International Freiberg Conference on IGCC & XtL Technologies
June, 17, 2005

OPERATING EXPERIENCE AND CURRENT STATUS OF PUERTOLLANO IGCC POWER PLANT

ELCOGAS S.A

Francisco García Peña

www.elcogas.es

INDEX

ELCOGAS

Introduction:

IGCC technology. General description

ELCOGAS

IGCC Technology. Advantages (1)

✓ **High efficiency**. Higher than others technologies of power generation from coal, and great potential to increase: net 42% → 50%

✓ **Feedstock flexibility** →
- Coal (diversity of qualities)
- Alternative fuels (pet-coke, municipal wastes, biomass, etc.)
- Availability of secondary fuel to the combined cycle

Reliability on energy supply

✓ **Product flexibility** → Electricity, H_2, CO_2, methanol, NH_3, gasolines, etc

Minor risk: Production according to markets

✓ **Sustainability:**
- Coal stocks for more than 200 years and better distribution
- Almost any fuel with enough carbon content is admitted

ELCOGAS

IGCC Technology. Advantages (2)

✓ Environment:

- Lower CO_2 emissions than other coal based plants. Best possibilities for zero emissions
- Low emissions of acid gases (SO_2, NO_x) and particles. Similar or better than NGCC
- Less wastes. Slag, ash, sulphur and salts are sub-products
- Less water consumption than other coal based plant. Similar to NGCC
- No dioxins/furans are produced when organic fuels are used
- Best method to eliminate Hg emissions

✓ Economics:

- Low cost fuel. Very competitive with natural gas. Fuels cost of KWh produced with coal is currently one third of produced with natural gas
- Lowest cost of CO_2 capture (pre-combustion)
- Wastes are commercial products. No cost disposal

ELCOGAS

IGCC Technology. Disadvantages

Technology is in demonstration level

- Four existing large coal based plants (USA & EU) report current IGCC availability between 60 and 75% (> 90 % considering secondary fuel)
- Main unavailability causes have been related to lack of maturity:
  - ✓ Design of auxiliary systems: Solids handling, down time corrosion, candle filters, proper materials and procedures
  - ✓ Performance of gas turbine high class with synthetic gas and other
  - ✓ Excessive integration between units, high dependence and delays start up
  - ✓ Processes are more complex than other coal based power plants. Learning is required. Existing IGCCs operated by petrochemical companies with refinery residues report IGCC availability over 92 % (Complexity of process similar to chemical industry, several trains in parallel, solids handling easier)

