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Trondheim CCS Conference

CO_2 Capture, Transport and Storage

RETROFITTING CO_2 CAPTURE IN REFINERIES

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ReCap project

- Project Participant
  - SINTEF Energy Research – Project owner
  - IEAEPL (IEA Environmental Projects Ltd., the operating agent of IEAGHG)
  - CONCAWE
- Sub-Contractor:
  - Amec Foster Wheeler
- Main funding body:
  - GASSNOVA

Background

- Global refining sector contributes to around 4% of the total anthropogenic CO_2 emissions and CCS is considered one of the technologies that could be applied to curb these emissions.
- No new refineries are expected to be built in OECD countries – studying the feasibility of cost of retrofitting is important.
- It is essential to have a good understanding of the direct impact on the financial performance and market impact posed by retrofitting refineries with CO_2 capture technology.

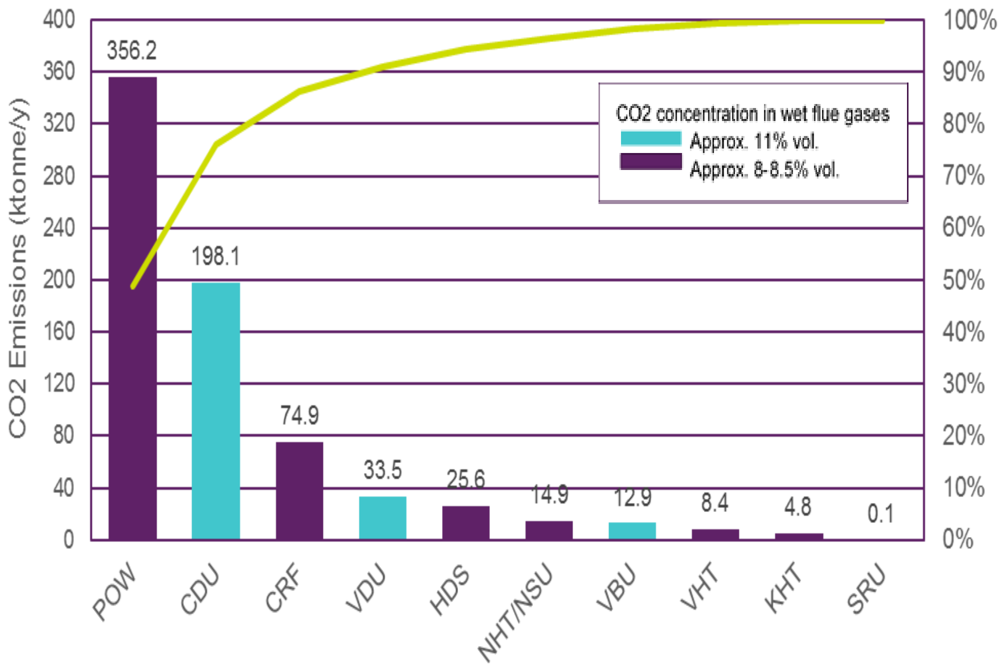
Motivation

- Policy makers should fully understand the cost of CCS deployment in this sector in order to develop policies
- Current open literature does not provide data that are comparable to each other.
- Studies are usually done in a top-down approach and results cannot be taken out of context and are very site specific.
- A consistent bottom-up approach is necessary to identify precisely what the oil industry is likely to achieve in terms of CO_2 reduction, the related costs, their impact on global competitiveness.

