Unconventional systems for seaborne CO2 transportation systems

Mr. Jacques TROLLUX

Mr. Frédéric VENY

Joint Managing Director of SOFREGAZ

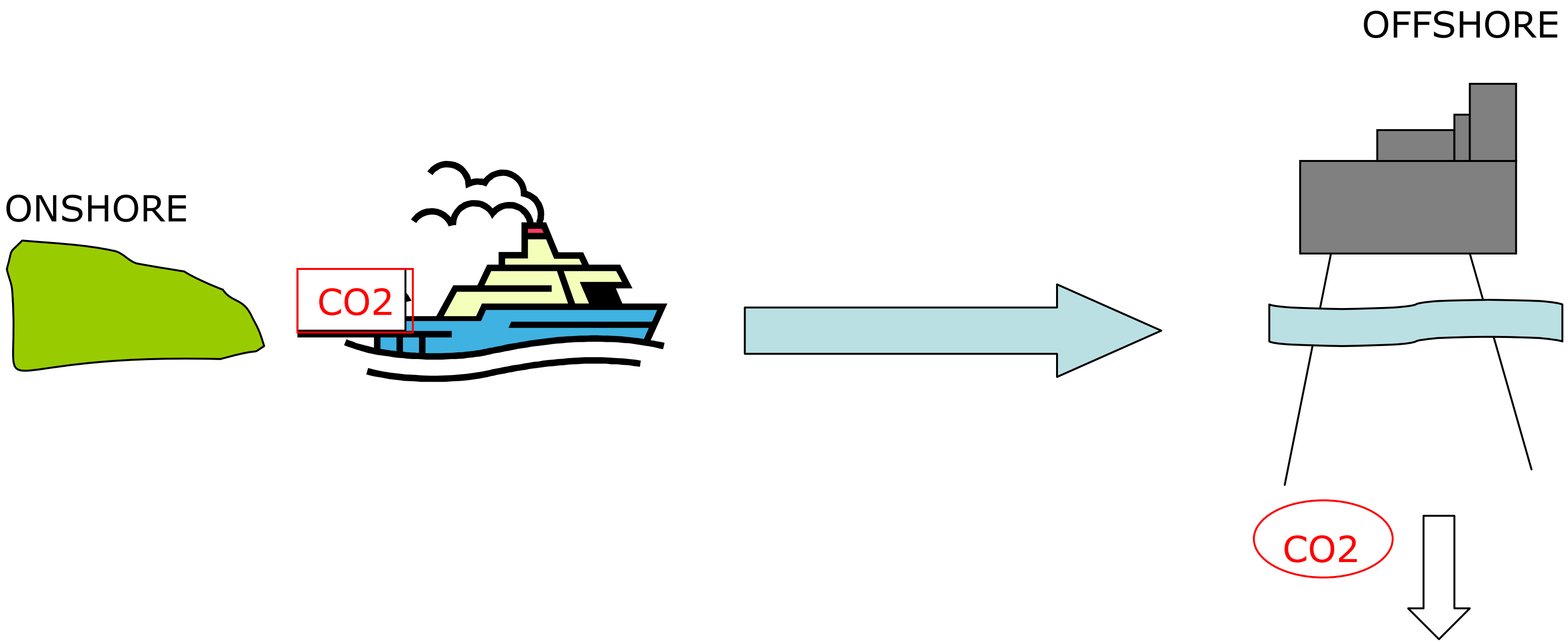
Conference in Roma

25 October 2010, Roma

Sofregaz

Maire Tecnimont

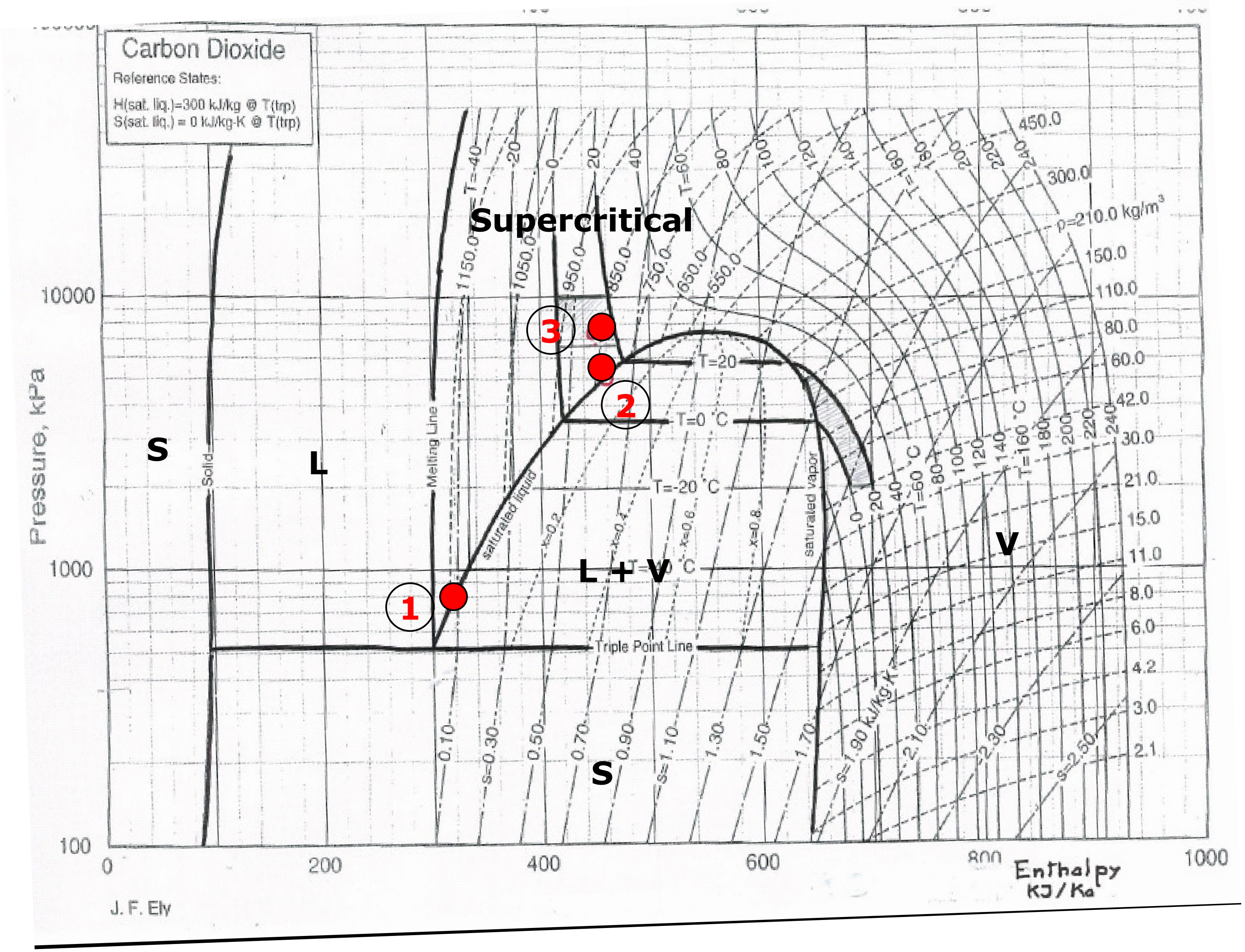
This paper will compare 3 alternates of CO_2 transported by ship from onshore to existing offshore platform.



LOOK AT THE CO2 DIAGRAM AND CHARACTERISTICS

Case	type	Pressure/ temperature	Ship back to shore	Form
1	conventional	8 bar -46 ° C	empty	Liquid
2	unconventional	50 bar + 15° C	empty	Liquid
3	unconventional	75 bar + 15° C	with NG	Supercritical

SIMPLIFIED DIAGRAM OF CO2



Case 1

Transport is made on liquid refrigerated form, pressure about 8 bars, temperature – 46° C

- Pressure should be selected to avoid plugging in solid under transitional pressure loss in piping (higher than triple point)
- Containment more difficult than LPG as combining both pressure and cold
- Thickness limitations for spheres

CONVENTIONAL SIMPLIFIED SCHEME (Case 1)