High investment cost

- Existing plants cost have been between 1,500 and 2,000 €/KW

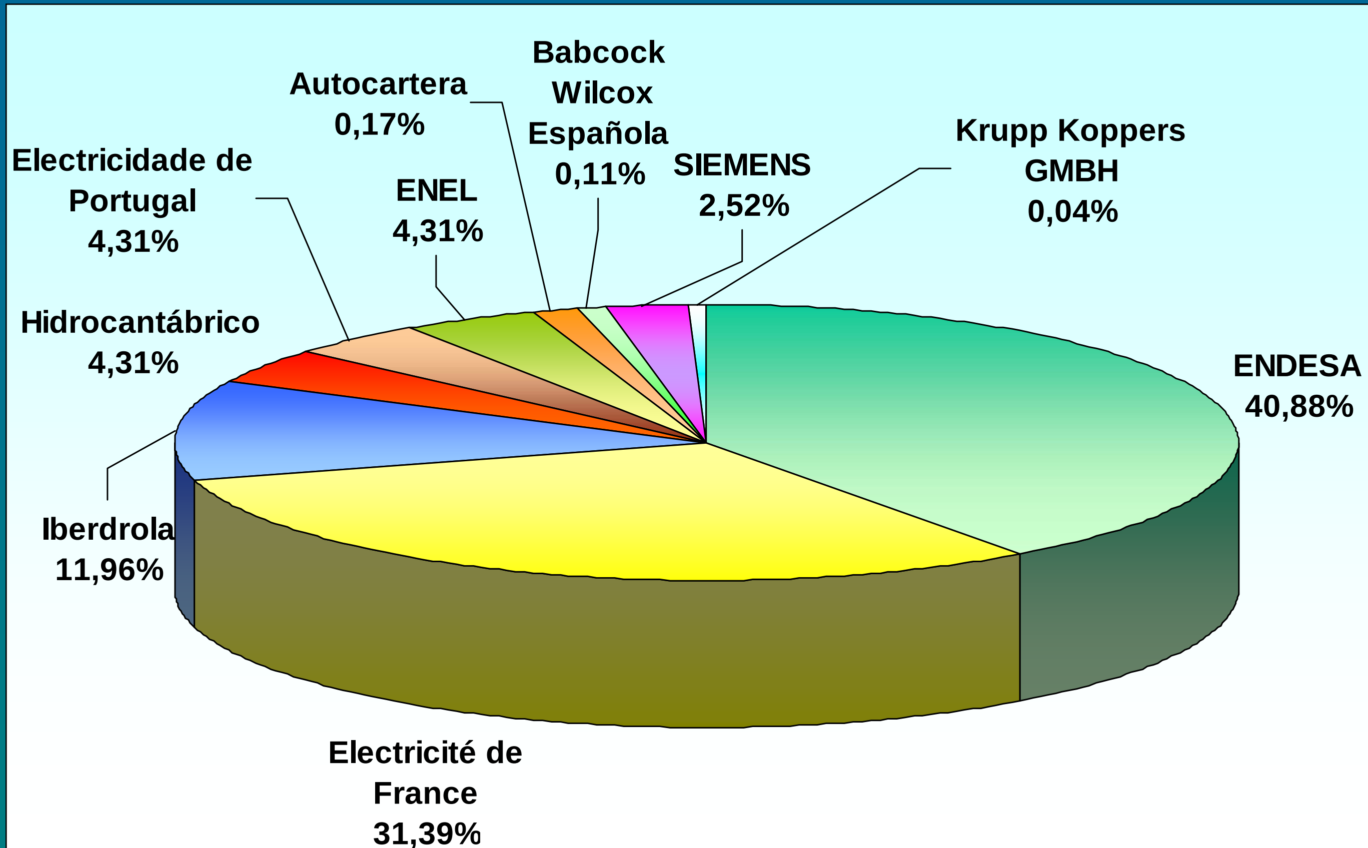
ELCOGAS

IGCC technology in Spain.

ELCOGAS experience.

