

Clean and Efficient Power Generation from Coal
24-25, Gliwice (Poland)

***ELCOGAS: R&D
activities towards zero
emissions IGCC plants***

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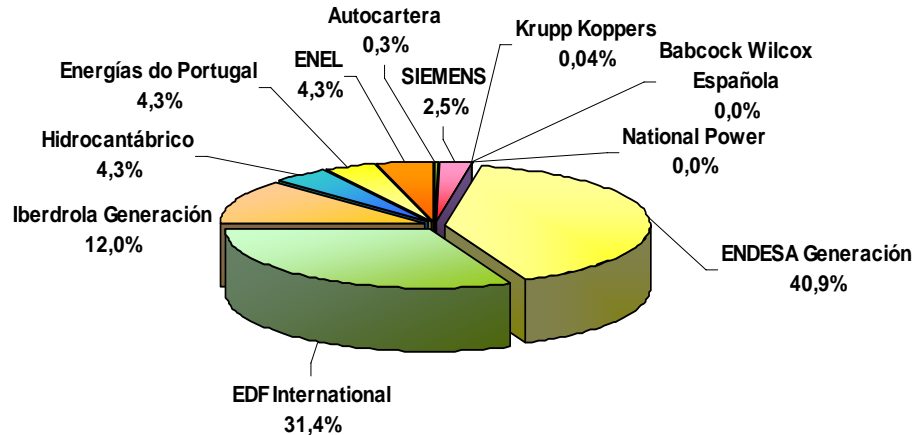
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1. ELCOGAS COMPANY

European company established in April 1992 to undertake the planning, construction, management and operation of a 335 MW_{ISO} IGCC plant located in Puertollano (Spain)

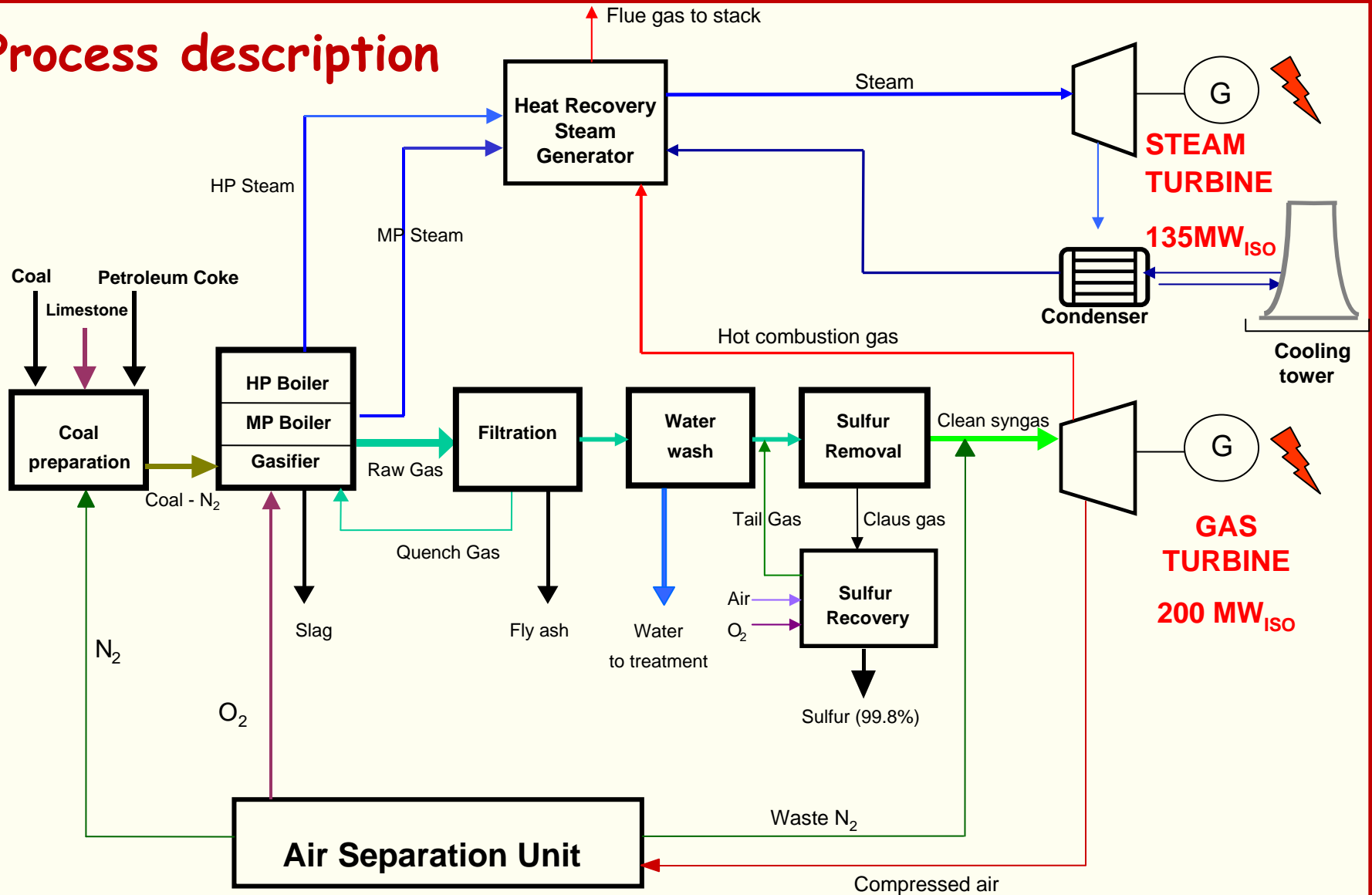


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2. PUERTOLLANO IGCC POWER PLANT DESCRIPTION

Process description



2. PUERTOLLANO IGCC POWER PLANT DESCRIPTION

Main data

Design Fuel is a mixture 50:50 of coal & petcoke (currently operating at 45:55).

