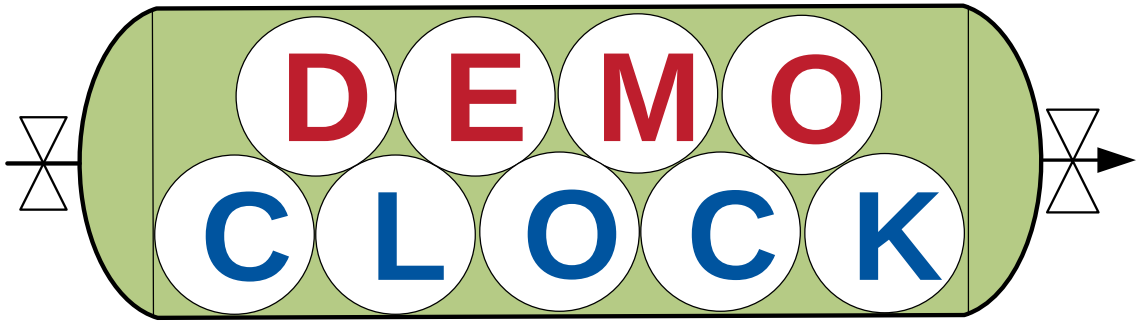
FOSTER WHEELER

CCS Conference 2013

Demonstration of a medium size packed bed Chemical Looping Combustion for CO_2 capture



SEVENTH FRAMEWORK PROGRAMME

Methodological approach for the commercial evaluation of the Democlock CLC technology

Luca Mancuso
Foster Wheeler
Process Manager, Power Division

Antwerp, May 28, 2013

Agenda

- Introduction
- Steps and methodology for the commercial evaluation of the technology
- Overview of the benchmark technologies: example of performances and costs
- Summary conclusions

Introduction

<u>Objective</u> - Preparation for the commercialization of the new CLC technology:

- Focus on the role of a full-scale CLC power plant in the CO_2 emission market
- Assessment of the potential benefits for final end-users (power producers, utility companies etc.)

<u>Status of the work</u>

- Construction of pilot reactor in Puertollano: feedback for the assessment
- Modeling of large-scale plant: almost completed
- Methodological approach for the commercial evaluation of the technology: already defined

Agenda

- Introduction
- Steps and methodology for the commercial evaluation of the technology
- Overview of the benchmark technologies: example of performances and costs
- Summary conclusions

Commercial evaluation

Steps identified for the commercial evaluation of the technology:

1. Acquisition of the plant performance and **H&M Balance** of a full-scale CLC power plant (WP5)
2. Preparation of the **Sized Equipment List** for the plant
3. Estimation of the Total Investment Cost (**TIC**)
4. Estimation of the Operating & Maintenance (**O&M**) costs
5. Estimation of the **Plant Revenues**
6. **Financial projection** of the costs and profits during the entire project life

Commercial evaluation (cont'd)

7. Calculation of the Levelized Cost of Electricity (**LCOE**)

8. Calculation of **Cost of CO_2 avoided**

$$\text{Cost of } CO_2 \text{ avoidance} = \frac{LCOE_{CCS} - LCOE_{Reference}}{CO_2\text{Emissions}_{Reference} - CO_2\text{Emissions}_{CCS}}$$

9. **Comparison** between the full-scale CLC plant and **benchmark technologies**: USC-PC and IGCC

10. **Sensitivity analyses** on the key factors that affect the economics of the CLC-pant (e.g. reactor cost), so to look at breakeven points (commercial attractiveness)

Total Investment Cost (TIC)

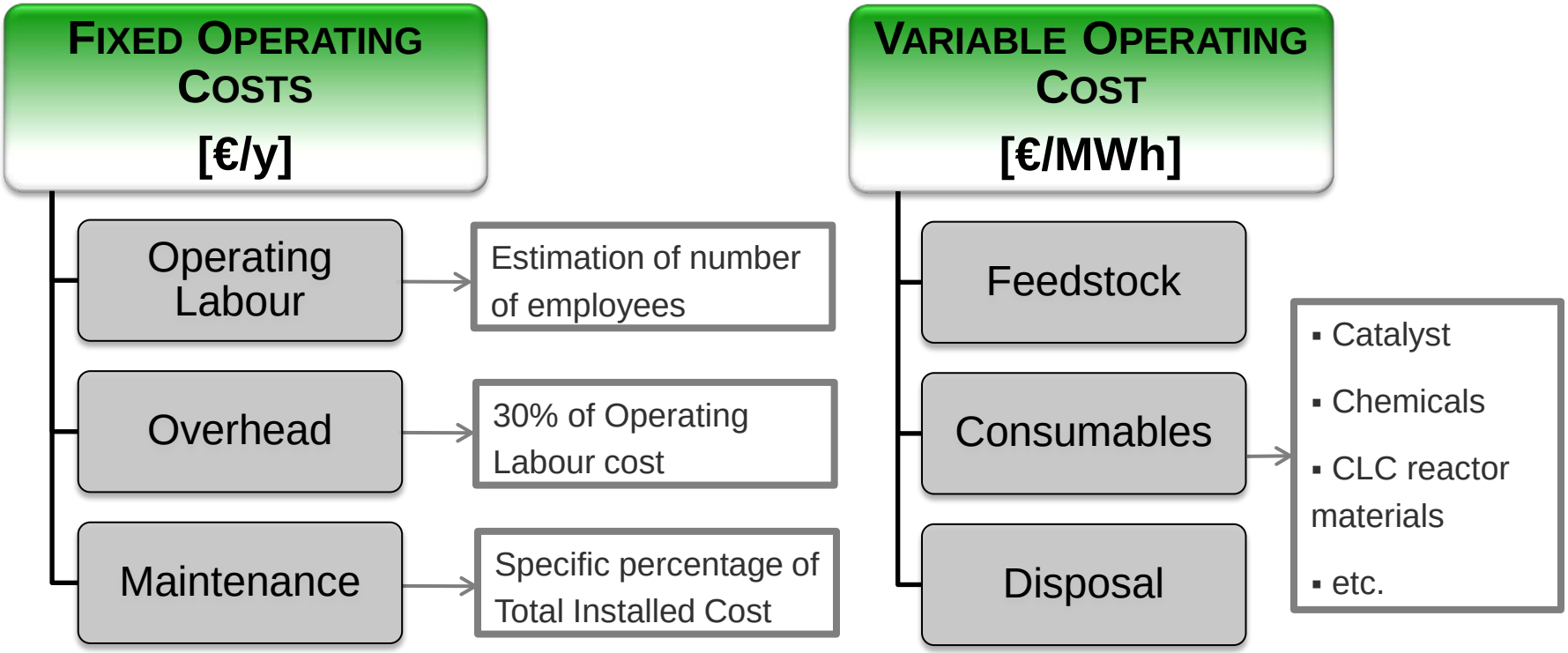
TIC
(from H&MB ➔ sized equipment list)

