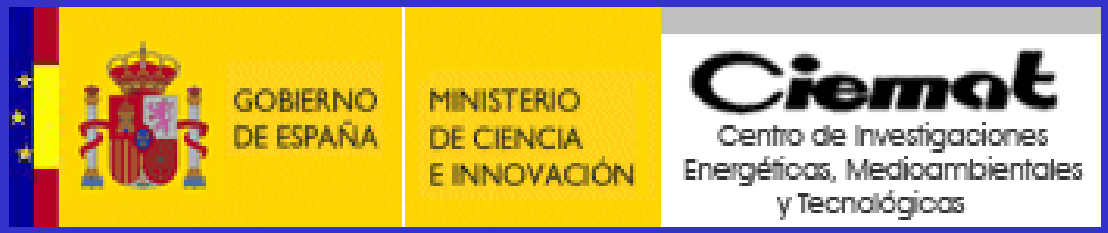

Spanish Situation on FBC

Juan Otero

Department of Energy

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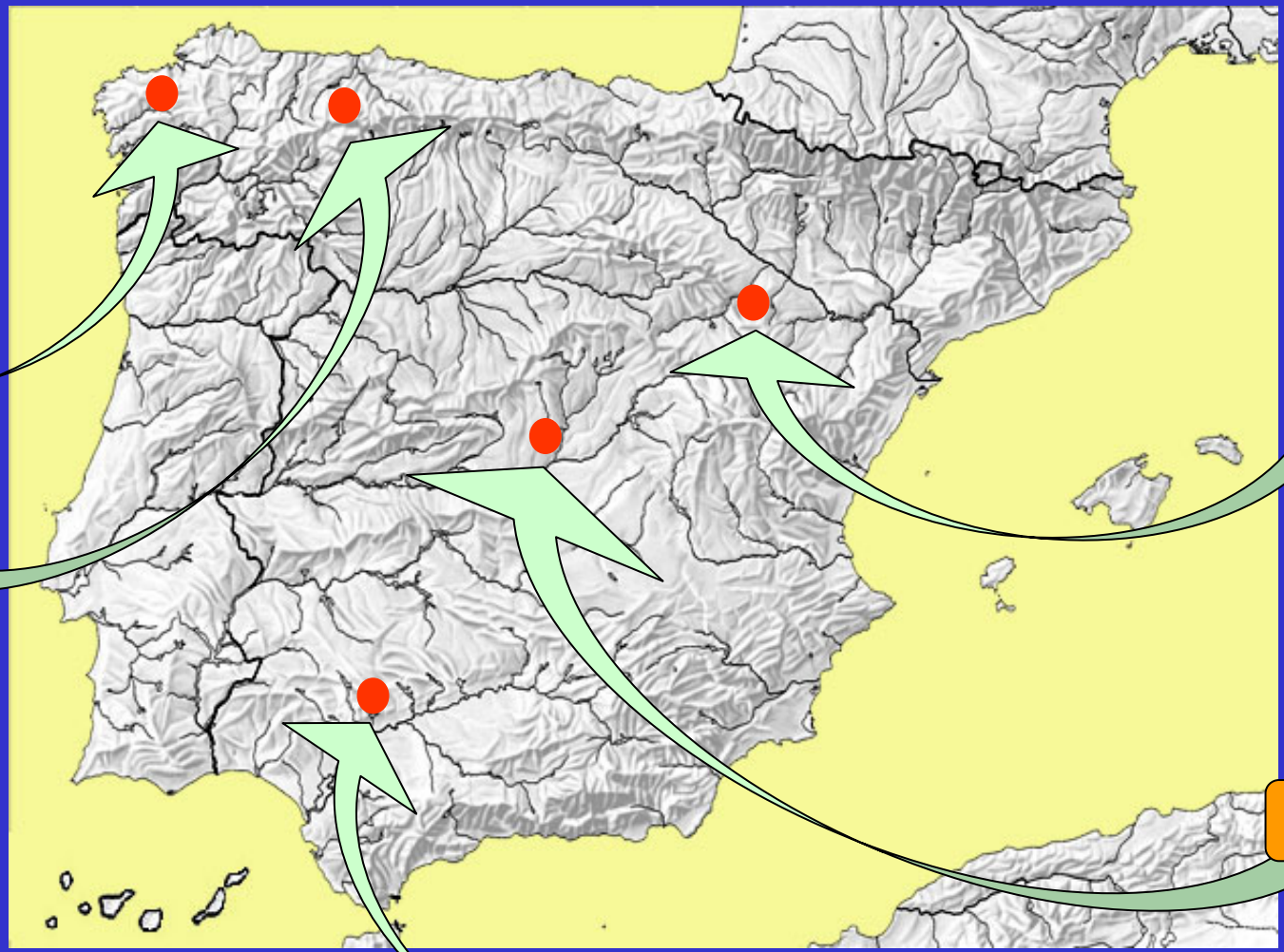
Industrial Facilities