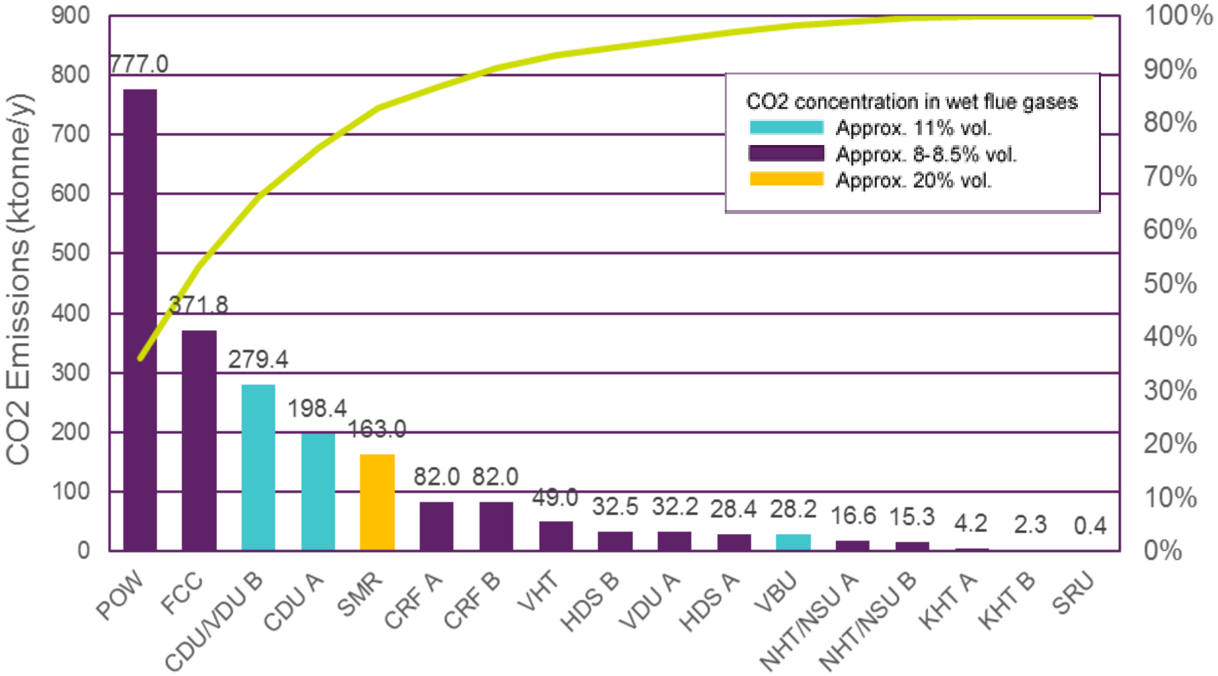
Base case refineries

- 4 base case refineries defined:
  - Simple refinery with a nomical capacity of 100,000 bbl/d
  - Medium and highly complex refineries with nominal capacity of 220,000 bbl/d
  - Highly complex refinery with nomical capacity 350,000 bbl/d