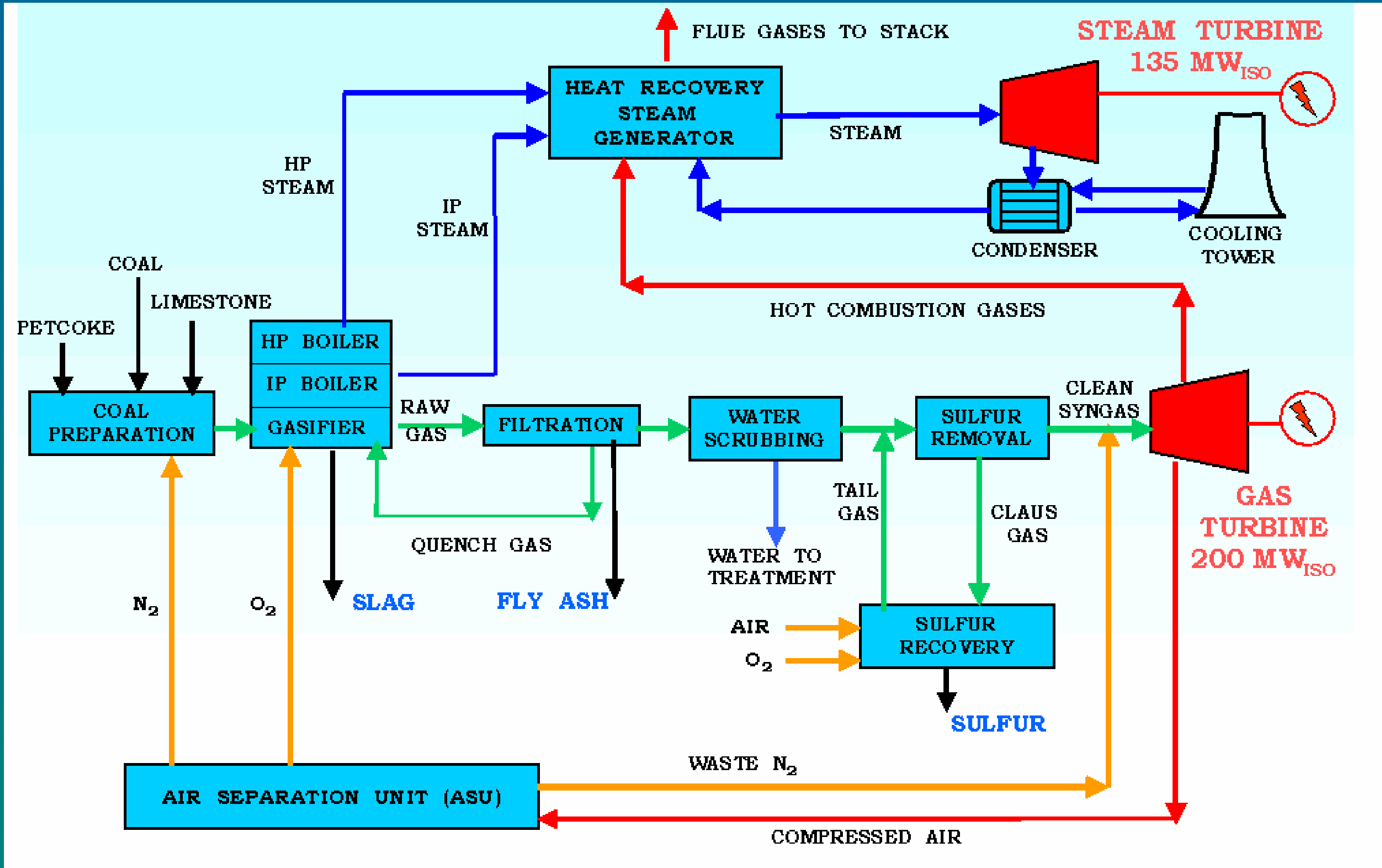
The ELCOGAS S.A. Company

ELCOGAS shareholders and percentage of capital



Spanish company shared by European companies, which was established in April 1992 to undertake the planning, construction, exploitation and commercialization of a 335 MW_{ISO} IGCC plant located in Puertollano (Spain)

ELCOGAS IGCC process. Block flow diagram



ELCOGAS operating data

Fuel composition

Mixture of low quality coal (high ash content) and petcoke (high sulphur content)