Sogama

La Pereda

Escatrón

CLOSED

Tirmadrid

Vetejar

La Pereda

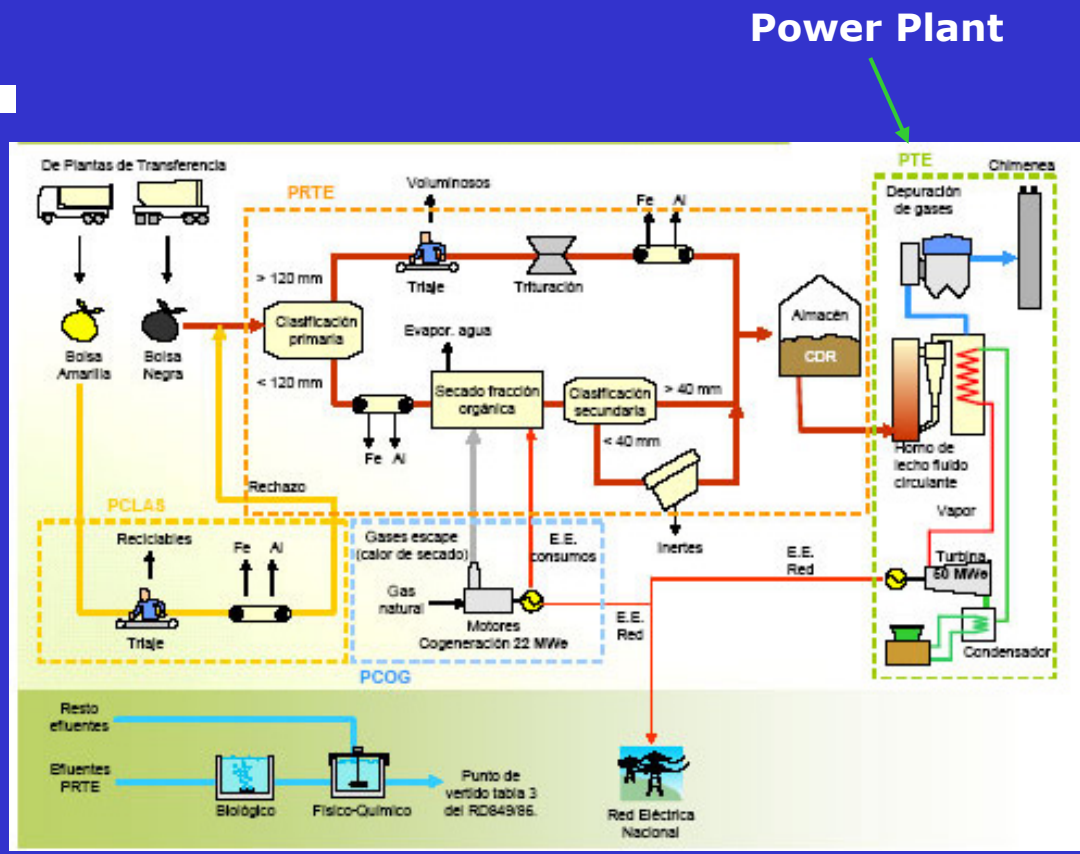
- Location: Mieres (Asturias)
- Fuel: Hard coal 65% ash
- Boiler: Foster Wheeler
- Type: CFB
- Capacity: 50 MW

Tirmadrid

- Location: Madrid
- Starting up:1996
- Fuel:MSW
- Type: BFB
- Capacity: 30 MW

Sogama

- Location: Cerceda (La Coruña)
- Starting up: 2002
- Fuel:MSW
- Type: 2 CFB
- Capacity:50 MW



Vetejar

- Location: Palenciana (Córdoba)
- Starting up: 1995
- Fuel: orujo (65% moisture)
- Boiler: Foster Wheeler
- Type: BFB
- Capacity: 12.5 MW

Centres of Research and Technological Development

- CIEMAT Madrid/Soria
- ETSI University of Seville-AICIA-INERCO
- INCAR-CSIC
- CIRCE
- University of Zaragoza

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

CIEMAT Madrid-Soria (I)
R&D Activities

- Coal and Waste Co-Combustion Processes.
- Biomass Gasification Processes.
- Gas Treatment Processes. Clean-up & Component Separation.
- Kinetics studies and Theoretical Development
- DNS for Combustion processes.

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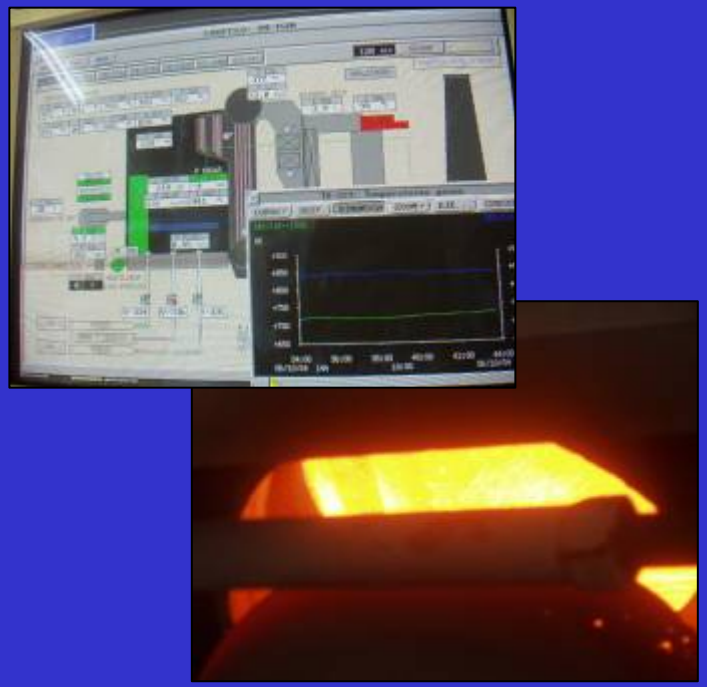
CIEMAT Madrid-Soria (II)

3.5 MW BFB Demonstration Plant

Steam at 40 bar



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CIEMAT Madrid-Soria (III)

1 MW BFB Pilot Plant

100kW BFB Pilot Plant

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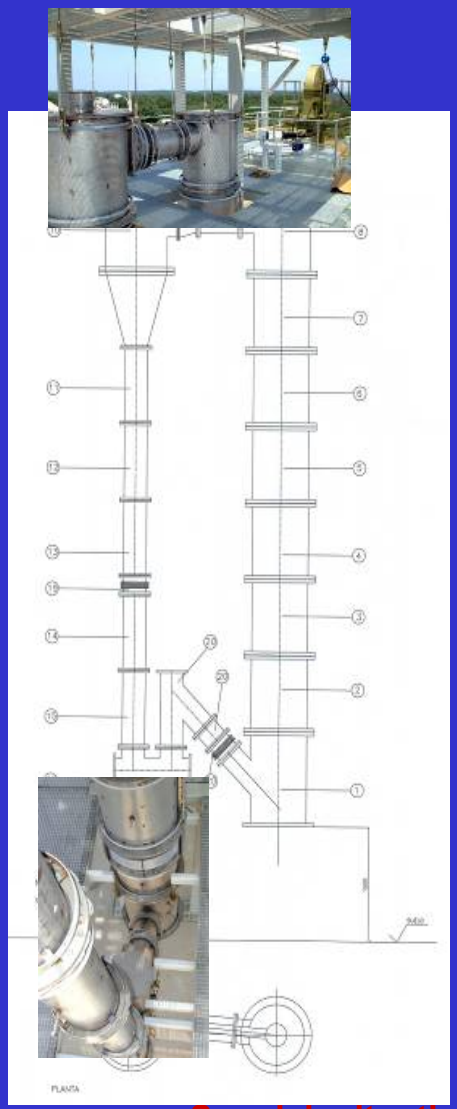
CIEMAT Madrid-Soria (IV)