DIRECT MATERIALS	CONSTRUCTION	OTHER COSTS	OWNER'S COSTS
• Machine and equipment • Bulk materials • I&C equipment • Electrical equipment • Transport to site	• Mechanical erection • Instrument and electrical installation • Civil works • Painting and insulation • Buildings • Site preparation	• Temporary facilities • Solvents, catalysts, chemicals • Commissioning • Training	• Land purchase • Local fees • Other local expenses

TOTAL INSTALLED COST

O&M Costs

O&M Costs
(for a year of normal operation)



Maintenance cost

Plant Sections	Maintenance cost as percentage of the total installed cost
Gasification, Boiler Island	4.0%
ASU, Syngas Treatment, AGR, SRU, Coal storage, CO_2 compression	2.5%
Power Island	5.0%
Balance of Plant	1.7%

Maintenance cost item	Percentage of the total maintenance cost
Materials	60%
Labor	40%

Macroeconomic assumptions for financial modeling

Objective: preliminary estimate of LCOE

- Dates
  - Reference year = 2013
  - Construction start = 2014
  - Commisioning & Operation = 2017
  - Plant life = 25 years
- Plant availability
  - USCPC = 90%
  - IGCC = 87%
- IRR (Discount rate) = 10%
- Inflation rate = 2%
- Depreciation period = 20 years
- Tax on income rate = 35%

Construction period of Power plants	
Construction year	**Percentage of the investment cost**
1	25%
2	45%
3	30%

Unitary costs and prices

Feedstock

- Coal cost = 70 €/t (2014) - subject to inflation rate
- Limestone = 40 €/t (2014) - subject to inflation rate

Products & byproducts

- Electricity price = 77 €/MWh (2013) - subject to inflation rate and Compaund Annual Growth Rate (CAGR) = 0.8%
- Exported LP steam price = evaluated as Electric equivalent (157 kWe per ton of LP steam)
- Sulfur price = 80 €/t (2014) - subject to inflation rate

