Commercial feasibility of integrated gasification combined cycle (IGCC)

Francisco García Peña – ELCOGAS Puertollano IGCC plant

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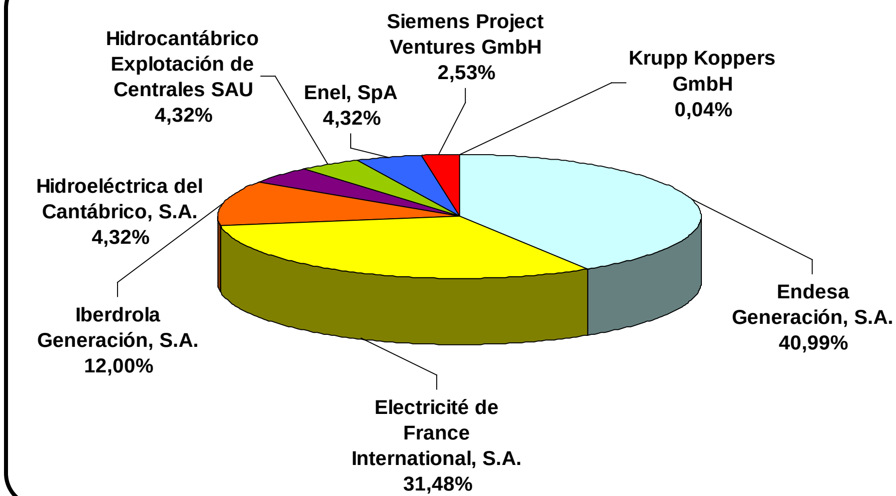
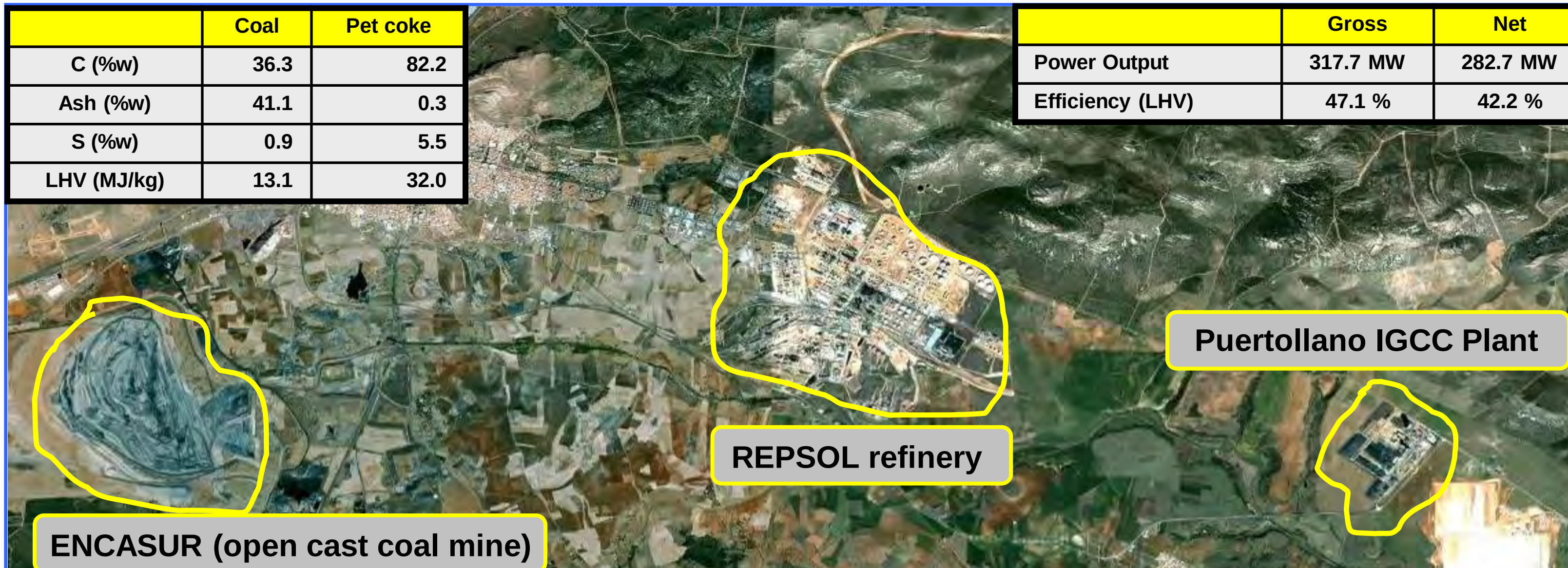
The ELCOGAS company

ELCOGAS is an Spanish company established in April 1992 to undertake the planning, construction, management and operation of a 335 MWe_{ISO} IGCC plant located in Puertollano (Spain)



	Coal	Pet coke
C (%w)	36.3	82.2
Ash (%w)	41.1	0.3
S (%w)	0.9	5.5
LHV (MJ/kg)	13.1	32.0

	Gross	Net
Power Output	317.7 MW	282.7 MW
Efficiency (LHV)	47.1 %	42.2 %



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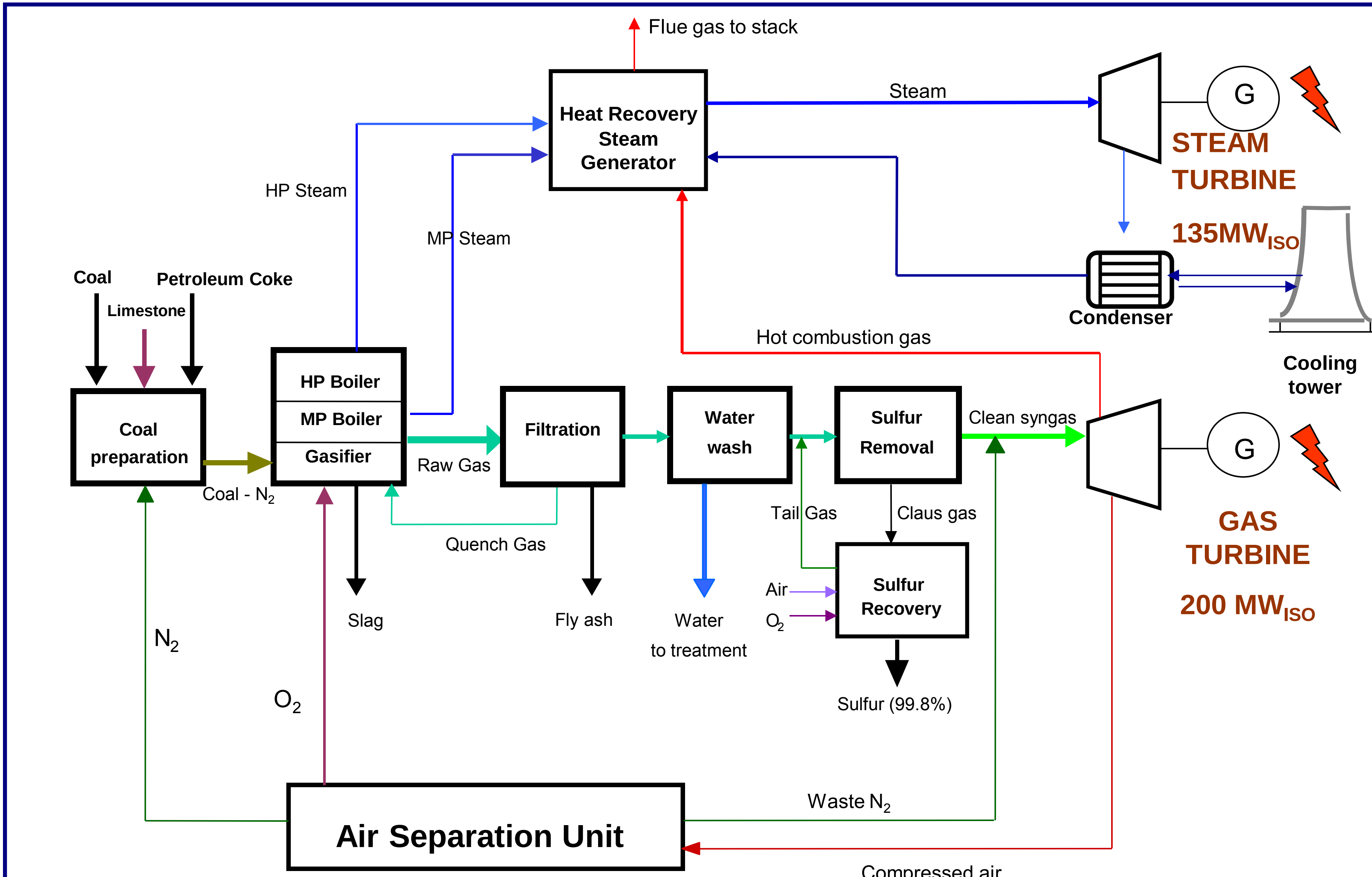
Description of the IGCC process