500 kW CFB PILOT PLANT GASIFIER

CIEMAT Madrid-Soria (V)

Cadagua

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BFB Pilot Plant Gasifier

Gas Cleanup Area

- Fuel: sewage sludge → 7.5% moisture and 12.1 MJ/kg of LHV
- Gasifier capacity: 2.4 t/day of dried sewage sludge
- Fluidising agent: AIR
- Gas Cleaning system: heat exchanger for gas cooling, gas filter (pre-coated bag house filter) and 3 gas scrubbers

R&D Activities

- CO_2-capture Technologies
- Bioenergy: Biomass thermochemical conversion/Gasification
- Advanced combustion gas clean technologies
- Modelling of combustion process
- Optimization of combustion process
- New concepts on Biomass Gasification

BFB gasification pilot plant (25 kW_{th})

Technical Data

Type of reactor	**BFB**
Bed inside diameter	**0.15 m**
Bed height	**1.40 m**
Freeboard inside diameter	**0.25 m**
Freeboard height	**2.15 m**
Pressure/Temperature	**1atm/ 800ºC**

BFB gasification bench-scale plant (5 kW_{th})

GASIFICATION DEMOSTRATION PLANT (3 MW_{th})

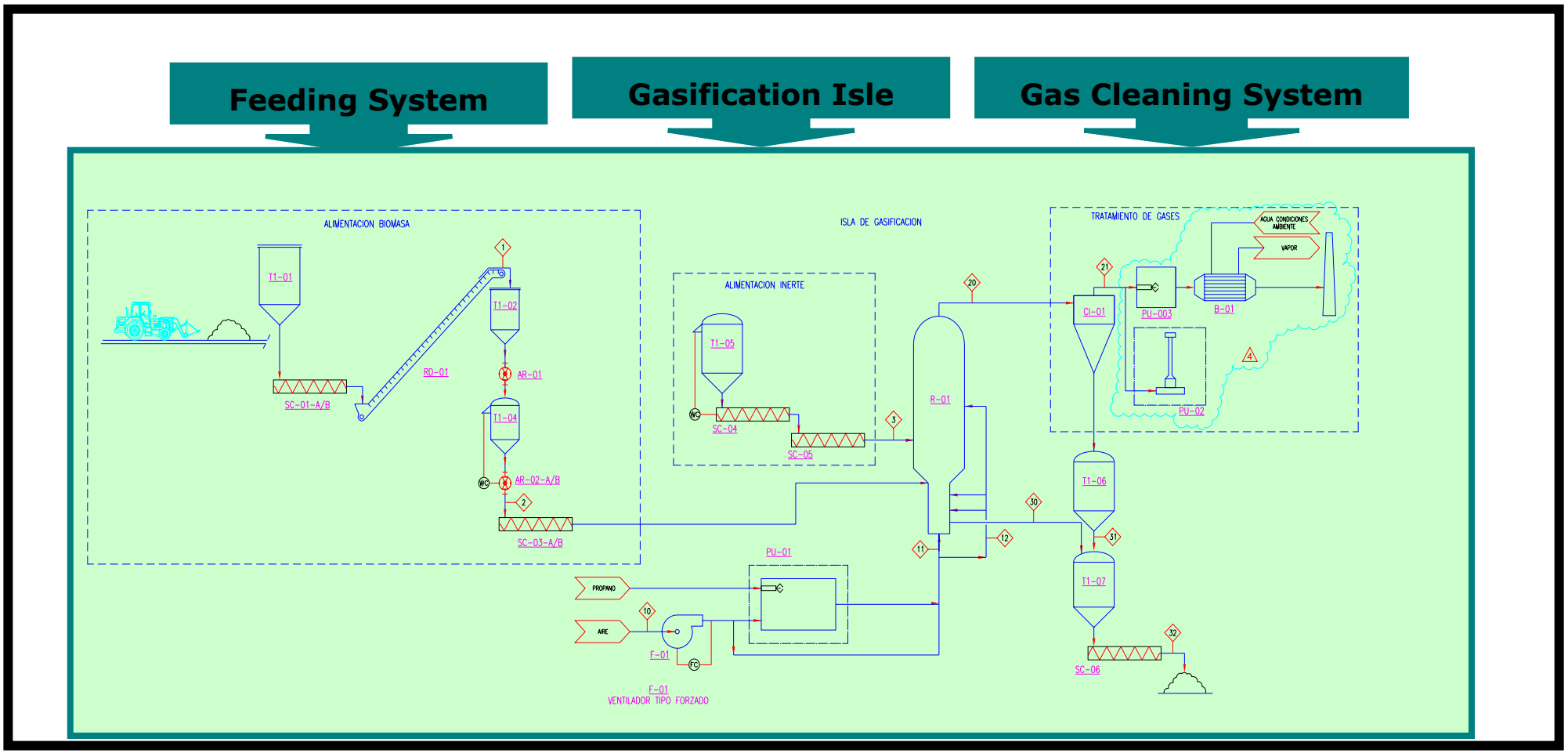
Plant Technical Data

Type of reactor	**BFB**
Thermal Capacity	**3 MW_{th}**
Oxidising agent	**Air**
Pressure/Temperature	**0.3 bar/ 800ºC**
Biomass feeding rate	**15 t/day**
Thermal Yield (cold gas)	**75 %**

