



The Enel's CCS projects

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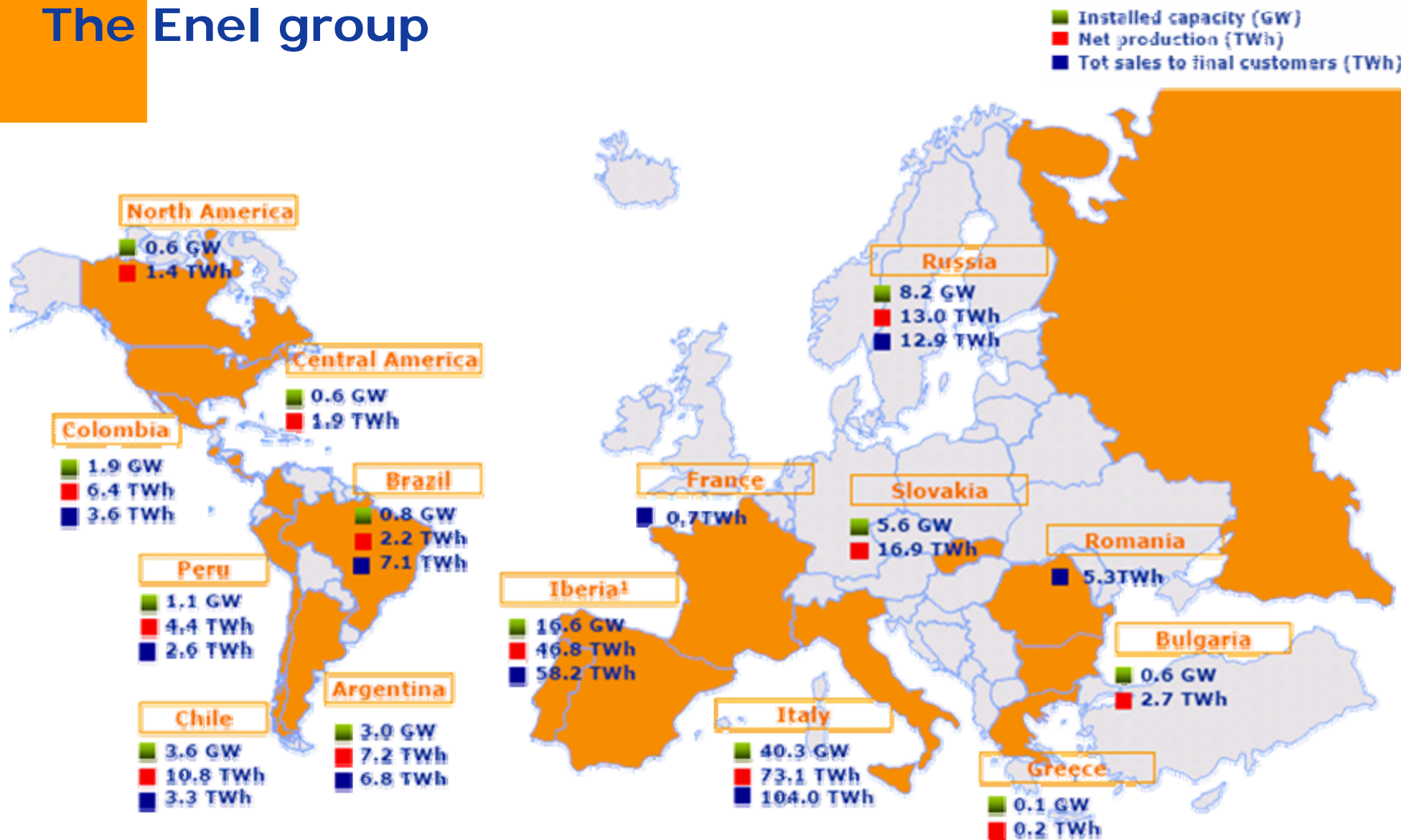
Enel - Engineering & Innovation Division

CO₂ NET EAST

2nd Regional Workshop for CE and EE Countries

Bratislava, 4th March 2009

The Enel group



Total installed capacity: 83 GW

Total net production: 187 TWh

The Enel's CCS projects

Why

- Enel shares the views expressed by the European Institutions and the Zero Emission Fossil Fuel Power Plants Technology Platform that:
 - ✓ Fossil fuels will continue to have a primary role for electricity generation in the decades to come
 - ✓ Contribution of coal is essential for the security of supply
 - ✓ Only the implementation of CCS technologies will allow to make the continued use of fossil fuels compatible with the objectives to reduce the GHG emissions in the atmosphere

Carbon Capture and Sequestration (CCS)

Why

- In Italy Enel plans to built 5000 MWe clean coal capacity, substituting existing oil fired or NG fired steam cycles

Clean coal plant characteristics:

- ✓ Closed coal management system
- ✓ $\eta = 45\%$
- ✓ extremely low emission levels

Torrevaldaliga Nord Power Plant (3 units, 2000 MWe)



First unit in service: Autumn 2008

- These assets need to be preserved in the carbon constrained scenario



CCS retrofit technologies required

The Enel's CCS projects

How

Therefore Enel has decided to take the lead in the development of CCS technologies by:

- Promoting two demo projects:
 - » **ENEL CCS1** **Post-combustion capture and storage demo project**
 - » **ENEL CCS2** **Oxy-coal combustion project**
- Developing knowledge and looking for cooperation in the area of pre-combustion technology
 - » **Power from Hydrogen & Zero Emission IGCC**