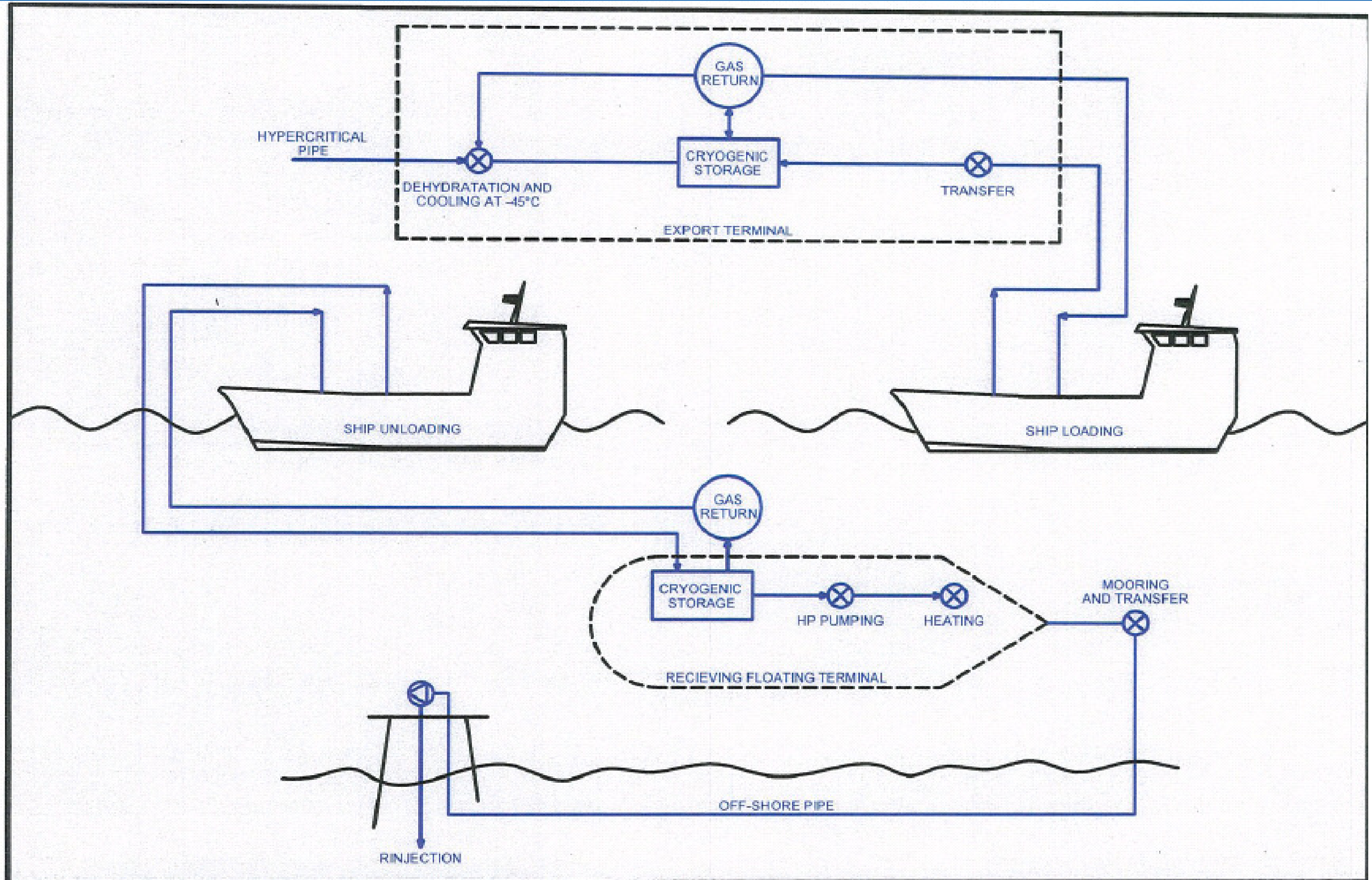


FIG. 1
SCHEMATIC OF A REFRIGERATED CO2 SHIPPING EXPORT

ECONOMICS FOR CONVENTIONAL SEABORNE TRANSPORTATION (Case 1)

Maire Tecnimont

Investment (CAPEX)

export terminal	379 MM$
6 ships (6 x 129 MM$)	774 MM$
receiving offshore facilities	220 MM$
Total investment	**1,373 MM$**