Used Biomass

- **Wood pellets**
- **Olive Stones**

PFD


Feeding System
Gasification Isle
Gas Cleaning System
ALIMENTACION BIOMASA
T1-01
T1-02
T1-04
SC-01-A/B
RD-01
AR-01
AR-02-A/B
SC-03-A/B
ALIMENTACION INERTE
T1-05
SC-04
SC-05
ISLA DE GASIFICACION
R-01
PU-01
PROPANO
AIRE
F-01
F-01
VENTILADOR TIPO FORZADO
TRATAMIENTO DE GASES
AGUA CONDICIONES AMBIENTE
VAPOR
CI-01
PU-003
B-01
PU-02
T1-06
T1-07
SC-06

CSIC

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

INSTITUTO NACIONAL DEL CARBÓN

Research area: Energy Processes & Emissions Reduction

- Utilization of coal and renewables for CO_2 emissions reduction and H_2 generation
- CO_2 capture in combustion and gasification processes
- Development of new materials for H_2 storage
- Fluidised bed combustion
- NO_x emissions reduction
- CO2 Capture from combustion flue gases using CaO Carbonation/calcination loop

CO_2 Capture from combustion flue gases using CaO Carbonation/calcination loop

30 kW twin CFB test facility at INCAR-CSIC

Calciner
T~ 900ºC

Carbonator
T ~ 650ºC

$CaCO_3 \longrightarrow CO_2 + CaO$

$CO_2 + CaO \longrightarrow CaCO_3$

O_2 + coal

Flue gas

CIRCE
Center of research on energy resources & consumption

- Non-profit private organisation, sponsored by

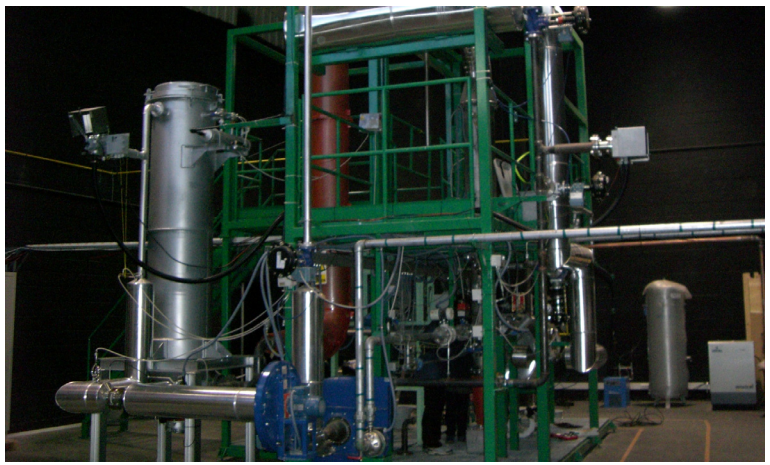
Utility **Mining** **Educational** **Government**

- R&D in energy and thermal and electrical engineering
- Experience in
  - coal & biomass combustion,
  - plant tests & monitoring in conventional (PF) and advanced (FBC, IGCC, co-firing) concepts,
  - laboratory work, simulation, CFD,
  - CO_2 capture systems (oxyfuel, calcium looping, process integration)

CIRCE
Center of research on energy resources & consumption

Research interest

- Oxyfuel combustion. 100 kWt O_2/CO_2 bubbling fluidized bed
  - 2.7 m height, 23 cm i.d. Recycling ratio: 0% to 80%. O_2: from 20% to 40%
  - Combustion efficiency
  - BFB temperature distribution
  - Heat transfer
  - Emissions
- Hydrodynamic Characterization CFB for Calcium Looping Systems. Cold flow
  - Two Plexiglas risers, 4 m height and 160-170 mm i.d
  - Pressure drop along CFB´s and loop-seals
  - Solid circulation measurement
  - System performance with design modifications



CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

icb
INSTITUTO DE CARBOQUIMICA

Instituto de Carboquímica de Zaragoza

- Chemical-Looping Combustion (CLC) for gaseous fuels (syngas, CH_4)
  - **Process and materials development**
- Chemical-Looping Combustion of coal
  - **Development of oxygen carrier materials**
  - **Process development**
  - **Process modelling and simulation**
- Oxyfuel combustion in fluidized bed
  - **Reduction of pollutant emissions**
- Hydrogen generation by Autothermal Chemical-Looping Reforming (CLR)
  - **Development of oxygen carrier materials**
  - **Process modelling and simulation**

Chemical-Looping Combustion installations

10 kW CLC unit for gaseous fuels

900 W Autothermal CLR unit

Contact: Prof. Juan Adánez

New Projects

- **HUNOSA/ENDESA**
- **CIUDEN - ENDESA**

HUNOSA/ENDESA/CSIC

- **There is confidence on the technical viability of carbonate looping cycles after successful experiments at conditions close to those expected in the real CFB carbonator reactor.**
- **Endesa, Hunosa and CSIC will built and run before the end of 2010 a 1 MW pilot dedicated to carbonate looping, close to a CFB power plant.**

CSIC

grupohunosa

endesa

Contact: Juan Carlos Abanades
e-mail: abanades@incar.csic.es
Direct phone: 34 985 11 89 80