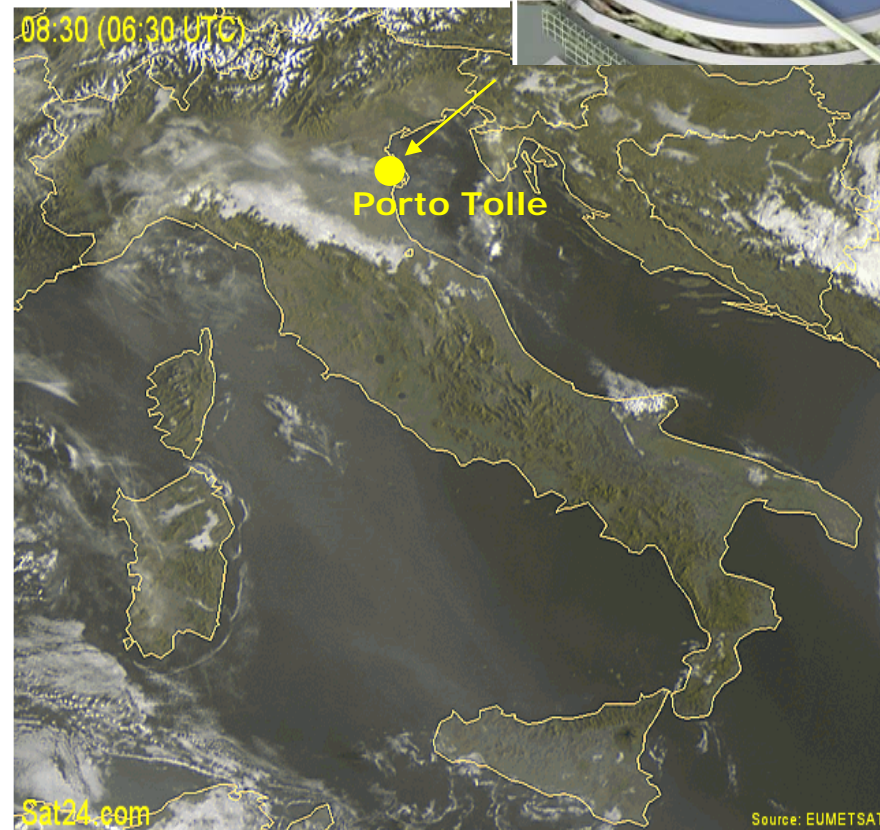
Enel CCS1

**The Porto Tolle post-combustion capture
and storage demo project**

Post-combustion capture and storage demo project

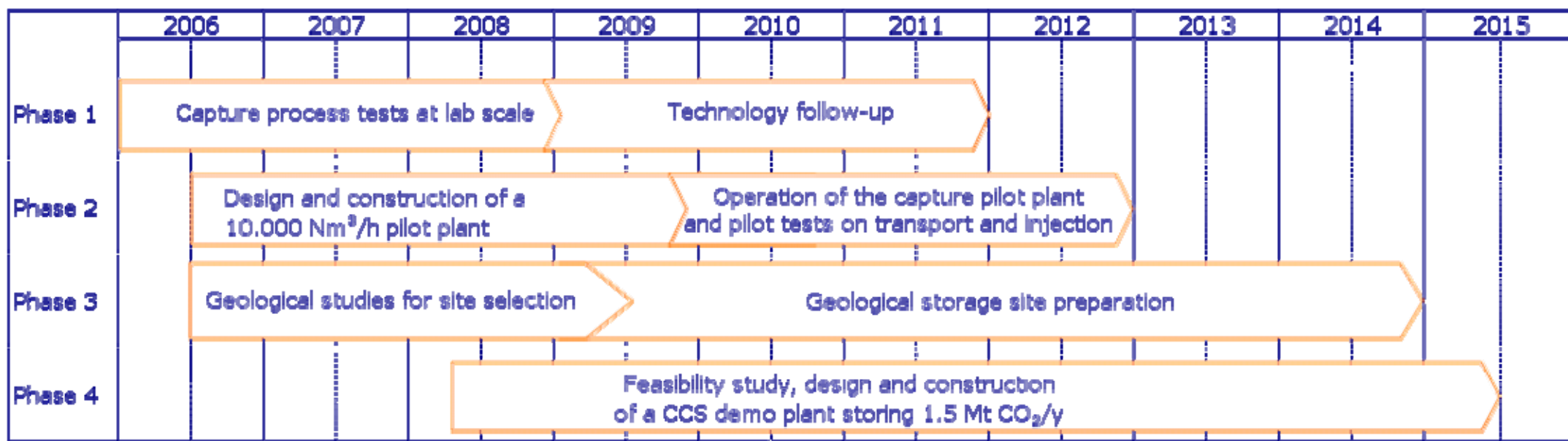
Project goal

To retrofit one 660 MW_e coal fired unit of Porto Tolle power station with CO₂ capture equipment and start CO₂ underground storage by 2015



Post-combustion capture and storage demo project

Time schedule



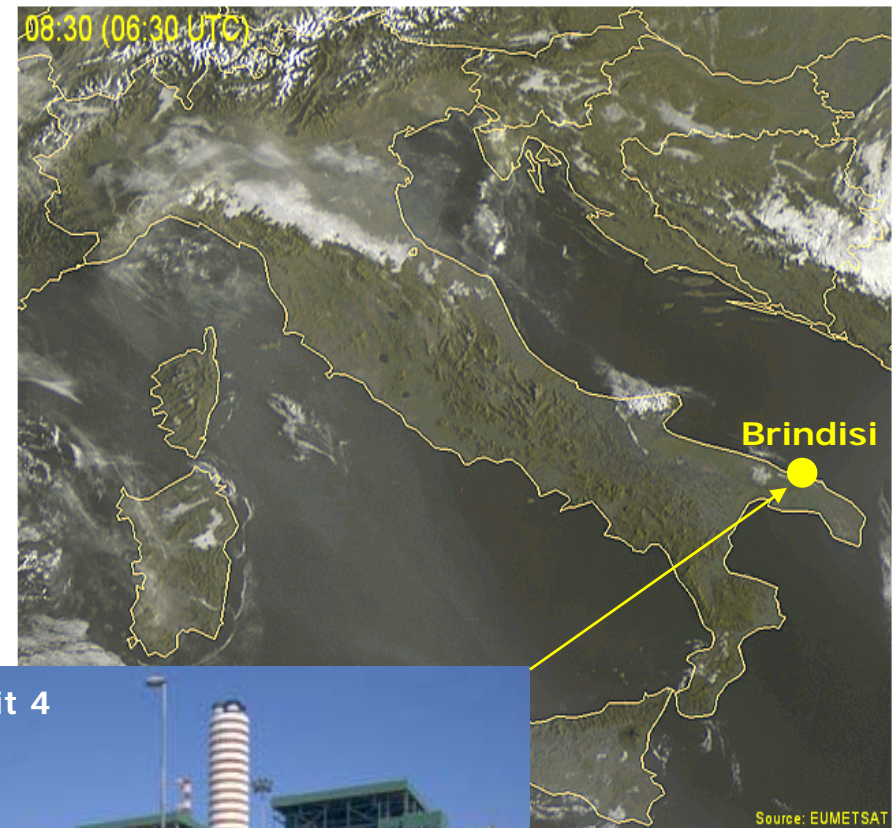
Phase 2 – Brindisi CO₂ capture pilot plant

Pilot plant site

- At the site of Brindisi coal fired power station a pilot plant for CO₂ separation via ammine scrubbing will be built. The plant will be installed on the Unit 4. The plant size will be 10.000 (Nm³/h), corresponding to about 2,5 t/h CO₂

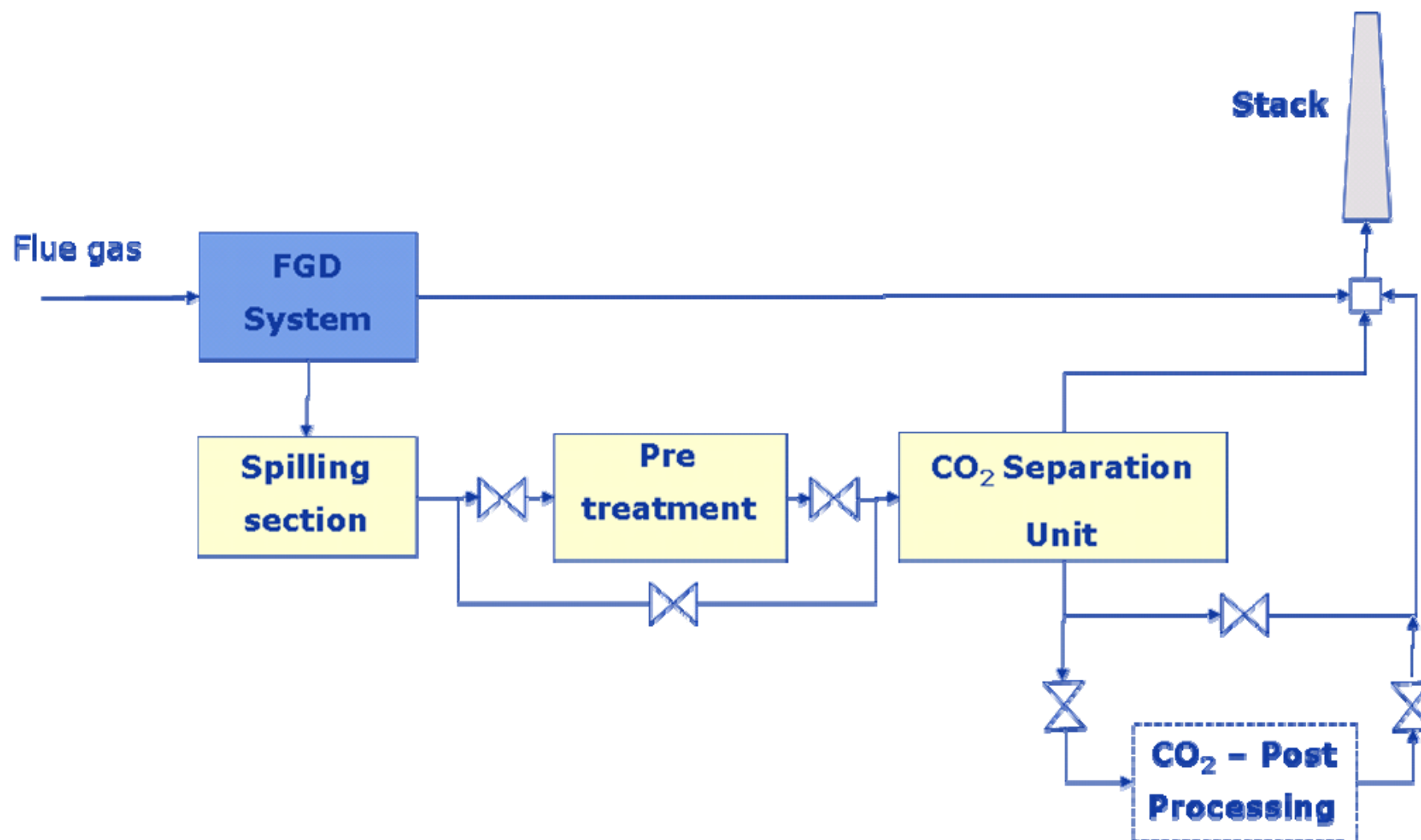
Pilot plant milestones

Specification completed	Jun 07
Contract award	Apr 08
Start site works	Jan 09
Plant completion	Dec 09



