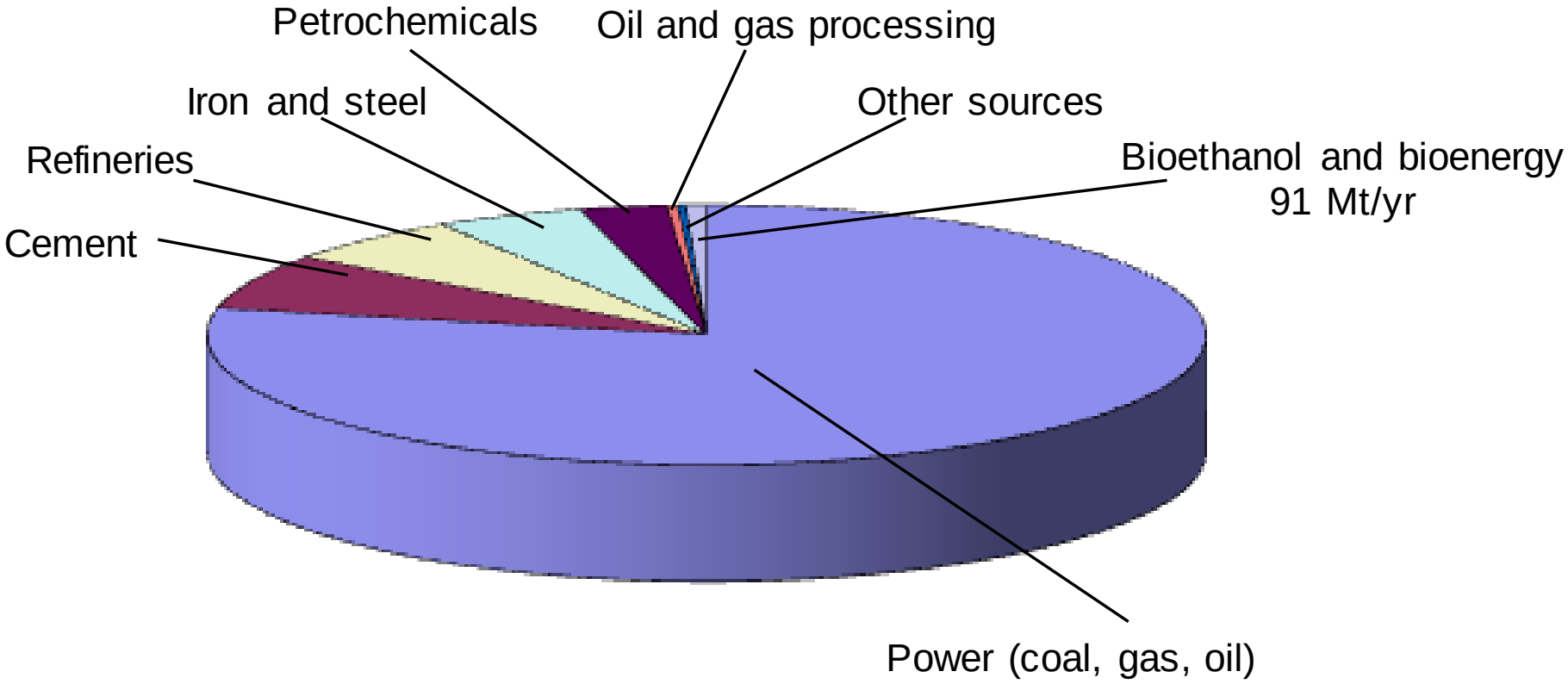
Specific costs (OPEX) for avoided CO_2 emissions

Low

- Upgrading (sweetening) of natural gas
- Ethanol production (fermentation part)
- Thermal bio methane
- Anaerobic digestion (sometimes)
- Hydrogen/ammonia production
- Fischer-Tropsch synthesis
- IGCC
- Blast furnaces (top-gas recycling, biomass is possible)
- Industrial processes with high amounts of waste heat (> 120°C)
- Mineral processes (cement kilns, biomass is possible, lime kilns)
- Power production in CHP mode (oxyfuel power production)
- Combustion processes without CHP mode

High

Share of CO_2 emission sources above over 100 ktonnes annually in the world



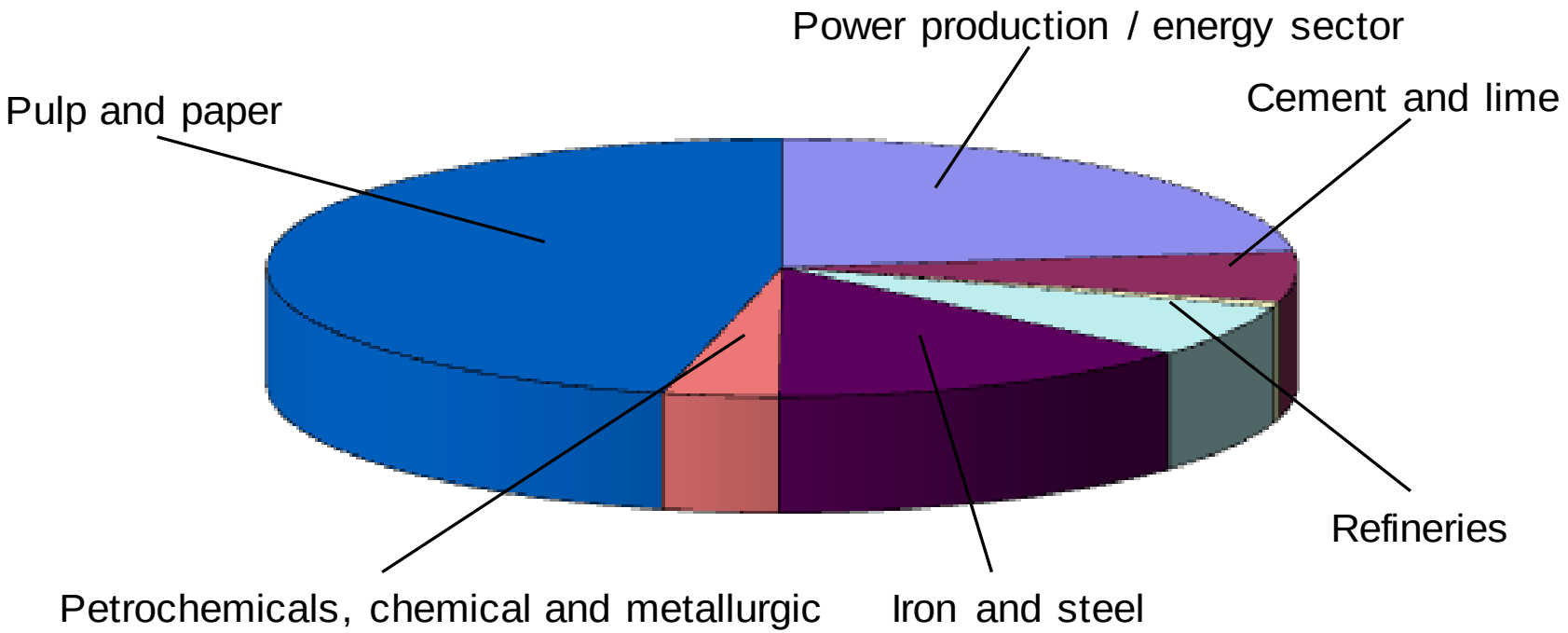
Source: IPCC 2005, data from 2000

Global large stationary CO_2 sources with emissions of more than 0.1 $MtCO_2$/year