CAPEX/year (7.5%/15 years)	**155.6 MM$/y**

OPEX

export terminal	37.9 MM$/y
6 ships (6 x 16.3 MM$)	97.8 MM$/y
receiving offshore facilities	22.0 MM$/y
Total OPEX	**157.7 MM$/y**
Total CAPEX + OPEX	**313.3 MM$/y**

Unit cost	**26.1 $/t**

UNCONVENTIONAL SOLUTIONS CONSIDERED CARBOTUBE (**patented P92943EPOO by MET**) – Cases 2 & 3

- Ambient temperature, under pressure
- Containment made with current pipes used in gas line
  - More weight than sphere
  - Less unit cost per kg
- Two solutions:
  - Liquid at 15° C, 50 bars ⟶ **Case 2**
  - Supercritical at 15° C, 75 bars ⟶ **Case 3**
- Shuttle type of shipping operation to minimize terminal facilities

SIMPLIFIED SCHEME FOR RECEIVING FACILITIES (Case 2)

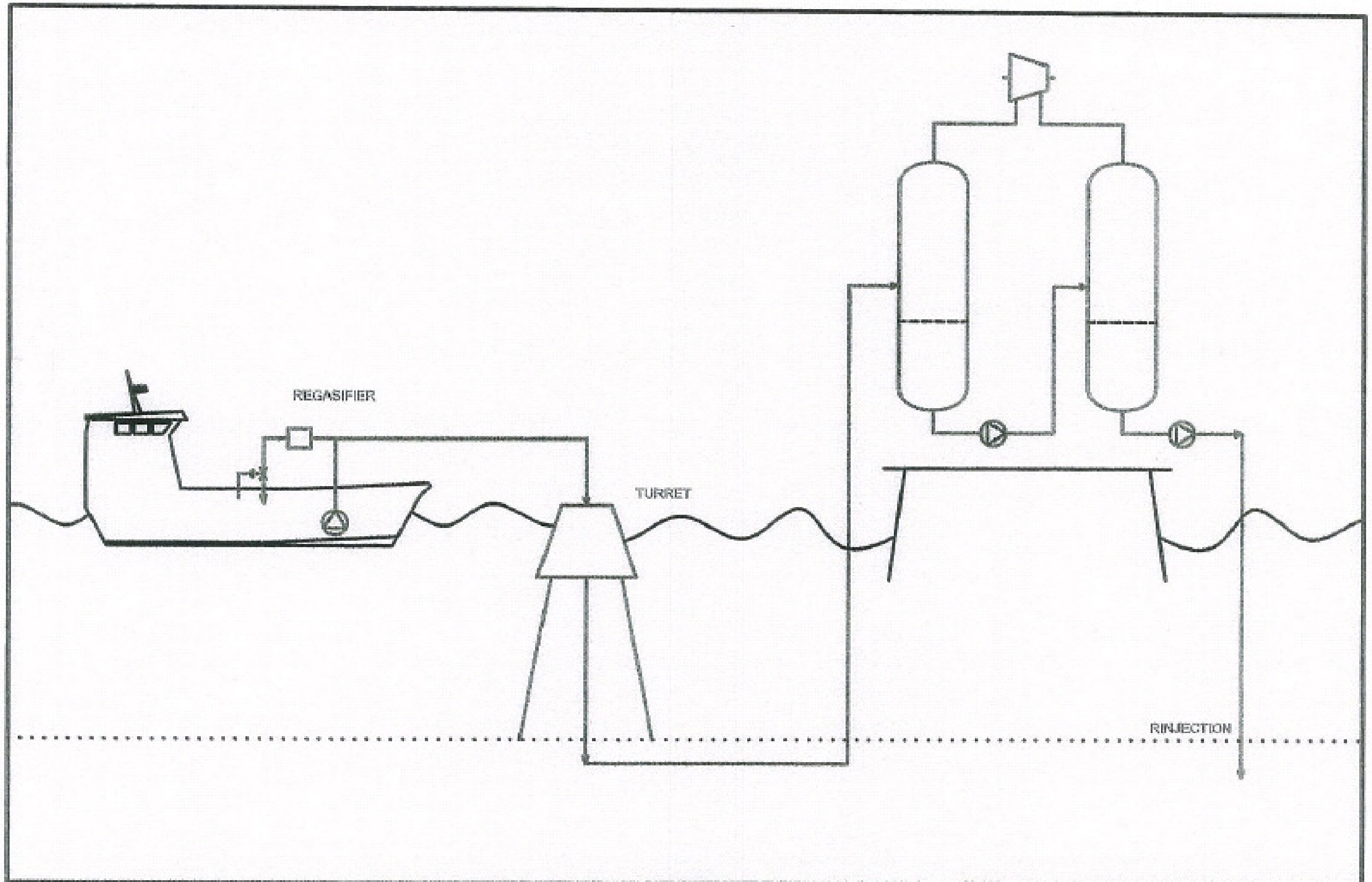


FIG. 3
SIMPLIFIED SCHEMA OF AN OFF-SHORE UNLOADING FOR
PRESSURIZED LIQUID CO2 AT AMBIENT TEMPERATURE

Investment (CAPEX)

export terminal	100 MM$
ships (8 x 123 MM$)	984 MM$