Description of the IGCC process

Fuel design values

Fuel design is a mixture 50/50 of coal/coke which now is 45/55. Moreover some tests with biomass were undertaken (meat bone meal, grape seed meal, olive oil waste).

Fuel

	COAL	PET COKE	FUEL MIX (50:50)
Moisture (%w)	11.8	7.00	9.40
Ash (%w)	41.10	0.26	20.68
C (%w)	36.27	82.21	59.21
H (%w)	2.48	3.11	2.80
N (%w)	0.81	1.90	1.36
O (%w)	6.62	0.02	3.32
S (%w)	0.93	5.50	3.21
LHV (MJ/kg)	13.10	31.99	22.55

Syngas composition

RAW GAS			CLEAN GAS		
	Real average	Design		Real average	Design
CO (%)	59.26	61.25	CO (%)	59.30	60.51
H_2 (%)	21.44	22.33	H_2 (%)	21.95	22.08
CO_2 (%)	2.84	3.70	CO_2 (%)	2.41	3.87
N_2 (%)	13.32	10.50	N_2 (%)	14.76	12.5
Ar (%)	0.90	1.02	Ar (%)	1.18	1.03
H_2S (%)	0.81	1.01	H_2S (ppmv)	3	6
COS (%)	0.19	0.17	COS (ppmv)	9	6
HCN (ppmv)	23	38	HCN (ppmv)	-	3

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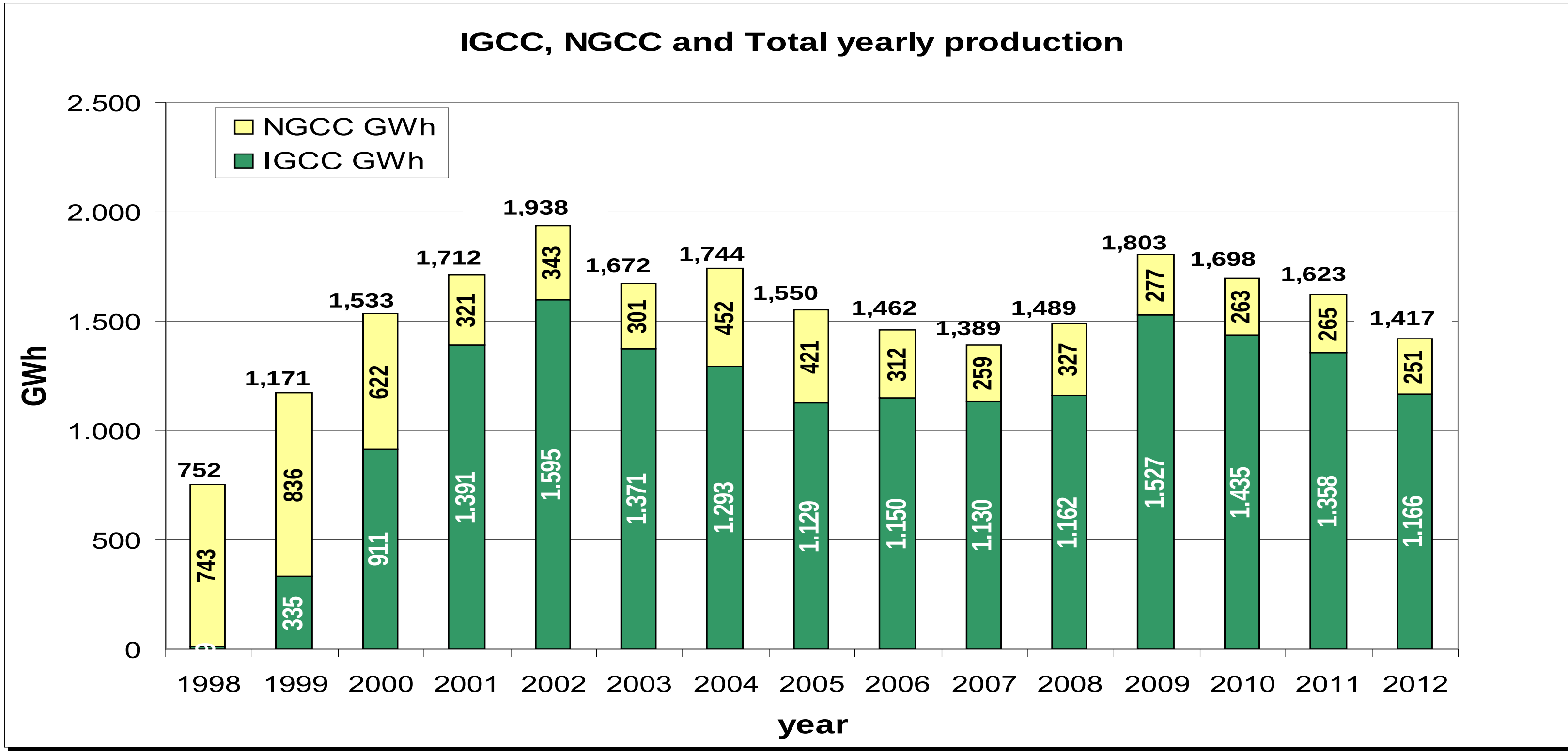
Operational data: Annual energy production



