The Enel's CCS strategy and projects

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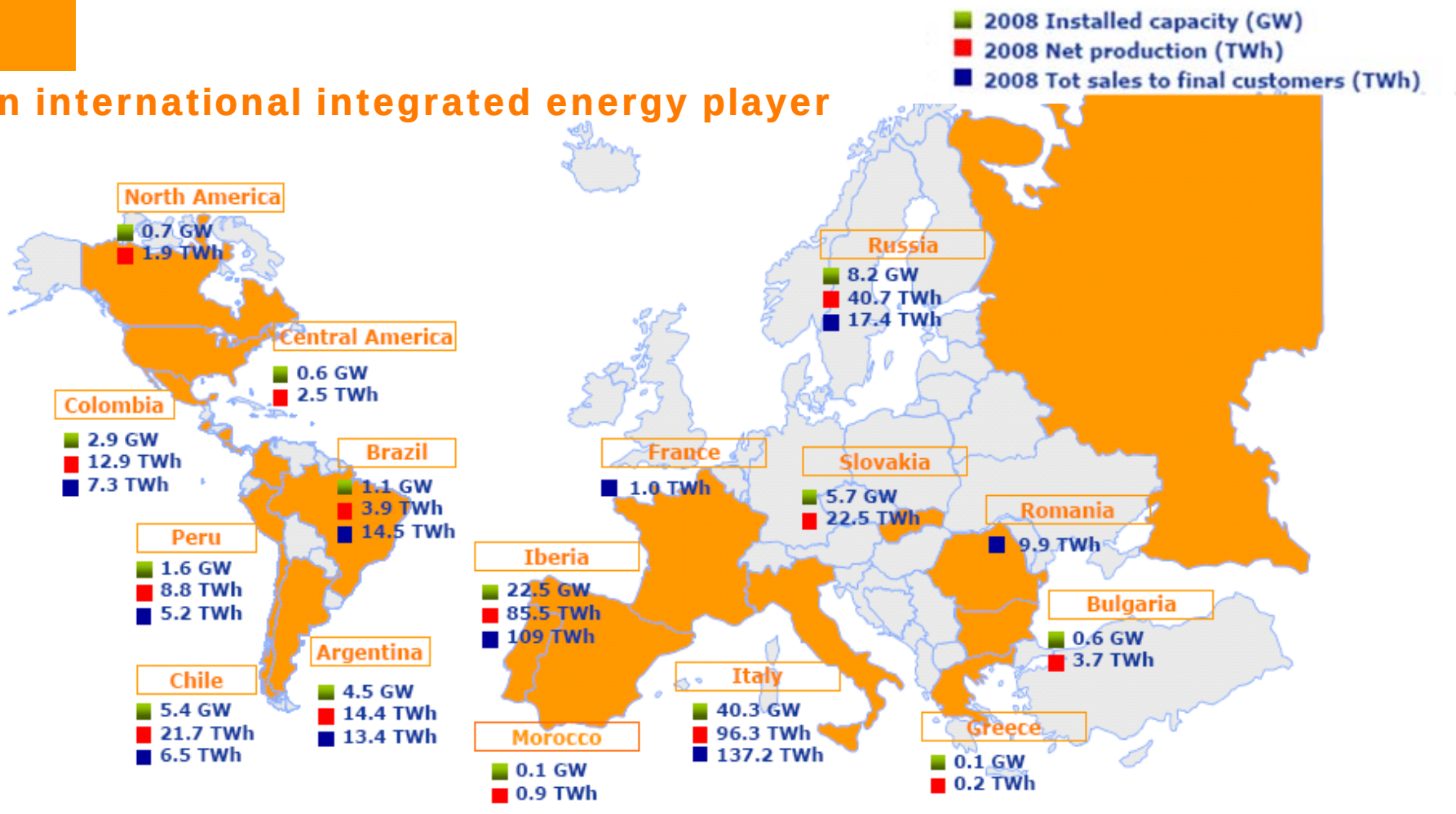
Enel - Engineering & Innovation Division

"Leading Low-Carbon Technology in Italy and the United States: Moving Research from the Laboratory to the Market "

Rome, 26th May 2009

The Enel group

An international integrated energy player



Total installed capacity: **~94 GW**

Total net production: **~316 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
  - ✓ η = 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 be a leader 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
  - » **ENEL CCS3** **Power from Hydrogen & Zero Emission IGCC**