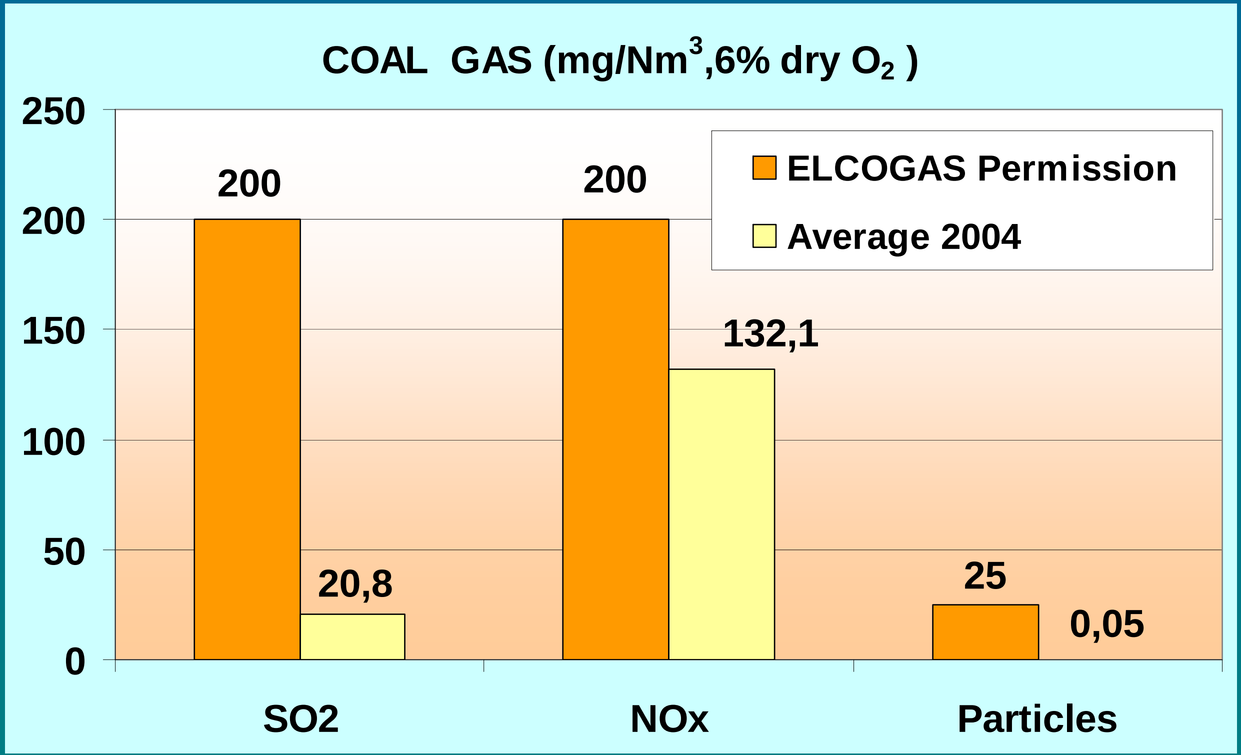
	COAL	PETCOKE	MIXTURE (50:50w)
Moisture (%)	11,80	7,00	9,40
Ash (%)	41,10	0,26	20,68
Carbon (%)	36,27	82,21	59,21
Hydrogen (%)	2,48	3,11	2,80
Nitrogen (%)	0,81	1,90	1,36
Oxygen (%)	6,62	0,02	3,32
Sulphur (%)	0,93	5,50	3,21
LHV (MJ/kg)	13,10	31,99	22,55
HHV (MJ/kg)	13,58	32,65	23,12
Kg/s			29,68

Syngas composition

	RAW GAS	CLEAN GAS
CO (%)	59,26	59,30
H_2 (%)	21,44	21,95
CO_2 (%)	2,84	2,41
N_2 (%)	14,32	14,76
Ar (%)	0,90	1,18
SH_2	0,83 %	3 ppmv
COS	0,31 %	9 ppmv
HCN (ppmv)	23	--
LHV (MJ/Kg)	10,36	9,76
HHV (MJ/Kg)	10,83	10,19
Kg/s	56,26	52,37

Operational experience

Environmental results (2004)



The environmental emissions of SO_2, NO_x and particulated material are much lower than the maximum allowed by the ELCOGAS Permission