Example of economic model

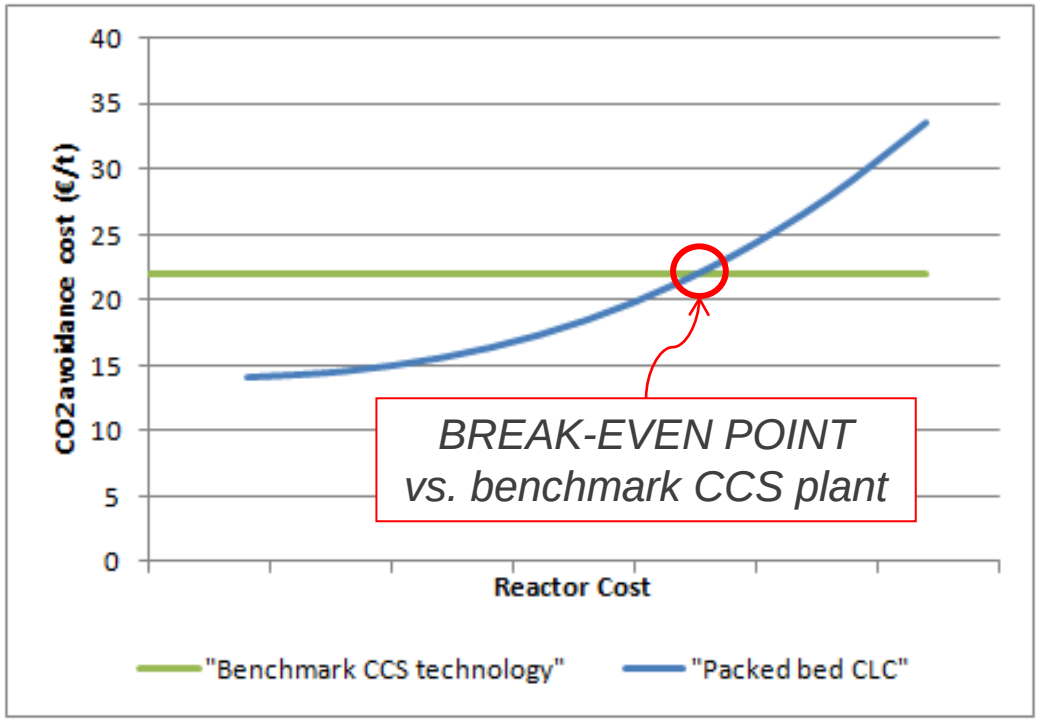
Operating life year counter			0	0	0	0	0	1	2	3	4	5	6	7	8	9	10
Year			2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Operating factor			0%	0%	0%	0%	0%	80%	100%	100%	100%	100%	100%	100%	100%	100%	100%
- **INVESTMENT COST**	(inflated)	M€/y	0,0	0,0	288,0	528,8	359,6	0,0									
FUELS																	
- Coal	**225,2** t/h	€/t	70,75	72,17	73,61	75,08	76,59	78,12	79,68	81,27	82,90	84,56	86,25	87,97	89,73	91,53	93,36
	7621,2 h/y	M€/y	0,00	0,00	0,00	0,00	0,00	107,25	136,74	139,48	142,27	145,11	148,01	150,97	153,99	157,07	160,21
Fuels subtotal		**M€/y**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**107,25**	**136,74**	**139,48**	**142,27**	**145,11**	**148,01**	**150,97**	**153,99**	**157,07**	**160,21**
OTHER CONSUMABLES																	
- Limestone	**20,3** t/h	€/t	39,23	40,02	40,82	41,63	42,46	43,31	44,18	45,06	45,97	46,88	47,82	48,78	49,75	50,75	51,76
	7621,2 h/y	M€/y	0,00	0,00	0,00	0,00	0,00	5,37	6,85	6,99	7,13	7,27	7,41	7,56	7,71	7,87	8,02
Other cons. subtotal		**M€/y**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**5,37**	**6,85**	**6,99**	**7,13**	**7,27**	**7,41**	**7,56**	**7,71**	**7,87**	**8,02**
PRODUCTS																	
+ Electricity	**700,3** MW	€/MWh	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44
	7621 h/y	M€/y	0,00	0,00	0,00	0,00	0,00	351,99	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98
Products subtotal		**M€/y**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**351,99**	**439,98**	**439,98**	**439,98**	**439,98**	**439,98**	**439,98**	**439,98**	**439,98**	**439,98**
CO_2 allowances																	
- CO_2	**552,6** t/h	€/t	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	7621 h/y	M€/y	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
CO_2 subtotal		**M€/y**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
O&M (except of fuels)																	
- Chemicals&Cons.	variable	**M€/y**	0,00	0,00	0,00	0,00	0,00	0,45	0,72	0,73	0,75	0,76	0,78	0,79	0,81	0,82	0,84
- Waste Disposal	variable	**M€/y**	0,00	0,00	0,00	0,00	0,00	17,86	18,21	18,58	18,95	19,33	19,72	20,11	20,51	20,92	21,34
- Labor	fixed	**M€/y**	0,00	0,00	0,00	0,00	0,00	7,61	7,76	7,91	8,07	8,23	8,40	8,57	8,74	8,91	9,09
- Maintenance	fixed	**M€/y**	0,00	0,00	0,00	0,00	0,00	42,69	43,54	44,41	45,30	46,21	47,13	48,07	49,04	50,02	51,02
O&M subtotal		**M€/y**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**68,60**	**70,23**	**71,64**	**73,07**	**74,53**	**76,02**	**77,54**	**79,09**	**80,68**	**82,29**
Working Capital																	
- Working Capital		**M€/y**	0,00	0,00	0,00	0,00	0,00	13,64	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
- **OPERATING COSTS**		**M€/y**	0,00	0,00	0,00	0,00	0,00	194,86	213,82	218,10	222,46	226,91	231,45	236,08	240,80	245,62	250,53
+ **OPERATING INCOME**		**M€/y**	0,00	0,00	0,00	0,00	0,00	351,99	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98
FREE CASH FLOW FOR THE FIRM (FCFF)																	
EBITDA		M€/y	0,00	0,00	0,00	0,00	0,00	157,12	226,16	221,88	217,52	213,07	208,53	203,90	199,18	194,37	189,45
Depreciation		M€/y		0,00	0,00	0,00	0,00	58,82	58,82	58,82	58,82	58,82	58,82	58,82	58,82	58,82	58,82
EBIT		M€/y	0,00	0,00	0,00	0,00	0,00	98,31	167,34	163,07	158,70	154,25	149,72	145,09	140,37	135,55	130,64
Taxes on income		M€/y	0,00	0,00	0,00	0,00	0,00	34,41	58,57	57,07	55,55	53,99	52,40	50,78	49,13	47,44	45,72
FCF		M€/y	0,00	0,00	-288,00	-528,77	-359,56	122,72	167,59	164,81	161,97	159,08	156,13	153,12	150,05	146,92	143,73
Cumulative Discount Factor (DF)		M€/y	1,00	0,91	0,83	0,75	0,68	0,62	0,56	0,51	0,47	0,42	0,39	0,35	0,32	0,29	0,26
Discounted FCF		M€/y	0,00	0,00	-238,02	-397,27	-245,59	76,20	94,60	84,57	75,56	67,47	60,20	53,67	47,81	42,56	37,85