CIUDEN- ENDESA

Gobierno de España

CIUDEN

TEST FACILITY FOR ADVANCED TECHNOLOGIES FOR CO_2 CAPTURE IN COAL POWER GENERATION

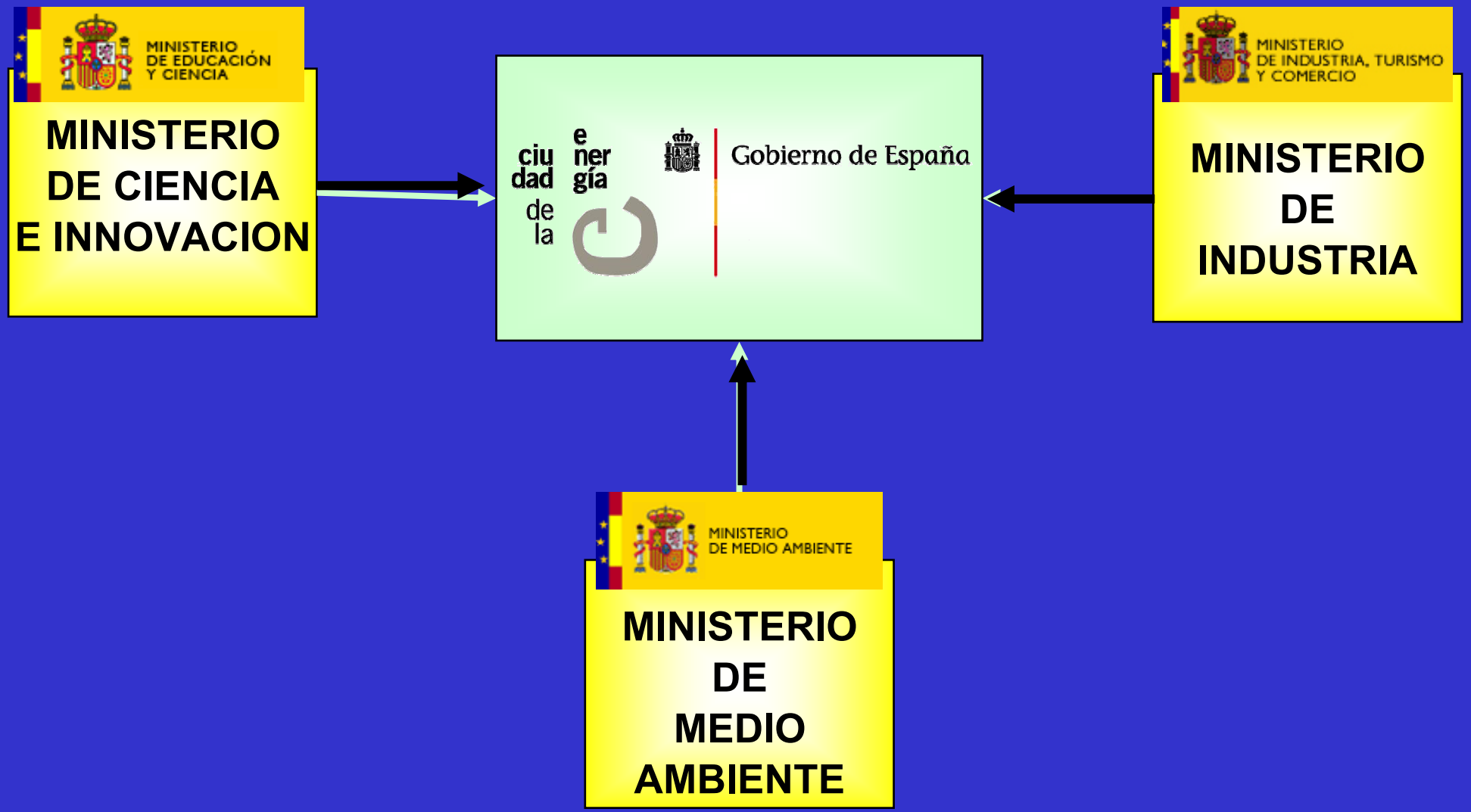
UPDATE AND UPGRADE

58Th IEA FBC IMPLEMENTING AGREEMENT

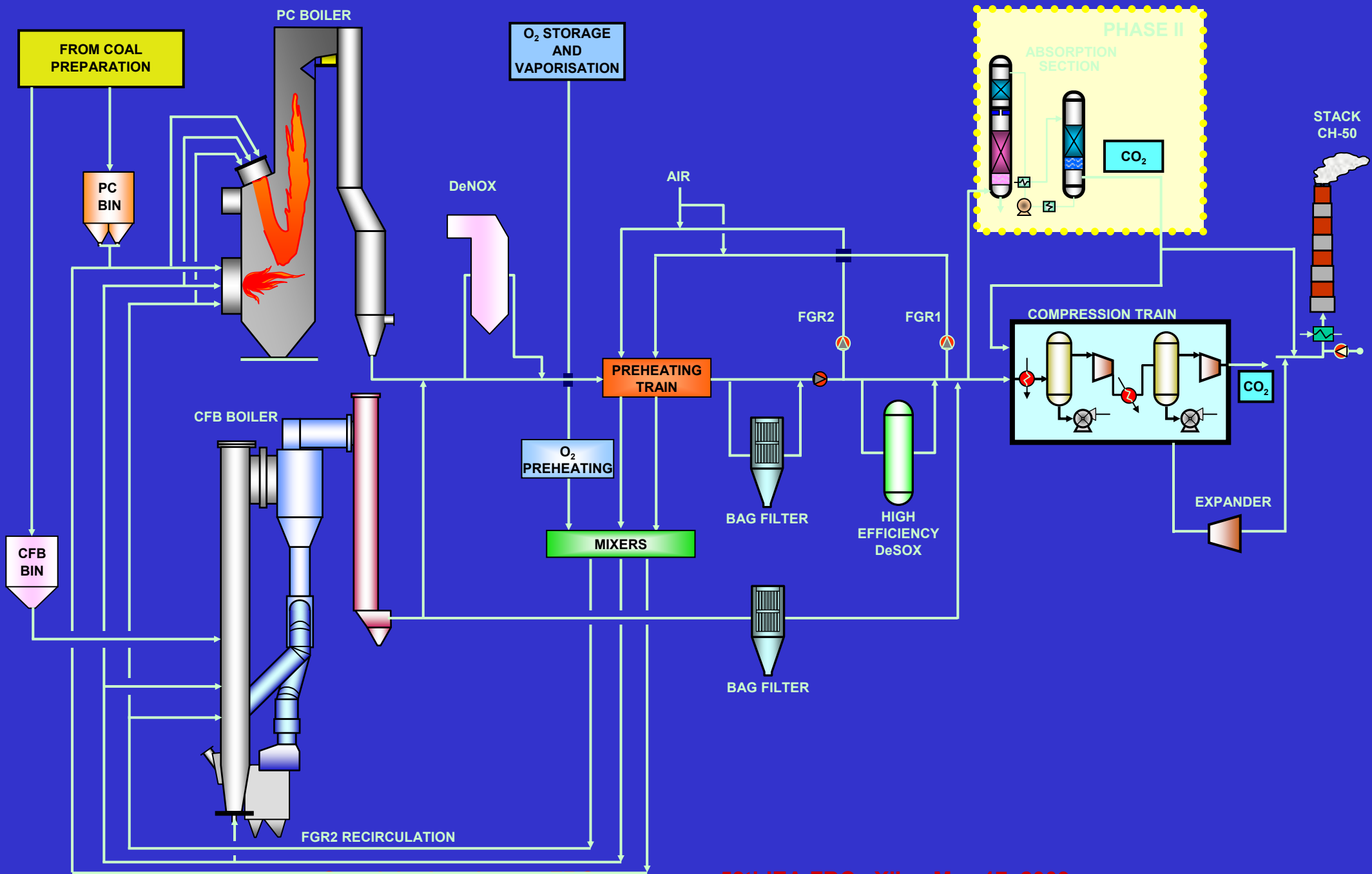
Prof. Dr. Vicente J. Cortés
CO_2 Capture Program Director
CIUDEN, SPAIN