Operational experience

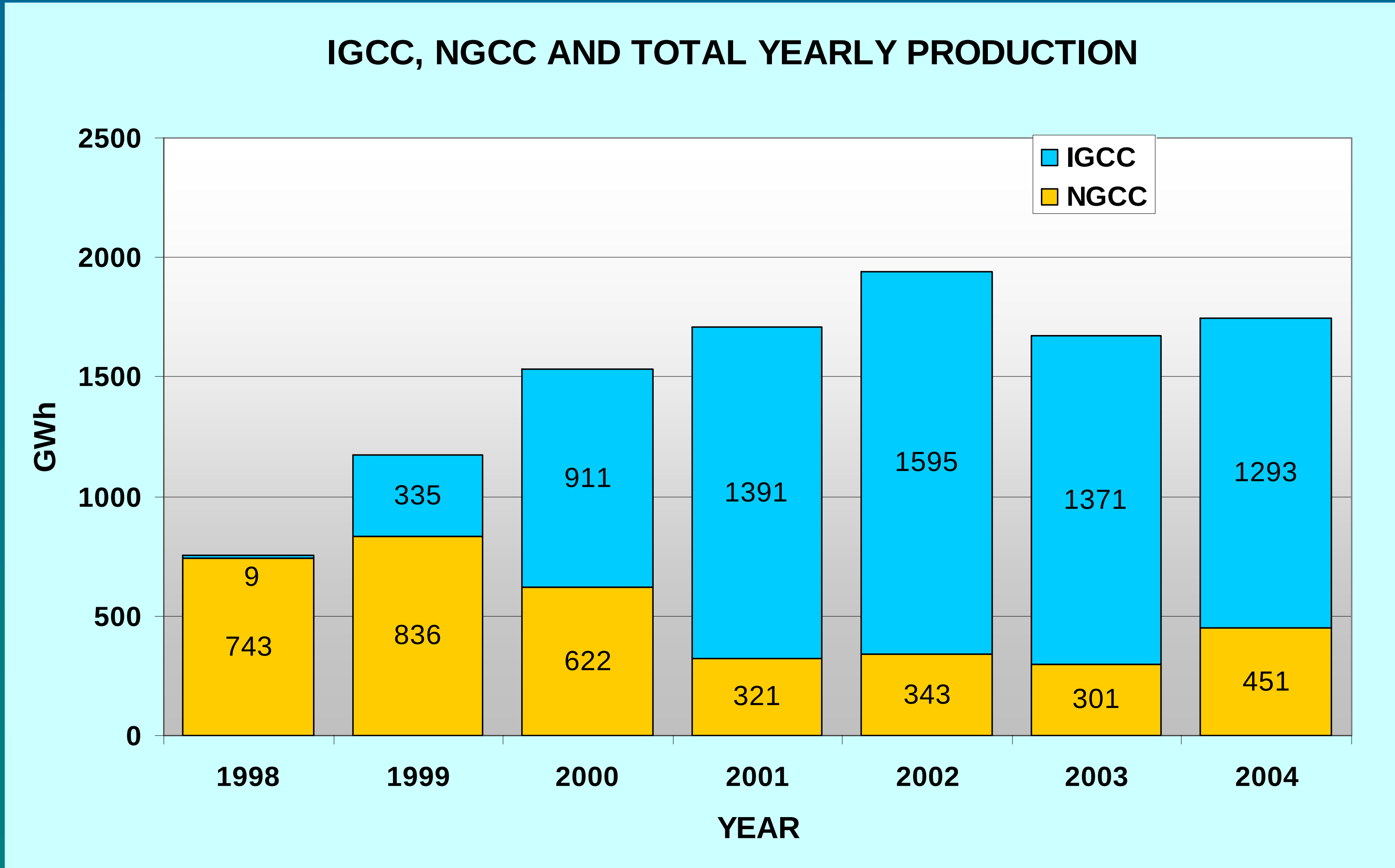
Commercial viability results: Production costs (2004)

Operating mode	Fuel	Heat rate (kJ_{HHV}/kWh)	Fuel price (€/GJ $_{HHV}$)	Fuel partial cost (€/MWh)	Production cost (€/MWh)
GNCC	Natural gas	7.649	3,84	29,37	29,37
IGCC	Coal	2.934	2,06	6,04	14,55
	Petcoke	5.994	1,18	7,07	
	Additional NG consumption	376	3,84	1,44	

The resulting production cost demonstrates IGCC competitiveness in the Spanish liberalized electricity market

Operational experience

Commercial viability results: Learning curve



Main unavailability causes (1)

1. Gas Turbine

- Optimization of syngas burners to prevent overheating / humming and to accomplish more stability and remaining life of the hot components.

- Up to last design of syngas burner was installed in 2003 preventive inspections of hot gas path every 500 – 1000 syngas operating hours. High rate of ceramic tiles change.

2. Gasifier

- Water leakage of membrane tubes due to flow blockages or local erosion. Design of distributors. Chemical control. Particle filtration. Loose parts.