Operating life year counter			11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	0
Year			2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Operating factor			100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	0%
- **INVESTMENT COST**	(inflated)	M€/y																
FUELS																		
- Coal	**225,2** t/h	€/t	95,22	97,13	99,07	101,05	103,07	105,14	107,24	109,38	111,57	113,80	116,08	118,40	120,77	123,18	125,65	128,16
	7621,2 h/y	M€/y	163,42	166,69	170,02	173,42	176,89	180,43	184,04	187,72	191,47	195,30	199,21	203,19	207,25	211,40	215,63	0,00
Fuels subtotal		**M€/y**	**163,42**	**166,69**	**170,02**	**173,42**	**176,89**	**180,43**	**184,04**	**187,72**	**191,47**	**195,30**	**199,21**	**203,19**	**207,25**	**211,40**	**215,63**	**0,00**
OTHER CONSUMABLES																		
- Limestone	**20,3** t/h	€/t	52,80	53,86	54,93	56,03	57,15	58,30	59,46	60,65	61,86	63,10	64,36	65,65	66,96	68,30	69,67	71,06
	7621,2 h/y	M€/y	8,18	8,35	8,52	8,69	8,86	9,04	9,22	9,40	9,59	9,78	9,98	10,18	10,38	10,59	10,80	0,00
Other cons. subtotal		**M€/y**	**8,18**	**8,35**	**8,52**	**8,69**	**8,86**	**9,04**	**9,22**	**9,40**	**9,59**	**9,78**	**9,98**	**10,18**	**10,38**	**10,59**	**10,80**	**0,00**
PRODUCTS																		
+ Electricity	**700,3** MW	€/MWh	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44	82,44
	7621 h/y	M€/y	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	0,00
Products subtotal		**M€/y**	**439,98**	**439,98**	**439,98**	**439,98**	**439,98**	**439,98**	**439,98**	**439,98**	**439,98**	**439,98**	**439,98**	**439,98**	**439,98**	**439,98**	**439,98**	**0,00**
CO_2 allowances																		
- CO_2	**552,6** t/h	€/t	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	7621 h/y	M€/y	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
CO_2 subtotal		**M€/y**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
O&M (except of fuels)																		
- Chemicals&Cons.	variable	**M€/y**	0,86	0,88	0,89	0,91	0,93	0,95	0,97	0,99	1,01	1,03	1,05	1,07	1,09	1,11	1,13	0,00
- Waste Disposal	variable	**M€/y**	21,77	22,20	22,65	23,10	23,56	24,03	24,51	25,00	25,50	26,01	26,53	27,06	27,61	28,16	0,00	0,00
- Labor	fixed	**M€/y**	9,27	9,46	9,65	9,84	10,04	10,24	10,44	10,65	10,86	11,08	11,30	11,53	11,76	12,00	0,00	0,00
- Maintenance	fixed	**M€/y**	52,04	53,08	54,14	55,22	56,33	57,45	58,60	59,78	60,97	62,19	63,43	64,70	66,00	67,32	0,00	0,00
O&M subtotal		**M€/y**	**83,94**	**85,61**	**87,33**	**89,07**	**90,86**	**92,67**	**94,53**	**96,42**	**98,34**	**100,31**	**102,32**	**104,36**	**106,45**	**108,58**	**1,13**	**0,00**
Working Capital																		
- Working Capital		**M€/y**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-13,64	0,00
- **OPERATING COSTS**		**M€/y**	255,54	260,65	265,86	271,18	276,60	282,14	287,78	293,53	299,40	305,39	311,50	317,73	324,09	330,57	213,92	0,00
+ **OPERATING INCOME**		**M€/y**	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	439,98	0,00
FREE CASH FLOW FOR THE FIRM (FCFF)																		
EBITDA		M€/y	184,44	179,33	174,12	168,80	163,38	157,85	152,20	146,45	140,58	134,59	128,48	122,25	115,90	109,42	226,06	0,00
Depreciation		M€/y	58,82	58,82	58,82	58,82	58,82	58,82	58,82	58,82	58,82	58,82	0,00	0,00	0,00	0,00	0,00	0,00
EBIT		M€/y	125,63	120,52	115,30	109,99	104,56	99,03	93,39	87,63	81,76	75,77	128,48	122,25	115,90	109,42	226,06	0,00
Taxes on income		M€/y	43,97	42,18	40,36	38,49	36,60	34,66	32,69	30,67	28,62	26,52	44,97	42,79	40,56	38,30	79,12	0,00
FCF		M€/y	140,47	137,15	133,76	130,31	126,78	123,19	119,52	115,78	111,96	108,07	83,51	79,46	75,33	71,12	146,94	0,00
Cumulative Discount Factor (DF)		M€/y	0,24	0,22	0,20	0,18	0,16	0,15	0,14	0,12	0,11	0,10	0,09	0,08	0,08	0,07	0,06	0,06
Discounted FCF		M€/y	33,63	29,85	26,46	23,44	20,73	18,31	16,15	14,22	12,50	10,97	7,71	6,67	5,75	4,93	9,26	0,00

NPV	M€	0
IRR	%	**10,0%**

COAC & Breakeven

$$\text{Cost of } CO_2 \text{ avoidance} = \frac{LCOE_{CCS} - LCOE_{Reference}}{CO_2\text{Emissions}_{Reference} - CO_2\text{Emissions}_{CCS}} \quad [€/\text{tonne } CO_2]$$