receiving offshore facilities	90 MM$
Total investment	**1,174 MM$**

CAPEX/year (11.33%)	**133 MM$/y**

OPEX

export terminal	37.9 MM$/y
ships (8 x 17.9 MM$)	97.8 MM$/y
receiving offshore facilities	22.0 MM$/y
Total OPEX	162.2 MM$/y
Total investment (CAPEX + OPEX)	**295.2 MM$/y**

Unit cost	**24.6 $/t**

Case 3

- CO_2 is transported at 75 bars / 15° C
- Containment is based on linear tubular gas line pipe modules connected in series
- Transfer is obtained by exchange with natural gas under slight differential pressure, assumed to be available on reinjection site or nearby
- Natural gas is delivered on the way back to export terminal, displaced by CO_2 loaded

Two possible containments

A. Horizontal tubular containment

- Bundle of 28” pipes (quadruple jointing) 12.7 mm
- Size of one bundle module 6.8 x 7.8 x 51 m

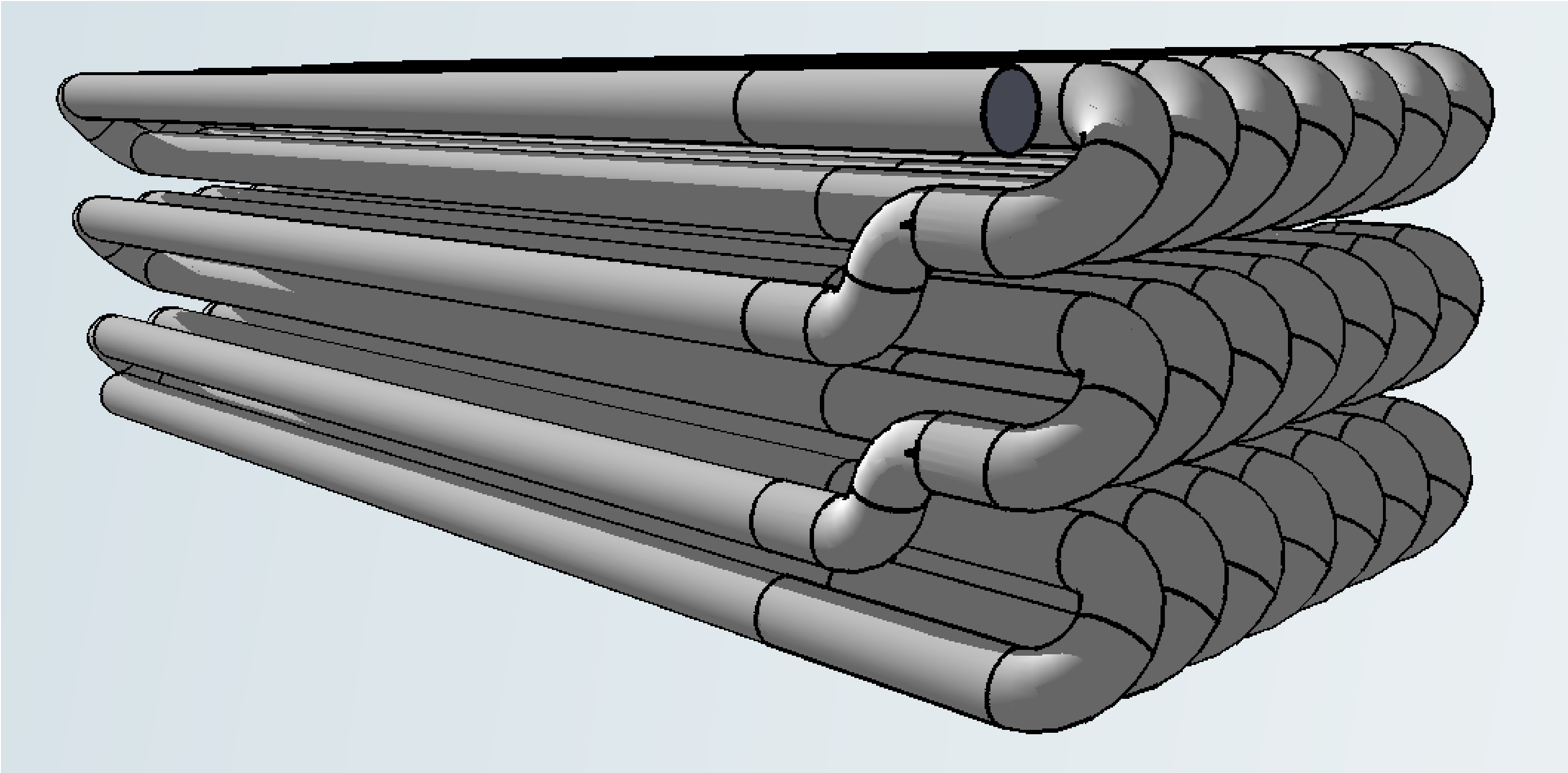
weight of steel	pipes	529 t	633 t
	fittings	24 t	
	frame	80 t	
Content of CO_2			746 t