1st 5 years: Learning curve

2003: Major overhaul Gas Turbine findings

2004 & 2005: Gas turbine main generation transformer isolation fault

2006: Gas turbine major overhaul & candle fly ash filters crisis

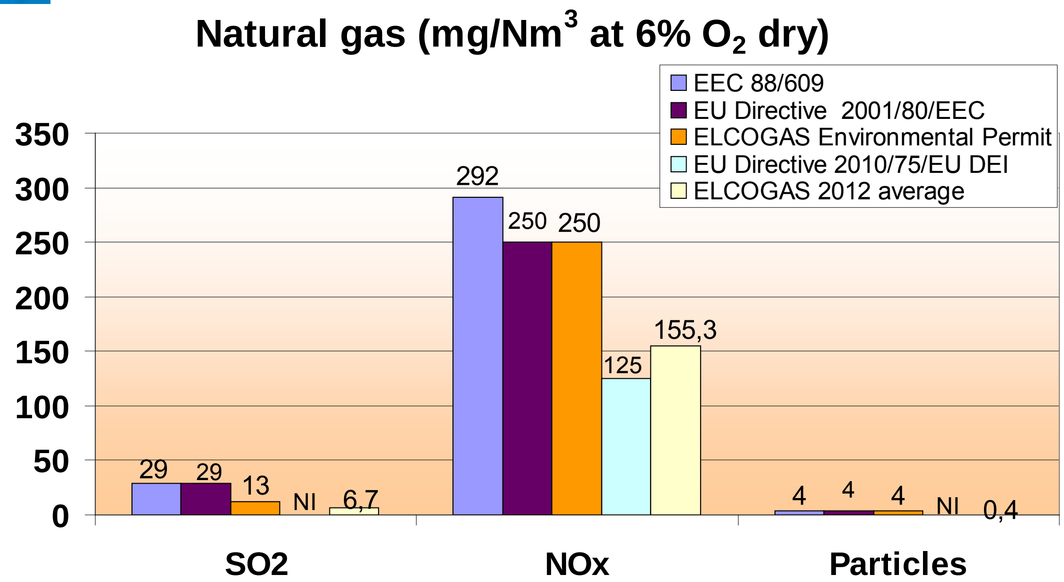
2007 & 2008: ASU WN_2 compressor coupling fault and repair MAN TURBO

2010: No operation due to non-profitable electricity price (30-40 days).

2011: 100,000 EOH Major Overhaul

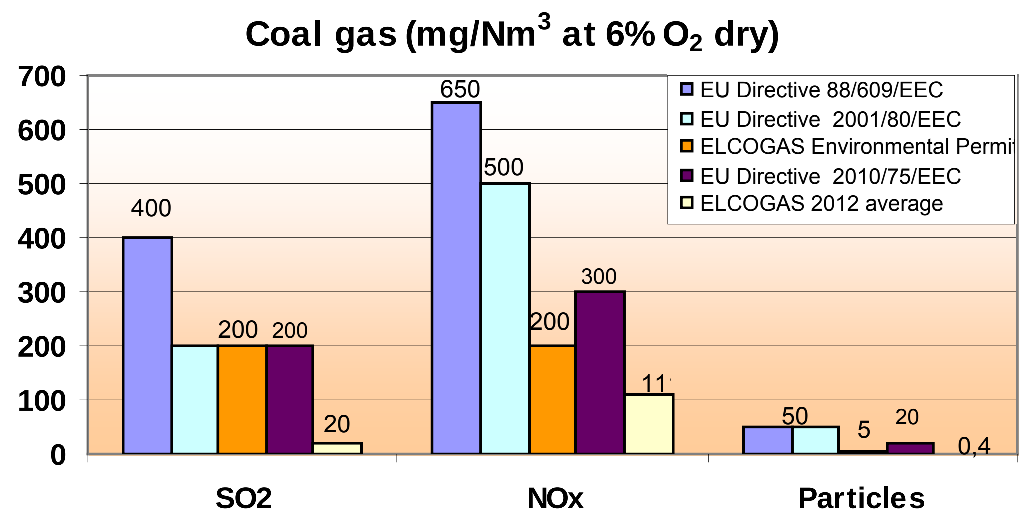
2012: **1,498 hours in stand-by due to regulatory restrictions**

Operational data: Emissions 2012



Natural gas (NGCC)

Coal gas (IGCC)



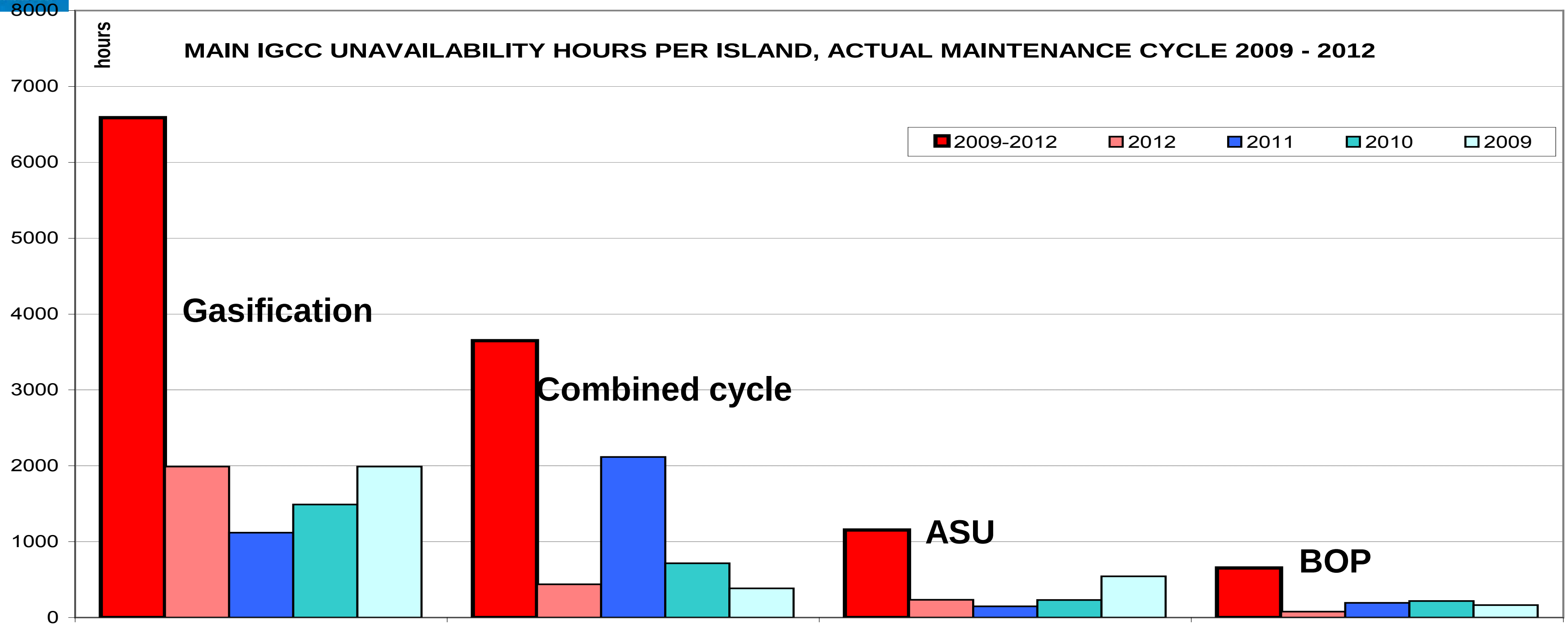
ELCOGAS power plant emissions in NGCC & IGCC modes

