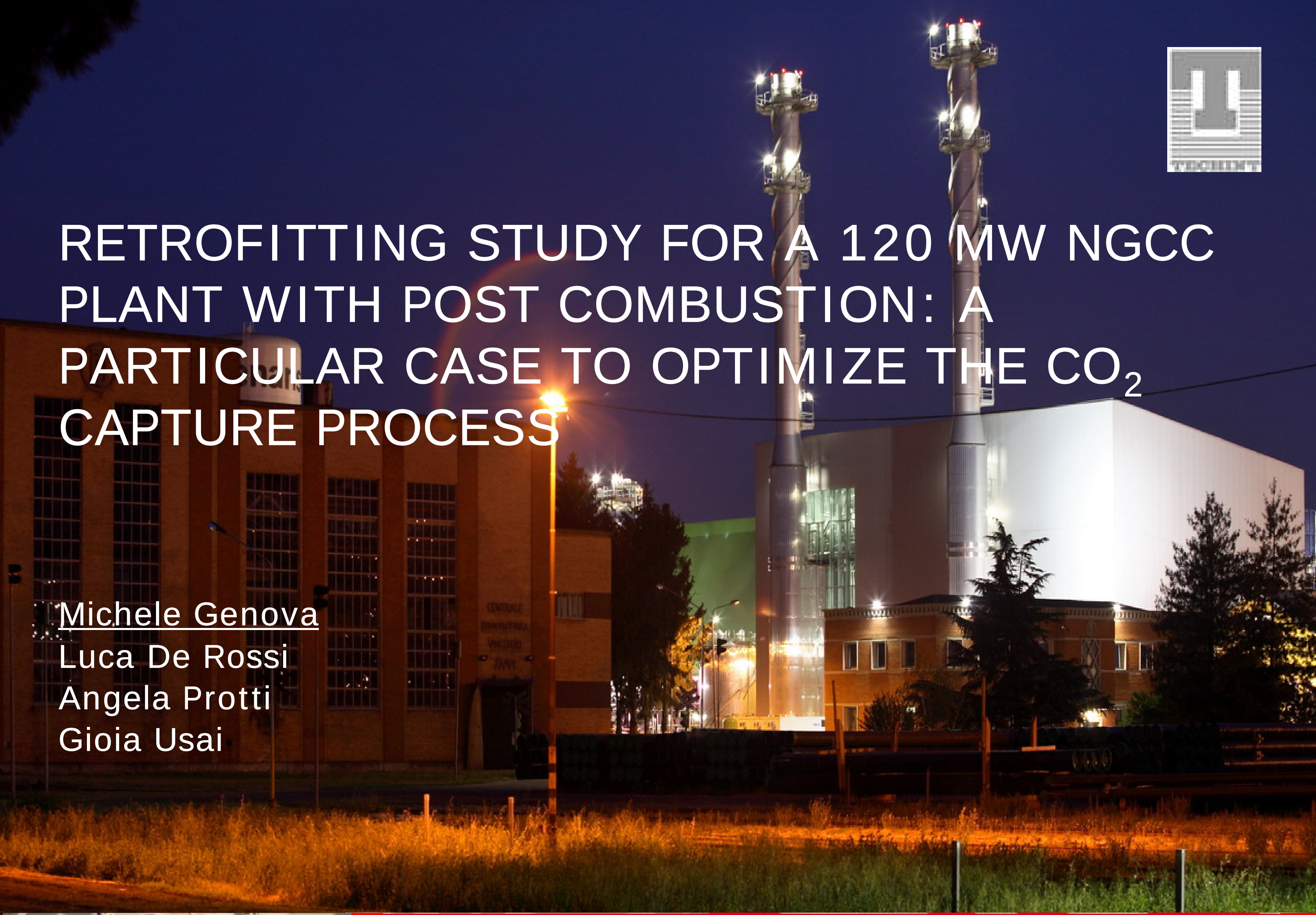


RETROFITTING STUDY FOR A 120 MW NGCC PLANT WITH POST COMBUSTION: A PARTICULAR CASE TO OPTIMIZE THE CO_2 CAPTURE PROCESS

Michele Genova
Luca De Rossi
Angela Protti
Gioia Usai

S4FE ROMA, 6TH-10TH JULY 2009 | SUSTAINABLE FOSSIL FUELS FOR FUTURE ENERGY

OUTLINE

- Introduction
- Description of existing NGCC plant and pre-feasibility study scope
- Operating configurations
- Post combustion technologies - State-of-the-art
- Process description
- Key factors to optimize energy requirement
- CO_2 final utilization
- Economics
- Conclusions

Techint Engineering & Construction

CANADA
- Techint E&C Inc.

ITALY
- Techint Compagnia Tecnica Internazionale
- Techint CimiMontubi

RUSSIA
- Techint Compagnia Tecnica Internazionale

MEXICO
- Techint S.A de C.V.

AFRICA
- Algeria
- Egypt
- Libya
- Nigeria

SAUDI ARABIA
- Saudi Techint Ltd

LATIN AMERICA
- Chile
- Colombia
- Ecuador
- Peru
- Trinidad & Tobago
- Uruguay
- Venezuela