- Gas leakage due to piping corrosion. Proper selection of materials. To avoid “cold ends” and down time corrosion.

- Fouling of Waste Heat boilers:
  - ✓ Sticky fly ash (reduced by decreasing gas inlet temperature to cooling surfaces. More quench flow)
  - ✓ Fluffy fly ash (reduced by increasing the velocity of the gas)

Main unavailability causes (2)

3. Grinding and mixing systems

   Clogging in mills feeding and mixing conveyors. Two trains of 60%. Lack of robustness of equipment.

4. Solids handling (slag and fly ash)

   Erosion of components by local high velocities. Substitution of parts for abrasion resistant materials. Revision of design and operating procedures.

5. Ceramic filters

   Life time of filtrating elements is half of expected (4000 h). Very expensive cost. To improve by changing supporting design of elements.

6. Fuel dust conveying and feeding systems

   Pressure control and fluidization stability. Design of fluidization systems and preventive maintenance of components.

7. COS catalyst

   2 – 3 changes by year of alumina based catalyst. Water carryover. Change to Titanium oxide catalyst (3 – 4 years) and preheater installation.

Lessons learned: Summary of improvements (1)

System / equipment	Potential improvements	Cost reduction
Coal preparation	Natural Gas consumption 3 grinding trains for availability	Elimination of mixing equipment. Elimination of steam preheaters
Coal dust conveying, sluicing and feeding	N_2 saving Resizing of vessels and nozzles	Elimination of concrete building, coal storage and lock hopper system simplification by pneumatic pumps
Gasifier	Recycling of fine slag Membranes flow distribution Quench gas ratio	Removing auxiliary burners. Reduction of surfaces by increasing velocity
Slag handling	Replacement of filtering system by settling system.	Simplification of slag water circuit. Elimination of one slag lock hopper and extractor.

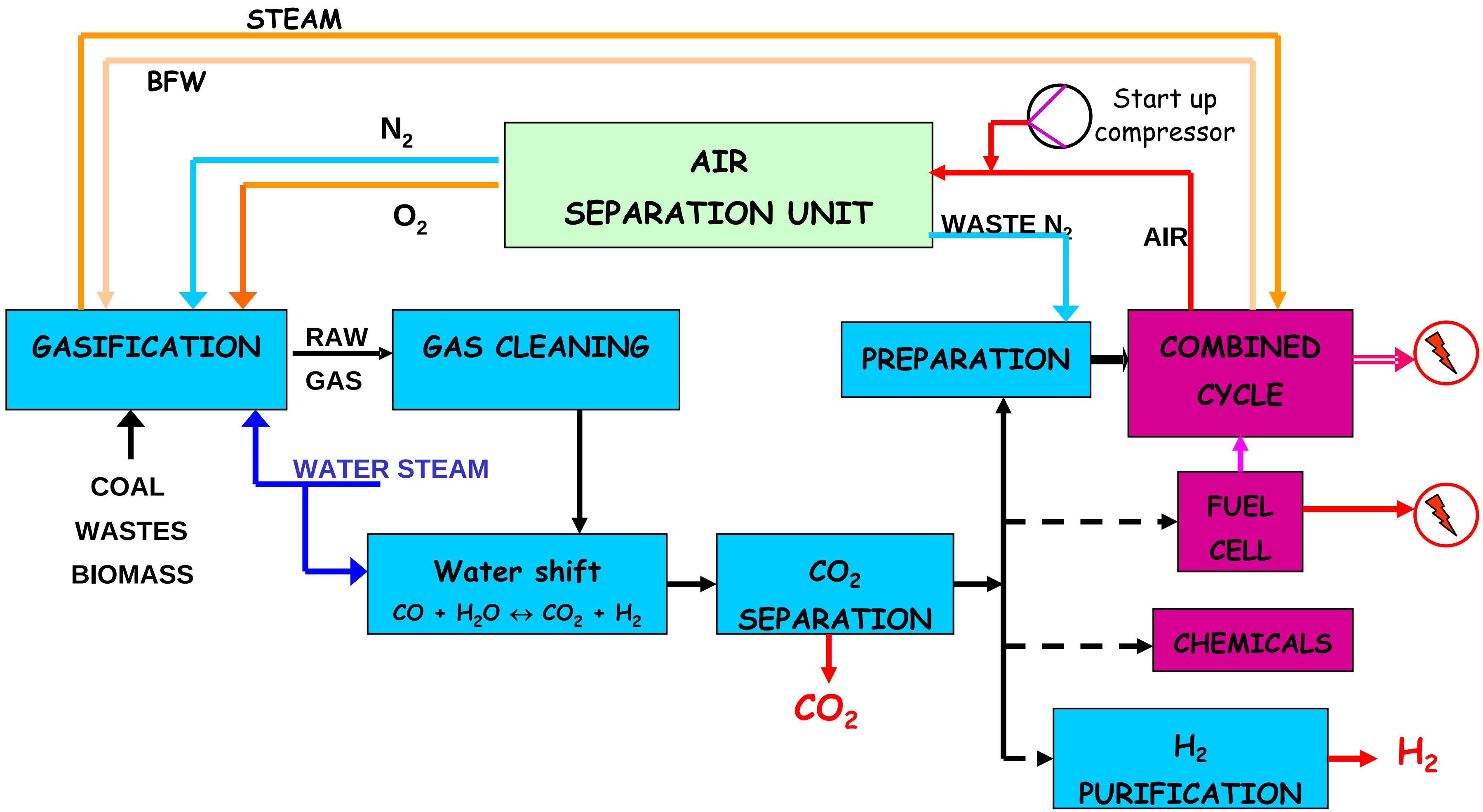
Lessons learned: Summary of improvements (2)