Fundación Ciudad de la Energía

An initiative of the Spanish Administration



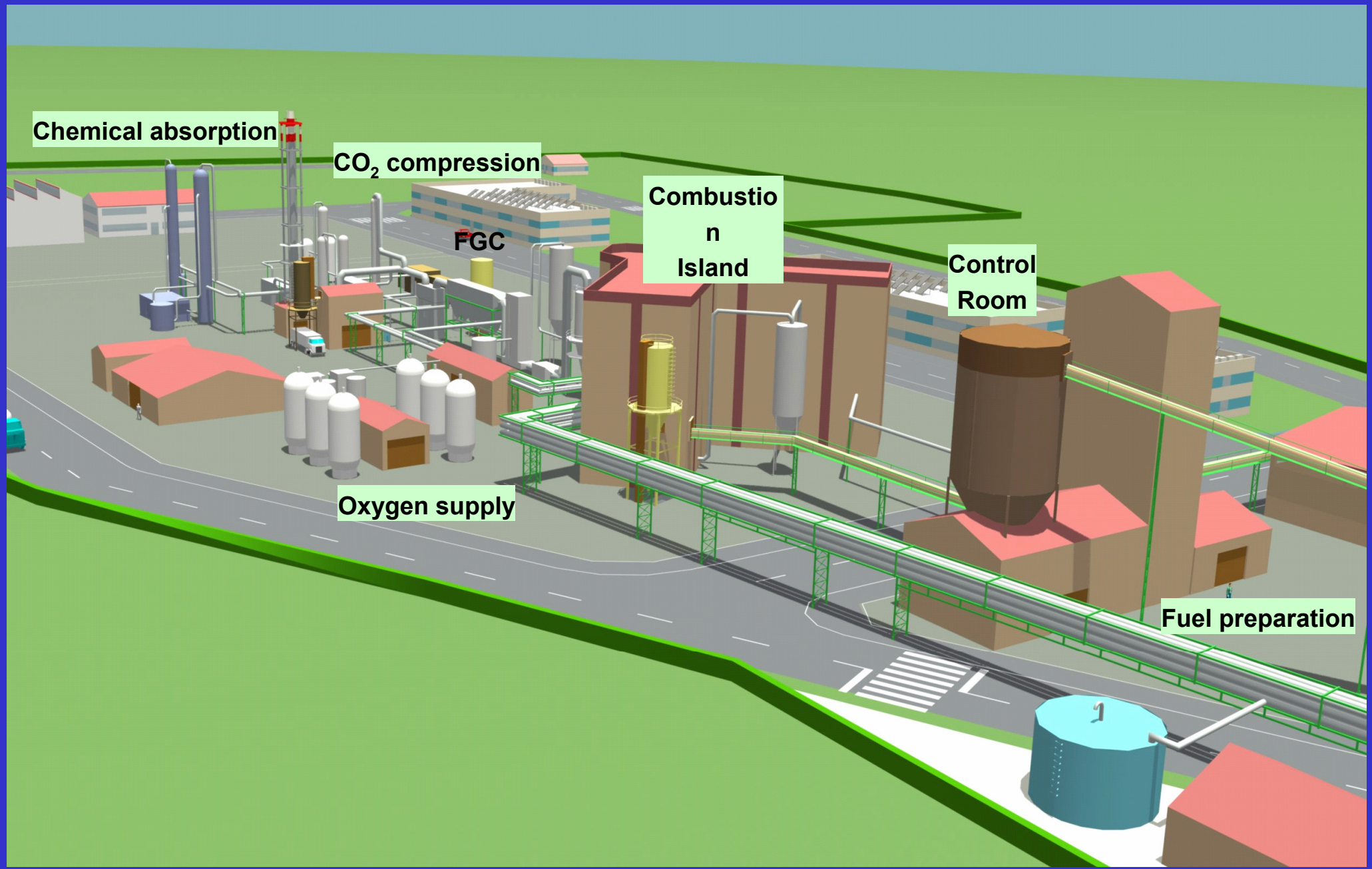
Simplified process diagram



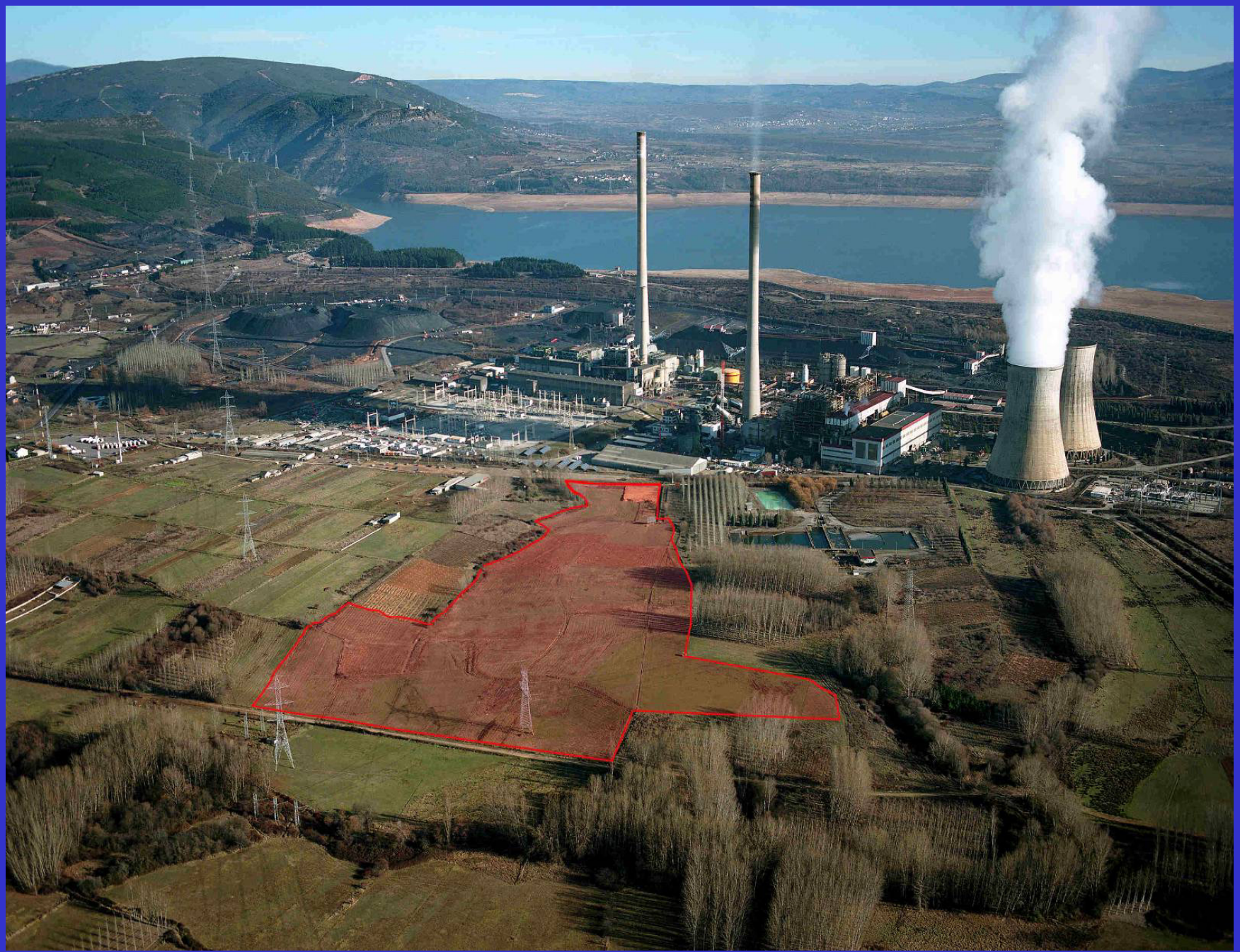
Relevant oxicombustion projects worldwide

LARGE SCALE INTEGRATED PILOT PROJECTS						
PROJECT	LOCATION	MWth		START-UP	MAIN FUEL	REMARKS
		PC	CFB			
VATTENFALL	GERMANY	30		2008	LIGNITES	1 BURNER
TOTAL	FRANCE	30		2009	NG/HC	1 BURNER INDUSTRIAL BOILER
CIUDEN	SPAIN	20	30	2010	ANT./ BIT./ PETCOKE	2+2 BURNERS
OXYBURNERS TEST FACILITIES						
B&W	USA.	30		2007	BIT., SUB B, LIGN.	1 BURNER
OXY-COAL UK	UK	40		2008		1 BURNER
BOILERS REFURBISHMENT/RETROFITTING						
PEARL PLANT	USA	66		2009	BIT.	JUPITER TECHNOLOGY
CALLIDE	AUSTRALIA	90		2010	BIT.	_