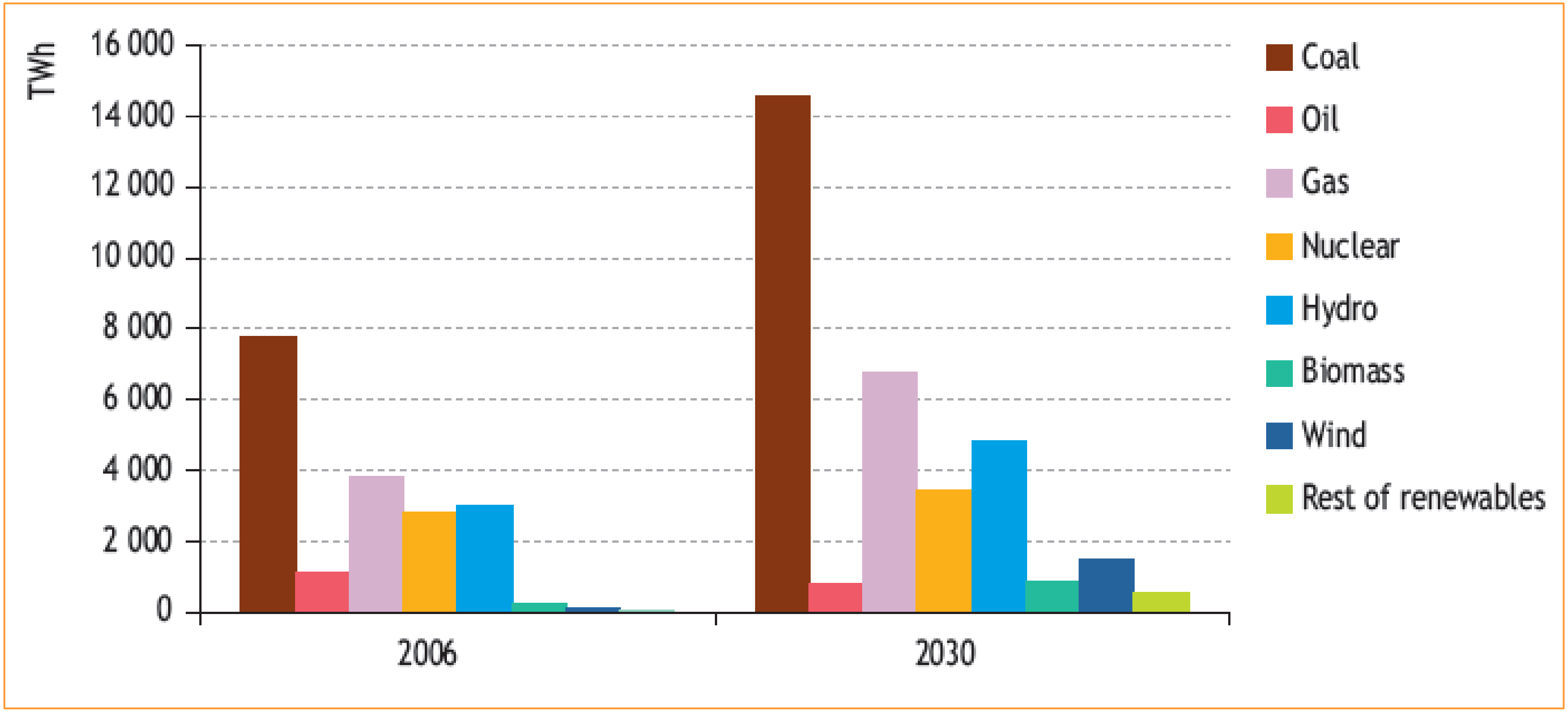
BRAZIL
- Techint S/A

ARGENTINA
- Techint Compañía Técnica Internacional
- Tesur

ASIA
- Techint International Construction

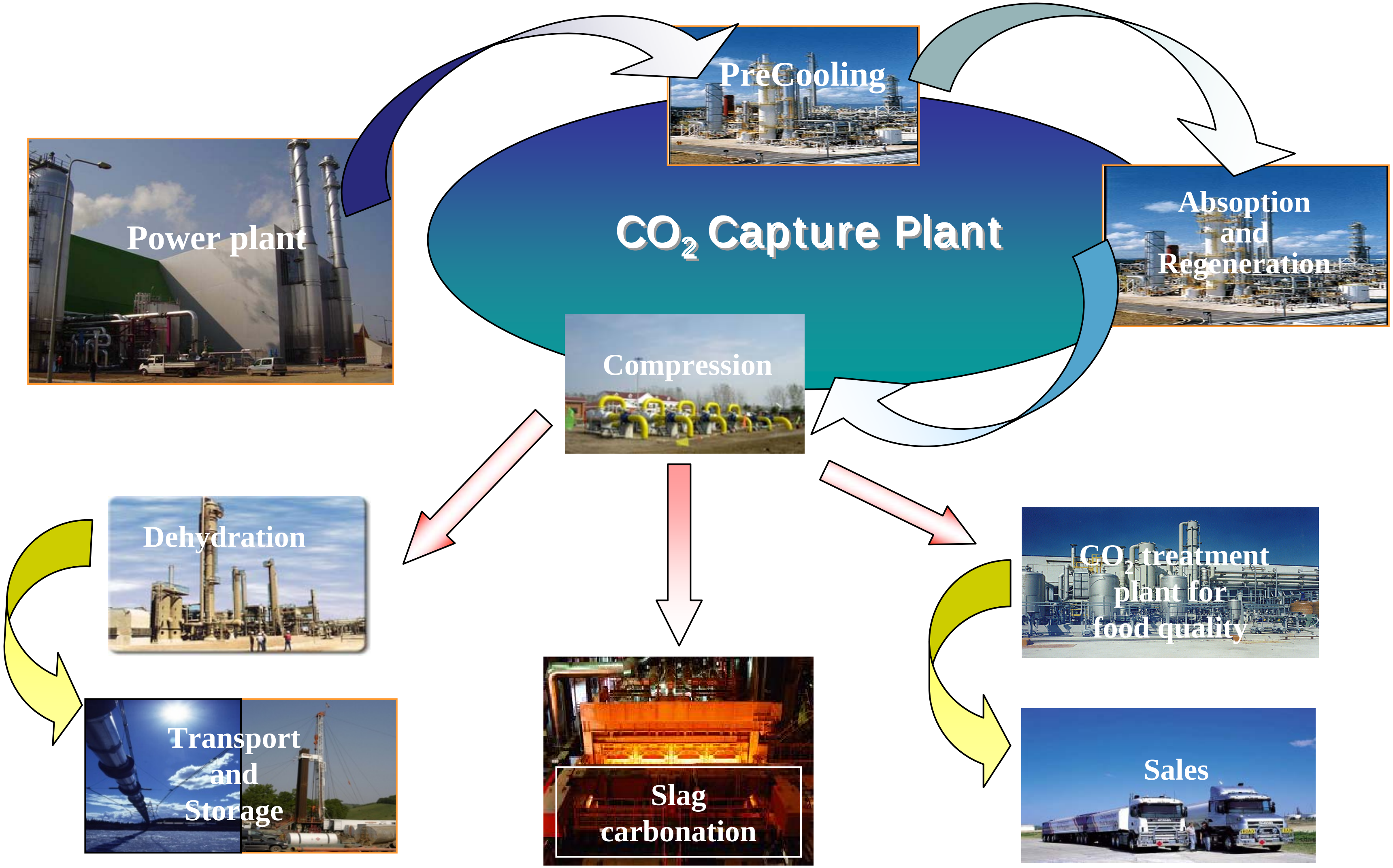
Work performed	2,100 US$ million
Backlog of orders	2,490 US$ million
Employees	20,200

World Electricity generation



Source: World energy Outlook 2008 – PART A, Chapter 6 (Figure 6.3)