Process	No. of sources	Emissions ($MtCO_2$/yr)
Fossil Fuels		
Power (coal, gas, oil and others)	4,942	10,539
Cement production	1,175	932
Refineries	638	798
Iron and steel industry	269	646
Petrochemical industry	470	379
Oil and gas processing	N/A	50
Other sources	90	33
Biomass		
Bioethanol and bioenergy	303	91
Total	**7,887**	**13,466**

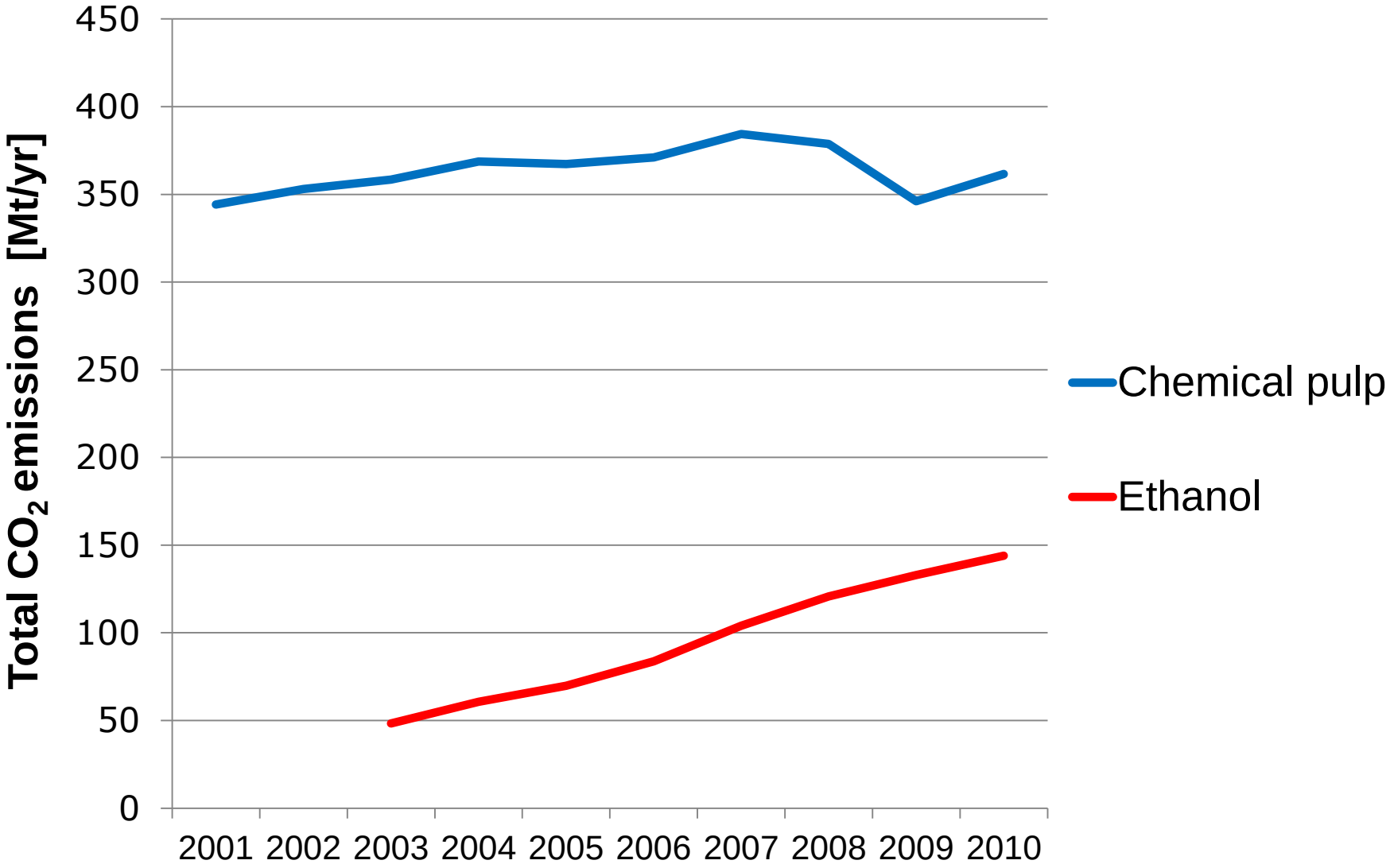
Source: IPCC 2005, data from 2000

Share of CO_2 emission sources above 100 ktonnes annually in Sweden