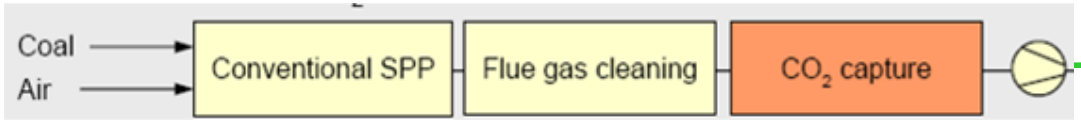
The Enel's CCS projects

How

Options	Capture systems	Compression & storage

1 **Post-combustion capture**

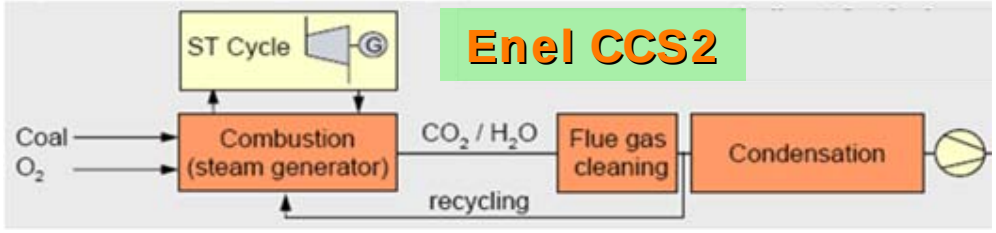
Enel CCS1



CO_2

2 **Oxy-combustion**

Enel CCS2

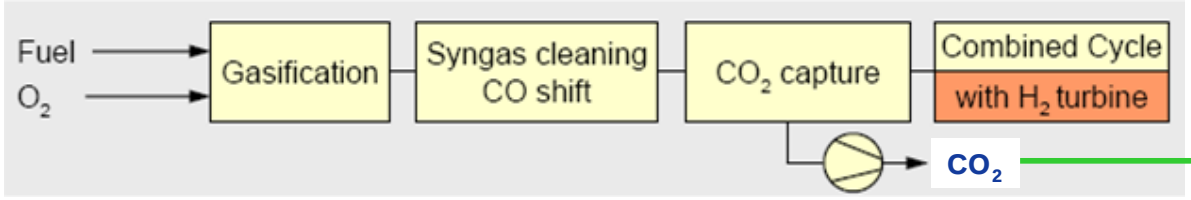


CO_2

CO_2 cleaning & compression

Transport & Storage

3 **Pre-combustion capture**