Dalmine CCS Framework



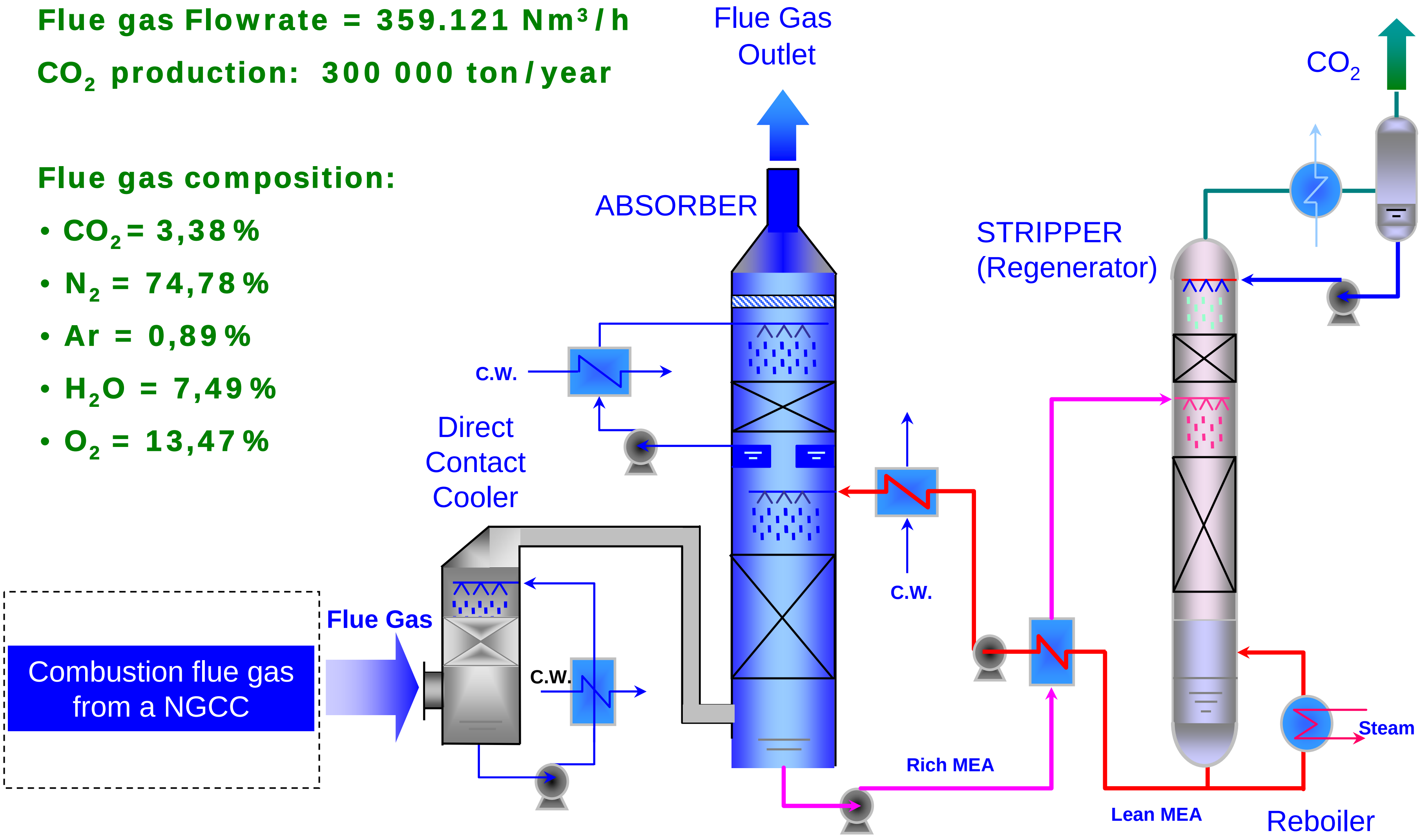
Case Study: 120MWe NGCC Plant

Flue gas Flowrate = 359.121 Nm^3/h

CO_2 production: 300 000 ton/year

Flue gas composition:

- **CO_2 = 3,38%**
- **N_2 = 74,78%**
- **Ar = 0,89%**
- **H_2O = 7,49%**
- **O_2 = 13,47%**



Main Post-combustion Technologies

1. Absorption by amine based solvent

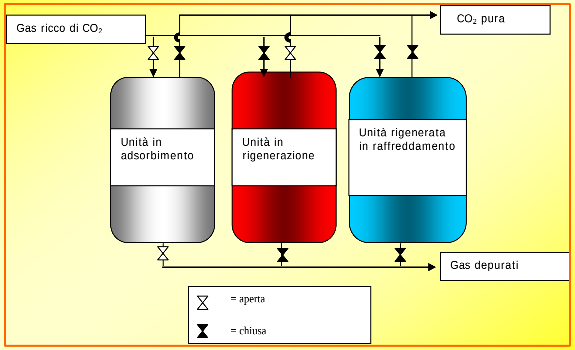
a) MEA (Mono-ethanolamine), process open art

b) Econamine FG Plus^{SM} Technology, process licenced by Fluor

c) KM CDR Process (KANSAI MITSUBISHI Carbon Dioxide Recovery Process), licenced by Mitsubishi Heavy Industries Ltd e Kansai Electric Co.Inc

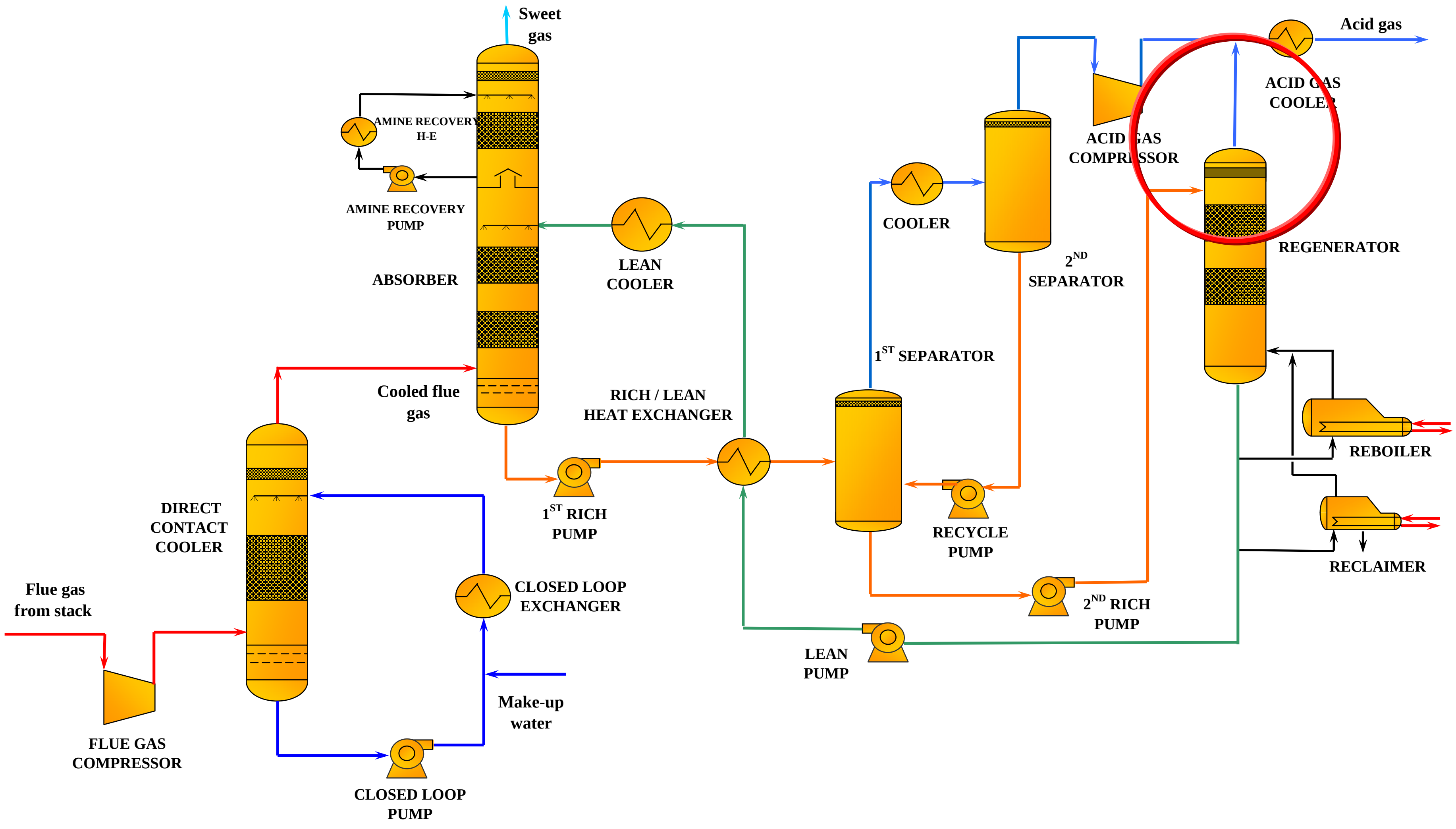
2. Chilled Ammonia Process (CAP) licenced by Alstom