Phase 2 – Brindisi CO₂ capture pilot plant

Pilot plant general flow diagram



Phase 2 – Brindisi CO₂ capture pilot plant

Raw gas specification upstream the CO₂ separation unit

	P.P. intake	After pre-treatment
Temperature	> 60 °C	50 °C (max)
SO ₂	400 mg/Nm ³ @6% O ₂ dry	< 20 mg/Nm ³ @6% O ₂ dry
NO ₂	< 40 mg/Nm ³ @6% O ₂ dry	< 40 mg/Nm ³ @6% O ₂ dry
SO ₃	8 – 10 ppm @6% O ₂ dry	-
Particulate	50 mg/Nm ³ @6% O ₂ dry	-
O ₂	7 – 9 %	7 – 9 %
CO ₂	14.5 % @6% O ₂ dry	14.5 % @6% O ₂ dry

Phase 2 – Brindisi CO₂ capture pilot plant

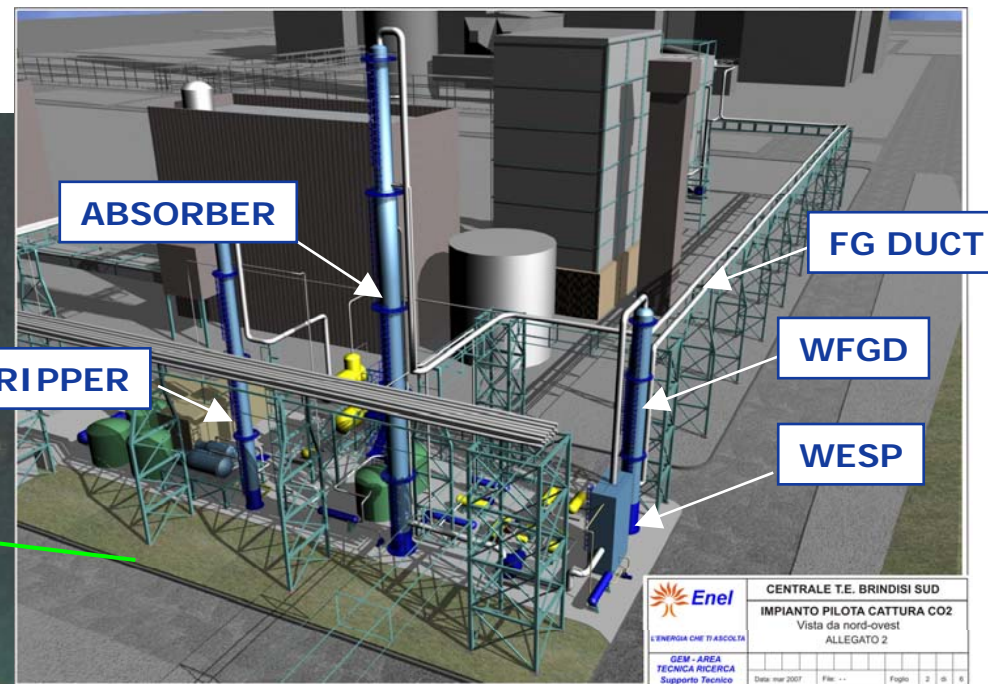
CO₂ separation unit – Design specification

Nominal flue gas capacity (Nm ³ /h wet)	10.000
Max flue gas capacity (Nm ³ /h wet)	12.000
CO ₂ removal efficiency at nominal conditions (%)	90
Min CO ₂ purity at max capacity (%)	98
MEA concentration in the solution (%w.)	20
Max solvent flow (t/h)	70
Cooling water (m ³ /h)	600
Max reboiler steam flow (kg/h)	7.000 (4 bar, saturated)

CO₂ separation unit



Phase 2 – Brindisi CO₂ capture pilot plant



Pilot plant milestones

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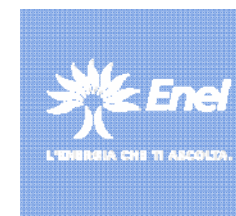
Brindisi coal fired power plant



The Eni – Enel Strategic Agreement on CCS



- On 21 October 2008, Eni and Enel signed a Strategic Cooperation Agreement to develop technologies for CO₂ capture, transport and geological sequestration and to accelerate the deployment of CCS. The goals of the cooperation program are:
 - ✓ To build the first integrated pilot project in Italy combining the Enel's CO₂ post-combustion capture project in Brindisi and the Eni's pilot CO₂ injection project in an exhausted gas field at Cortemaggiore (Piacenza). The start of the CO₂ injection (8.000 t/y) is scheduled for the Autumn of 2010
 - ✓ To carry out a detailed feasibility study for the construction of a large scale integrated CCS demo plant for an Enel's Porto Tolle power station
 - ✓ To jointly evaluate the CO₂ storage potential in Italy



Eni - Enel cooperation

Phase 2 - Integrated pilot project

- **Capture** – Enel's post-combustion capture pilot plant in Brindisi (10.000 m³/h di fumi) in operation from December 2009 and separating 5000 tCO₂/y
- **Liquefaction** – CO₂ liquefaction and cryogenic storage system to be built in Brindisi treating the CO₂ produced by the pilot capture plant
- **Transport** – 230 tracks per year
- **Storage** – ENI gas field in Cortemaggiore (Piacenza). Injection starting in October 2010. Total CO₂ injected: 24000 ton

CORTEMAGGIORE



BRINDISI

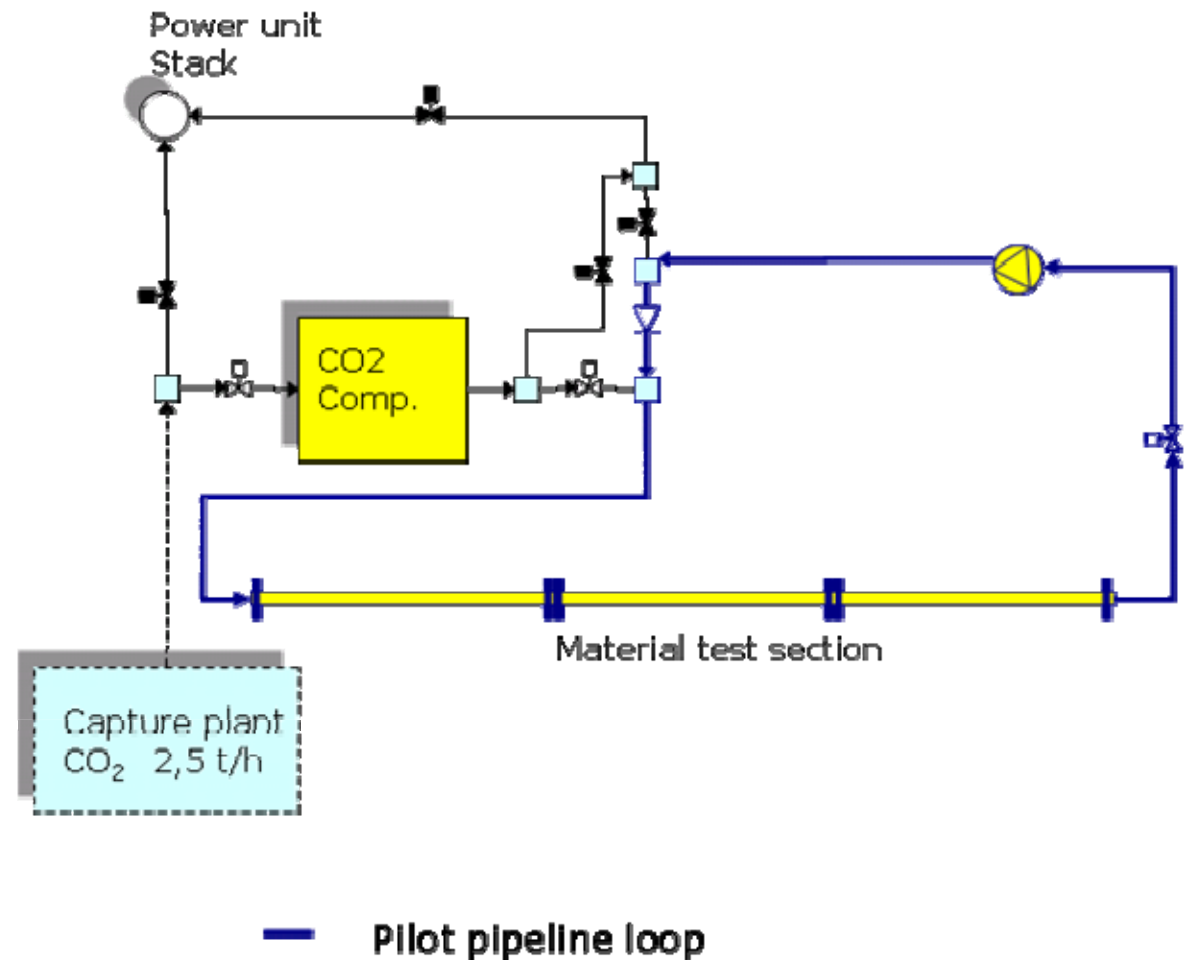


Eni - Enel cooperation

Phase 2 - CO₂ pilot pipeline in Brindisi

The availability of the pilot pipeline will allow to collect experimental data to be used to:

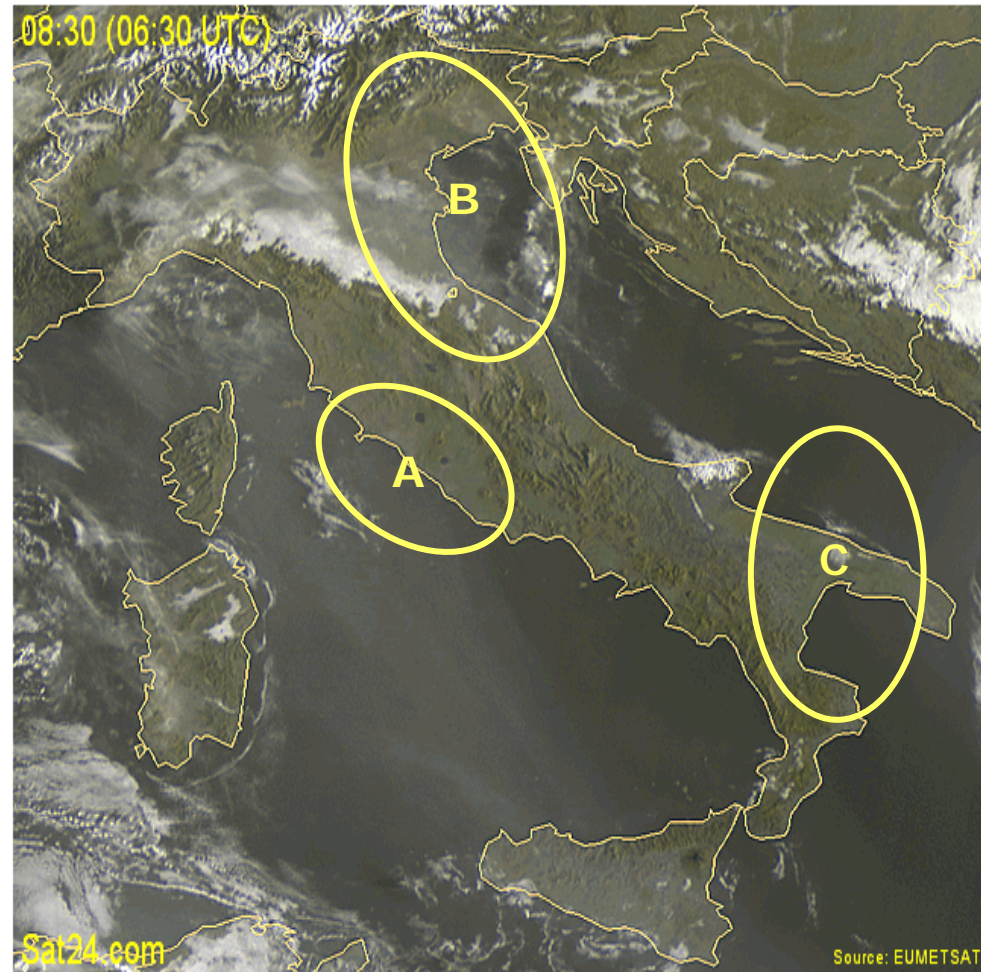
- Validate design models (both stationary and dynamic)
- Optimize operating procedures
- Study corrosion problems related to the presence of impurities in the CO₂ stream



Expected operation start: October 2010

Phase 3 - Storage site selection

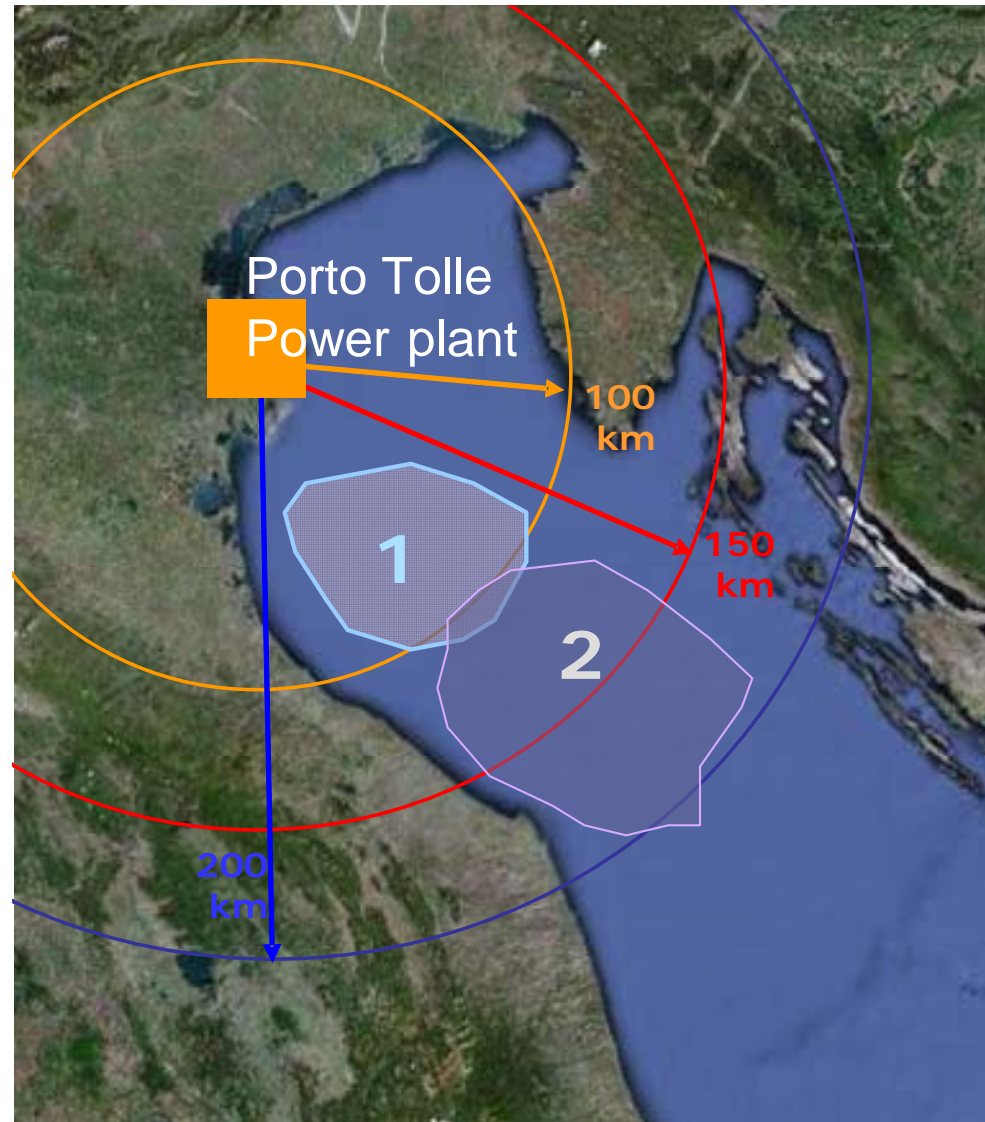
- Italy has theoretically a significant potential for CO₂ geological storage into deep saline aquifers
- Since 2006 Enel is evaluating in detail the storage potential in areas A, B and C that are the areas surrounding possible sites for the post-combustion capture demo. Studies are carried out in cooperation with INGV (Istituto nazionale di Geofisica e Vulcanologia), OGS (Istituto nazionale di Oceanografia e Geofisica Sperimentale) and other Italian geological Institutes



Phase 3 - "Northern Adriatic" area (B)

Preliminary results

- The most promising potential (~1.300 Mt CO₂) is shown by off-shore saline formations about 150-200 km south-east of the power plant.