CO_2 emissions from base case refineries



Base Case 1



Base Case 2

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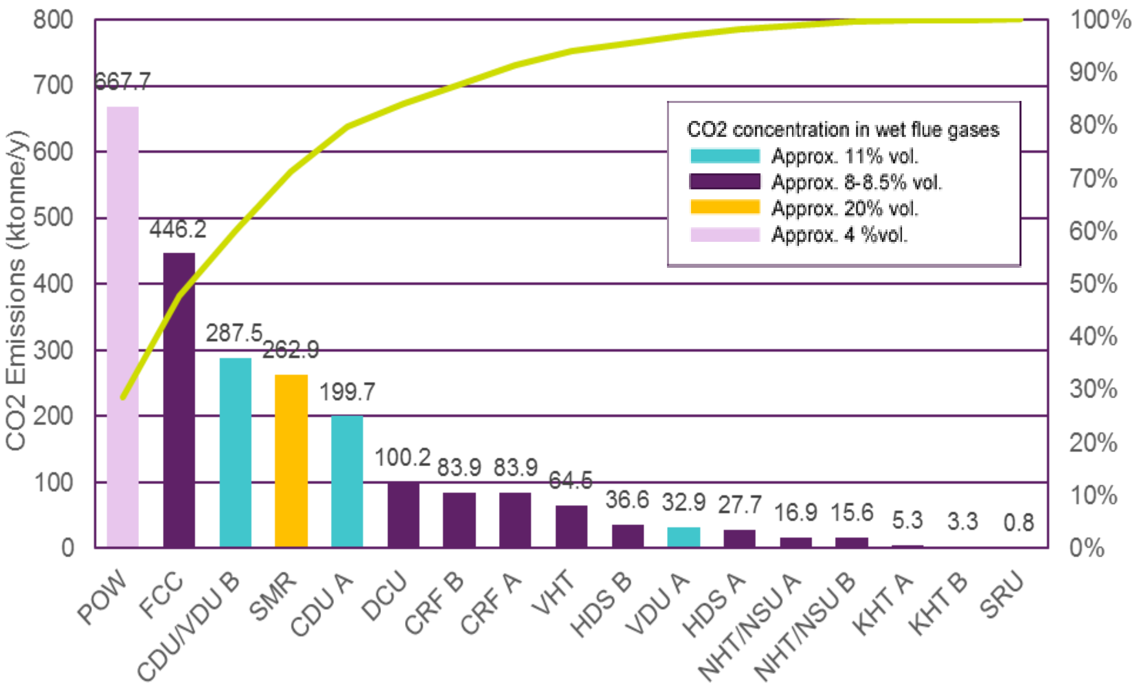
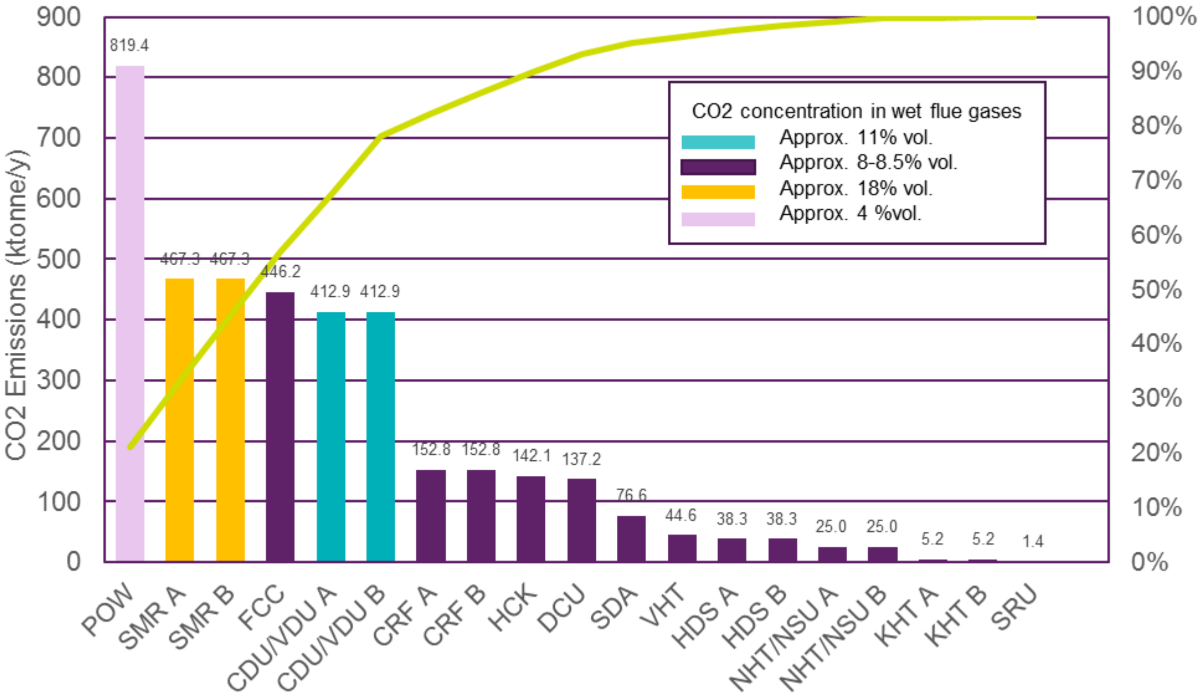
CO_2 emissions from base case refineries