3. Solids sorbents

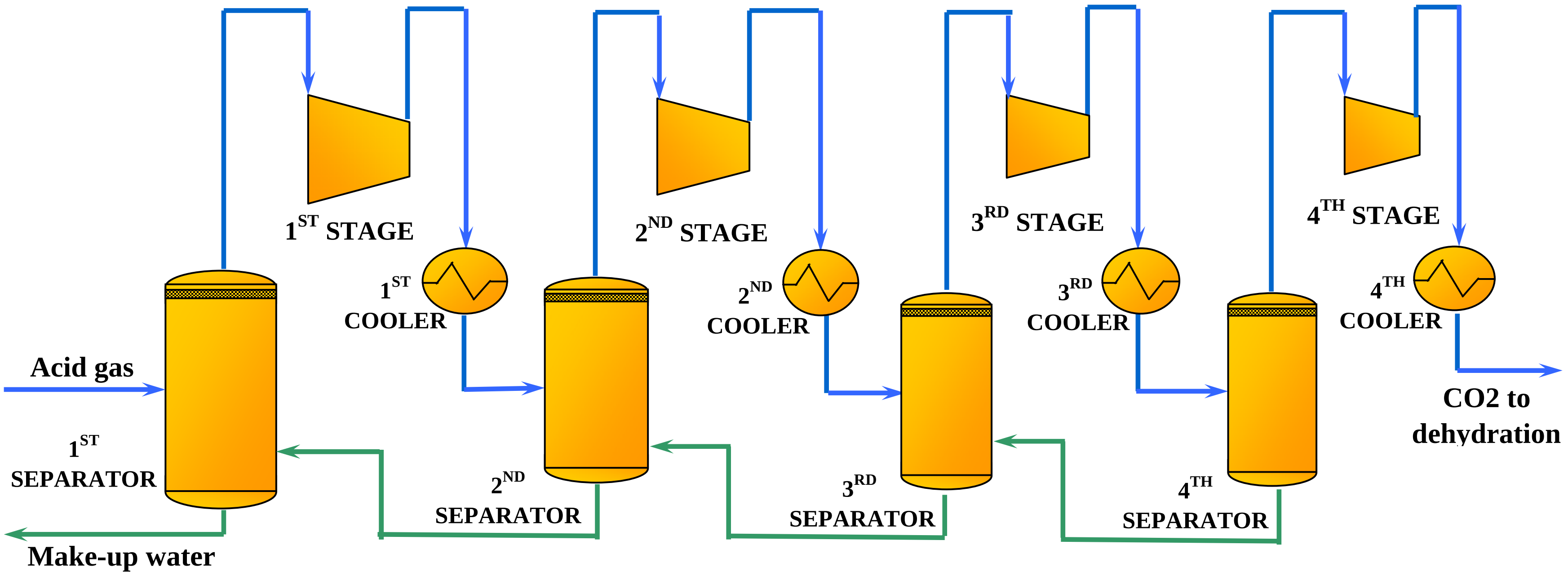


Source: ERSE

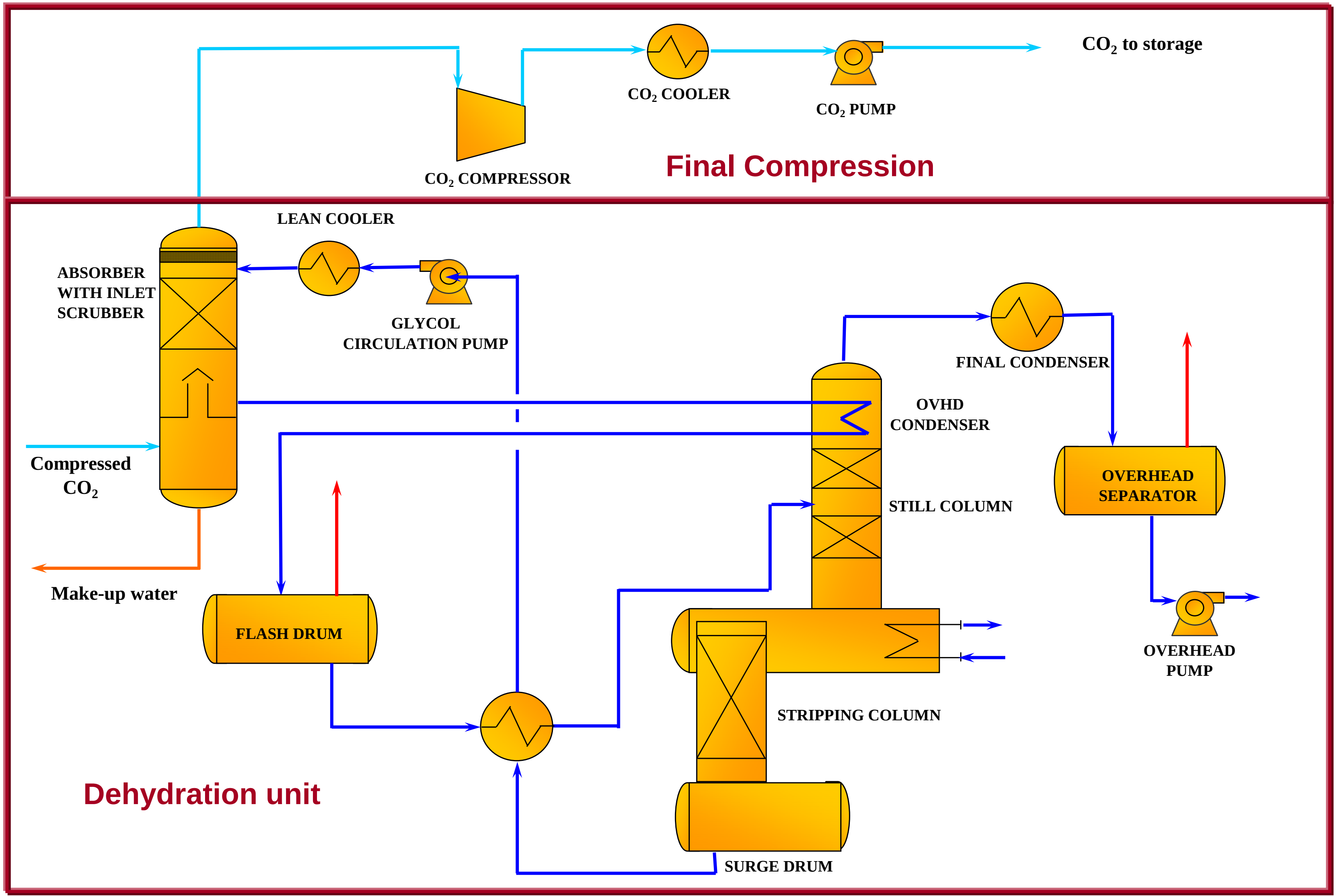
PFD: Precooling, Absorption and MEA Regeneration



PFD: Compression Unit



PFD: dehydration and final compression



Key factor: Reboiler Duty [1]

The reboiler duty is a function of:

- Lean solvent loading.
- Operating conditions of flash drum (if any).
- Sensible heat (**Qs**) to increase the temperature of the feed solution to the temperature of the lean solution leaving the reboiler .
- Heat of reaction (**Qr**), the energy to reverse the amine acid-gas reaction and dissociate the amine acid-gas compounds.
- Latent and sensible heat (**Qv**) required to convert reflux water into steam which serves as the stripping vapor.

Key factor: Reboiler Duty [2]