CO_2 avoidance cost (COAC)

Indicates how much it costs to capture CO_2 with the assessed CLC plant with respect to the benchmark plant without CO_2 capture

Agenda

- Introduction
- Steps and methodology for the commercial evaluation of the technology
- Overview of the benchmark technologies: example of performances and costs
- Summary conclusions

Benchmark Technologies

Case	Feedstock	Type	Main Product	CCS	CLC
1 (*)	Coal	USC-PC	Power	No	-
2	Coal	USC-PC	Power	Yes	-
3 (*)	Coal	IGCC	Power	No	-
4	Coal	IGCC	Power	Yes	-
5…..	**Coal**	**IGCC**	**Power**	**Yes**	**Yes**

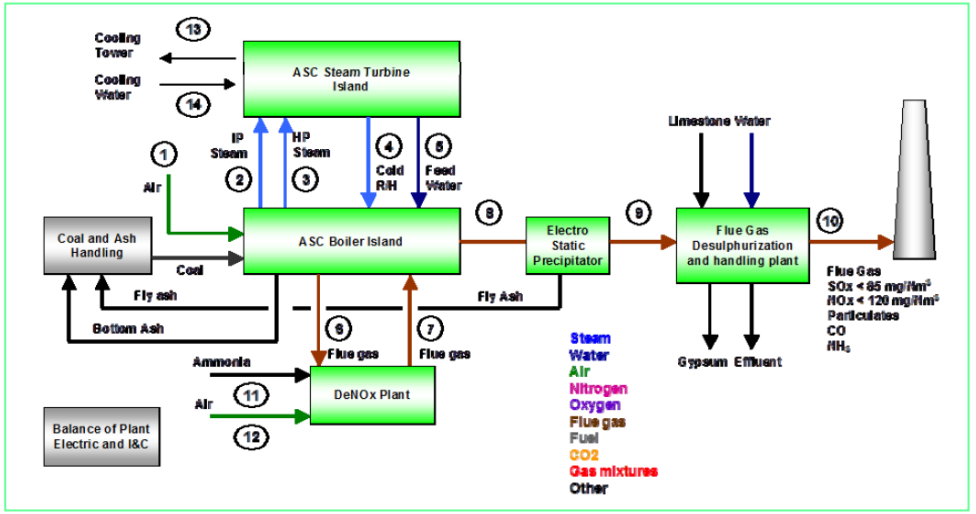
(*) *Reference technology for CO_2 avoidance cost calculation*

Plant Performance (preliminary)

Case 1 – USC-PC without carbon capture

	Unit	Value
Coal input	kg/s	66.6
Coal thermal input	MWth (LHV)	1676.6
Gross Power Output	MWe	861.4
Net Power Output	MWe	758.7
Net electric efficiency	% (LHV)	45.25
Carbon capture ratio	%	-
CO_2 equivalent emission	g/kWh	768

Preliminary, for reference only



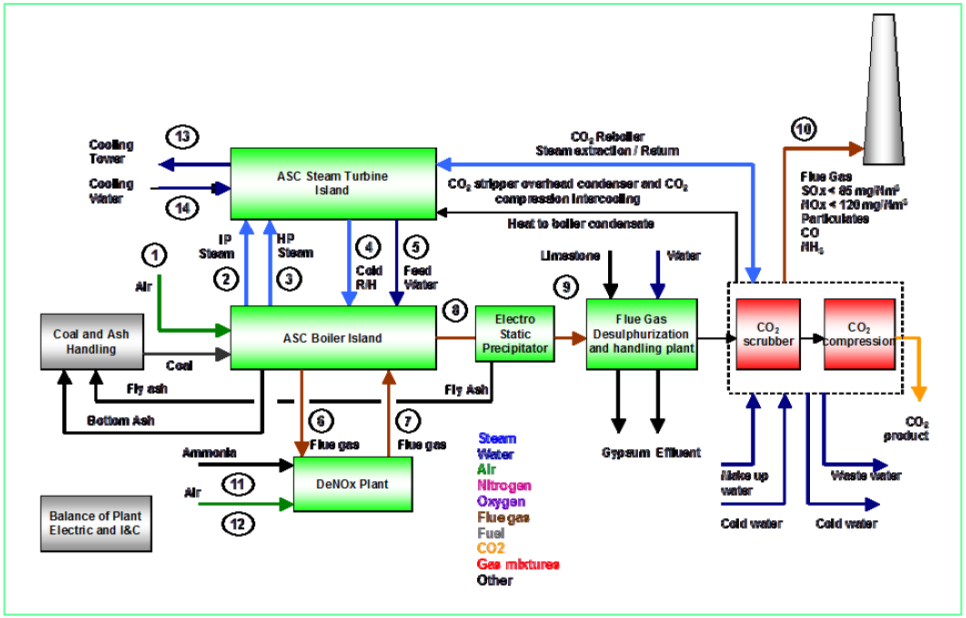
Deliverable 5.1 (Figure 2.1)

Plant Performance (preliminary)

Case 2 – USC-PC with carbon capture

	Unit	Value
Coal input	kg/s	66.6
Coal thermal input	MWth (LHV)	1676.6
Gross Power Output	MWe	686.9
Net Power Output	MWe	580
Net electric efficiency	% (LHV)	33.5
Carbon capture ratio	%	90.43
CO_2 equivalent emission	g/kWh	104