Successful tests with:

- MBM 2% (50 tpd)
- Olive oil wastes 8% (10% planned)
- Washed coal, Venezuela petcoke ...

	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

POWER OUTPUT	GAS TURBINE (MW)	STEAM TURBINE (MW)	GROSS TOTAL (MW)	NET TOTAL (MW)
	182.3	135.4	317.7	282.7
EFFICIENCY (LHV)	GROSS		NET	
	47.12%		42.2%	
EMISSIONS	g/kWh		mg/Nm ³ (6% Oxygen)	
SO ₂	0.07		25	
NO _x	0.40		150	
Particulate	0.02		7.5	

Power output and emissions

2. PUERTOLLANO IGCC POWER PLANT DESCRIPTION

Raw and clean gas data

Raw Gas			Clean Gas		
	Actual average	Design		Actual 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 ₂ S (%)	0.81	1.01	H ₂ S (ppmv)	3	6
COS (%)	0.19	0.17	COS (ppmv)	9	6
HCN (ppmv)	23	38	HCN (ppmv)	-	3

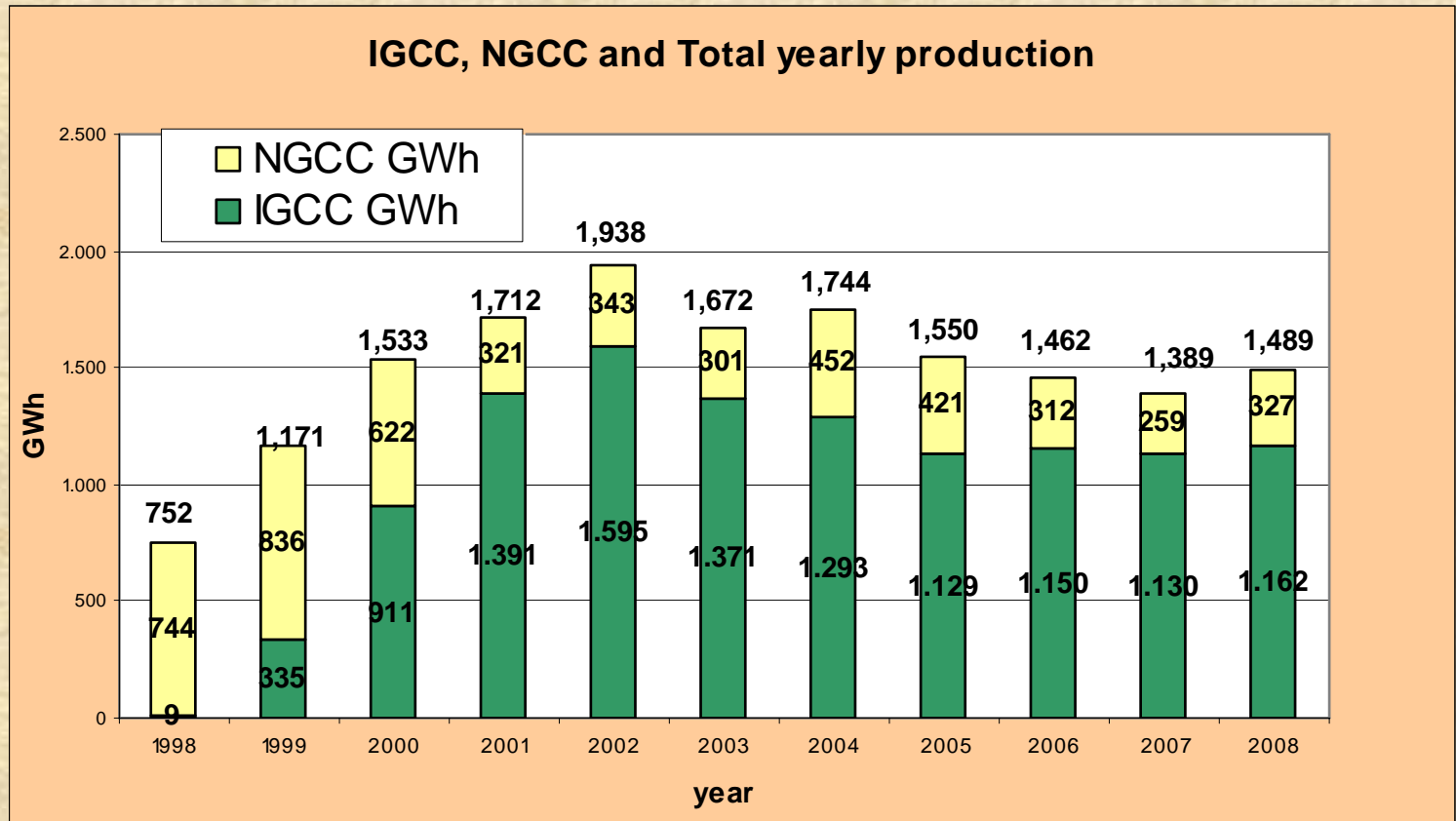
2. PUERTOLLANO IGCC POWER PLANT

Project milestones

1992	Main contracts award
Jun 1996	First synchronization of gas turbine
Oct 1996	Commercial operation with natural gas
Jun 1997	Performance test of the Air Separation Unit
Mar 1998	First switch over from natural gas to coal gas
Nov 2000	First 1,000 GWh produced with coal gas as IGCC
Dec 2008	Total: 17,551 GWh IGCC: 11,476 GWh