Base Case 3



Base Case 4

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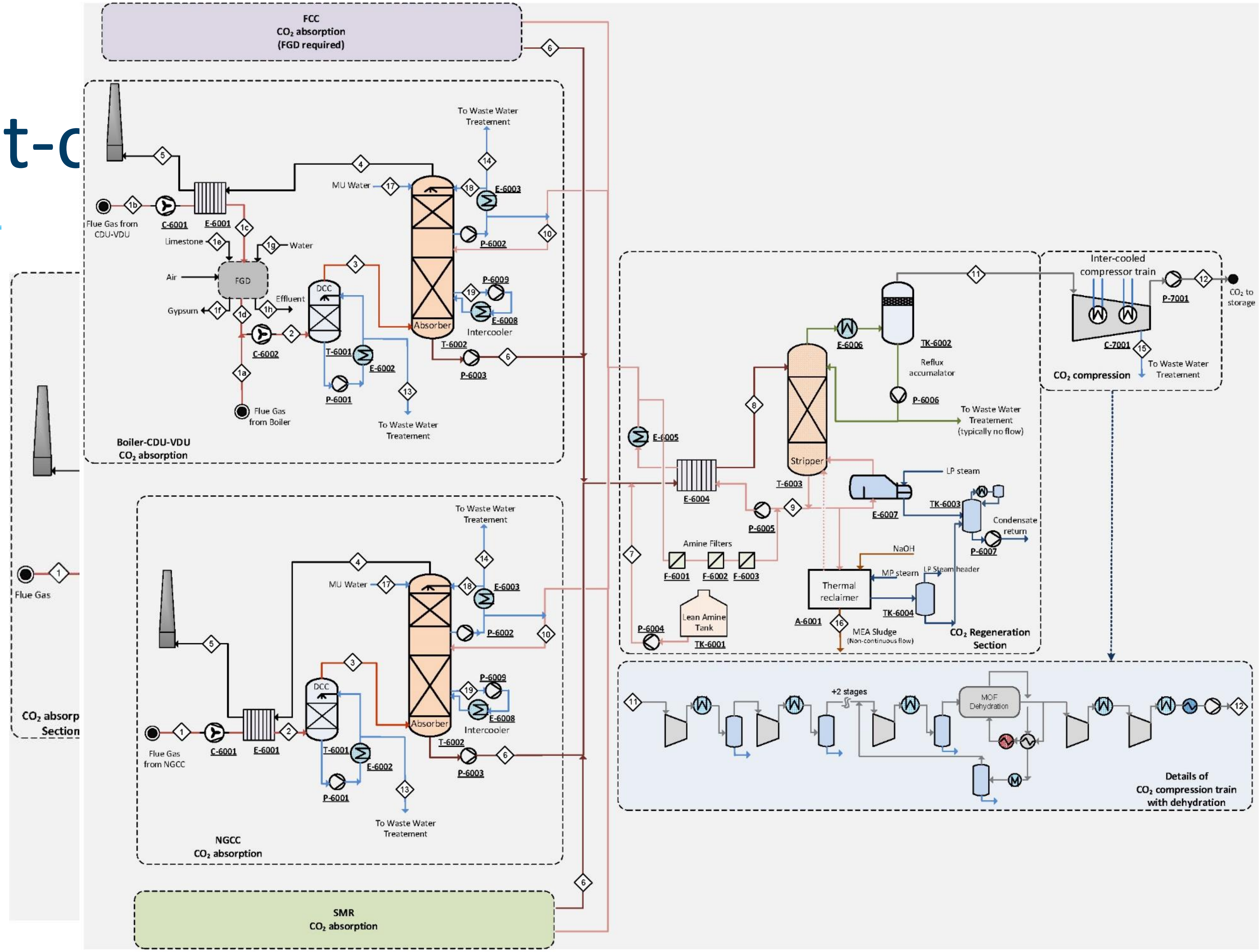
Base Case 4: Capture Cases

		CO_2 [t/h] @ operating point	% of total CO_2 emissions	CO_2 %vol	CO_2 %wt	Flue gas [t/h] @ operating point
D1	POW[1]	76.0	20.9%	4.23	6.6	1160.5
		21.4		8.1	12.9	165.5
D2	FCC	53.1	11.4%	16.6	24.6	215.9
D3	CDU-A/VDU-A	49.2	10.5%	11.3	17.2	286.5
D4	CDU-B/VDU-B	49.2	10.5%	11.3	17.2	286.5
D5	SMR	19.8	25.1%	17.7	26.7	438.6
		97.5				

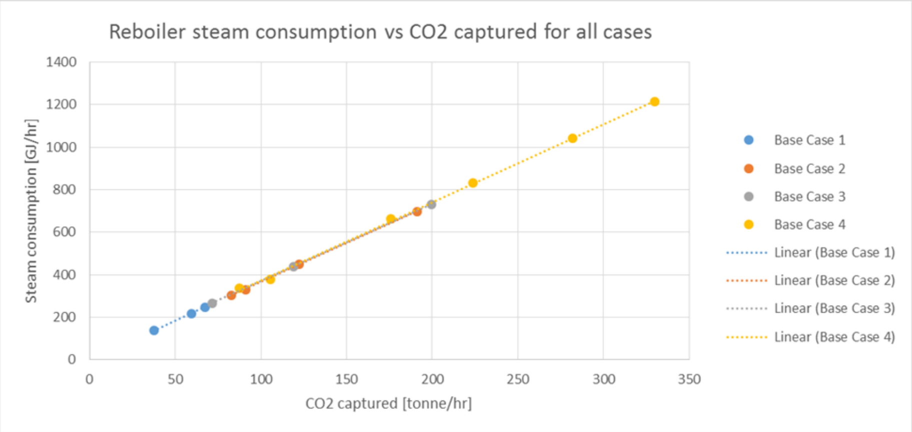
		CO_2 emissions [t/h] @ operating point	% of total CO_2 emissions	Avg CO_2 vol%
04-01	D1	97.4	20.9	4.7
04-02	D1+D3+D4	195.8	42.0	6.7
04-03	D1+D2+D3+D4+D5	366.2	78.5	9.4
04-04	D5	117.3	25.1	17.7
04-05	D1+D3+D4+D5	313.1	67.1	8.7
04-06	D1+D2+D3+D4	248.9	53.3	7.7