Preliminary, for reference only



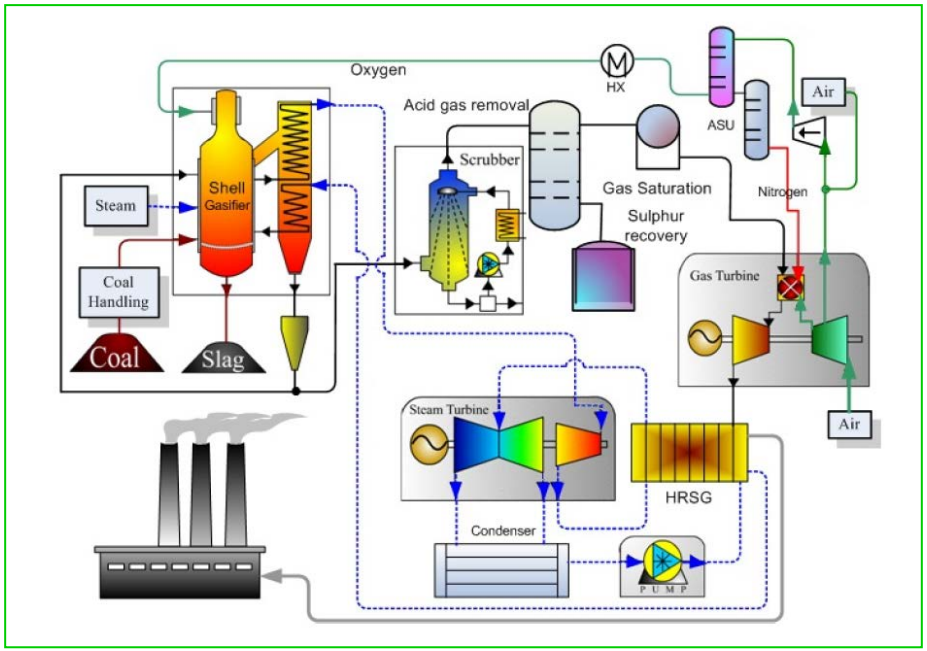
Deliverable 5.1 (Figure 2.2)

Plant Performance

Case 3 - IGCC without carbon capture

	Unit	Value
Coal input	kg/s	30.5
Coal thermal input	MWth (LHV)	817.4
Gross Power Output	MWe	439
Net Power Output	MWe	369
Net electric efficiency	% (LHV)	45.2
Carbon capture ratio	%	-
CO_2 equivalent emission	g/kWh	766

Preliminary, for reference only



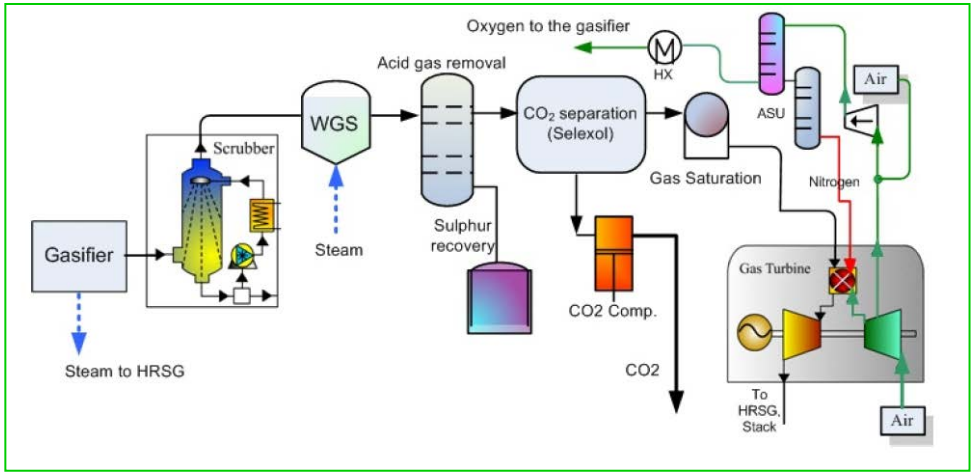
EBTF (Figure 8.2)

Plant Performance

Case 3 - IGCC with carbon capture

	Unit	Value
Coal input	kg/s	33.7
Coal thermal input	MWth (LHV)	904
Gross Power Output	MWe	430
Net Power Output	MWe	317
Net electric efficiency	% (LHV)	35.1
Carbon capture ratio	%	93
CO_2 equivalent emission	g/kWh	103

Preliminary, for reference only



EBTF (Figure 8.3)

TIC (preliminary)

Case 3 - IGCC without carbon capture

FOSTER WHEELER

CASE 3 - ESTIMATE SUMMARY

Project Demoys
Date: Sept 2012 REV. 0

FIGURES IN EURO

POS	DESCRIPTION	UNIT 900 €	950 €	1000 €	2000 €	2100 €	2200 €	3000 €	BOP €	TOTAL €
1	DIRECT MATERIALS	61,259,000	11,574,000	109,919,000	11,731,000	18,221,000	15,781,000	179,910,000	111,376,000	519,771,000
2	CONSTRUCTION	16,322,000	2,055,000	43,931,000	5,169,000	7,562,000	6,307,000	39,948,000	54,406,000	175,700,000
3	OTHER COSTS	2,337,000	1,105,000	15,729,000	3,067,000	8,162,000	2,108,000	17,163,000	10,624,000	60,295,000
A	**Total Installed costs**	**79,918,000**	**14,734,000**	**169,579,000**	**19,967,000**	**33,945,000**	**24,196,000**	**237,021,000**	**176,406,000**	**755,766,000**
B	Owner's cost (5% of A)									37,800,000
	TOTAL INVESTMENT COST									**793,566,000**