$$Q = Qs + Qr + Qv$$

$$Qs = W\,Cp_{sol}\,(T_R - T_F)$$

$$Qr = W_{CO2}\,h_r$$

$$Qv = W_{steam}\,\lambda$$

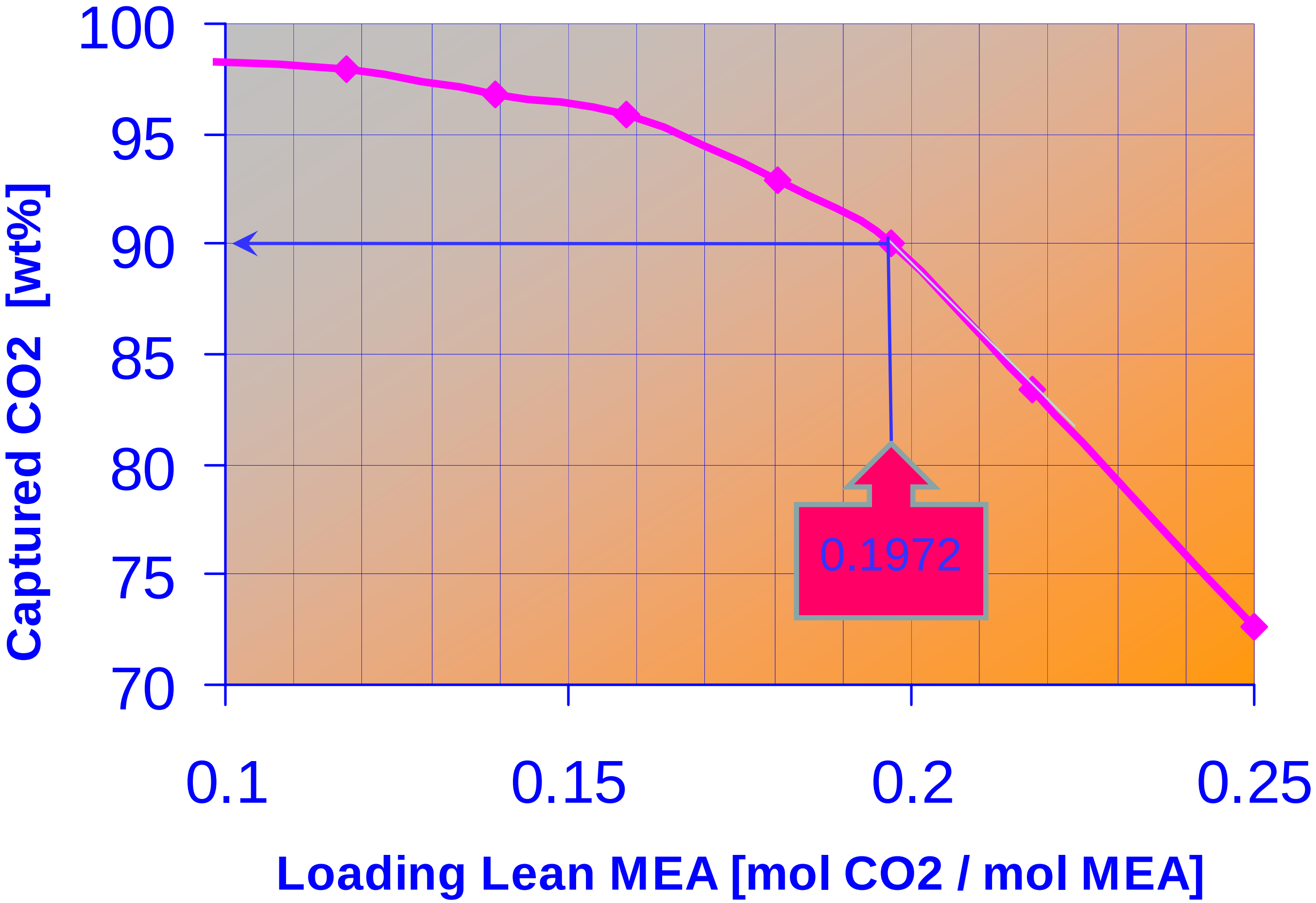
Where:

Q *is the reboiler duty [kJ/h]*
W *is solvent flowrate [kg h^{-1}]*
W_{CO2} *is CO_2 flowrate in the rich solvent [kg h^{-1}]*
W_{steam} *is minimum steam flowrate [kg h^{-1}]*
H_r *is the heat of reaction from CO_2 and MEA [KJ/kg]*
λ is the latent heat [kJ/kg]
Cp_{sol}, *is solvent specific heat [KJ Kg $^{-1}$K^{-1}]*
T_R *is reboiler temperature [K]*
T_F *is temperature of feeding solvent to regenerator [K]*

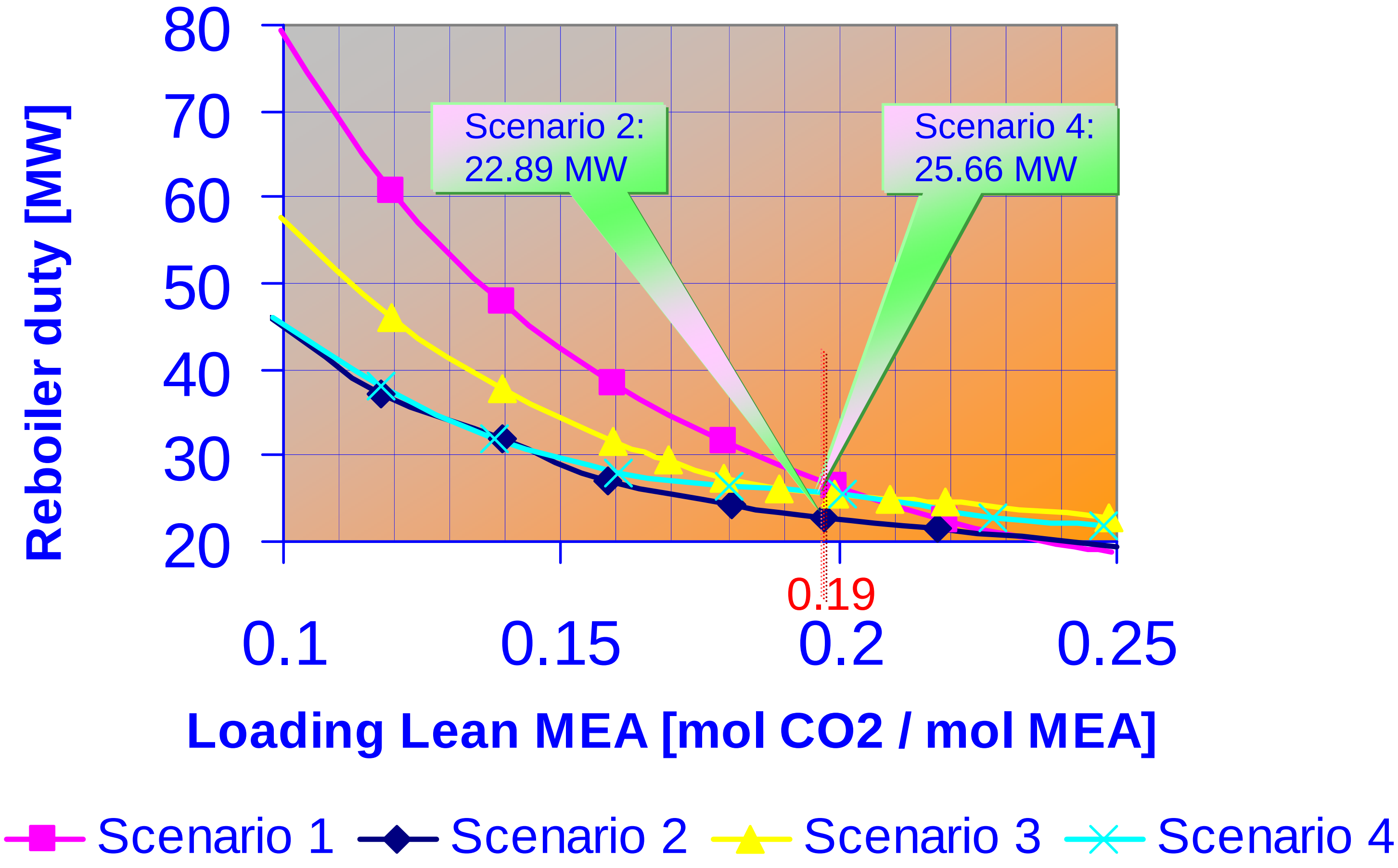
Regeneration unit Scenarios

	Flash Drum	OVHD condenser and reflux system
Scenario 1	✓	✓
Scenario 2	✓	-
Scenario 3	-	-
Scenario 4	-	✓