B. “COSELLE” type with 8” coiled

Typical size of one coselle	diameter 19 m / height 5 m 12,800 m of coiled 8” pipe	
Weight	(320 + 50)	370 t
Content of CO_2	375 t	375 t

FIGURE OF ONE HORIZONTAL BUNDLE MODULE (Case 3)

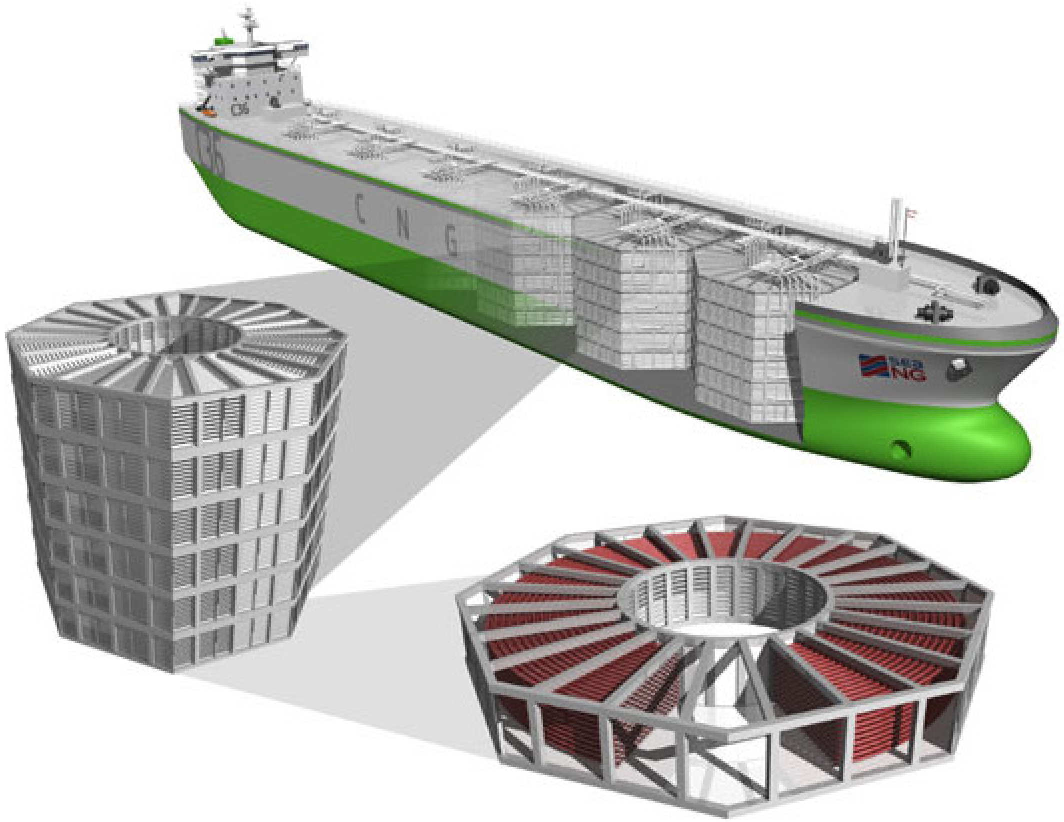
Maire Tecnimont



Typically one bundle will be like a 2,500 m fold-up pipeline, and the 16 modules installed in one ship compartment a 40-km fold-up pipeline

Interface will then move at less than 0.5 m/s

FIGURE OF ONE COSELLE (Case 3)



ECONOMICS
12 MTPA (supercritical 75 bars) – Case 3

Investment (CAPEX)	
export terminal	75 MM$
ships (8 x 148 MM$)	1,184 MM$
receiving offshore facilities	70 MM$
Total investment	**1,329 MM$**
CAPEX/year (11.33%)	**150.5 MM$/y**
OPEX	
export terminal	10 MM$/y
ships (8 x 17.9 MM$)	143.2 MM$/y
receiving offshore facilities	7 MM$/y
Total OPEX	**162.5 MM$/y**
CAPEX + OPEX	**313 MM$/y**
Less added value of gas (5 $MMbtu)	
846 t of gas x 250 $/t	- 211 MM$/y
Total/year	**102 MM$/y**

Unit cost	**8.51 $/t**

SUMMARY OF COMPARISON

		Case 1	Case 2	Case 3
		8 bar -46° C	50 bar +15° C	75 bars +15° C
Item designation	units	Refrigerated solution	Ambient pressurized	Ambient supercritic + GN return
Investment				
- export terminal	MM $	379	100	75
- ships (number)	MM $	774 (6)	984 (8)	1,184 (8)
- receiving off-shore	MM $	90	90	70
Total investment	**MM $**	**1,373**	**1,174**	**1,329**
OPEX				
- export terminal	MM $/y	37.9	10	7.5
- ships (number)	MM $/y	97.8	143.2	148
- receiving off-shore	MM $/y	22	9	7
Total OPEX	**MM $/y**	**157.7**	**162.2**	**162.5**
BALANCE / YEAR				