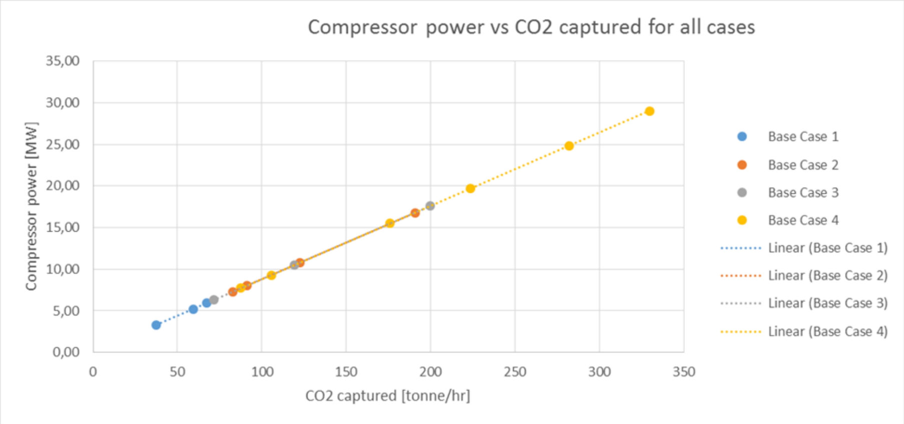
Post-c

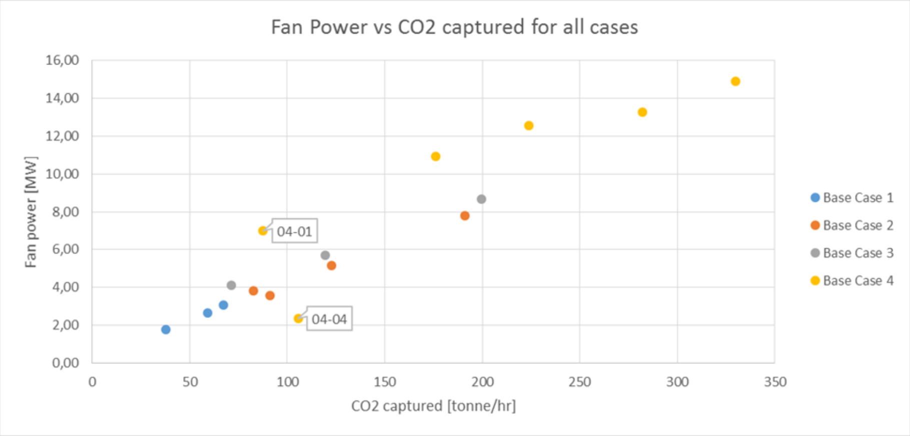


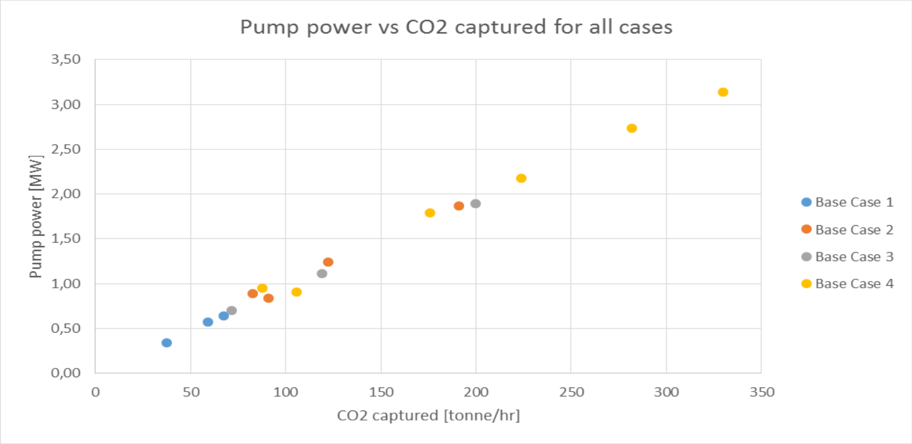
FCC
CO_2 absorption
(FGD required)
To Waste Water Treatement
MU Water
E-6003
P-6002
P-6009
E-6008
Intercooler
Absorber
T-6002
P-6003
Flue Gas from CDU-VDU
C-6001
E-6001
Limestone
Water
Air
FGD
Effluent
Gypsum
DCC
C-6002
T-6001
E-6002
P-6001
Flue Gas from Boiler
Boiler-CDU-VDU
CO_2 absorption
Flue Gas
CO_2 absorp
Section
Flue Gas from NGCC
NGCC
CO_2 absorption
SMR
CO_2 absorption
E-6005
E-6004
E-6006
TK-6002
Reflux accumulator
P-6006
To Waste Water Treatement (typically no flow)