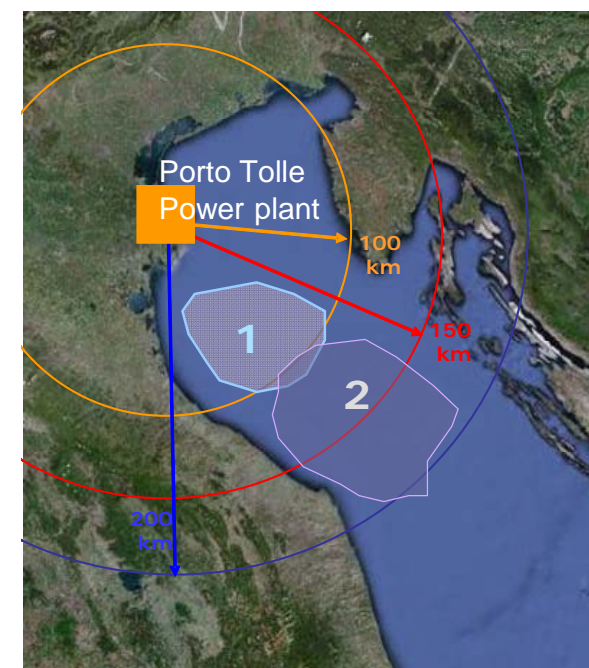
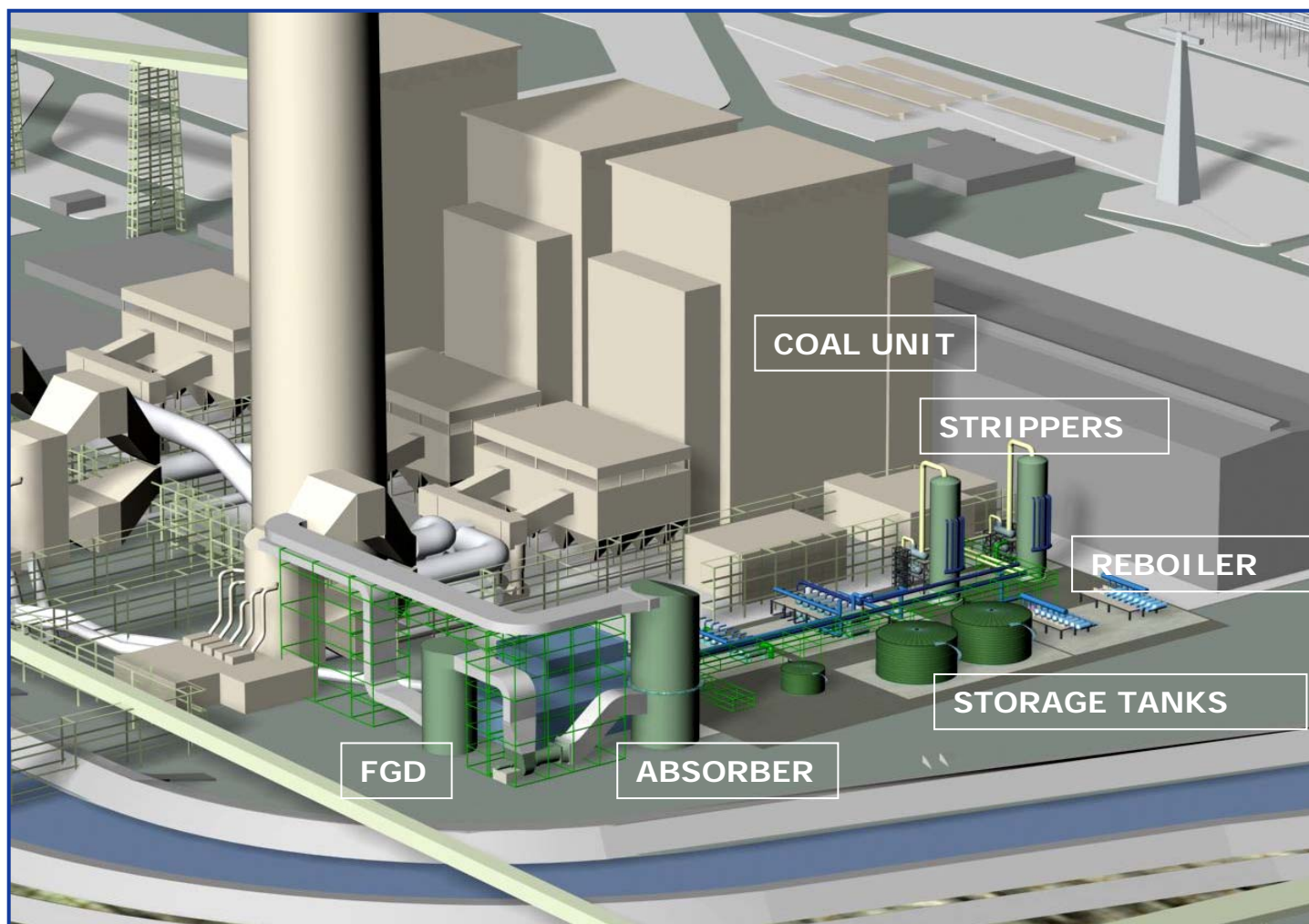