Enel CCS3

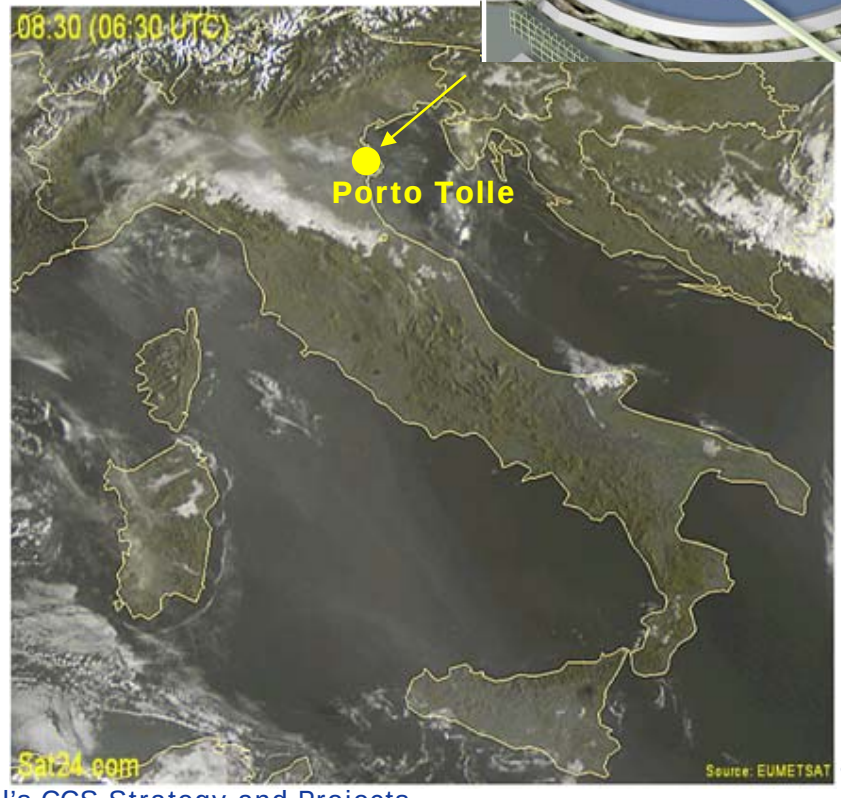
Enel CCS1

Post-combustion capture and storage demo project

Post-combustion capture and storage demo project

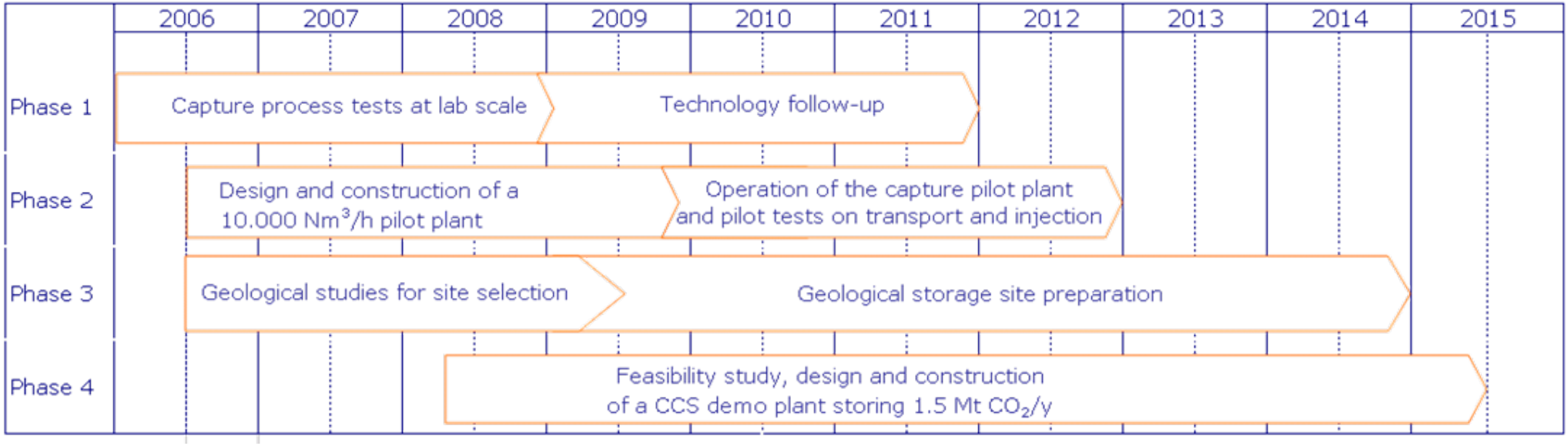
Project goal

To retrofit one 660 MW_e coal fired unit of Porto Tolle power station with CO_2 capture equipment and start CO_2 underground storage by 2015