Up to 2008, 4450 modifications have
been installed in plant

2. PUERTOLLANO IGCC POWER PLANT: Operating data



1st 5 years: Learning curve

2003: Major overhaul Gas Turbine findings

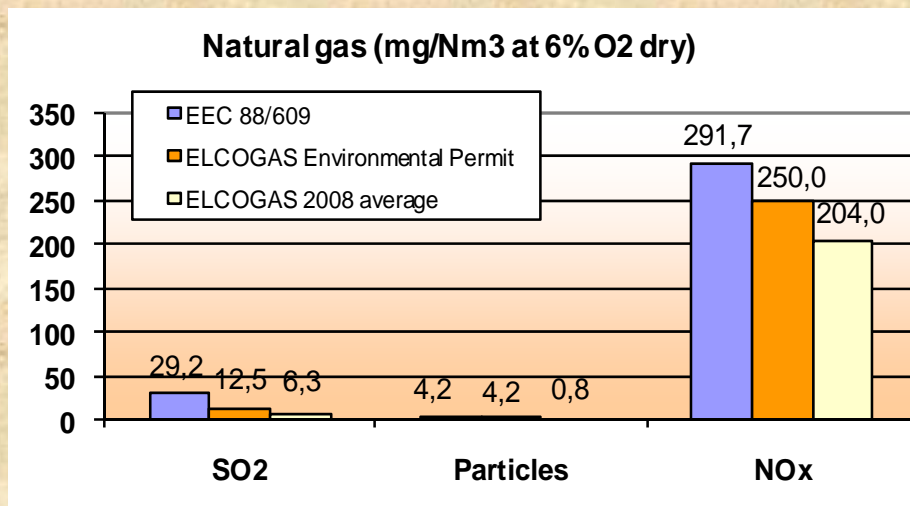
2004 & 2005: Gas turbine main generation transformer isolation fault

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

2007 & 2008: ASU WN₂ compressor coupling fault and repair MAN TURBO

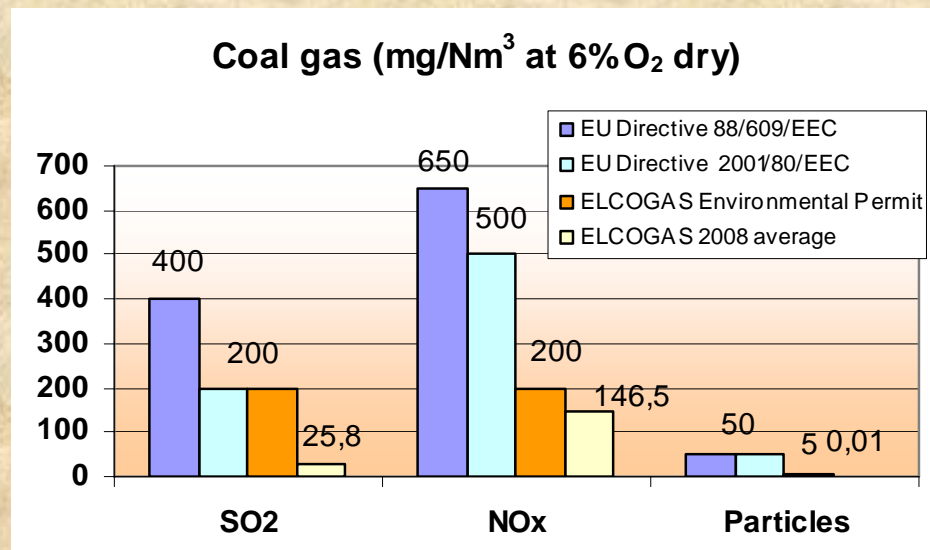
2. PUERTOLLANO IGCC POWER PLANT: Operating data

Emissions in NGCC and IGCC modes



Emissions in NGCC mode

Emissions in IGCC mode

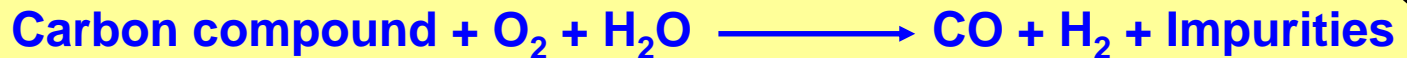


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3. FUTURE OF IGCC TECHNOLOGY. H₂ co-production and CCS