Phase 4

Porto Tolle post-combustion demo plant

Phase 4 – Porto Tolle post-combustion demo plant

Porto Tolle power plant

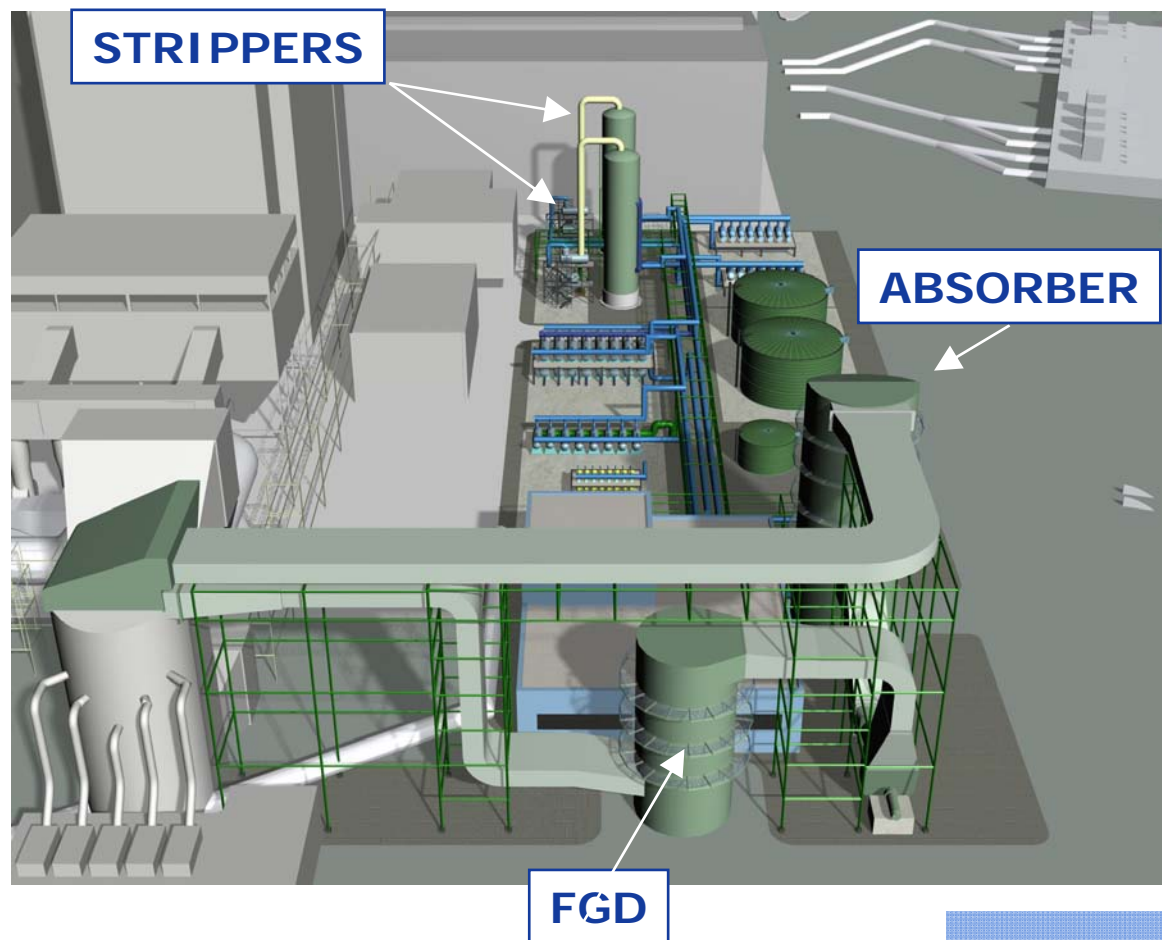


Storage site area

Phase 4 – Porto Tolle post-combustion demo plant

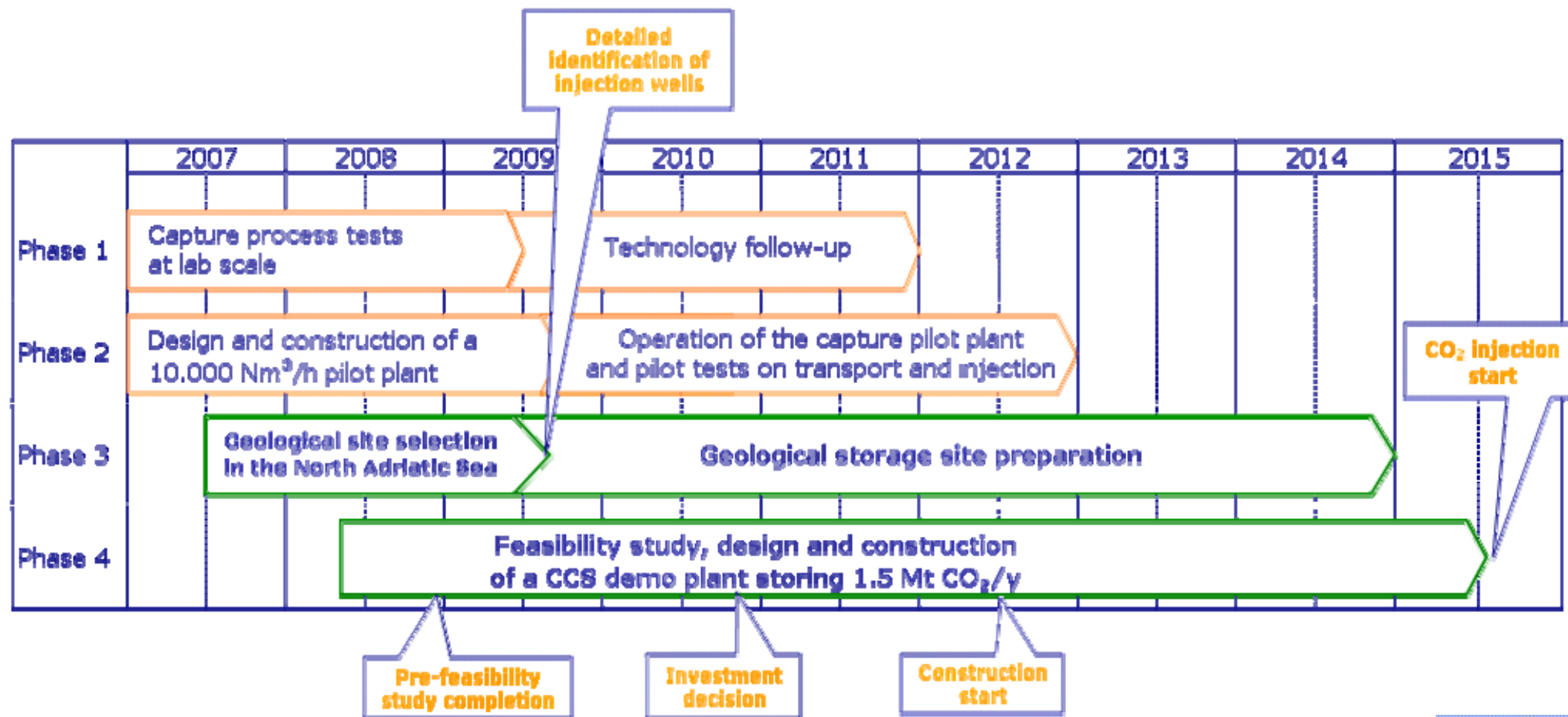
Demo main features

Type of Project	Retrofit
Power generation	660 MWe
Primary fuel	Bituminous coal
Secondary fuel	Biomass
Power Generation Tech	USC-PC
% of flue gas treated	50 %
CO ₂ Capture Tech	Post Combustion Capture with Amine
Stored CO ₂	1,5 Mt/y
CO ₂ Capture rate	90%
CO ₂ Storage solution	Deep saline aquifer
Storage location	150 km South-East – Nord Adriatic Sea
CO ₂ value chain	Pure storage