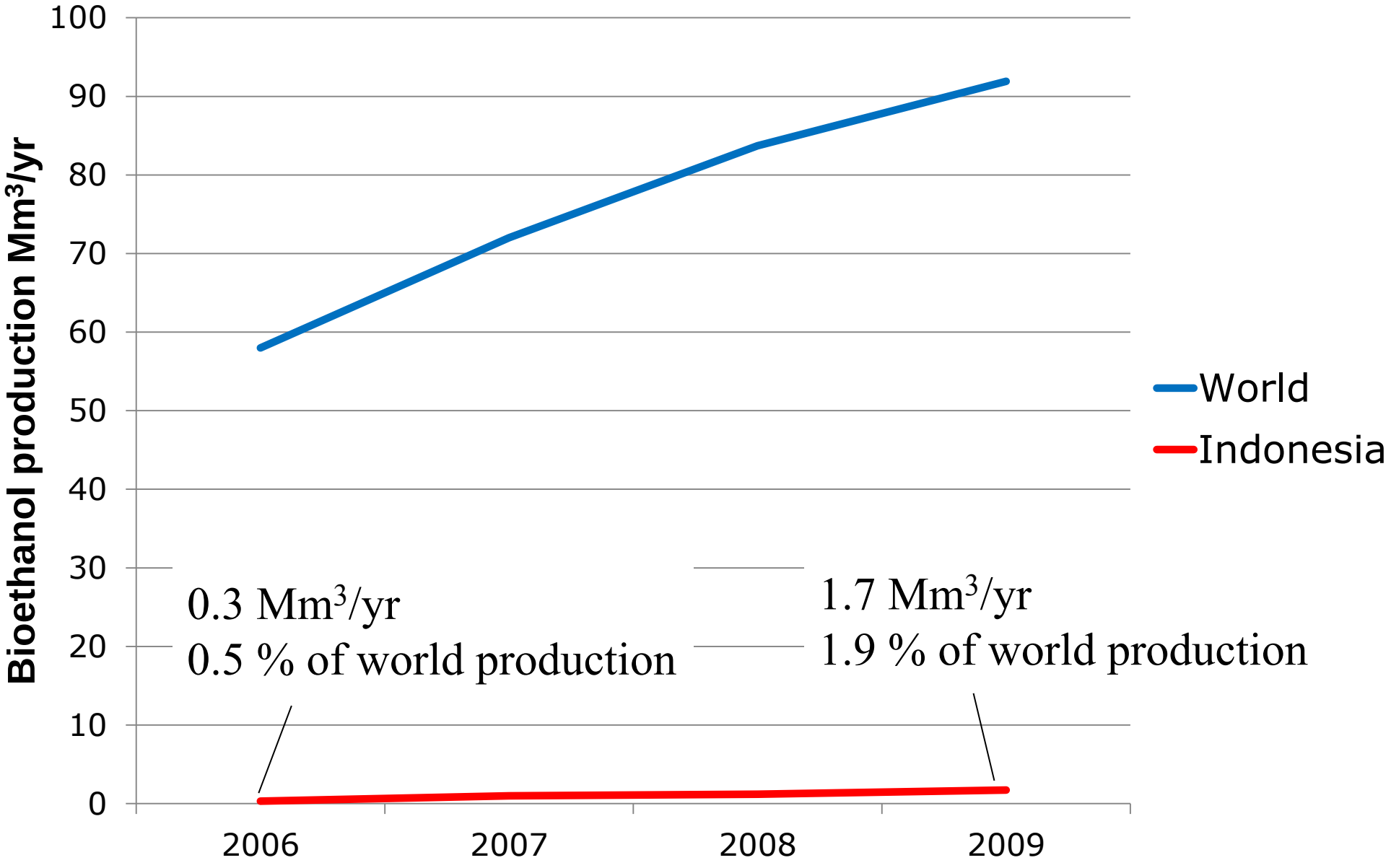
Source: ÅF 2008, data from 2006

Total global CO_2 emissions from production of chemical pulp and ethanol



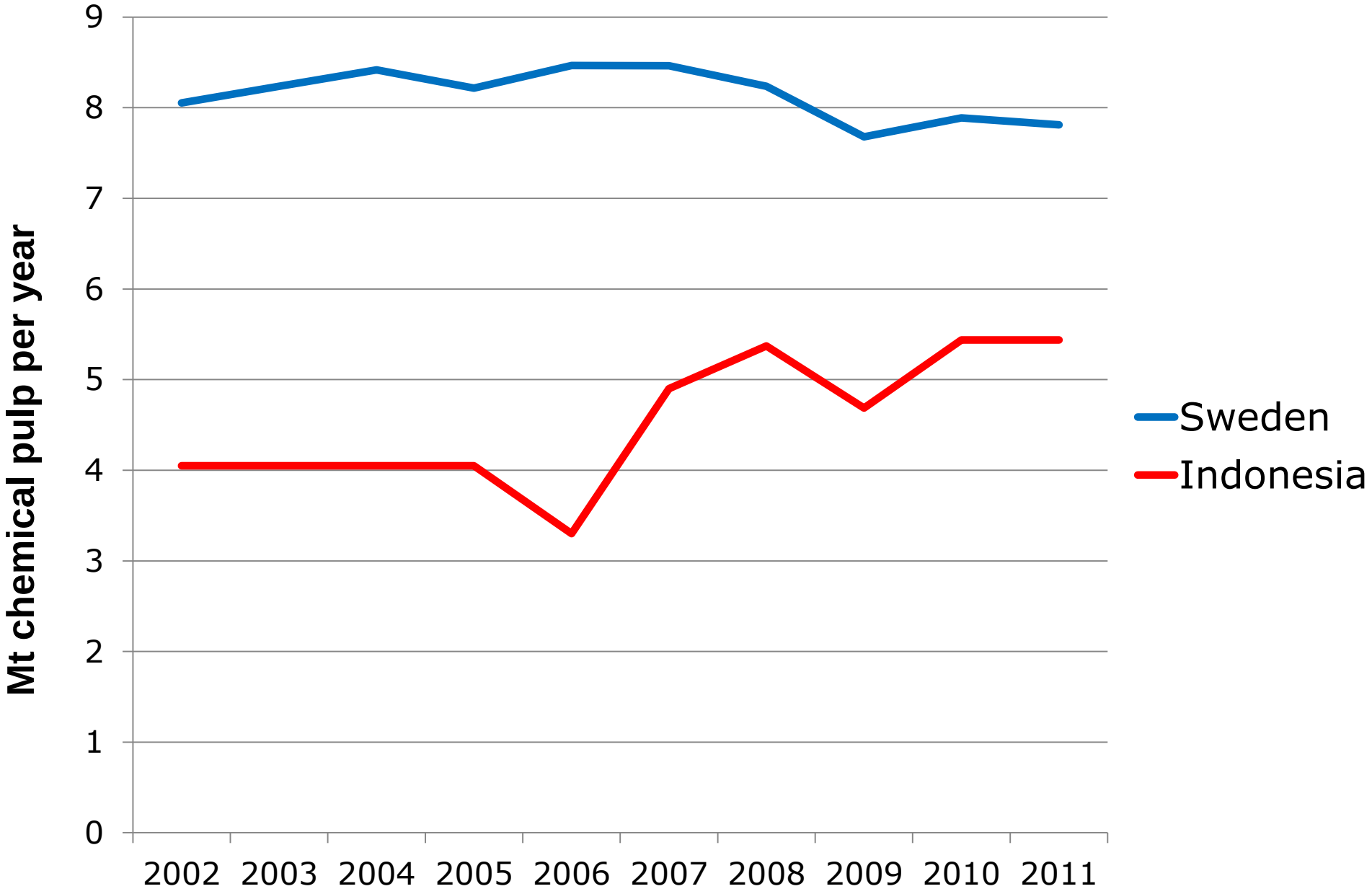
Source: FAO for production data together with estimates of specific CO_2 emissions

Global and Indonesian bioethanol production



Source: FAO and USDA

Annual chemical pulp production in Sweden and Indonesia



Source: FAO

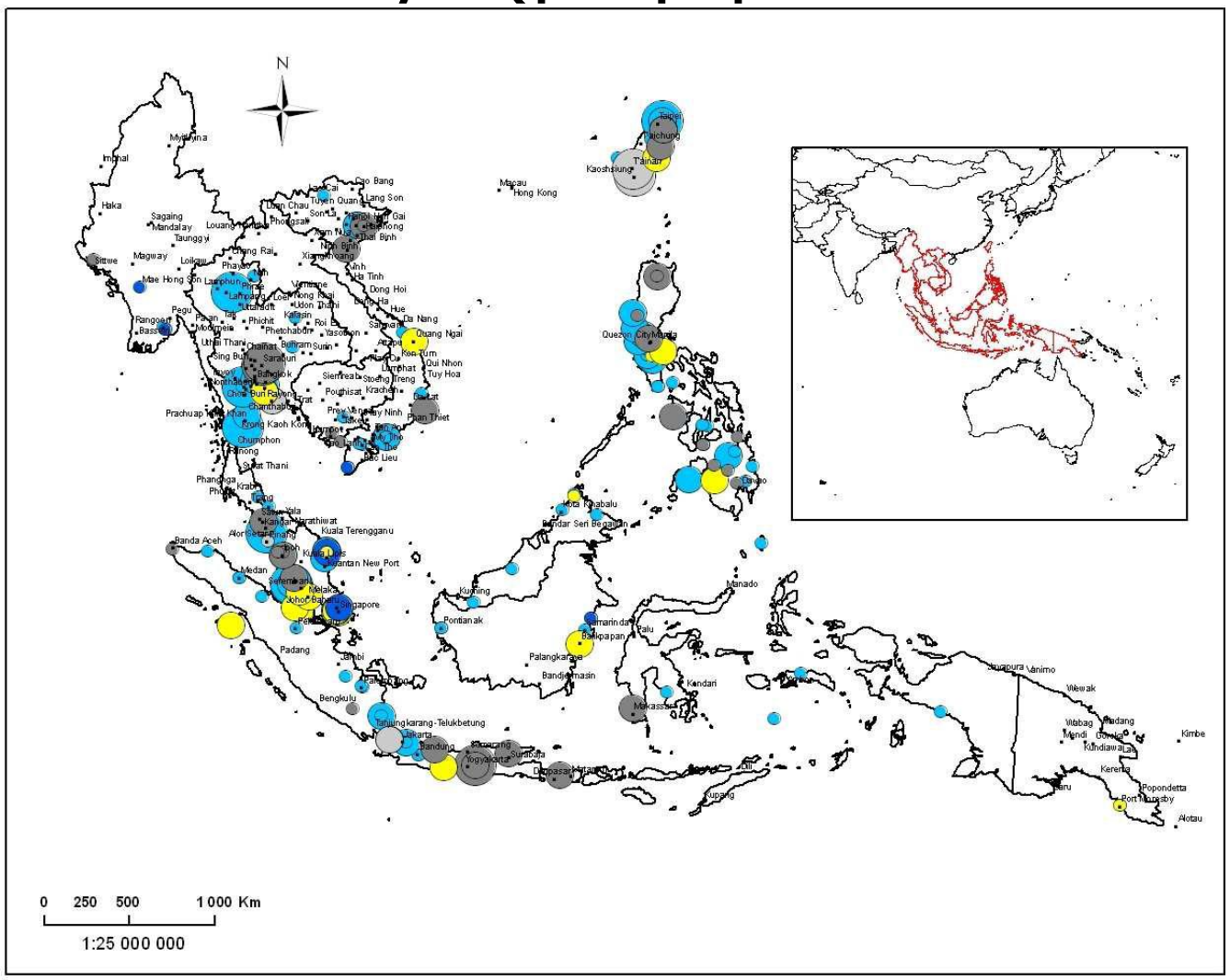
CO_2 emissions from kraft pulp mills in Indonesia