Operational data: Variable Cost

Fuel mode	Fuel	Consume (GJ_{PCS})	Production (GWh)	Heat rate (GJ_{PCS}/GWh)	Fuel cost (€/GJ_{PCS})	Partial cost (€/MWh)	Total cost (€/MWh)
GT	Natural gas	59,987	2.891	20,748	10.46	216.98	**216.98**
NGCC	**Natural gas**	**249,495**	**22.154**	**11,262**	**10.46**	**117.77**	**117.77**
NGCC + ASU	Natural gas	1,854,675	155.148	11,954	10.46	125.01	**125.01**
NGCC+ASU+ Gasifier (by flare)	Natural gas	351,147	33.373	10,522	10.46	110.03	**128.69**
	Coal	67,459		2,021	3.49	7.05	
	Petocke	195,947		5,871	1.98	11.61	
IGCC	**NG auxiliar consumption**	**257,700**	**992.811**	**260**	**10.46**	**2.71**	**26.30**
	Coal	**2,536,891**		**2,555**	**3.49**	**8.91**	
	Petocke	**7,368,734**		**7,422**	**1.98**	**14.67**	

Note: Net energy variable costs (average 2012)

Unavailability in 4 years maintenance cycle (2009 – 2012)

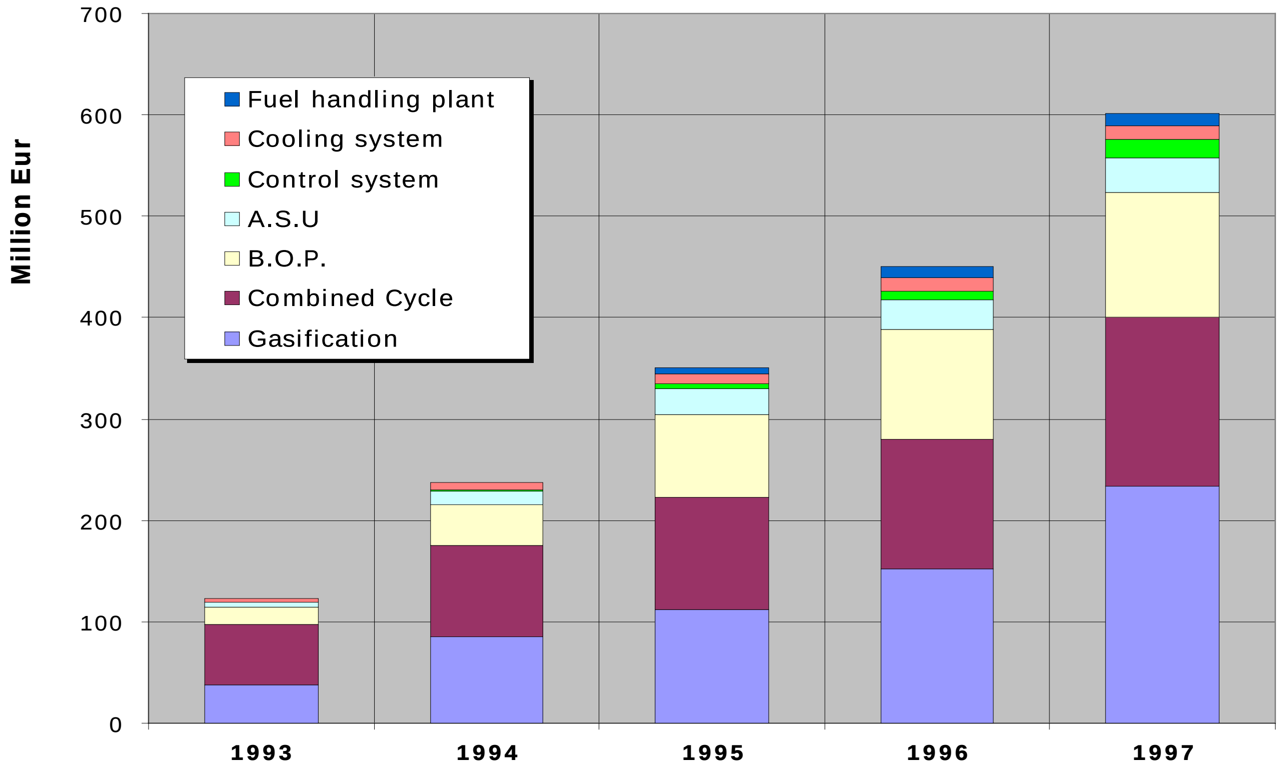


Technology at demonstration state

- First four large coal-based plants (USA & EU, 1994 - 1998) show 60-80% of IGCC availability (> 90 % considering auxiliary fuel)
- Main unavailability causes related with its maturity lack :
  - Auxiliary system design: solid handling, downtime corrosion, ceramic filters, materials and procedures
  - Performance of last generation turbines with syngas or natural gas
  - Excessive integration between units. High dependence and start-up delay
  - More complex process compared to other coal-based plants. Learning is necessary. IGCC power plants using petroleum wastes show higher availability than 92%

Operational data: Costs

ACCUMULATED INVESTMENT COST COSTS:

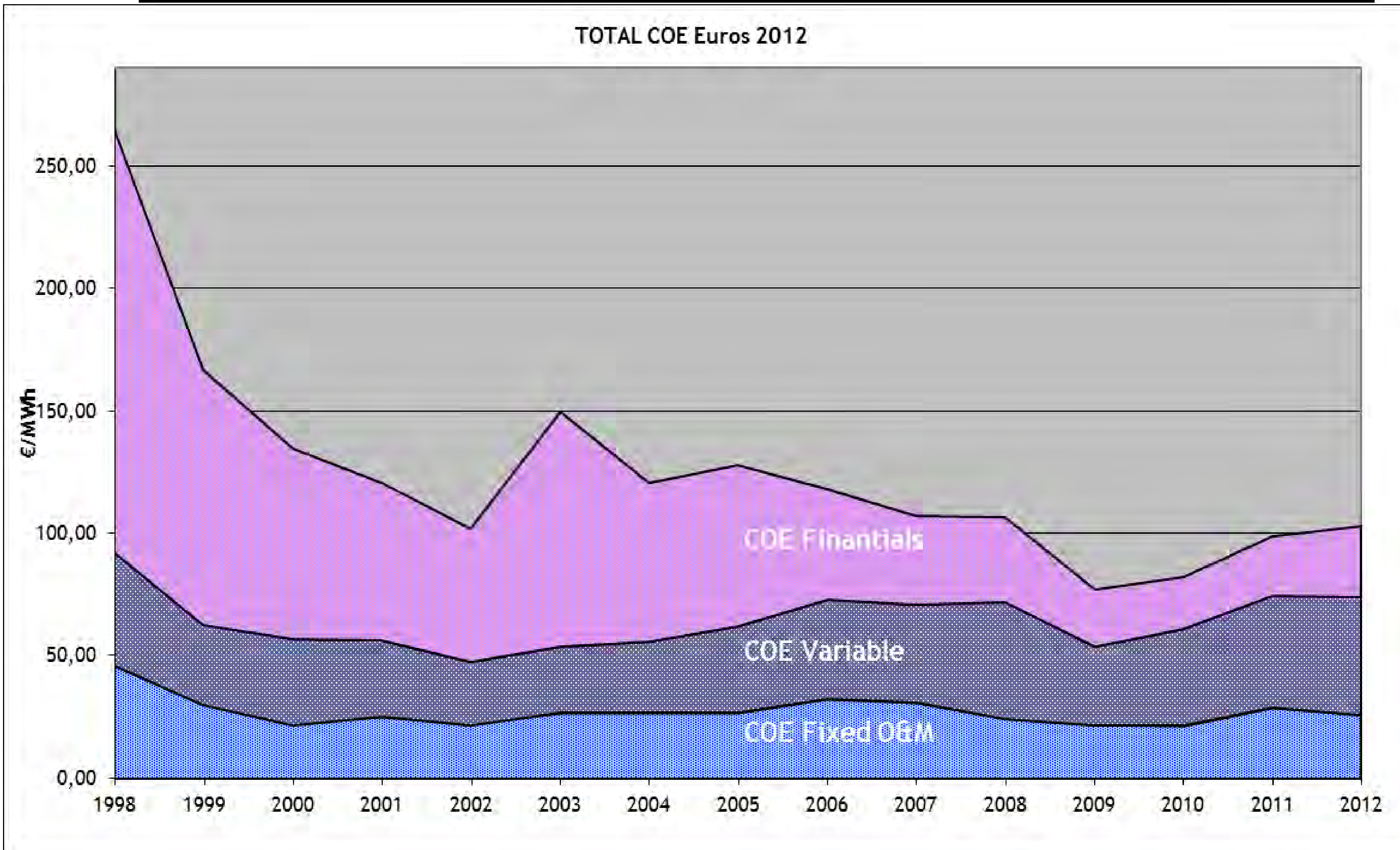


REPRESENTATIVE YEAR (2008) OPERATING COSTS,

WITHOUT FINANCIAL COSTS: Total: **83.602 K€ (57.90 €/MWh)**

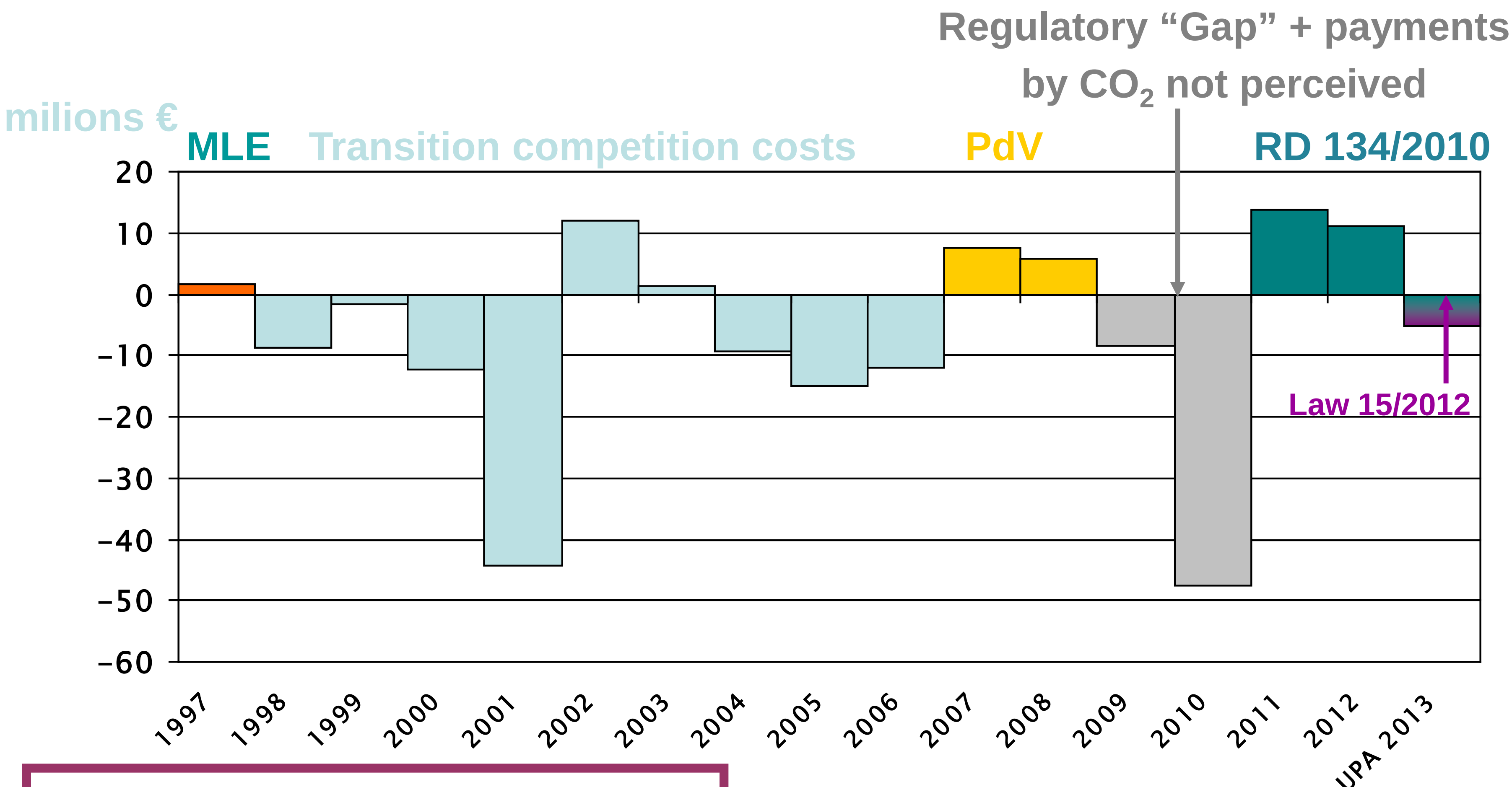
- **Fixed costs:**
  - Total: 29.441 K€ (20.39 €/MWh)
- **Variable costs:**
  - Fuels: 54.276 K€ (37.59 €/MWh)

Cost Of Electricity €/MWh



Operational data: Economic results

Benefit or lost before taxes, is directly related to the regulatory framework of each time.



Σ Losts 110,7 milions €

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1.4 CO_2 separation and H_2 production