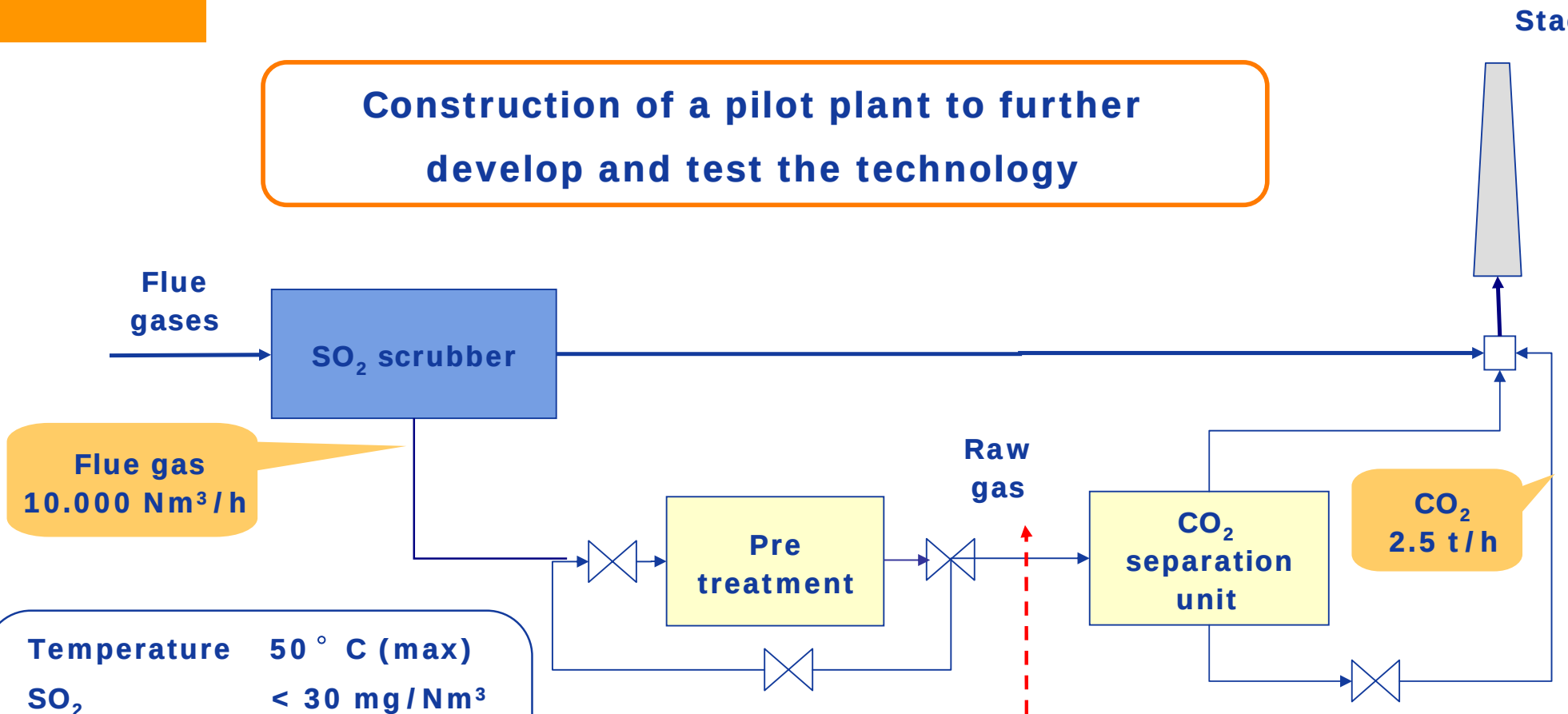
Post-combustion capture and storage demo project