- CAPEX	MM $/y	155.6	133	150.5
- OPEX	MM $/y	157.7	162.2	162.5
- GN added value	MM $/y	/	/	-211
Total	**MM $/y**	**313.3**	**295.2**	**102**
Unit Cost	**$/t**	**26.1**	**24.6** **-6%**	**8.5** **-67%**

OTHER ADVANTAGES OF SHIPPING AT AMBIENT TEMPERATURE

- Export terminal very simplified
- It could be installed in small places with berthing capacities or even other turret mooring
- No problem of safety linked to large refrigerated spheres
- Offshore connection is easier
- Less shut down to foresee as less mechanical equipment at both ends

- The cost of CO_2 shipping with **conventional** refrigerated scheme seems too important to implement a global possible scheme within an overall CO_2 value of 20-30 $/t
- Solution with ambient temperature **unconventional gas** gives some advantages of simplifying terminals and then related environmental constraints
- But their costs, only slightly below the conventional one, remain too high unless cost is offset by valorisation of stranded gas on way back, in the supercritical mode

Then the most important point is to identify offshore reinjection structures with stranded gas resources with the same structure or nearby.

Thank you for your attention

Rome
Via di Vannina, 88/94
00156 Rome
Ph. +39 06 4122 351
Fax +39 06 4122 35610

Milan
Viale Monte Grappa, 3
20124 Milan
Ph. +39 02 6313.1
Fax +39 02 6313.9052

Turin
Corso Ferrucci, 112/a
10138 Turin
Ph. +39 011 0056111
Fax +39 011 0056444

Paris
4, Allée de Seine
93200 Saint-Denis
Ph. +33.1/80.60.30.00
Fax +33.1/80.60.30.88

info@mairetecnimont.it – www.mairetecnimont.it