Step 1: Syngas production from gasification



Step 2: "Shifting" or water-gas reaction



Step 3: H₂ and CO₂ separation

H₂

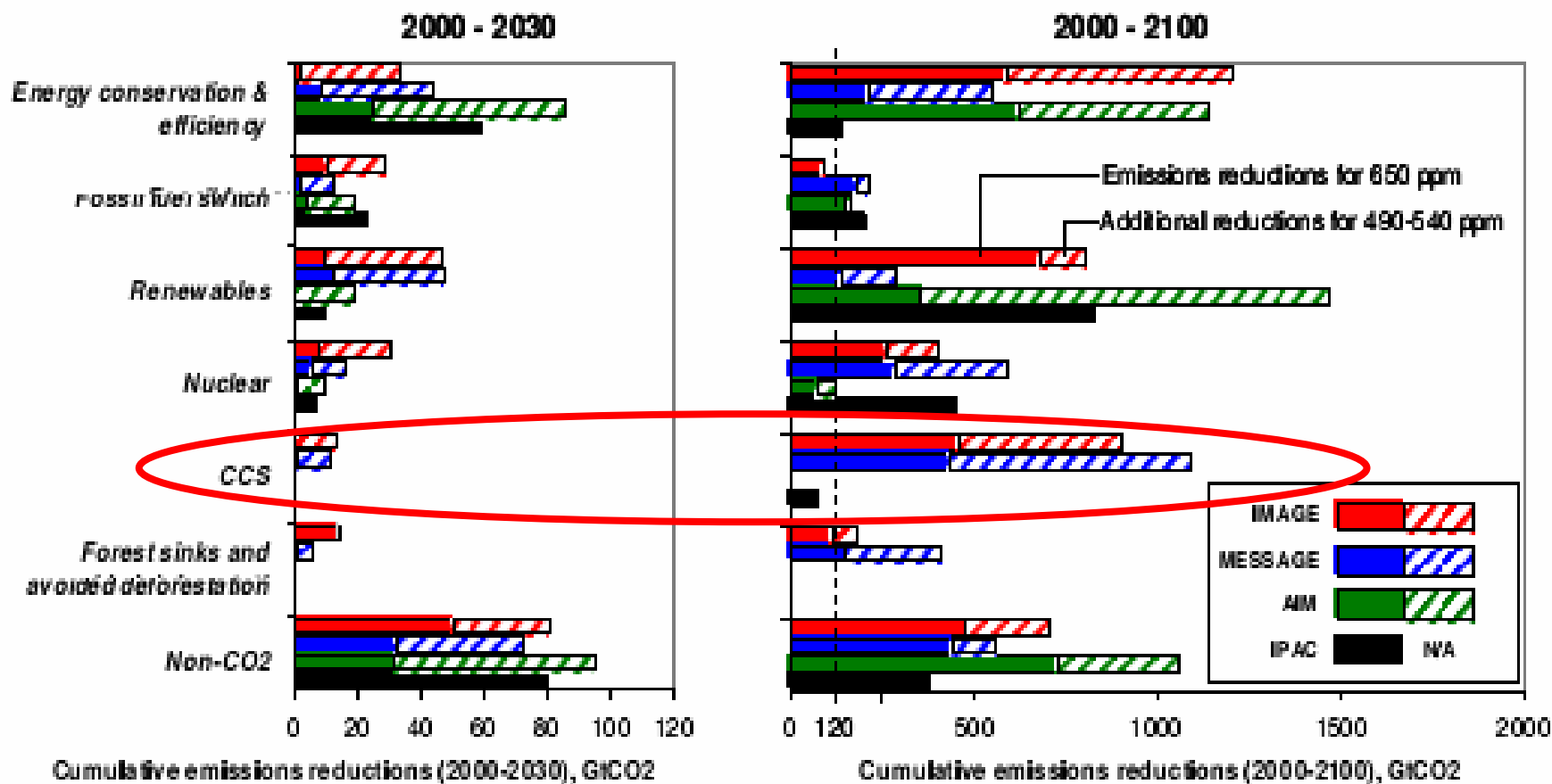
&

CO₂

- Fly ash
- Char
- Cl⁻
- CN⁻
- SH₂
- COS
- CO₂
- N₂
-

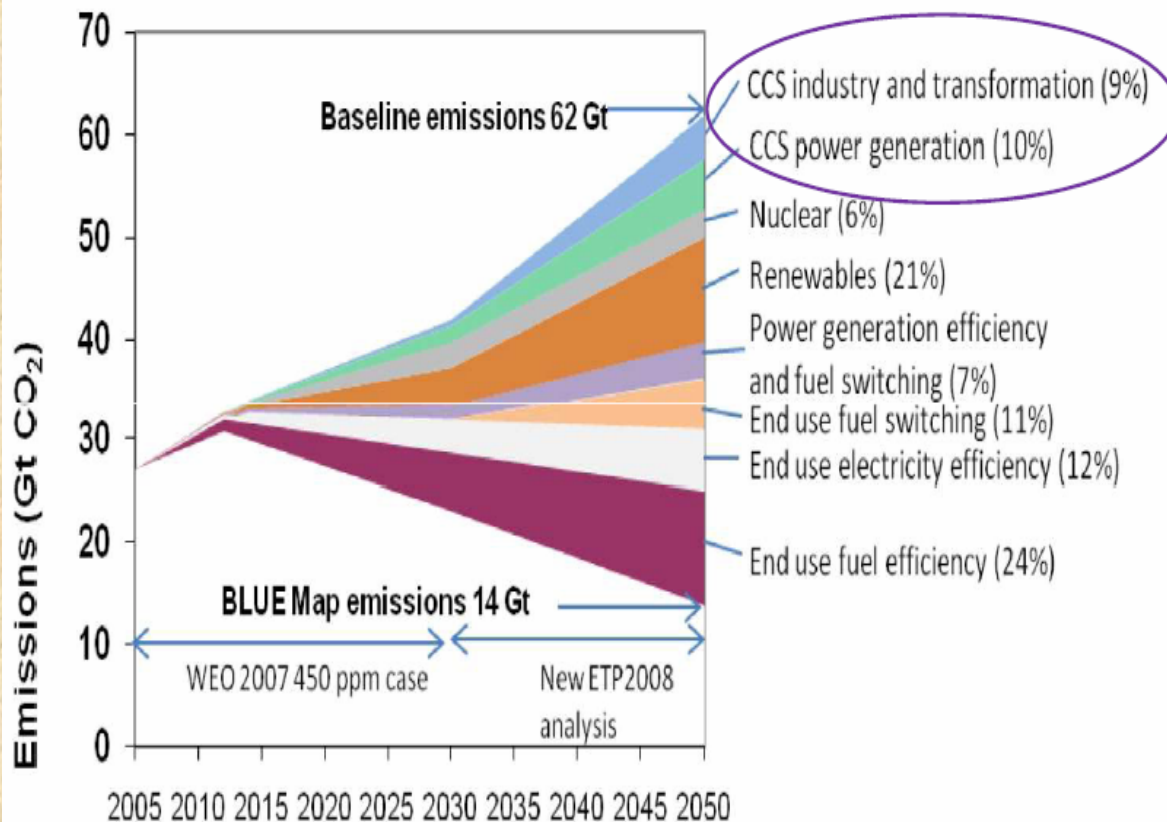
H₂ production from fossil fuels involves CO₂ generation ⇒
To talk about "clean" H₂ it is required to consider CCS

CLIMATE CHANGE MITIGATION - IPCC



CLIMATE CHANGE MITIGATION

CCS Within a Carbon Abatement Portfolio



CCS: a Key Part of a Low-cost GHG Strategy

- Without new policies, global emissions increase 130% by 2050, corresponding to a 4-7°C temperature rise
- CCS provides 1/5th of the needed CO₂ reductions in 2050
- Without CCS, cost of stabilisation rises by 70%
- CCS is the *only* low-carbon solution for coal, cement, and iron & steel sectors

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4. ELCOGAS R&D INVESTMENT PLAN

PUERTOLLANO IGCC ACTIONS

- **BASED ON THE OPPORTUNITY THAT AN IGCC PLANT REPRESENTS**
- **CONTRIBUTION CAN BE RELEVANT IN:**
 - **CLIMATE CHANGE MITIGATION**
 - **ENERGY SUPPLY RELIABILITY**

MAIN LINES OF R&D PLAN ARE:

- **CO₂ EMISSION REDUCTION IN UTILIZATION OF FOSSIL FUELS**
- **H₂ PRODUCTION BY GASIFICATION OF FOSSIL FUELS**
- **DIVERSIFICATION OF RAW FUELS AND PRODUCTS**
- **OTHER ENVIRONMENTAL IMPROVEMENTS**
- **IGCC PROCESSES OPTIMISATION**
- **DISSEMINATION OF RESULTS**

4. ELCOGAS R&D INVESTMENT PLAN

Dissemination of results:

- **Forum** participations. CO₂, H₂, and sustainability associations and Technological Platforms. European and Spanish. **Coordinating working groups in Technological Spanish Platforms.**
- Participation in **conferences**, seminars, congresses.
- **Consulting** services. **Germany, China, Chile**
- Attending and promoting technical **visits**. **Generally international visits.**



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4. ELCOGAS R&D INVESTMENT PLAN