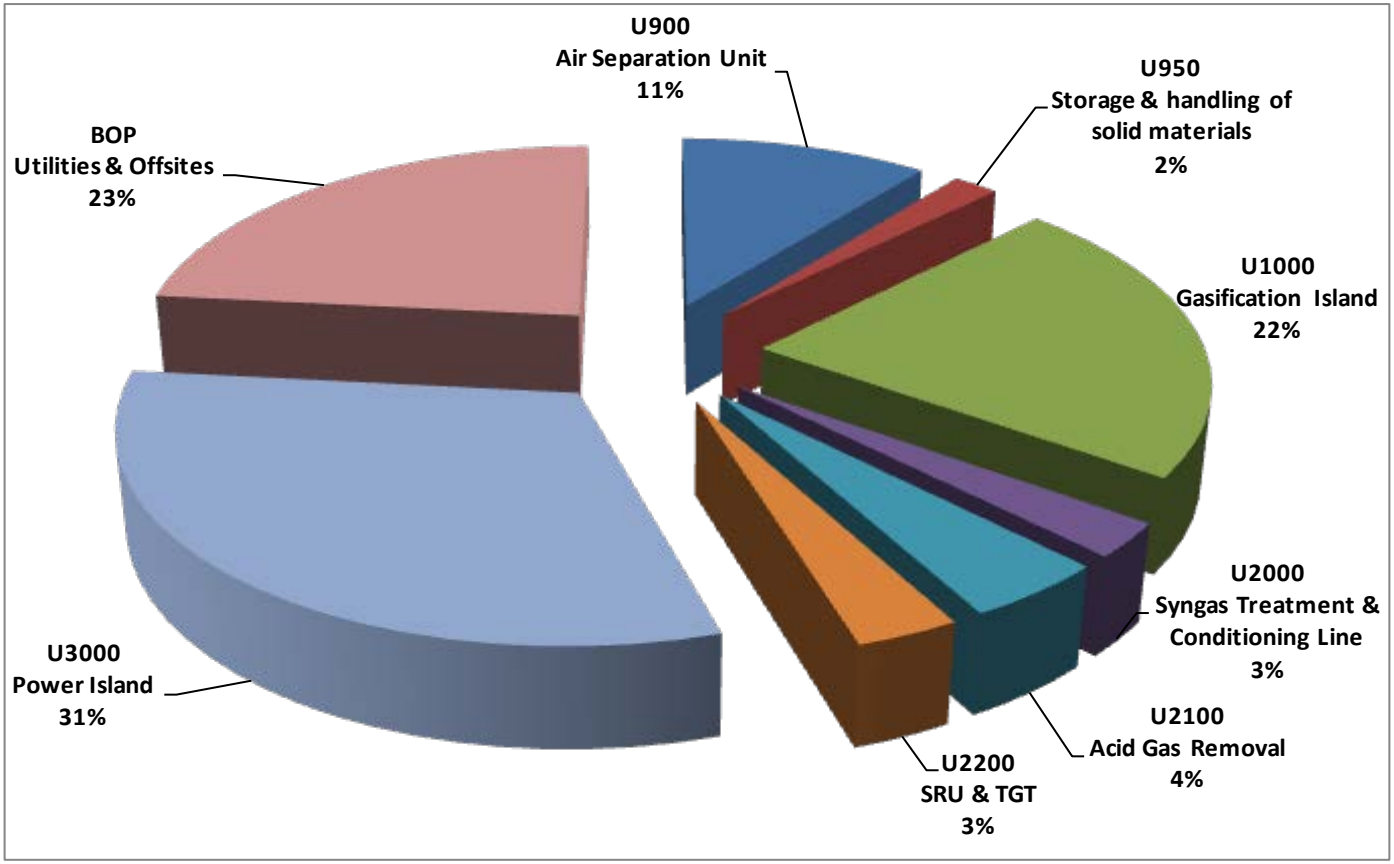
REMARKS

1) ESTIMATE ACCURACY +/- 35%
2) TODAY COSTS @ 2Q2012
3) EXCLUSIONS:
- TAXES AND LOCAL AUTHORITIES
- CAPITAL AND OPERATION SPARE PARTS
- START-UP COSTS
- FINANCIAL/LEGAL/INSURANCE COSTS
- V.A.T.
- LICENSE (except of Gasification and AGR)

UNIT	
900	ASU
950	Storage and Handling of solid materials
1000	Gasification Island
2000	Syngas treatment & conditioning line
2100	Acid Gas Removal
2200	SRU & TGT
3000	Power Island
BOP	Utilities&Offsites
369.2	MWe, Net Power Output
2149	€/MWe, Specific Investment Cost

TIC (preliminary)

Case 3 - IGCC without carbon capture



O&M (preliminary)