Phase 4 – Porto Tolle post-combustion demo plant

Time schedule





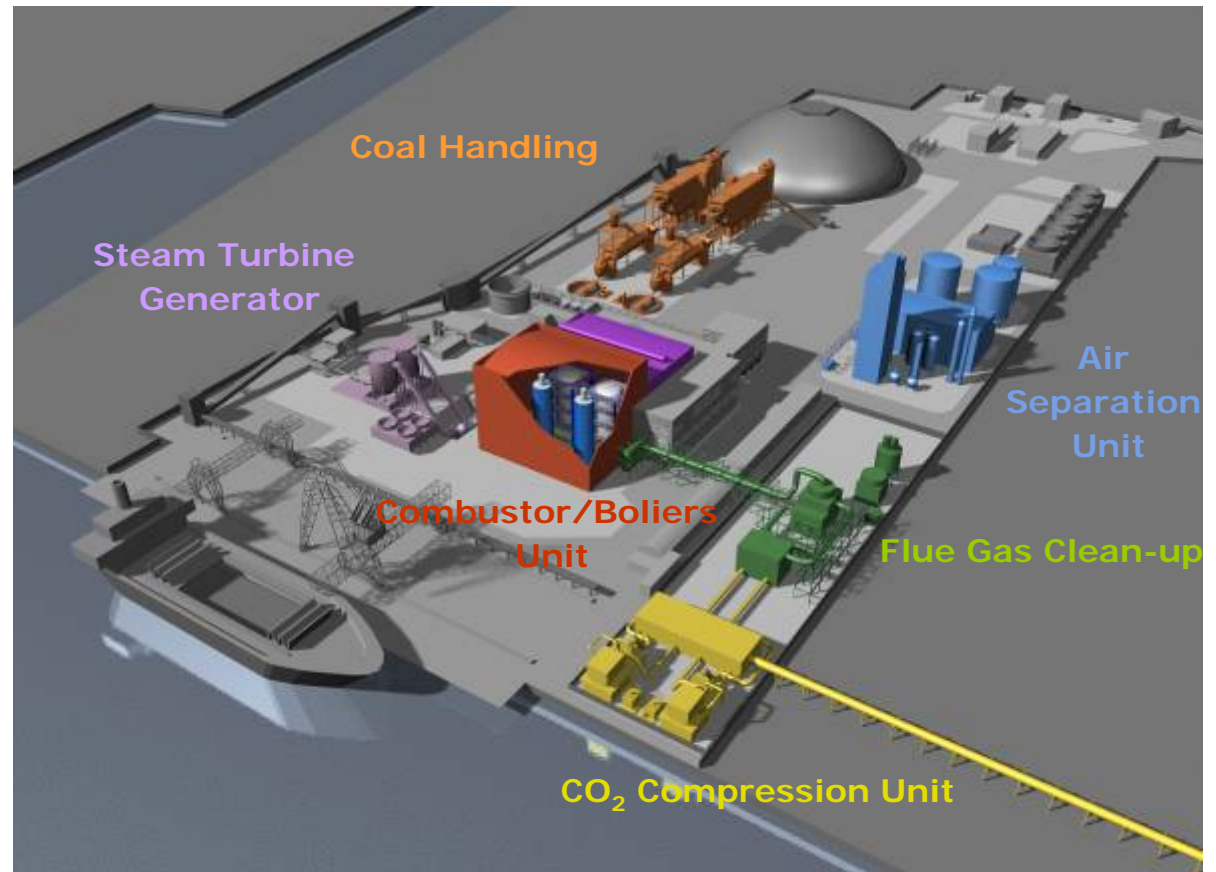
Enel CCS2

The oxy-coal combustion project

Oxy-coal combustion project

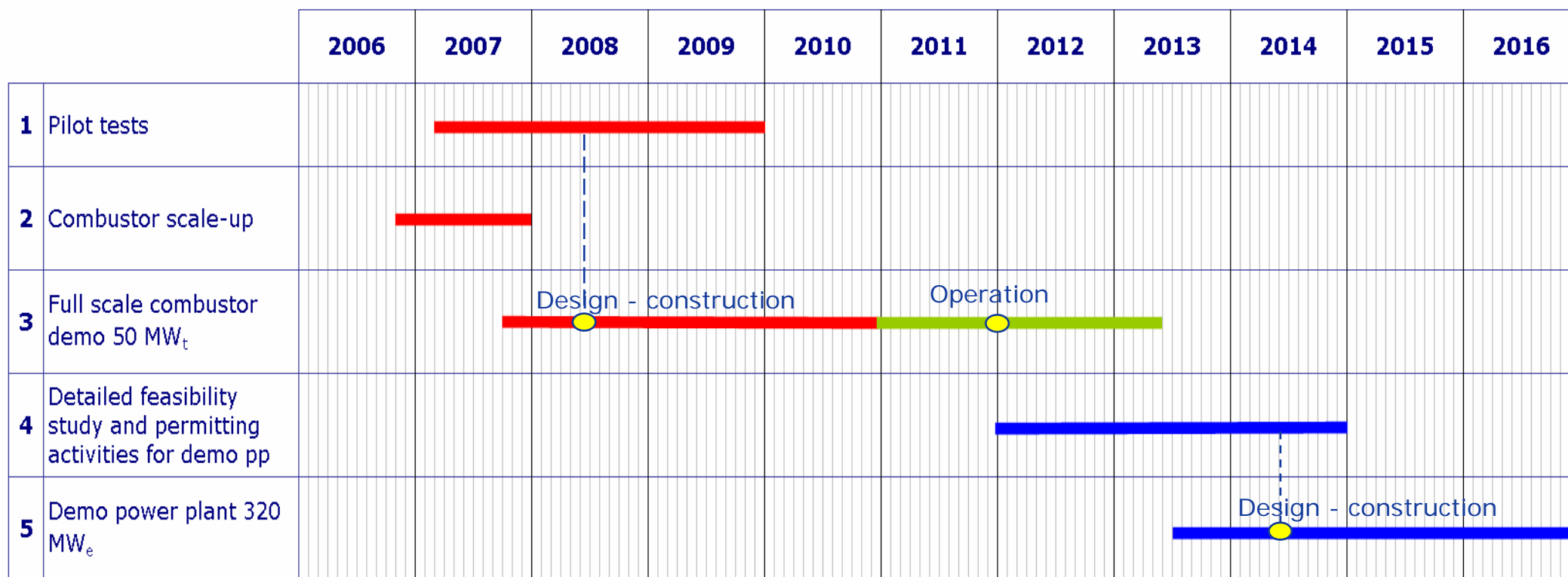
Project goal

To build by 2016 a 320 MWe
zero emission coal fired
power plant based on a
pressurized oxy-combustion
technology already proved
at pilot scale



Oxy-coal combustion project

Time schedule

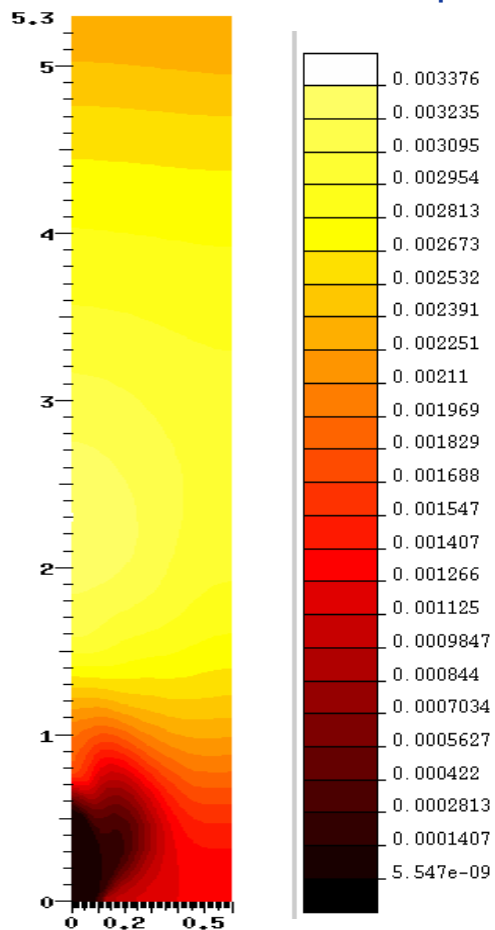


-  Decision point
-  Activities in progress

Oxy-coal combustion project

Phase 1 and 2

Modelling for combustor scale-up



Tests using coal on
the 5 MWth
Isotherm pilot plant.



ITEA facility in Gioia del Colle

Preliminary design
of full scale
combustor demo

Positive investment
decision for Phase 3
April 2008

Oxy-coal combustion project

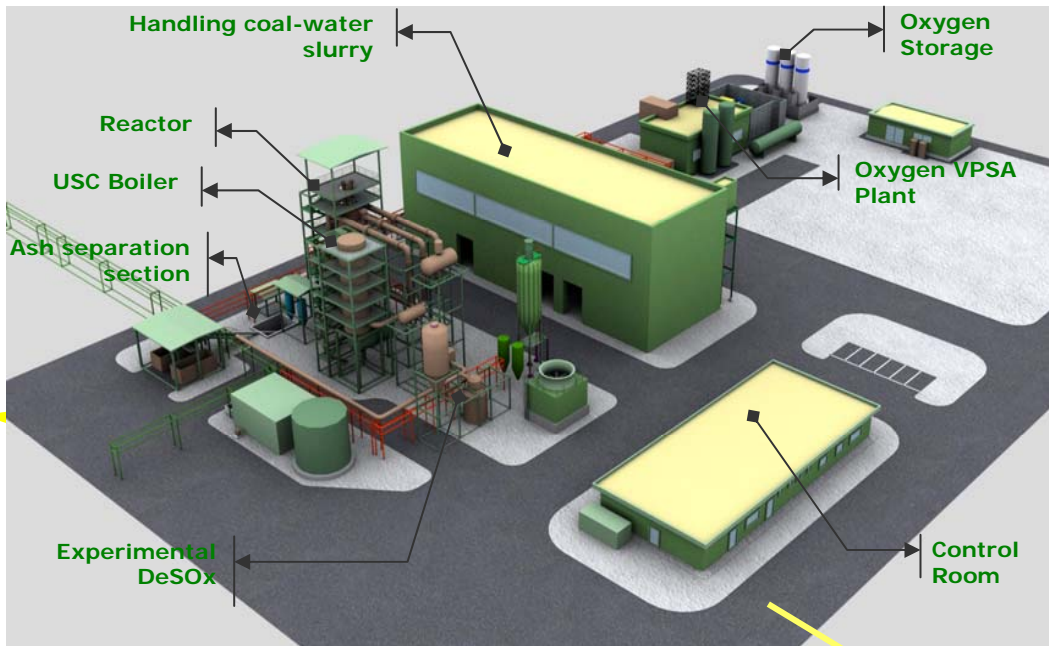
Phase 3 - Full scale combustor demo

Technical data

Combustor power	48 MWt
Process pressure	10 bar
Fuel	coal slurry
Boiler	pressurized, new design
Oxygen	cryogenic storage/VSA
Oxygen mass flow rate	400 t/d @ 90% purity
Steam generation	55 t/h @ 240 bar - 600° C

Oxy-coal combustion project

Phase 3 – Full scale combustor demo



Brindisi coal fired power plant



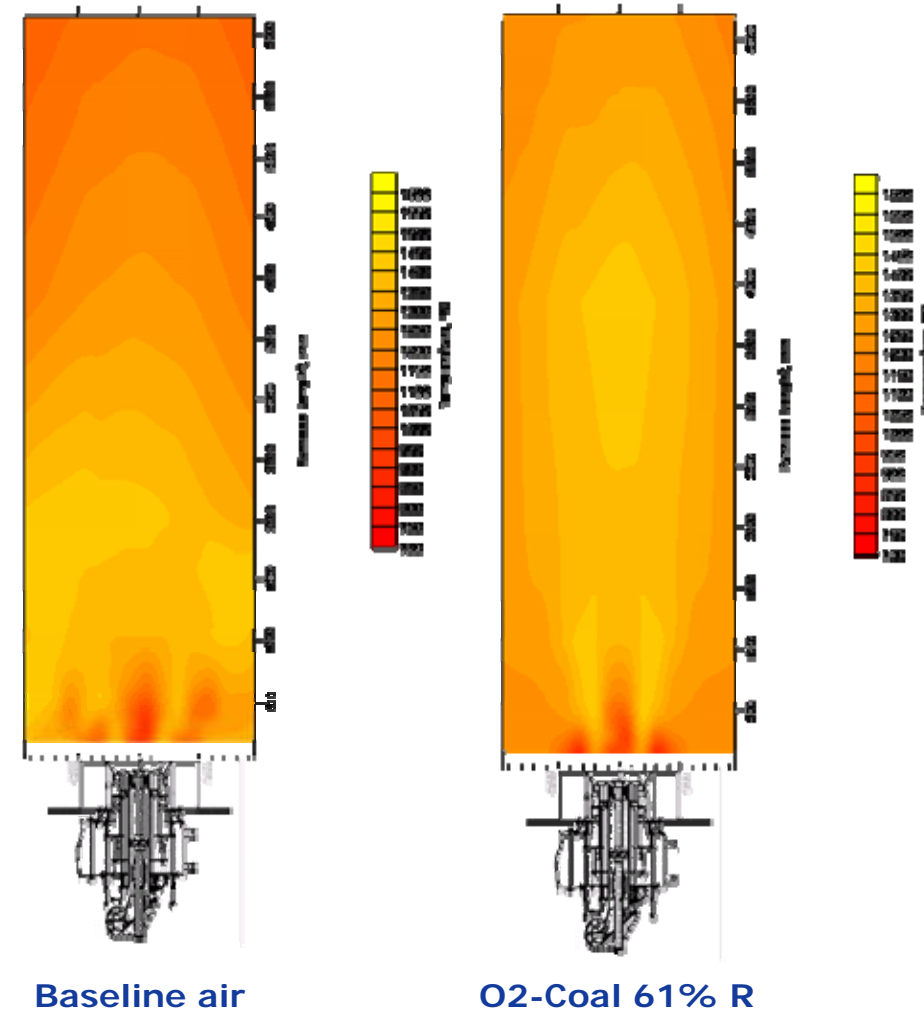
Project milestones

Invest. decision	Apr 08
Ground breaking	Apr 09
Assembling	Jan 10
Commissioning	Dec 10