The total CO_2 emissions from Indonesian kraft pulp mills were approximately 16 Mt CO_2 per year
(2010 and 2011, 90 % biogenic origin)

"Asia Pulp and Paper (APP) is actively developing a large BHK market pulp mill to be located in south Sumatra. Details are not finalized, but the mill is expected to have a nominal capacity of between 1.5 and 2.0 million tonnes per year of BHK, making it the largest single pulp line in the world."
(RISI, Febr 2012)

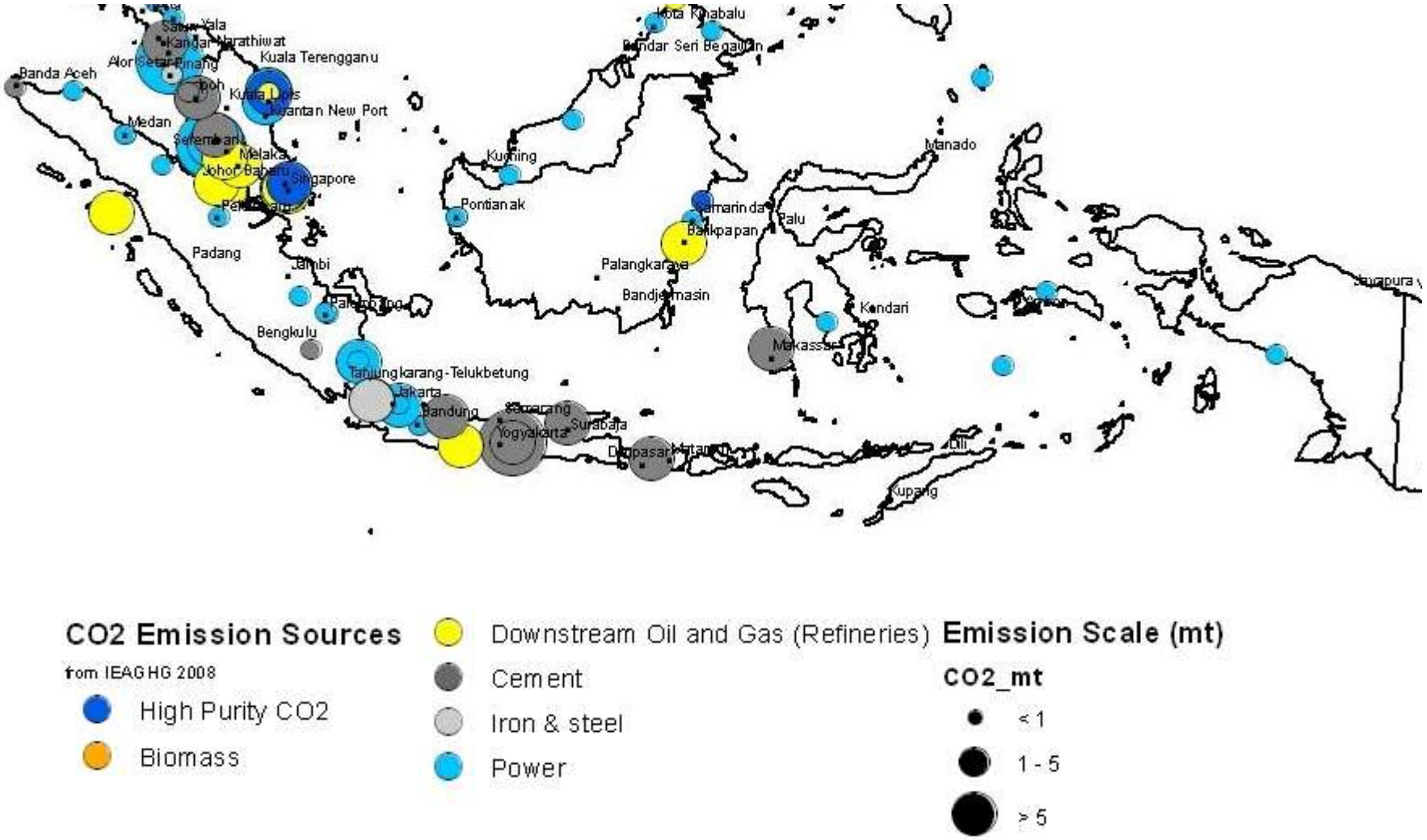
- This plant will generate 4-6 Mt CO_2 annually

CO_2 emission sources in Southeast Asia, total 330 Mt/yr (pulp production is missing)