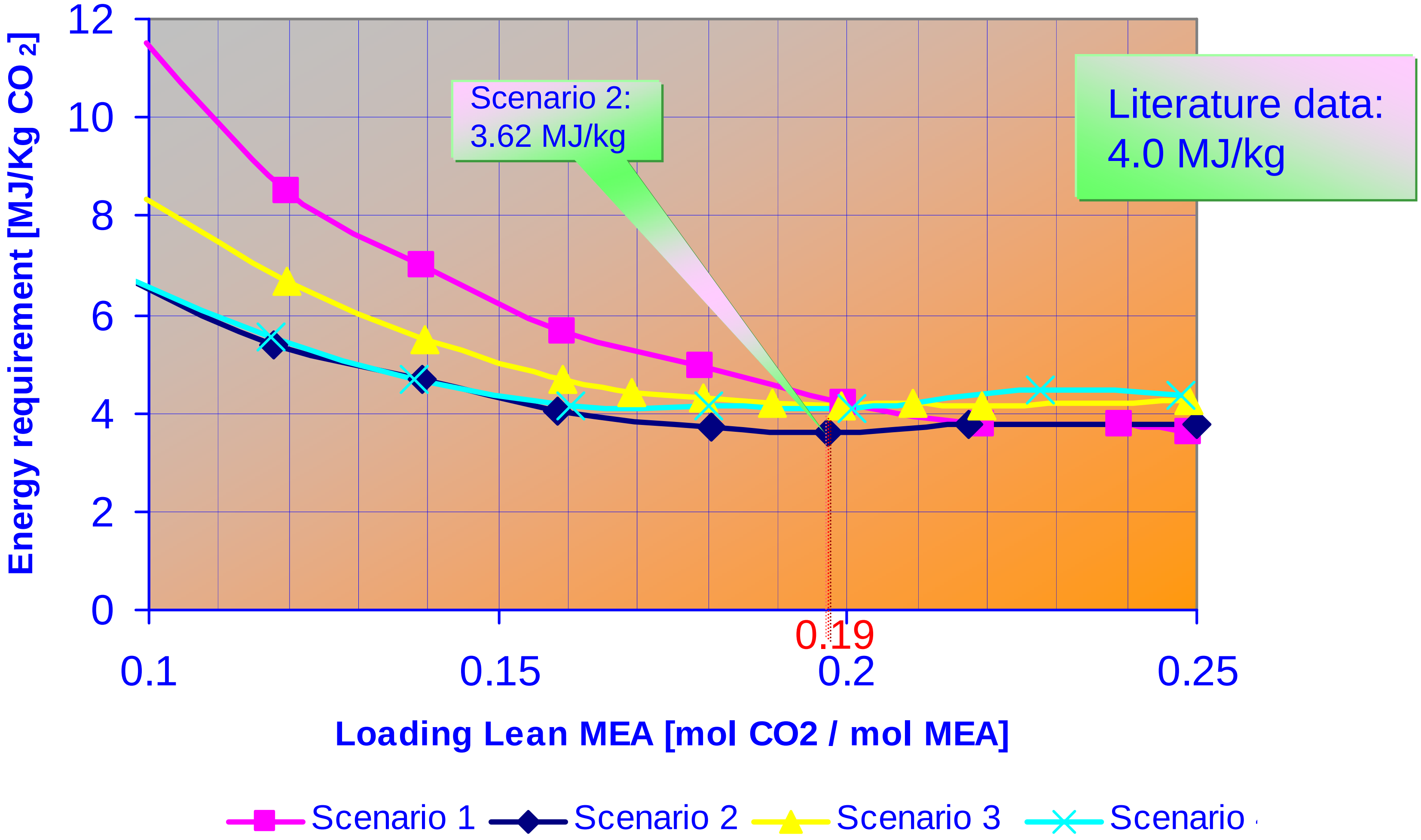
Captured CO_2 vs Loading



Reboiler duty vs Loading



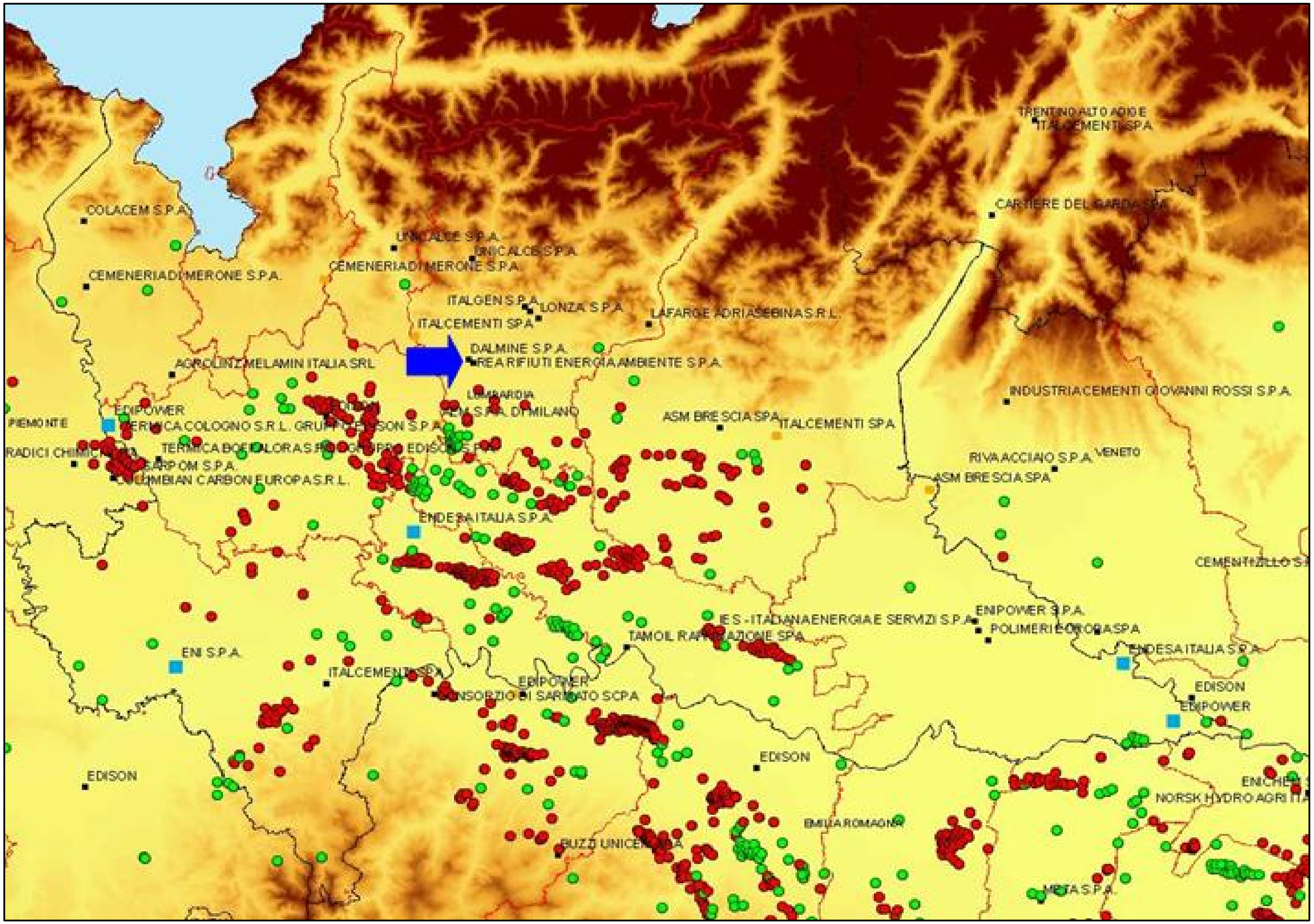
Energy Requirement vs Loading



Scenario 2:
3.62 MJ/kg

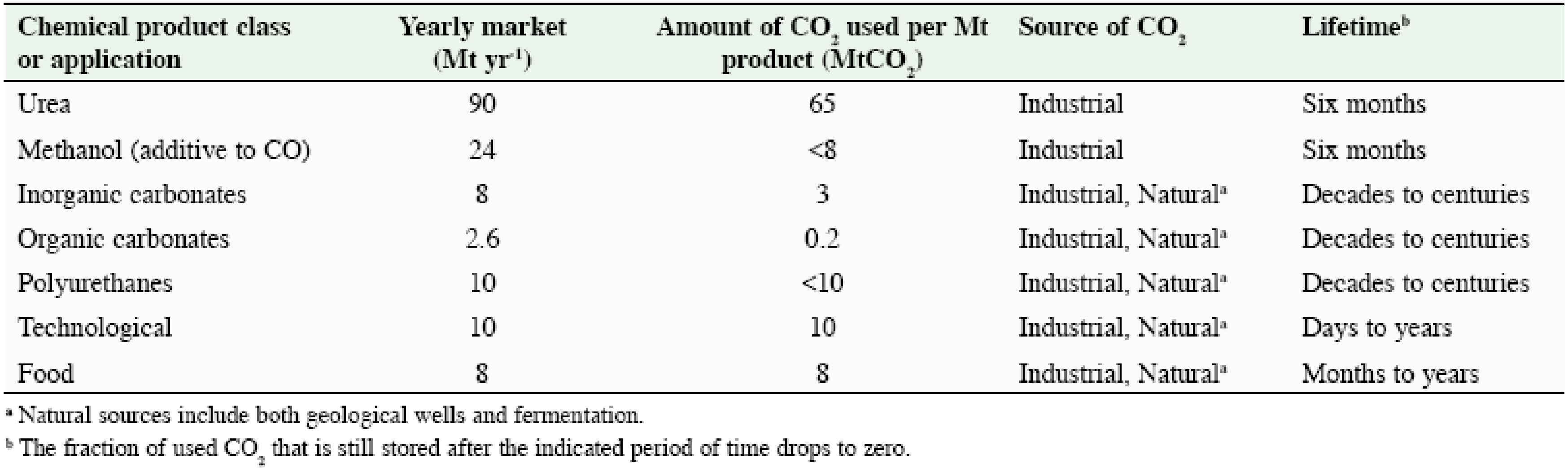
Literature data:
4.0 MJ/kg

Geological storage: a possible site



Source: ERSE

CO_2 industrial applications



Chemical product class or application	Yearly market ($Mt\ yr^{-1}$)	Amount of CO_2 used per Mt product ($MtCO_2$)	Source of CO_2	Lifetime[b]
Urea	90	65	Industrial	Six months
Methanol (additive to CO)	24	<8	Industrial	Six months
Inorganic carbonates	8	3	Industrial, Natural[a]	Decades to centuries