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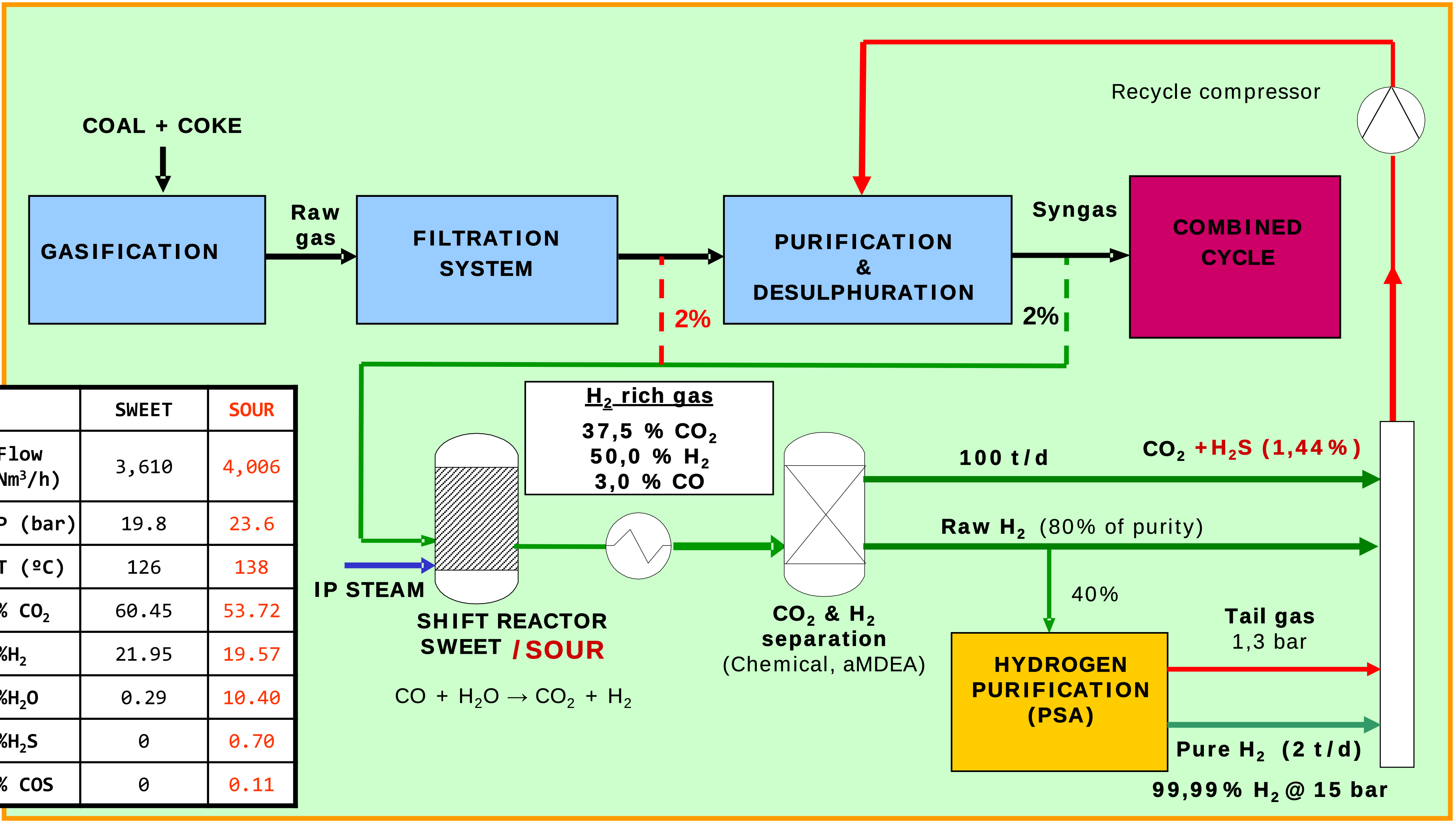
2.2 Engineering plant modifications

2.3 “Demonstration project”

2.4 CO_2 capture experience

CO_2 separation and H_2 production



	SWEET	SOUR
Flow (Nm^3/h)	3,610	4,006
P (bar)	19.8	23.6
T (ºC)	126	138
% CO_2	60.45	53.72
%H_2	21.95	19.57
%H_2O	0.29	10.40
%H_2S	0	0.70
% COS	0	0.11

CO_2 capture & H_2 production pilot plant

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What is gasification?

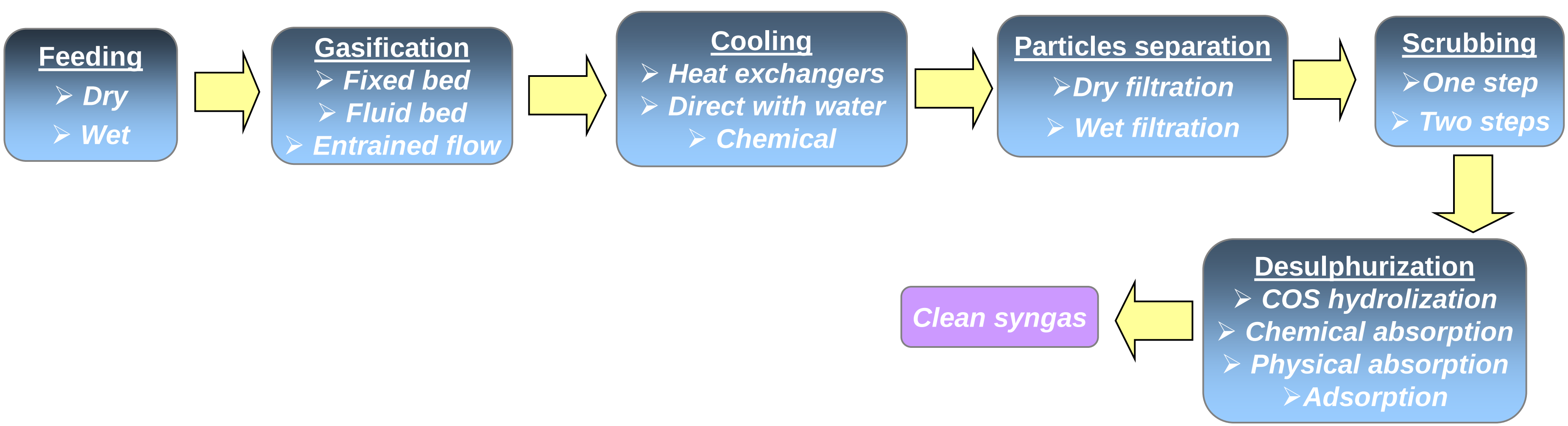
Gasification itself is not the core neither the root of the project nor plant problematic. It is the design, detailed design, of the auxiliary systems.

Each plant is different because they depend on:

- Available raw fuel
- Chosen gasifier technology
- Expected use of syngas
- Environmental regulations