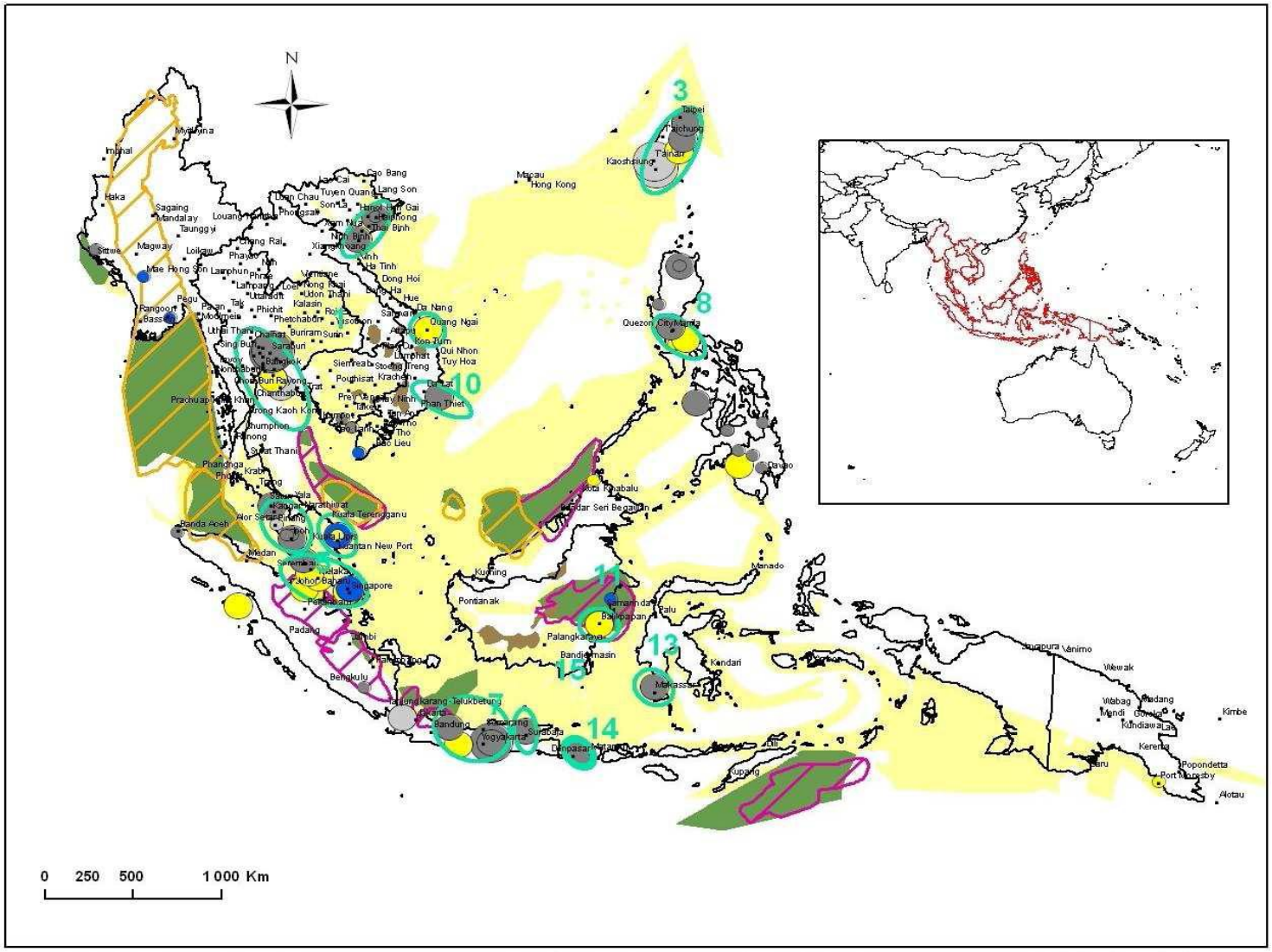
Source: GLOBAL INDUSTRIAL CCS TECHNOLOGY ROADMAP, Geogreen/UNIDO

CO_2 emission sources in Indonesia



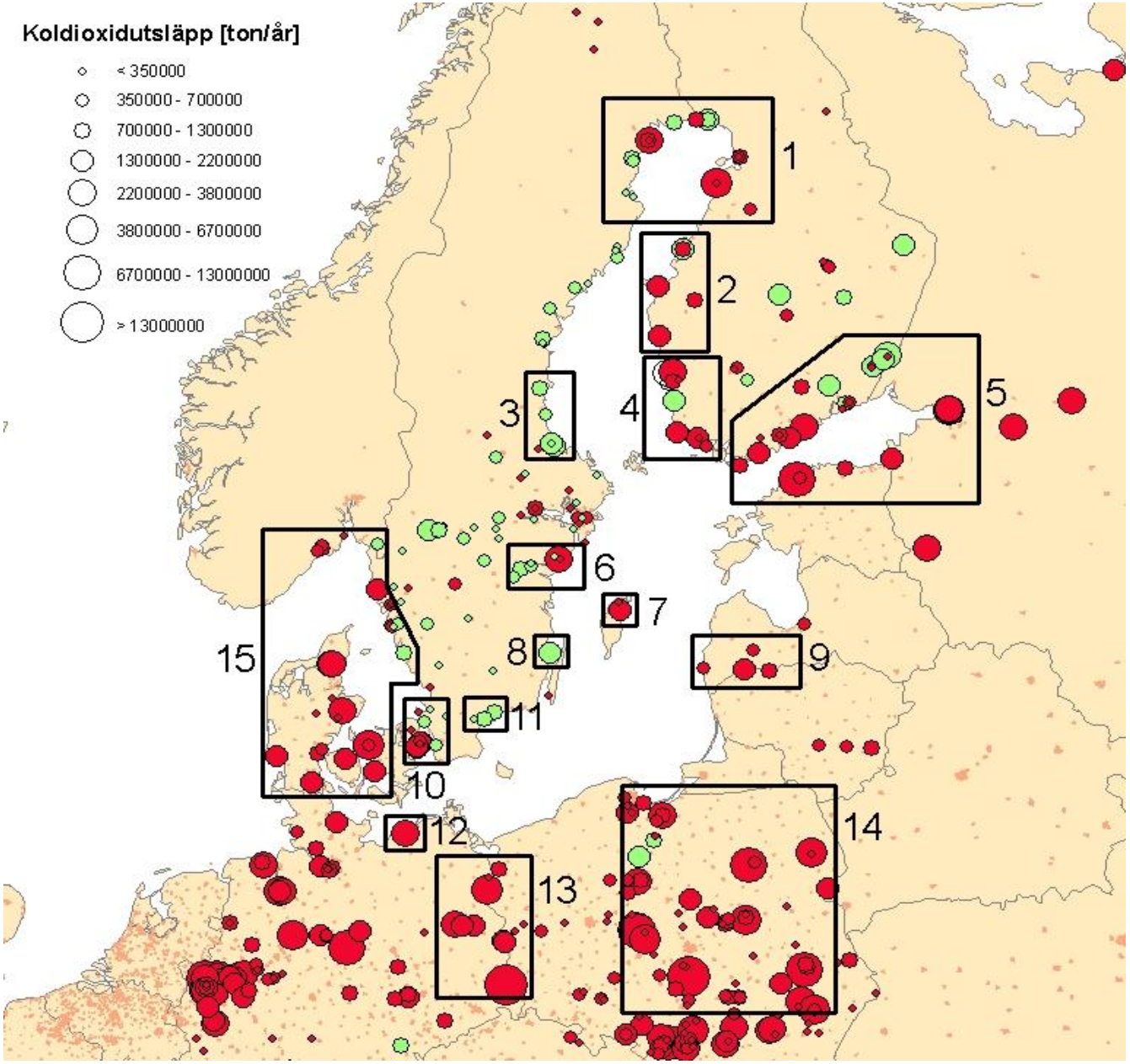
Source: GLOBAL INDUSTRIAL CCS TECHNOLOGY ROADMAP, Geogreen/UNIDO