Organic carbonates	2.6	0.2	Industrial, Natural[a]	Decades to centuries
Polyurethanes	10	<10	Industrial, Natural[a]	Decades to centuries
Technological	10	10	Industrial, Natural[a]	Days to years
Food	8	8	Industrial, Natural[a]	Months to years

[a] Natural sources include both geological wells and fermentation.

[b] The fraction of used CO_2 that is still stored after the indicated period of time drops to zero.

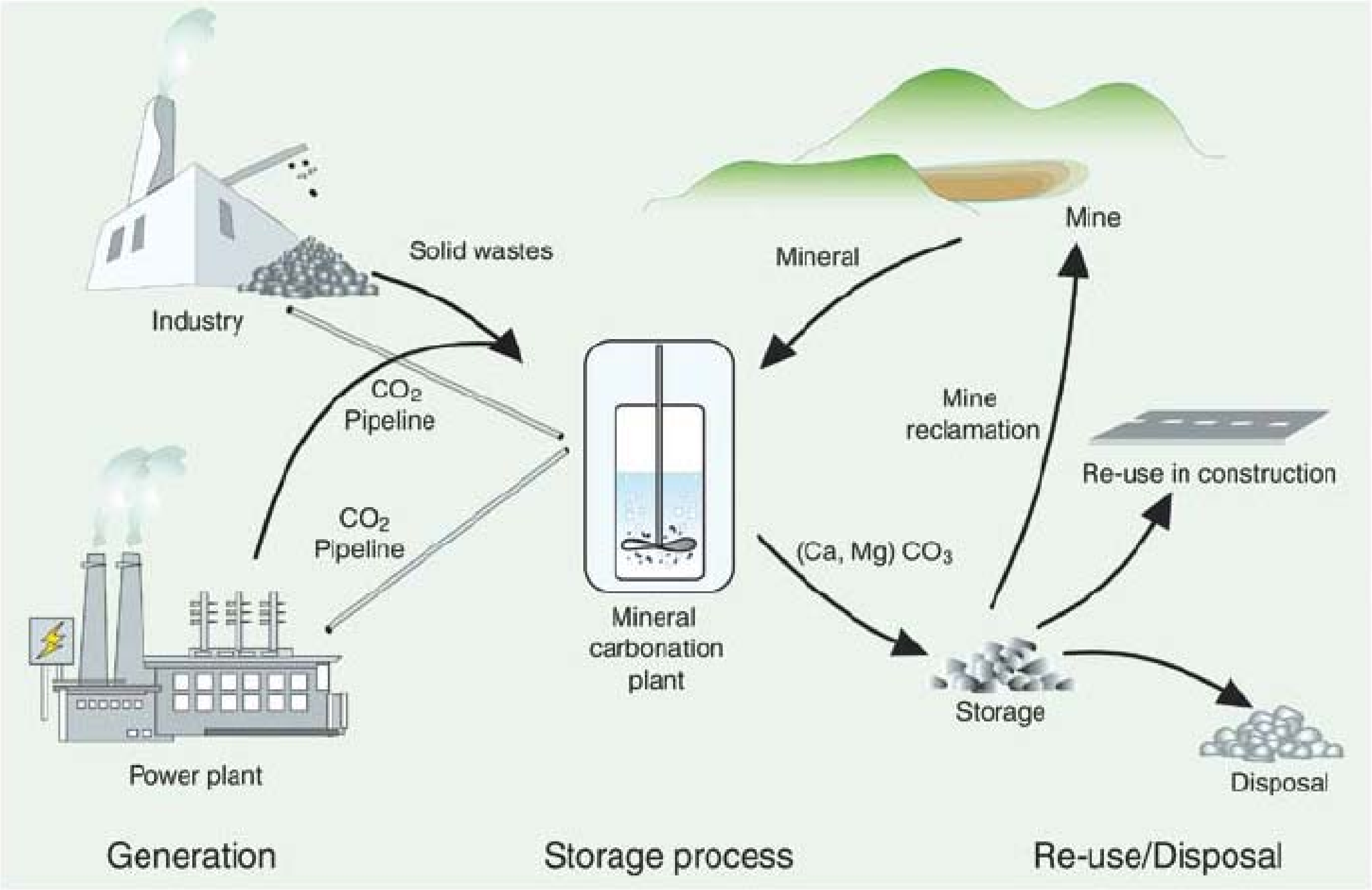
Source: : IPCC Special Report on Carbon Dioxide Capture and Storage – 2005 (Cap.7 - Mineral carbonation and industrial uses of carbon dioxide – M. Mazzotti and others)