System / equipment	Potential improvements	Cost reduction
Dry dedusting filter	Improvement of candle filter cleaning system. Improvement of candle filter material and design.	Fly ash recycle removal, reduction of vessels Elimination of fly ash wet discharge system
Gas scrubbing and stripping	Reduction of water carryover from scrubber (Start up)	Controlling filter removing/Scrubber resizing
Sulphur removal	COS catalyst	Equipment dimension decrease using enriched air
Air Separation Unit	Increase of liquid N_2 storage capacity Start up compressor	Oxygen storage removing
Gas turbine	New higher efficiency gas turbine Syngas preparation	Scale benefits Simplification of control & control components

Future R&D overview

ELCOGAS

Future of IGCC technology



Future of IGCC technology

IEA estimation H_2 production cost year 2020 (€/GJ)

H_2 from natural gas with CO_2 capture	5.6 - 8.9
H_2 from coal – IGCC, with CO_2 capture	6.5 - 8.9
H_2 from biomass (gasification)	8.1 - 14.5
H_2 from nuclear energy	12.1 - 16.2
H_2 from wind energy	13.7 - 18.6
H_2 from solar thermic	21.8 - 28.3
H_2 from solar photovoltaic	38.0 - 60.6

ELCOGAS

IGCC technology: Main challenges

1. **To improve reliability.** It has to be achieved by introducing in next generation of plants the lessons learned, giving continuity to the technology.
2. **To decrease investment costs.** Main points are: scale economy (larger plants), better efficiency with last generation of gas turbines and combined cycles, design optimization according to lessons learned.
3. **To introduce CO_2 capture concept.** IGCC technology is the best option for zero emission plants based on fossil fuels.
4. **To introduce the technology in the H_2 economy.** Diversification of products will improve economic scenarios.
5. **To improve environmental performance even more.** By considering the use of wastes and biomass in co-gasification with coal.

ELCOGAS pilot plant project

✓ Project aims: CO_2 capture and hydrogen production from a 2% of the syngas produced at the plant:

- **H_2 production: 2.500 Nm^3/h**, to direct sold or to applications (fuel for engines, gas turbines or fuel cells, chemical synthesis)
- **CO_2 captured: 25.000 t/year** (capture efficiency > 85%) to direct use or to geological sequestration tests

✓ Total investment: 15 million €

✓ Project has been presented to the spanish R&D National Programme (2005)

ELCOGAS pilot plant process