Stripper
T-6003
LP steam
E-6007
TK-6003
Condensate return
P-6005
P-6007
Amine Filters
F-6001
F-6002
F-6003
NaOH
MP steam
LP Steam header
Thermal reclaimer
A-6001
TK-6004
Lean Amine Tank
P-6004
TK-6001
MEA Sludge
(Non-continuous flow)
CO_2 Regeneration Section
Inter-cooled compressor train
P-7001
CO_2 to storage
C-7001
CO_2 compression
+2 stages
MOF Dehydration
Details of
CO_2 compression train
with dehydration

Results from simulations









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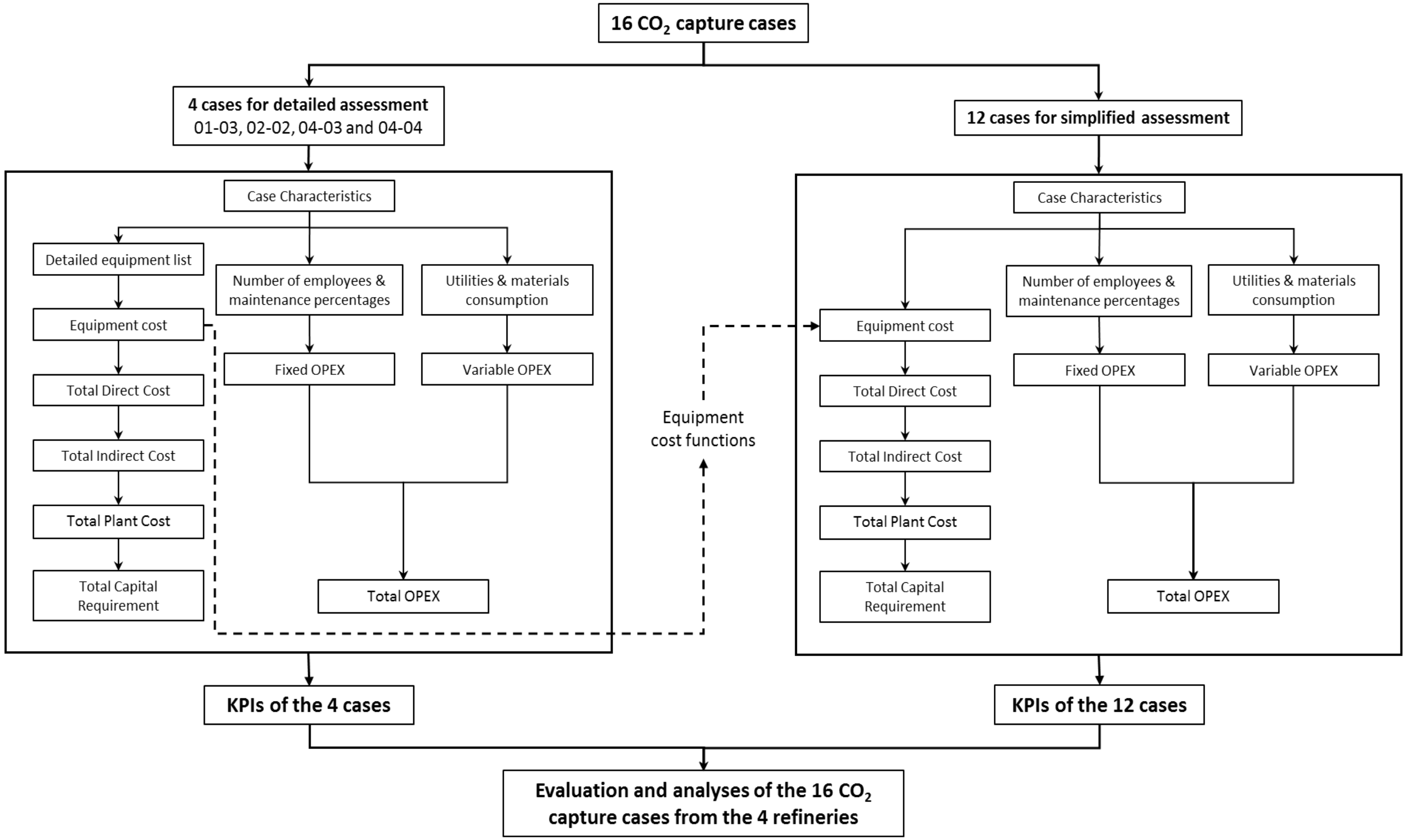
Methodology for techno-economic analysis