”Hotspots” for industrial CCS in Southeast Asia



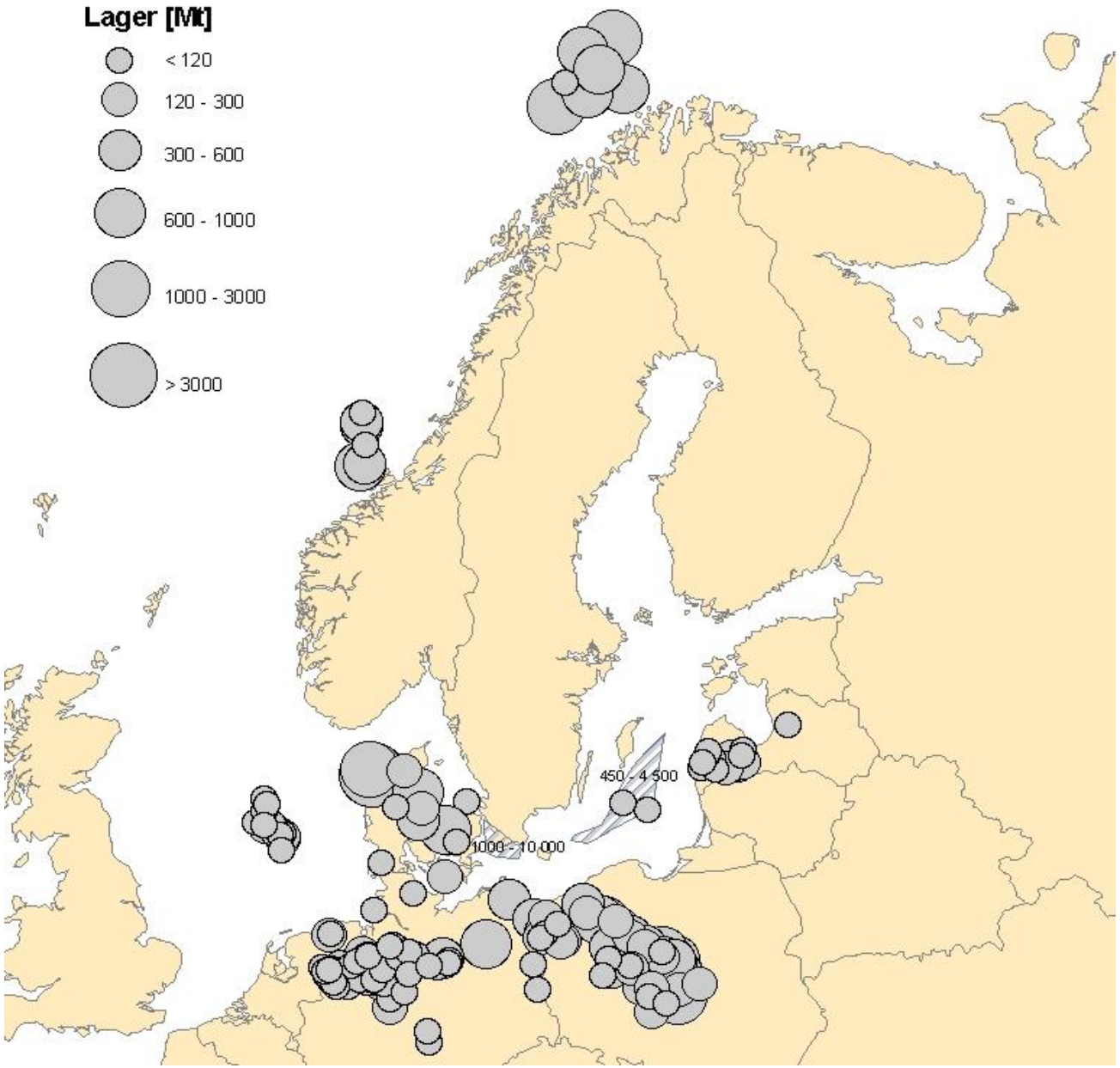
Source: GLOBAL INDUSTRIAL CCS TECHNOLOGY ROADMAP, Geogreen/UNIDO

Clusters with emission sources – in total more than 300 million tonnes of CO_2 annually



Source: ÅF, Chalmer's Data Base, Swedish Forest Industries, Finnish Forest Industries