<u>So Engineering & O&M expertise are crucial</u>

➢ Syngas production by gasification. Processes



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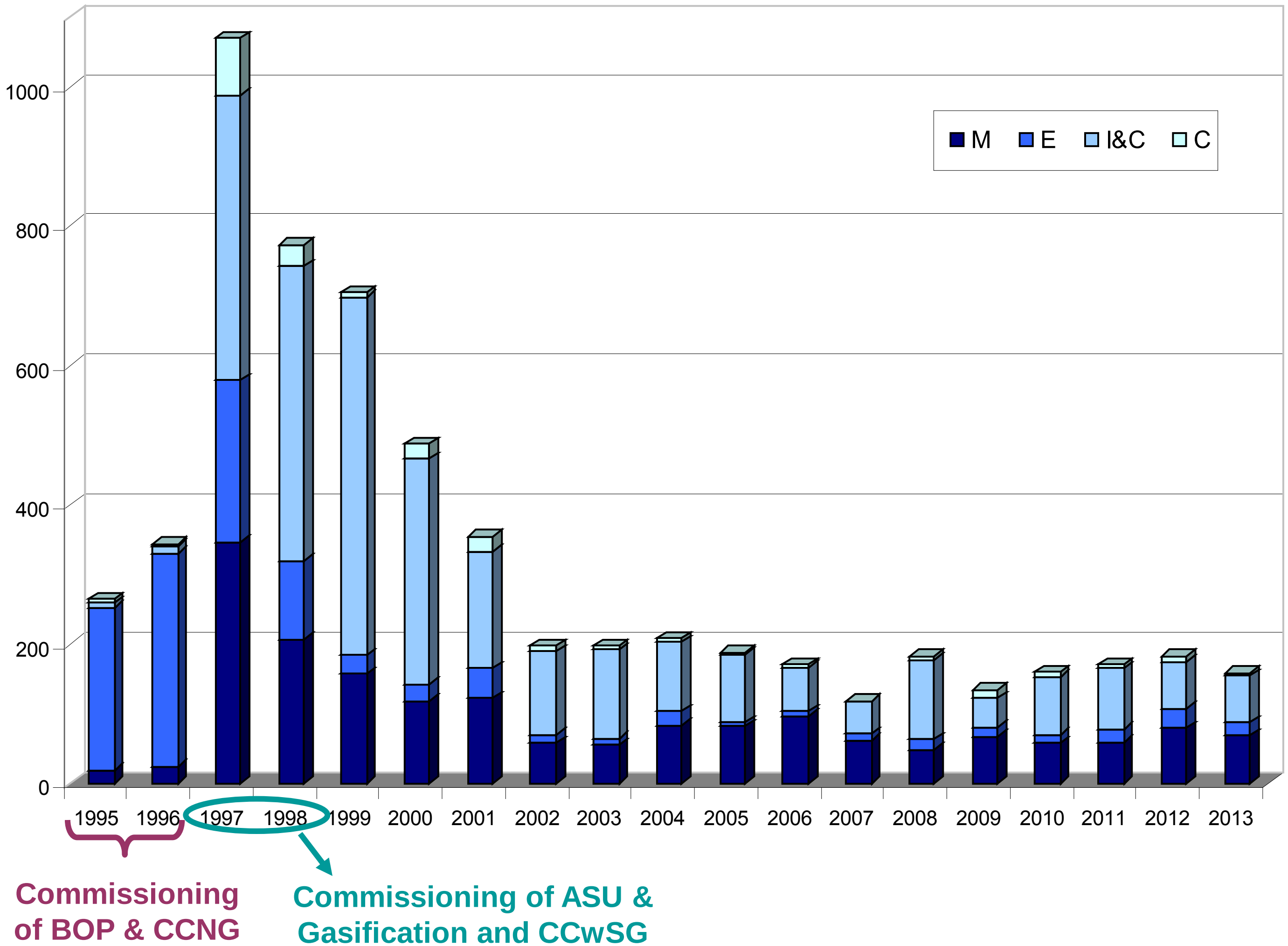
Engineering plant modifications

ANNUAL EVOLUTION OF APPROVED DESIGN CHANGES



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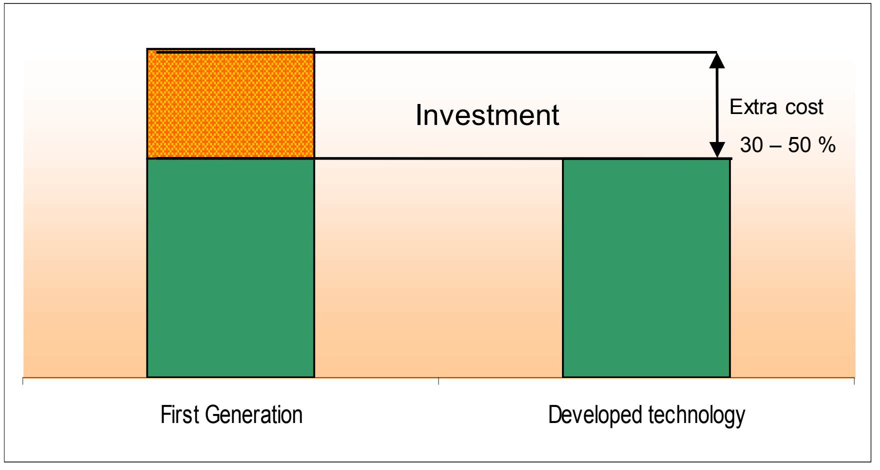
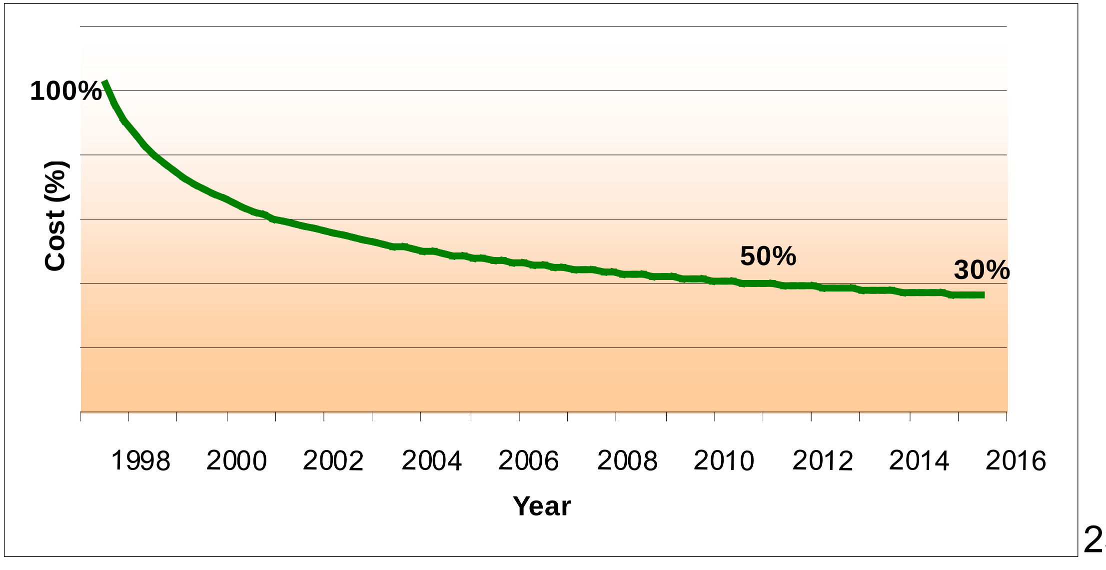
Investment costs at ELCOGAS. Learning



REGULATORY SUPPORT Is essential in technology demonstration project at commercial scale