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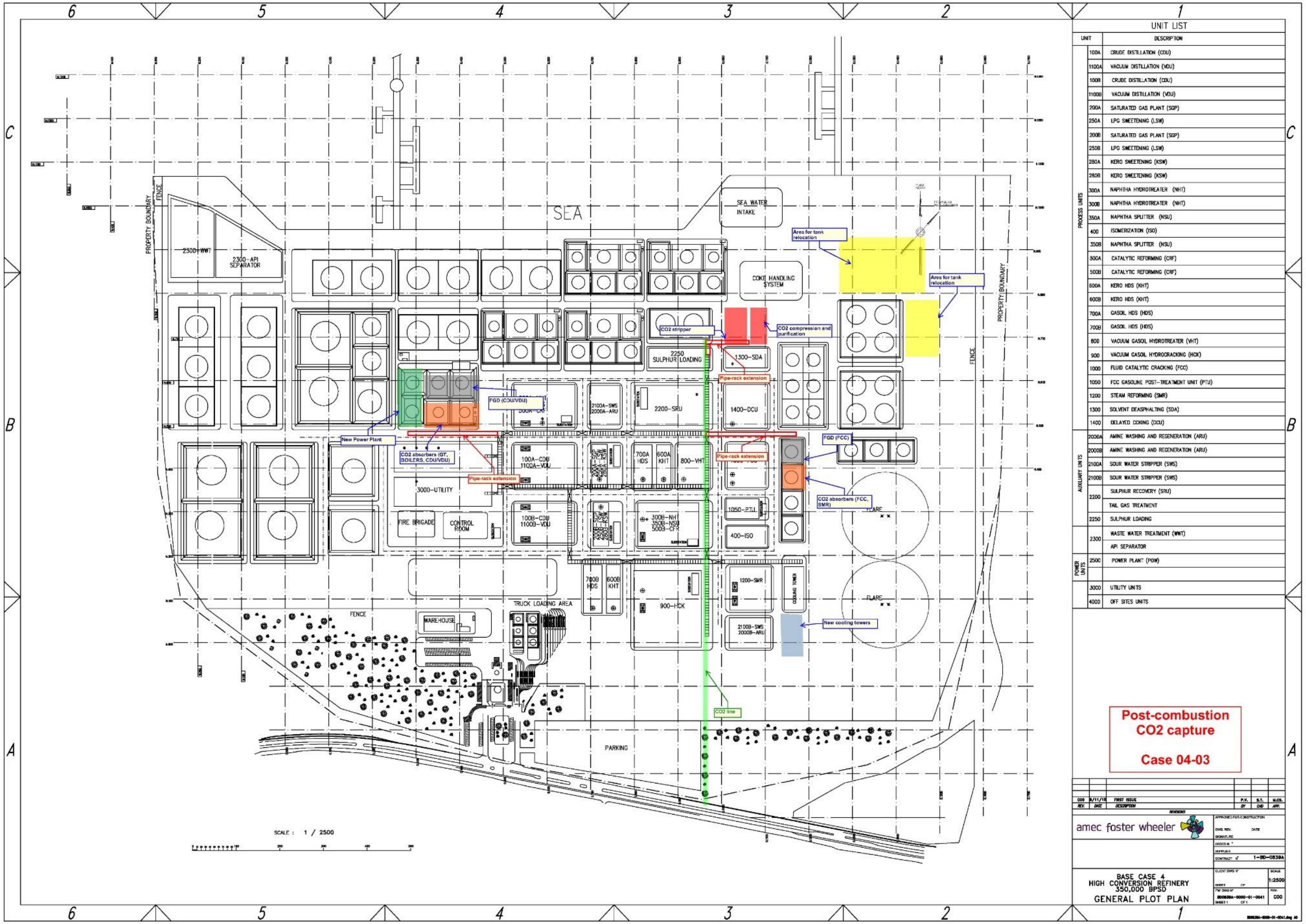
Plot plan example