Potential geological CO_2 storages

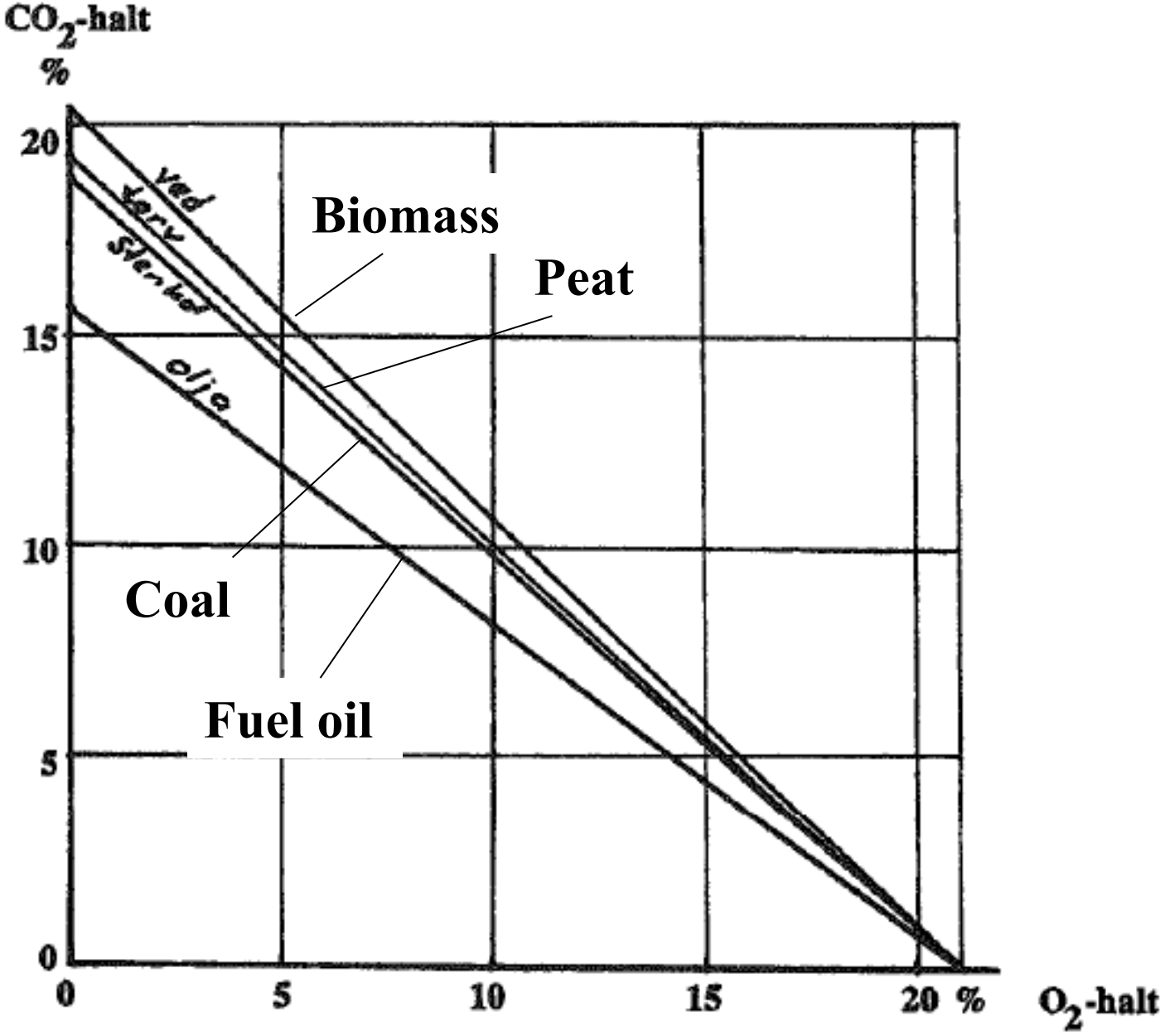


Source: Chalmer's Data Base, SGU

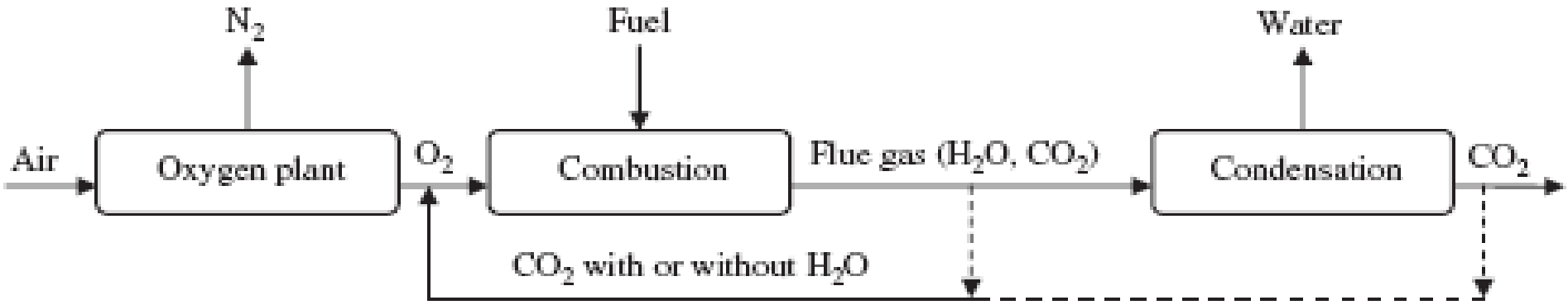
BECCS may be cost-effective in comparison with other applications for CCS

- In several processes for conversion of biomass to transportation fuels, there are steps where CO_2 should be removed from the product stream
- CO_2 concentration in dry flue gases is higher than for fossil fuels
- Oxyfuel combustion may be efficiently applied on some processes that emits CO_2 of biotic origin