CO_2 Sale on Italian market

CAPACITY OF ITALIAN MARKET

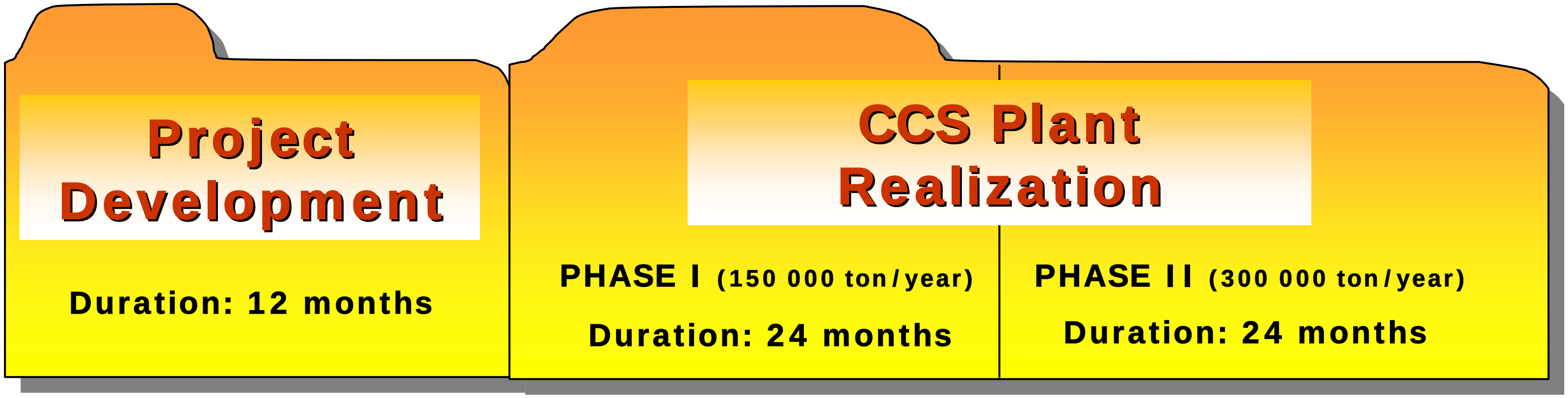
300.000 ton/year

Mineral sequestration: carbonation steel slag



Source: IPCC Special Report on Carbon Dioxide Capture and Storage (2005)

CCS Project Phases



Project Development

Duration: 12 months

CCS Plant Realization

PHASE I (150 000 ton/year)

Duration: 24 months

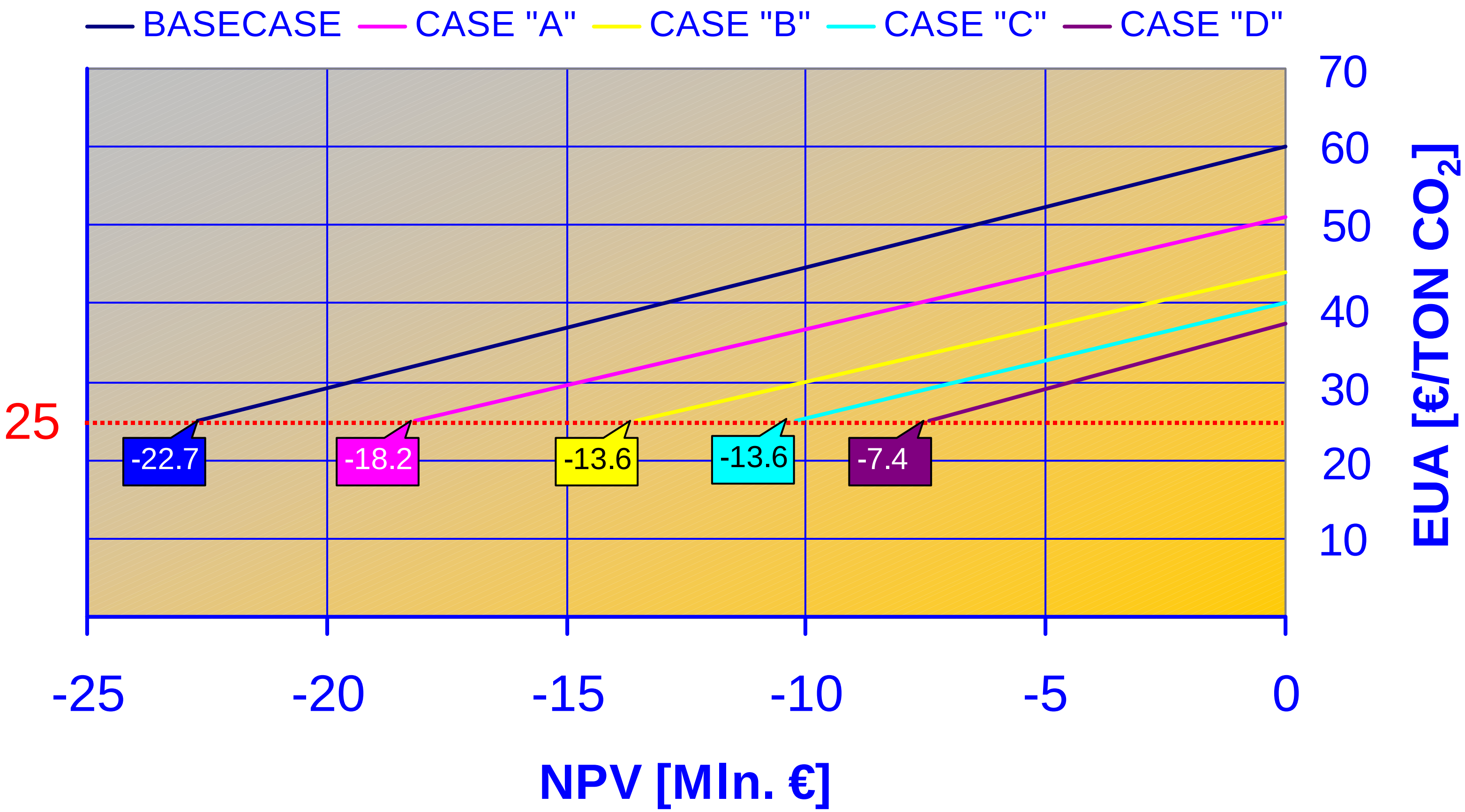
PHASE II (300 000 ton/year)

Duration: 24 months

Business Plan: five scenarios

	WACC (%)	CAPEX (Mln€)	Absorbed Power (MWh/tCO$_2$)	Electricity Costs (€/MWh)	OPEX (Mln€/a)
BASECASE	8 – 10	60,7	1,06	79	2,0
Case A	8 - 10	-10%	1,06	79	2,0
Case B	8 - 10	-10%	-20%	79	2,0
Case C	8 - 10	-10%	-20%	-10%	2,0
Case D	8 - 10	-10%	-20%.	-10%	-20%

Financial feasibility: EUA vs NPV



The range of EUA values which makes the initiative economically sustainable is 40-60 €/tCO_2: as per many financial projection, it is a reasonable quotation after 2013

CONCLUSIONS

- Dalmine project aims to set-up a well structured Italian frame for post-combustion technology development
- Further the “usual” geological storage, other industrial application, as use in food industries and mineral carbonation, have been identified
- The economic simulations evidenced the feasibility of the initiative in an EUA range of 40-60 €/tCO_2, a reasonable value after 2013
- The activities carried out up to now will allow to start with a basic design to select the best technology to be applied
- The current financial crisis represents a constrain in developing CCS projects unless a significant contribution from the Governments is granted

ACKNOWLEDGEMENTS

- Power Plant data: Tenaris Dalmine
- Solvent simulation: ENEA
- Chiller ammonia process : Politecnico di Milano
- Storage: ERSE (former CESI RICERCA)
- Carbonation: ETH of Zurich and Università di Tor Vergata Roma

THANK YOU FOR YOUR ATTENTION