Atmospheric oxy-combustion tests in a 3 MW facility



- A 3 MW combustion test facility in Enel's Livorno labs was modified to oxygen operation
- Oxy-coal atmospheric combustion tests were successfully performed with different recycle ratios
- Results of the first experimental campaign are under evaluation



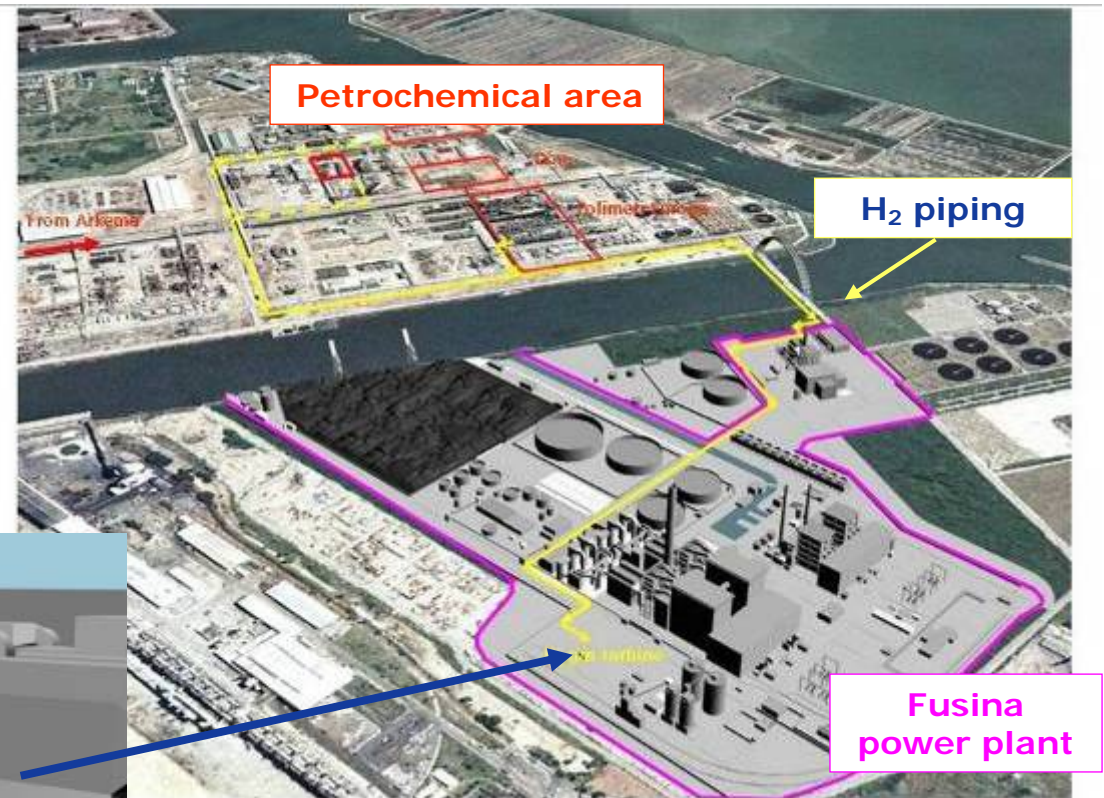


Power from Hydrogen & Zero Emission IGCC

Power from Hydrogen

The Fusina hydrogen burning power plant

- On the pre-combustion technology, Enel is sharing the experience of Elcogas IGCC plant and is now focusing its attention on proving, at industrial scale, the power generation from hydrogen.
- A 12 MWe combined cycle fed by hydrogen produced by petrochemical industries is under construction in Fusina power plant



Power from Hydrogen

The Fusina hydrogen power plant



Project milestones

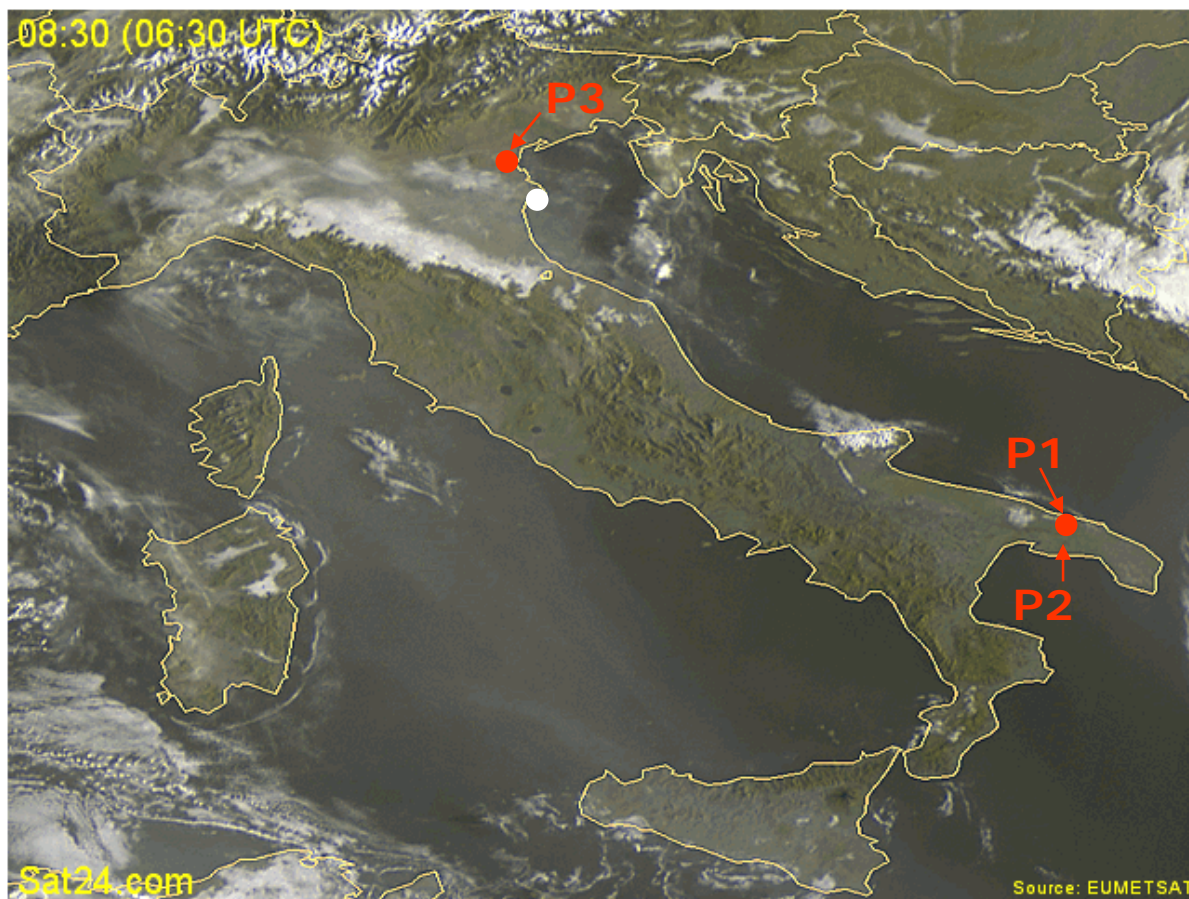
GT order	Mar 07
Combustor tests	Sep 07
Start site works	Dec 07
NG commissioning	Apr 09
H2 commissioning	Jul 09

Zero Emission IGCC

Enel initiatives

- Enel is partner of:
 - ✓ **DYNAMIS**, a project funded under the 6th FP, for a pre-engineering study of the European ZEIGCC
 - ✓ **DECARBit**, a project funded under the 7th FP, focused on high-potential, cost-efficient advanced capture techniques in pre-combustion schemes
- Enel is looking for cooperation opportunities in demonstrating Zero Emission IGCC technology.

Summary of Enel's initiatives on CCS



Legenda

Pilot plants

P1 = Post combustion capture pilot

P2 = Oxy-combustion pilot

P3 = H₂ CC pilot

CCS Demo plants

- Porto Tolle post-combustion demo



Thank you
for your kind attention