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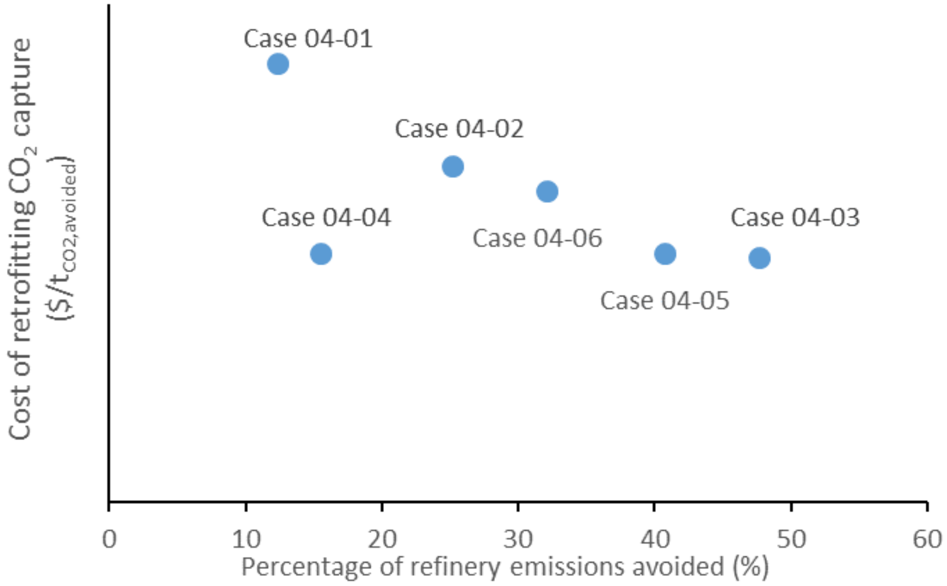
Base Case 4: Cost of retrofitting CO_2 capture



Important factors affecting CO_2 avoidance cost

- Utility plant
  - NG cost
- CO_2 capture plant
  - CO_2 concentration
  - Quantity of CO_2 captured
  - Flue Gas Desulphurization units
- Interconnecting sections

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Summary

- ReCAP has evaluated the cost of **retrofitting** CO_2 capture technologies in an integrated oil refinery an understand its implication to:
    - CO_2 avoidance cost
    - Refinery fuel balance
    - Utilities requirement
    - Contructability
- Provided industry with data and tools to estimate impact of CO_2 capture in their respective refineries

Summary

CO_2 avoidance cost ($\$/t_{CO2,avoided}$)	Characteristics	ReCap Cases
Very high	Very low CO_2 concentration in flue gas (4-5%) coupled with a small amount of CO_2 captured (around 750 kt_{CO2}/y)	04-01
High range	Low to medium CO_2 concentration in flue gas (6-9%), very low amount of CO_2 captured (300-600 kt_{CO2}/y), significant fraction of the flue gases require FGD (50-100%) or a combination of these factors	02-04, 01-02, 01-01, 03-01, 01-03, 04-02
Medium range	Low to medium CO_2 concentration in flue gas (6-9%), low amount of CO_2 captured (600-750 kt_{CO2}/y), small fraction of the flue gases require FGD (20-50%) or a combination of these factors	03-02, 04-06, 02-02, 02-01
Low range	Medium to high CO_2 concentration in flue gas (10-18%), large amount of CO_2 captured (2000-3000 kt_{CO2}/y), small fraction of the flue gases require FGD (<10%) or a combination of these factors	03-03, 02-03, 04-05, 04-04, 04-03

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