Optimisation of IGCC processes: Oriented to improve availability & costs

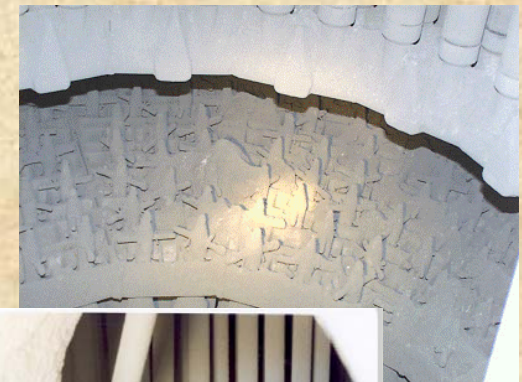


Test materials

Gasifier materials/Syngas corrosion processes



Elimination of membrane water leakages at reaction chamber



Gas Turbine burners tests

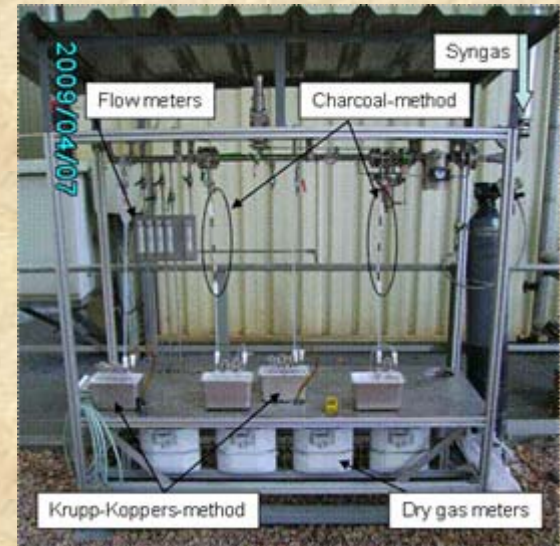


Ceramic filters

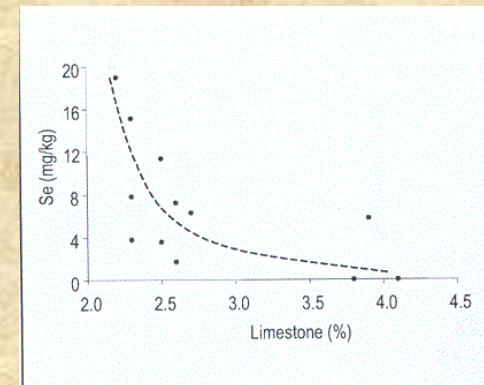


Other environmental improvements:

- Liquid **wastes** reduction. **Change of waste water treatment plant**
- Improvement of syngas **cleaning** systems. Currently participating in project **AGAPUTE** (RFCS, 2004-08, to study improvements in syngas cleaning). Hg task.
- Improvements in **Sulphur** Recovery plant. In progress several modifications to improve availability and to reduce S emissions.
- Operation and additives **parameters** optimization. Included in AGAPUTE to study dosing of limestone, oxygen, steam, vs. concentration of contaminants in slags, fly ash and washing water
- Emissions reduction during start up and other **transitory** situations.



Overview of the test rig for mercury and carbonyls analysis



Cross correlation between limestone content in the fuel and Se bulk fly ash content

4. ELCOGAS R&D INVESTMENT PLAN

Diversification of raw fuels and products:

Project PIIBE (ESP-CENIT). To impulse biofuels technologies in Spain. ELCOGAS coordinates the subproject about biodiesel from gasification by real co-gasification 10% of biomass and syngas characterization (F-T process in laboratory)

Agreement with a private European Company to install a pilot plant in IGCC of Puertollano to develop process to obtain **gasoline from syngas**

Project PEIXE VERDE. (ESP-PSE). Technical-economic study about uses of syngas as fuel for fishing ships in different scales of production

Co-gasification of car manufacture **wastes** (shredder fibres) was agreed with supplier.

Available to do tests of gasification of **different fuels** at large scale to help in design of new IGCC plants



Biomass yard

Clean H₂ production by gasification of fossil fuels:

- H₂ production in **IGCC**. Project HYDROSEP (RFCS, to study IGCC adaptation to H₂ production)
- Study and tests of new processes of H₂ purification. Project SPHERA (ESP-CENIT)
- Available to collaborate with new H₂ & Fuel Cells **Experimental National Centre** of Puertollano

4. ELCOGAS R&D INVESTMENT PLAN

CO₂ EMISSION REDUCTION

IGCC Efficiency Optimisation

Analysis of viability to improve efficiency based on **Critical Assessment** of Puertollano IGCC design (3-6% efficiency improvement and 20-30% fixed costs reduction)

Auxiliary consumption optimisation. **New revision**

Development of **tools** to improve efficiency. Supervision on line of main (120) equipment efficiency. **Installed and in tests**

Integration optimisation. Improvement of **controls** to adjust heat & mass balances in real operation

And

CO₂ capture for CCS with IGCC

4. ELCOGAS R&D INVESTMENT PLAN.

CO₂ line – “Singular and strategic project PSE-

CO₂” TARGETS

To demonstrate the **feasibility of capture of CO₂ and production of H₂** in an IGCC that uses solid fossil fuels and wastes as main feedstock.

To obtain **economic data** enough to **scale** it to the full Puertollano IGCC capacity in synthetic gas production.

PARTICIPANTS & BUDGET

ELCOGAS – UCLM – Ciemat – INCAR CSIC

13 M€ (initially 18.5 M€)

COORDINATED

Project of pilot plant in existing IGCC of Puertollano is part of a Spanish national initiative, “**Advanced technologies of CO₂ conversion, capture and storage**” and it is coordinated with other related projects:

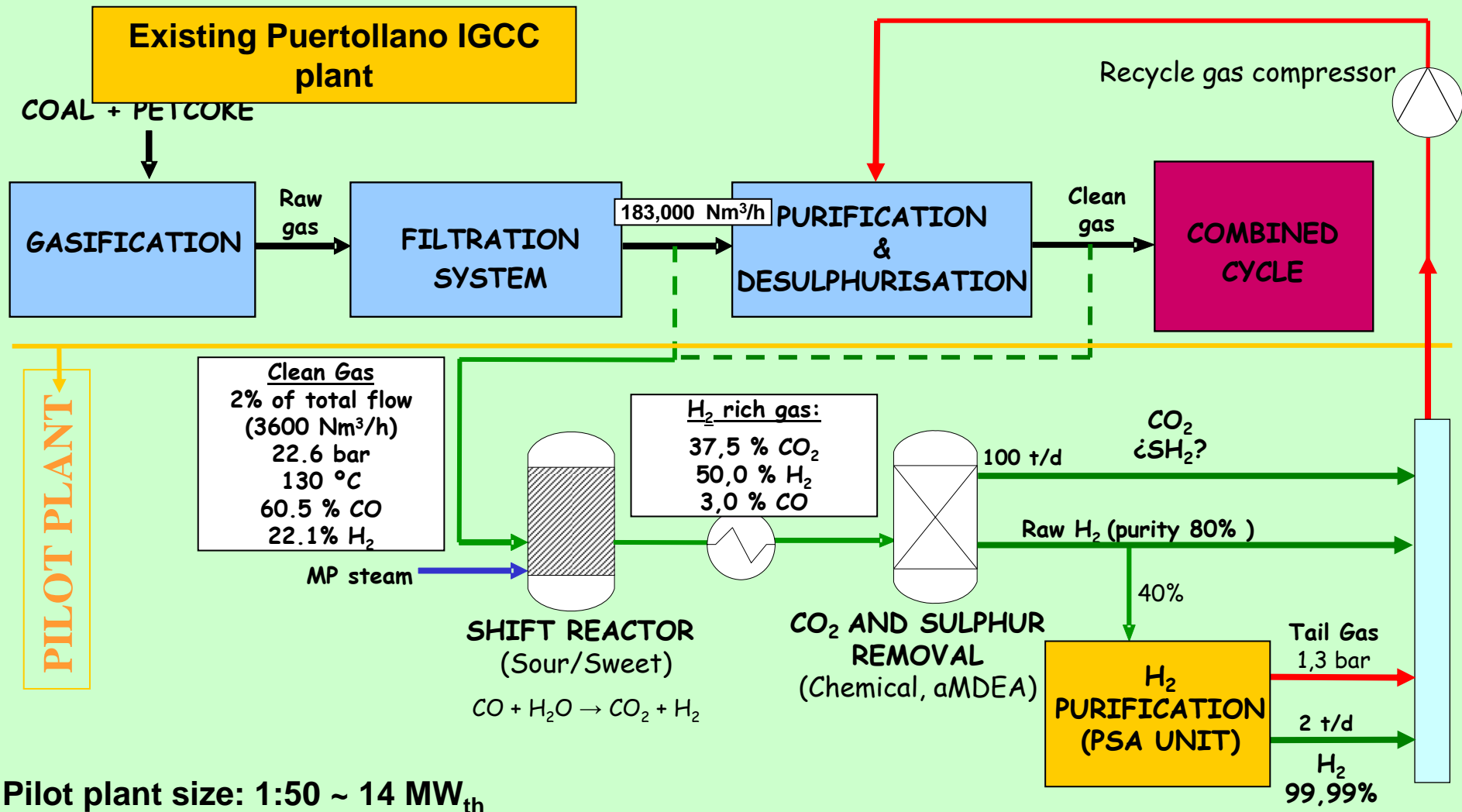
Project # 2 is to explore CO₂ capture with oxyfuel technology in a 20MW pilot plant. To be built in El Bierzo, NW of Spain (coordinator CIUDEN)

Project # 3 is to study and regulate geological storage in Spain (coordinator IGME)

Project #4 is to study public awareness of CCS technologies (coordinator CIEMAT)

4. ELCOGAS R&D INVESTMENT PLAN.

CO₂ line – “Singular and strategic project PSE-CO₂”