Total production cost



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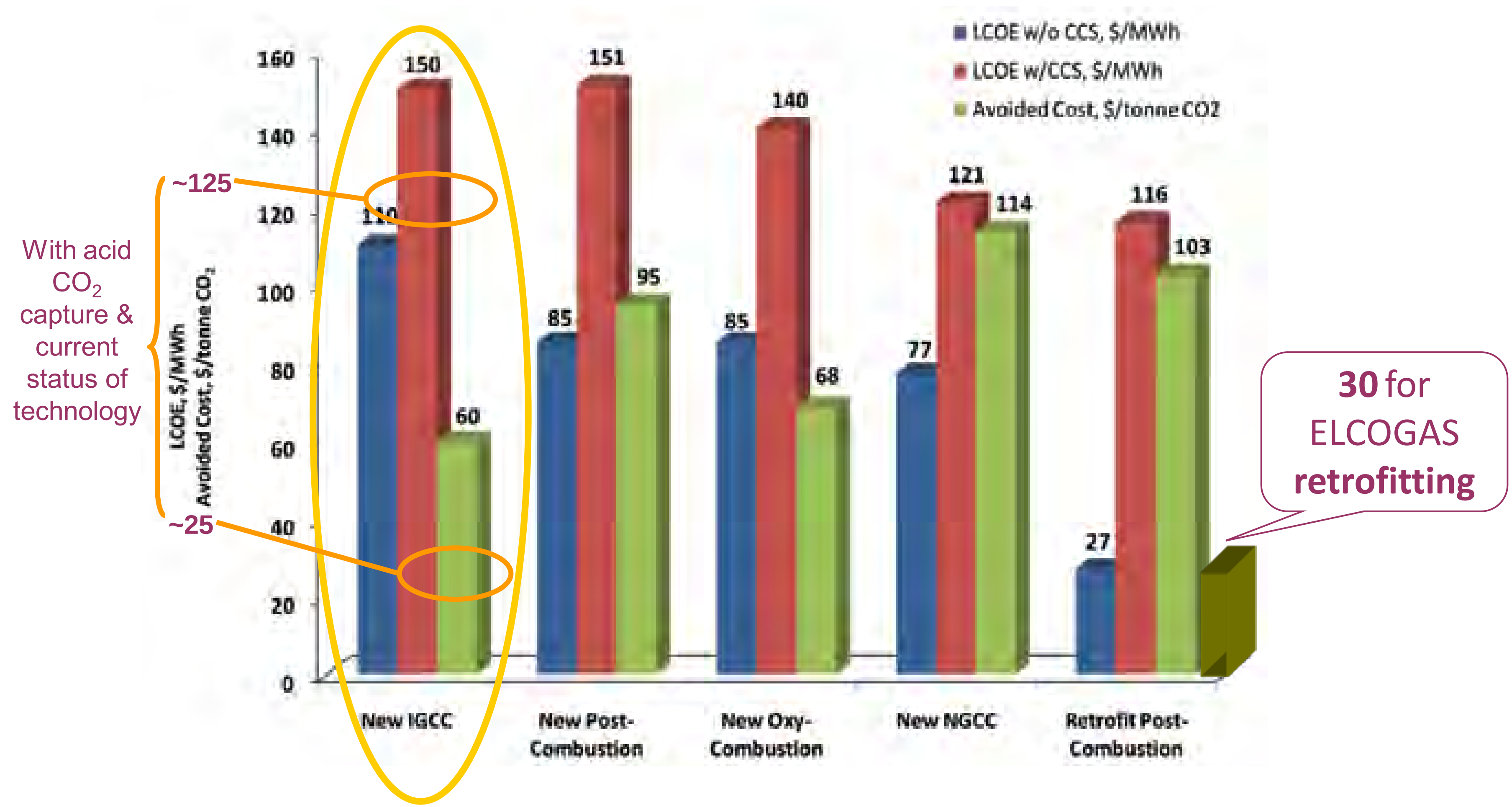
Real experience at ELCOGAS: Pilot plant

Comparison between costs of CO_2 capture technologies

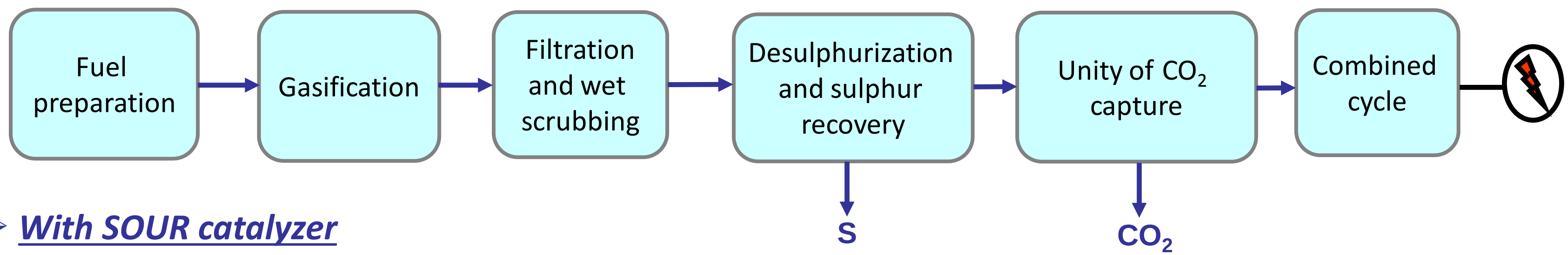


Source: *DOE/NETL CCS RD&D ROADMAP (December 2010)*

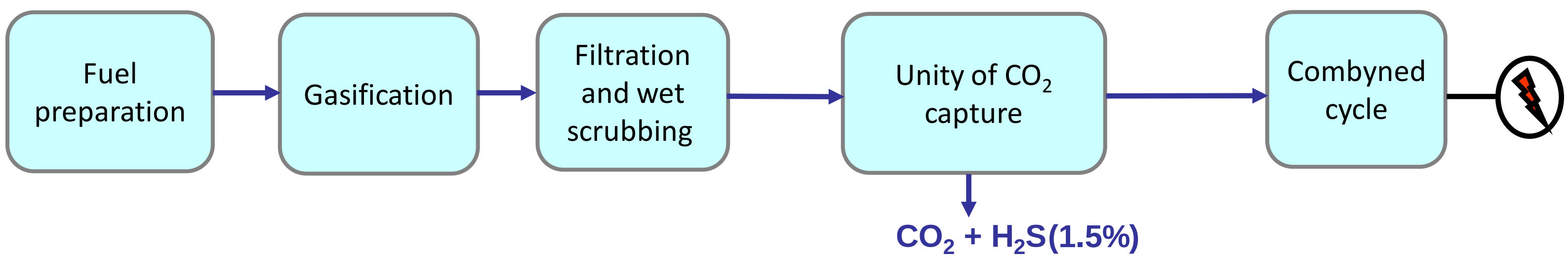
Real experience at ELCOGAS: results and learning

CO_2 capture in IGCC

- ***With SWEET catalyzer***



- ***With SOUR catalyzer***



Based on our CO_2 capture pilot plant, we have scaled the cost of a CO_2 capture unit at scale 1:1 about 350 M€. Approximately that is the cost of the desulphurization and sulphur recovery unit in an IGCC w/o CO_2 capture.

By installing an IGCC with CO_2 acid capture to store or use CO_2 together with ~1.5% H_2S, the investment costs are similar w/o CO_2 capture. And the only penalty is the decreasing efficiency: From 42 → 33% currently

and from 50 → 44% near future

Summary

TECHNOLOGY DEMONSTRATION POWER PLANT AT COMMERCIAL SCALE REQUIRES A LONG TERM REGULATORY FRAME

IGCC WITH OR WITHOUT CCS IS A PROMISING TECHNOLOGY WITH **MINIMUM** VARIABLE COSTS AND **BEST** ENVIRONMENTAL PERFORMANCE

FOLLOWING GENERATION MUST **LEARN** FROM EXISTING PLANTS

MAIN **BURDEN** FOR DEPLOYMENT: HIGH INVESTMENT REQUIRES LONG TERM **REGULATORY** FRAME

Commercial feasibility of integrated gasification combined cycle (IGCC)

Francisco García Peña – ELCOGAS Puertollano IGCC plant

THANK YOU FOR YOUR ATTENTION

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