CO_2 concentrations in dry flue gases from different fuels

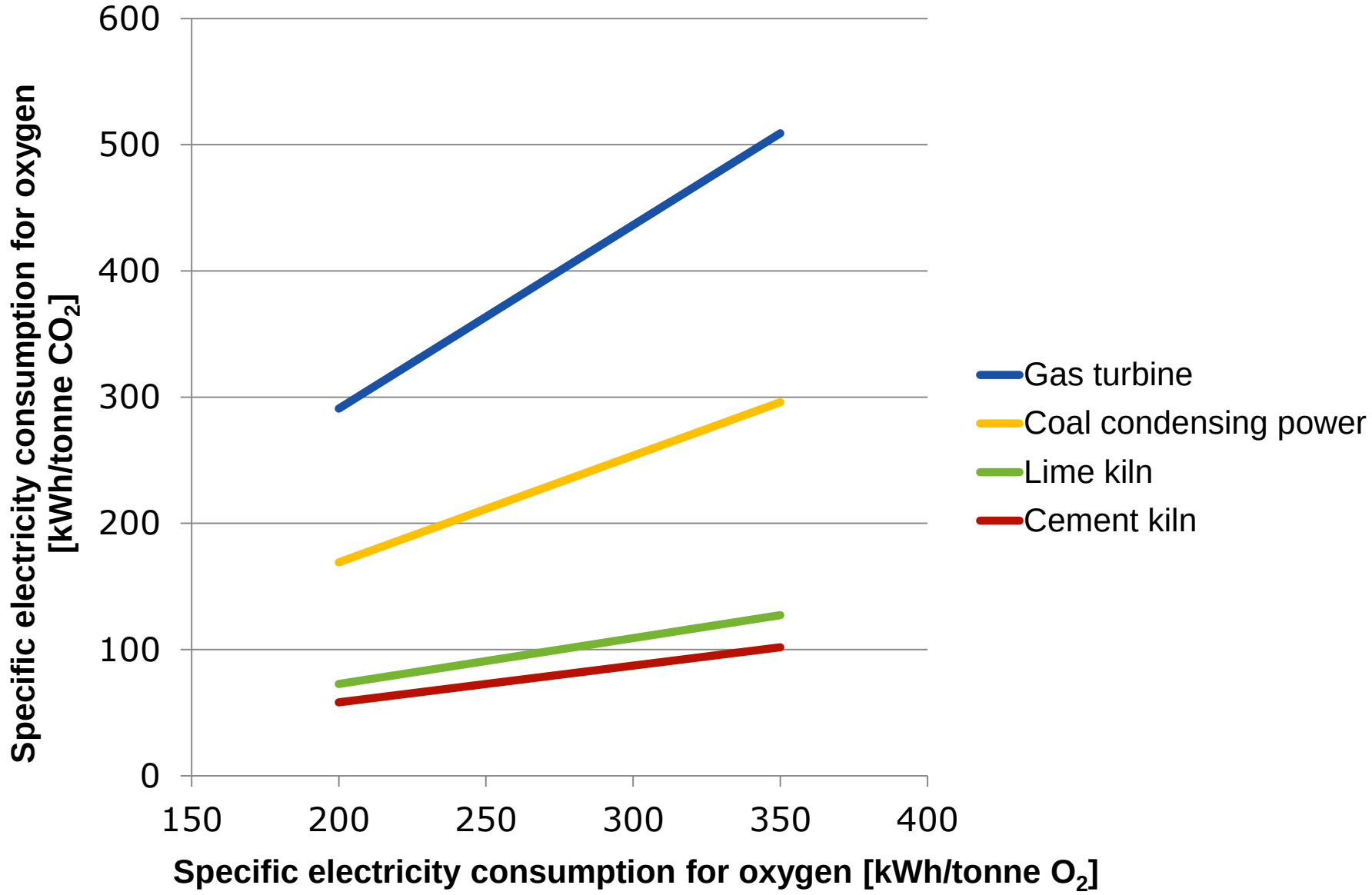


Carbon capture by oxyfuel combustion

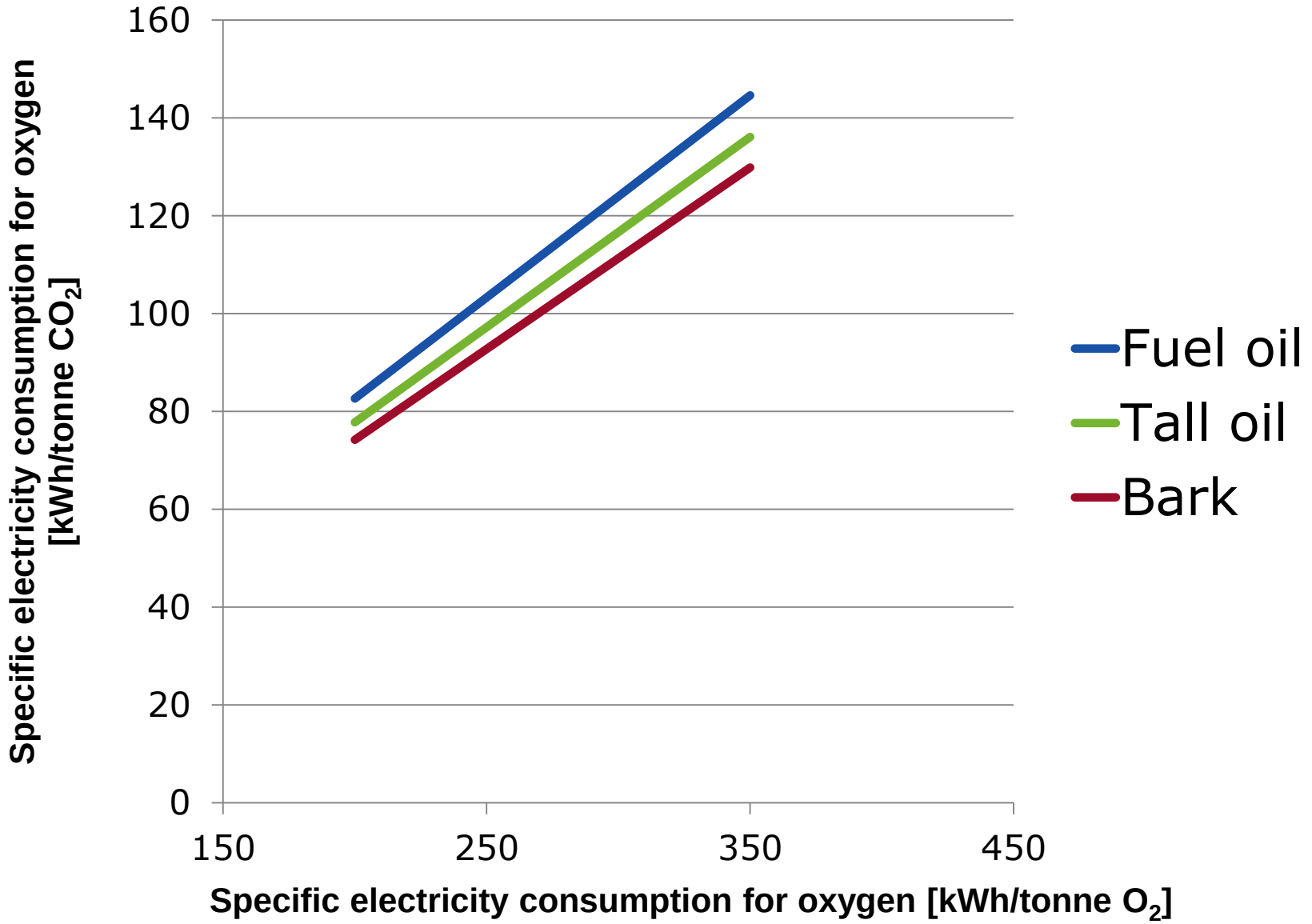


Combustion process	**Fuel**	**"Oxygen efficiency" [mole CO_2/mole O_2]**
Gas turbine	Natural gas (methane)	0.50
Coal condensing power	Coal (sub-bituminous)	0.86
Lime kiln	Fuel oil	2.00
Cement kiln	Coal	2.50

Carbon capture by oxyfuel combustion



Carbon capture by oxyfuel combustion in a lime kiln

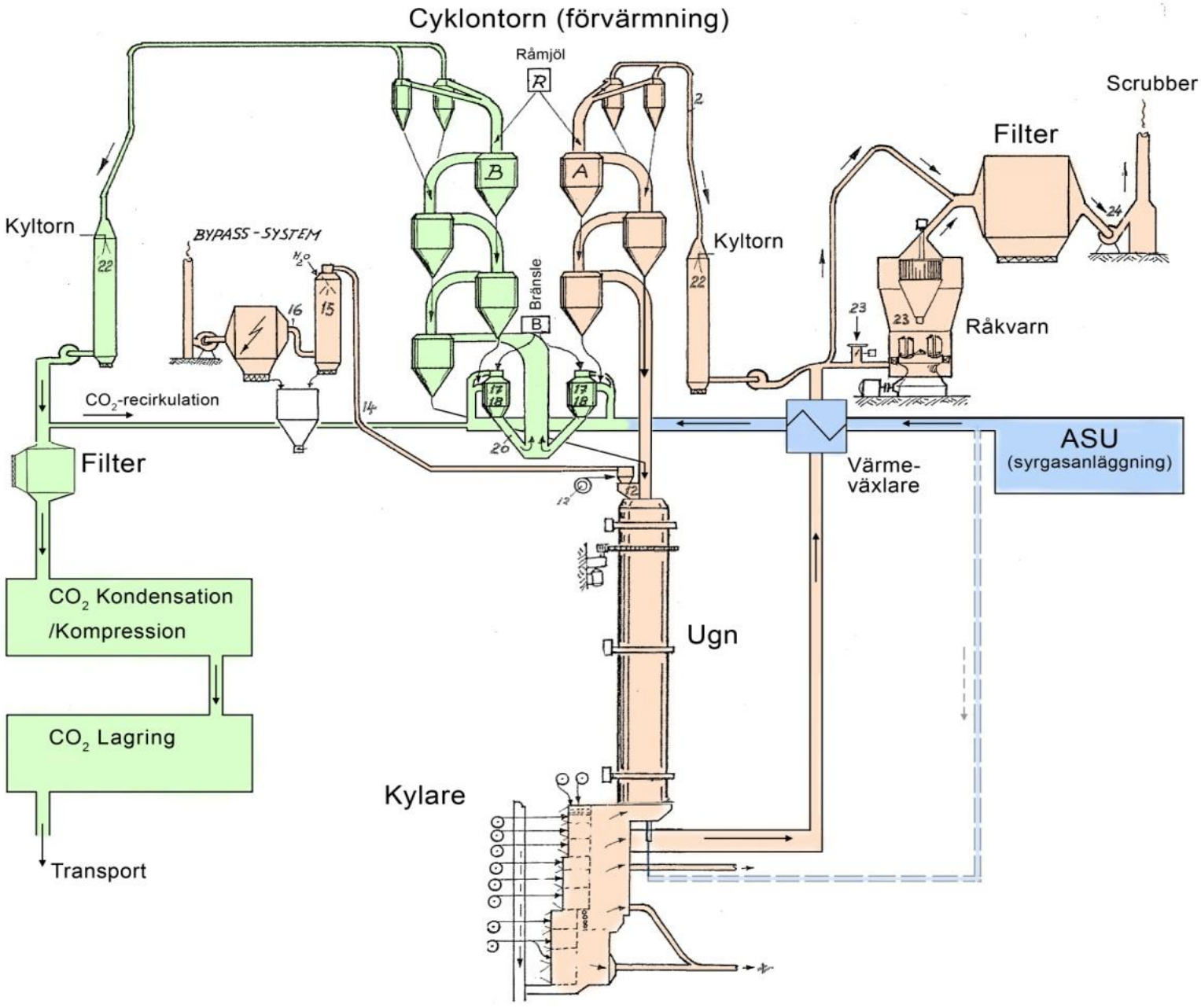


A biofuelled lime kiln at a kraft pulp mill

A biofuelled lime kiln at a kraft pulp mill

A rotary cement kiln in Sweden

Carbon capture by oxyfuel combustion



Fuels used in a the largest cement plant in Sweden (> 2 Mt cement /yr)

	Coal	Petcoke	Rubber (tyres)	Plastics, paper and biomass	Meat and bone meal
1989	60 %	40 %			
1994	50 %	30 %	20 %		
1999	Plastic materials are introduced as fuel				
2001	Meat and bone meal is introduced as a fuel				
Today	30 %	20 %	20 %	25 %	5 %