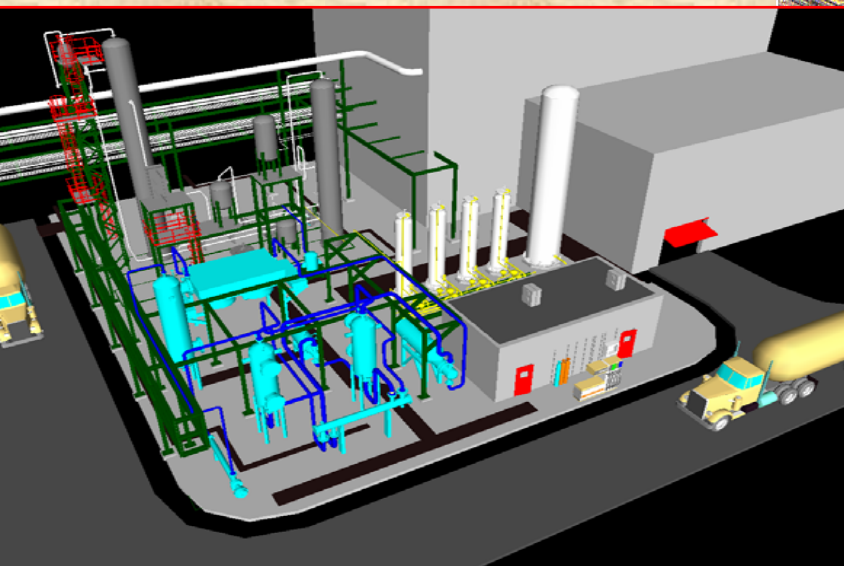
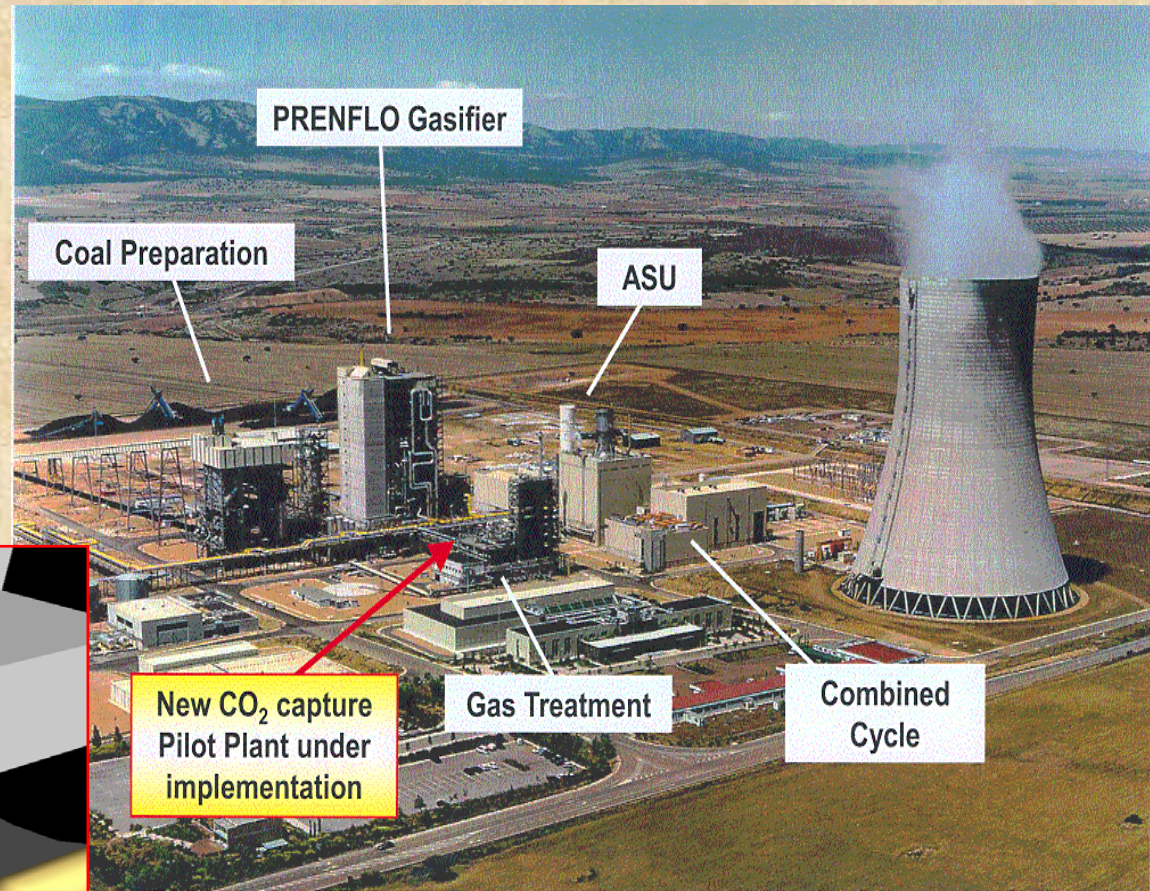


4. ELCOGAS R&D INVESTMENT PLAN.

CO₂ line – “Singular and strategic project PSE- CO₂” View (Sept 09)



General view of the ELCOGAS power plant



3D view

Done:

- ✓ 98 % engineering work
- ✓ 97% equipments bought
- ✓ 30% construction

Mechanical Erection: started on 17th August 2009

End commissioning: March 2010

End of programmed tests (under PSE): March 2011


KEY CONTRACTORS

Engineering	Empresarios Agrupados
CO ₂ Unit	Linde-Caloric
PSA Unit	Linde
Civil work	Construcciones Ocaña-Cañas
Control	Zeus Control
Reactors	Tecnical
Heat exchangers	Tecnical and Boreal-Vila
Catalysts	Johnson Matthey
Piping and fitting	Masa, Sidsa and Cuñado
Control valves	SAMSON
Safety and relief valves	Tyco Valves and Controls
Manual valves	SAIDI
Electrical components	GE Power
On-line analysis system	ABB Process Automation Division

***Pilot plant** for CO₂ capture & H₂ production integrated in an IGCC*

Activities to be done **after PSE**, as R&D platform:

- ❖ Water shift reaction **catalyst** optimization. Tests of different catalyst
- ❖ **New processes** to separate CO₂-H₂
- ❖ CO₂ different **treatment** processes
- ❖ Improvement of **integration** efficiency between CO₂ separation processes and IGCC plant

 **Other proposals** from Industry or Research community to use the IGCC plant and its pilot plant to develop of process, equipments, components or even pre-engineering of new plants with CCS and Zero emissions

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5. CONCLUSIONS

IPCC → Unless greenhouse gas emissions are cut by 50-80% by 2050 (especially CO₂), the impact of global warming will be disastrous.

World energy demand → Expected to double by 2050.

So → We must **act fast using a portfolio of solutions** (mainly, energy efficiency improvement, renewables and CCS) to reduce CO₂ emissions in the required massive scale.

IGCC technology can contribute to this aim because:

☐ Existing IGCC plants are an opportunity to **develop cleaner electricity with fossil fuels**

☐ **Diversification of fossil fuels use** according to the reserves and total life cycle is absolutely necessary

☐ **Clean co-production of H₂ and electricity** is possible and can be adapted to market demand

☐ **Massive H₂ production is currently possible** and technology is available

ELCOGAS: R&D activities towards zero emissions IGCC plants

Thank you for your attention

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