Case 3 - IGCC without carbon capture

FOSTER WHEELER		Project:	Demoys
		Date:	October 2012
		Revision:	Rev 0

Maintenance Costs (2013) - Case 3

Complex section	Maintenance %	Capital Cost Euro	Maintenance Euro/Year
Unit 900 - Air separation Unit	2.5	79,918,000	1,998,000
Unit 950 - Feedstock handling & prep.	4.0	14,734,000	589,000
Unit 1000 - Gasification Island	4.0	169,579,000	6,783,000
Unit 2000 - Syngas treatment&cond. line	2.5	19,967,000	499,000
Unit 2100 - Acid Gas Removal Unit	2.5	33,945,000	849,000
Unit 2200 - SRU & TGT	2.5	24,196,000	605,000
Unit 3000 - Combined Cycle	5.0	237,021,000	11,851,000
BOP - Balance of Plant (BOP)	1.7	176,406,000	2,999,000
TOTAL		755,766,000	**26,173,000**
		Maint. % =	3.5

Total O&M Costs (2013) - Case 3

		Euro/year
Fixed Costs	Direct labour	8,400,000
	Adm./gen overheads	2,520,000
	Maintenance	26,173,000
	Subtotal	**37,093,000**
Variable Costs	Feedstock (coal)	65,969,000
	Fluxant	1,049,000
	Make-up water	1,396,000
	Solvent, Chemicals & Catalysts	2,008,000
	Subtotal	**70,422,000**
TOTAL O&M COSTS		**107,515,000**

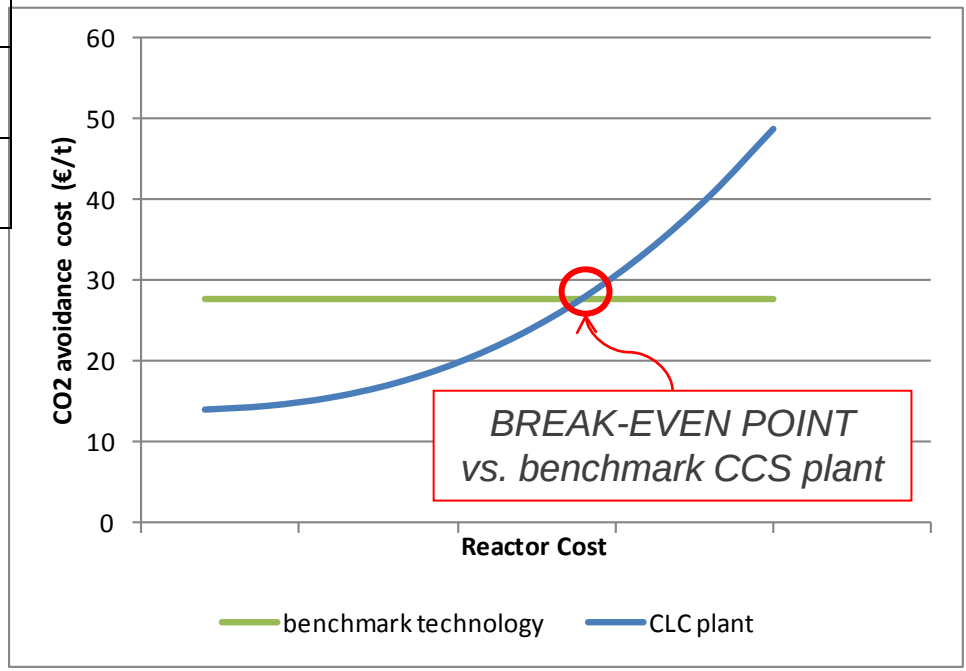
Coal IGCC Plants

	ASU	Gasification	Power Island & Utilities	TOTAL	Notes
OPERATION					
Area Responsible	1	1	1	3	daily position
Assistant Area Responsible	1	1	1	3	daily position
Shift Superintendent		5		5	1 position per shift
Electrical Assistant		5		5	1 position per shift
Shift Supervisor	5	5	5	15	3 positions per shift
Control Room Operator	5	10	10	25	5 positions per shift
Field Operator	5	30	20	55	10 positions per shift
Subtotal				**111**	
MAINTENANCE					
Mechanical group		4		4	daily position
Instrument group		7		7	daily position
Electrical group		5		5	daily position
Subtotal				**16**	
LABORATORY					
Superintendent+Analysts		6		6	daily position
Subtotal				**6**	
TOTAL				**133**	

Financial modeling and sensitivity analysis

IGCC-based cases		Case 3	Case 4
Net Electric Power Output	*MW*	369,2	317,2
Levelized Cost of Electricity (LCOE)	***€/MWh***	**90,50**	**119,53**
Carbon capture ratio	*%*	-	93
CO_2 released to atmosphere	t_{CO2}/h	423,6	32,8
CO_2 specific emission (Emission/Output)	t_{CO2}/MWh	1,147	0,103
Cost of CO_2 avoidance	**$€/t_{CO2}$**	**-**	**27,80**

Example of the results



Agenda

- Introduction
- Steps and methodology for the commercial evaluation of the technology
- Overview of the benchmark technologies: example of performances and costs
- Summary conclusions

Summary conclusions

- The route to evaluate the strategic values of the new CLC technology has been clearly identified
- Methodological approach to be followed for the potential commercialization of the full-scale plant has been settled
- Assessment of the benchmark technologies is almost complete
- Steps forward up to conclusion of the project are:
  - Complete assessment for the benchmark technologies
  - Make design and economical modeling of the CLC plant at full scale (consider feedback from the Puertollano IGCC plant)
  - Perform sensitivity analyses to evaluate the commercial attractiveness of the CLC technology

THANK YOU
FOR YOUR ATTENTION

Foster Wheeler Italiana:

Luca_Mancuso@fwceu.com

www.fosterwheeler.it