Model of the plant

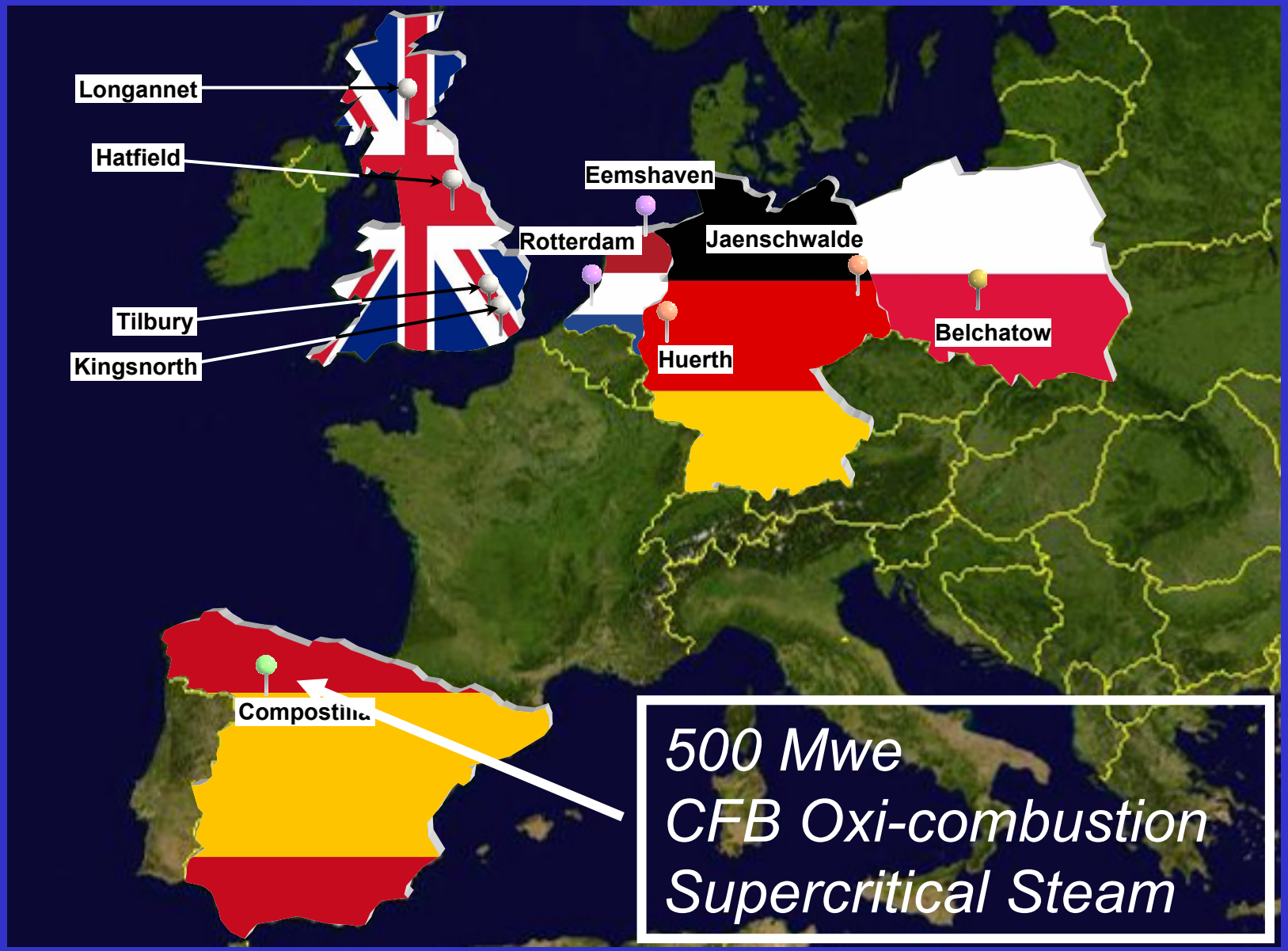


The site, near COMPOSTILLA II Power Plant



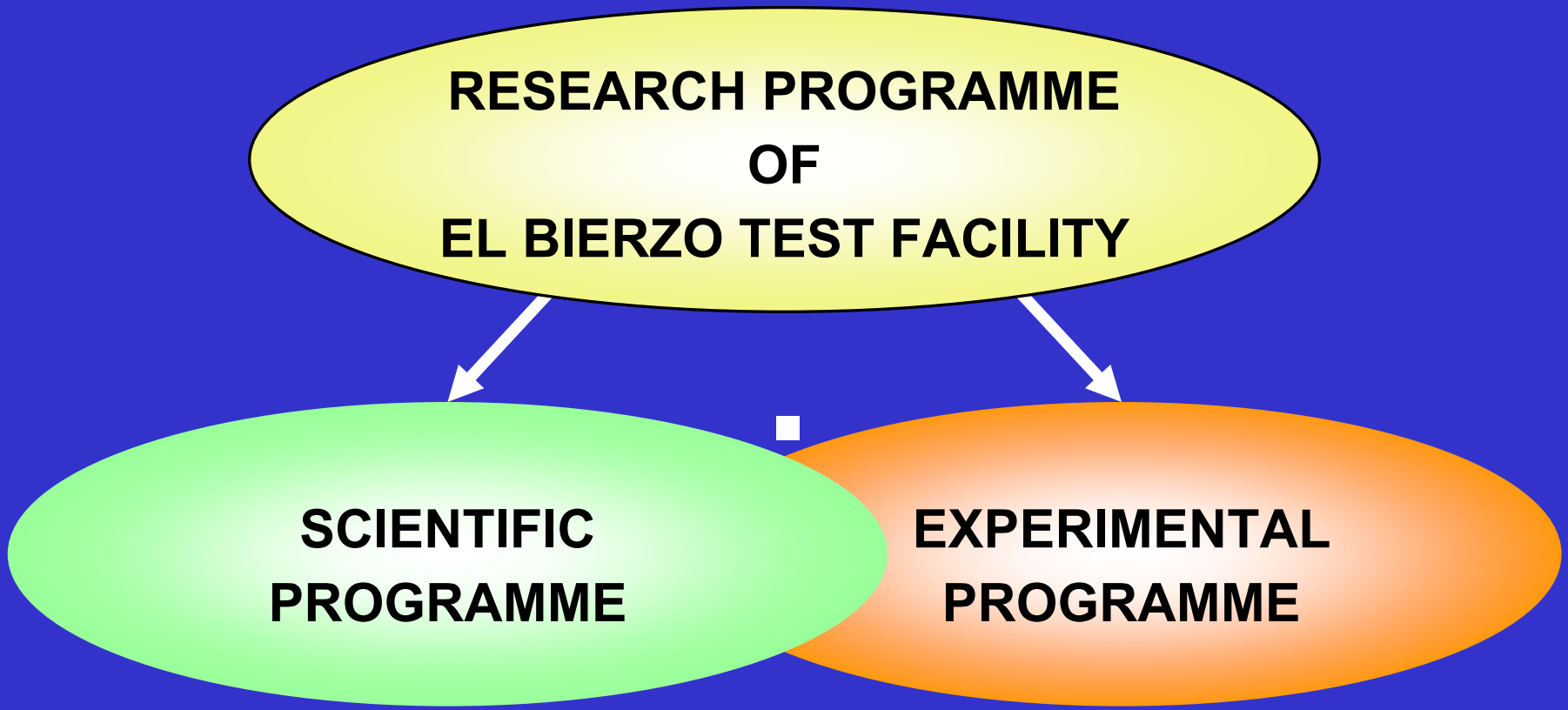
Time schedule

ENDESA



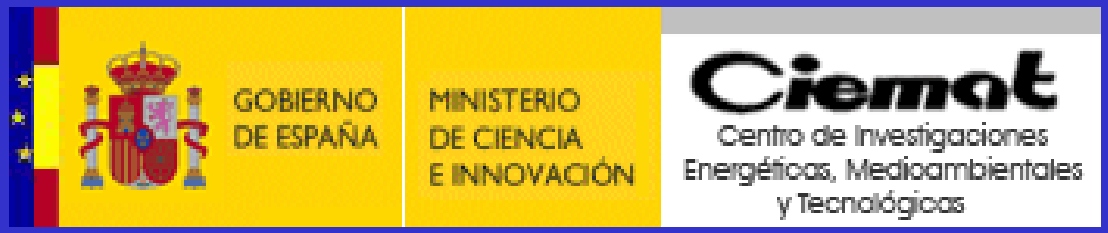
EU Coal Power Generation Demonstration Plants (near 500 Mwe) planed

The R&D programme structure



PERFORMED BY RELEVANT RESEARCH INSTITUTIONS

PERFORMED AT THE FACILITY IN COOPERATION WITH RESEARCH INSTITUTIONS, TECHNOLOGY PROVIDERS AND TECHNOLOGY USERS



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