Time schedule



Phase 2 - Brindisi CO_2 capture pilot plant

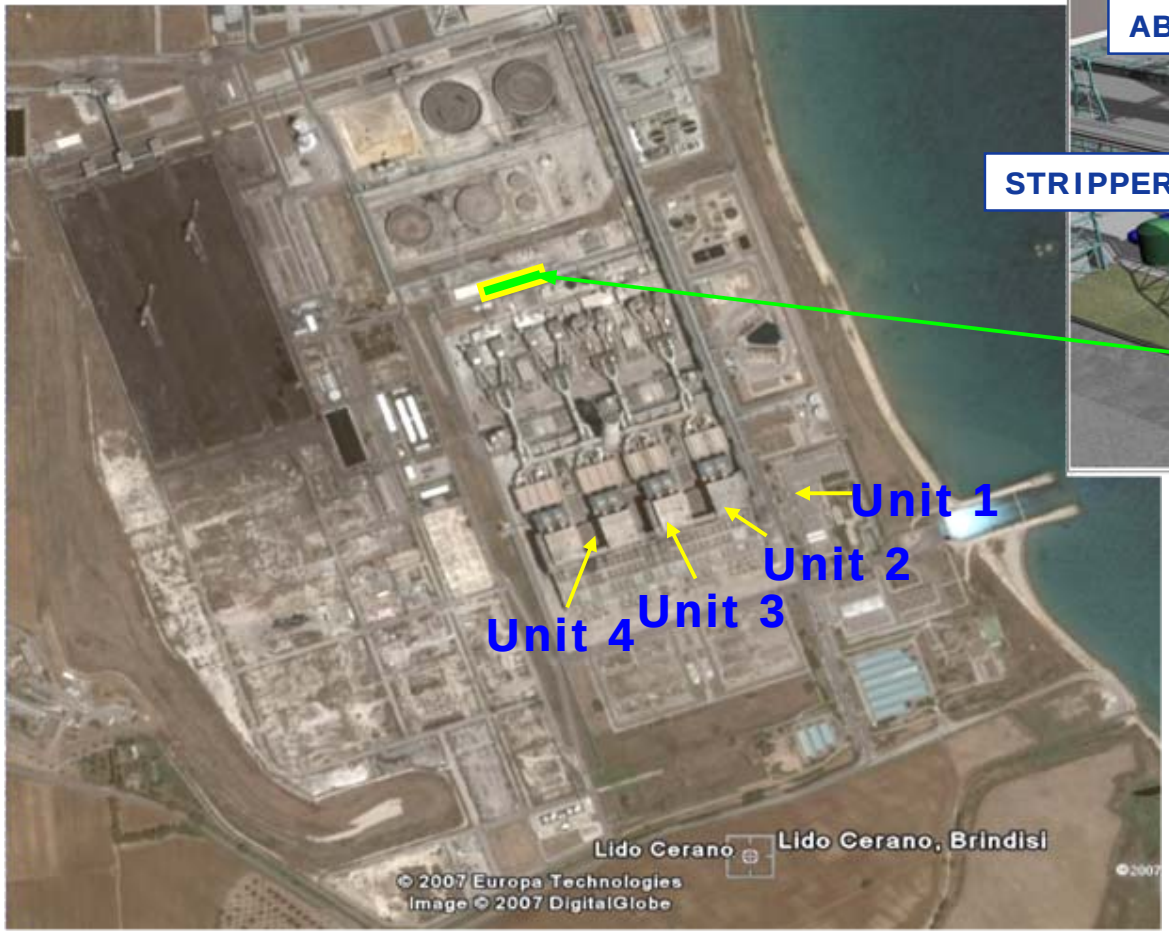
Construction of a pilot plant to further develop and test the technology

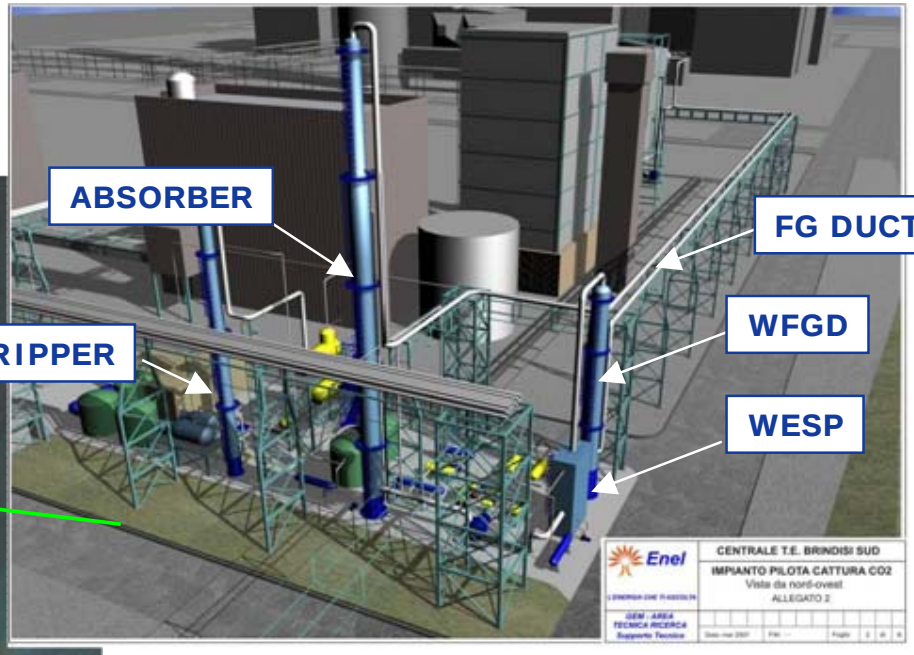


Temperature	50 ° C (max)
SO_2	< 30 mg/Nm³
NO_2	< 40 mg/Nm³
SO_3	< 1 ppmv
Particulate	< 2 mg/Nm³

Phase 2 – Brindisi CO_2 capture pilot plant

Brindisi coal fired power plant





Pilot plant milestones

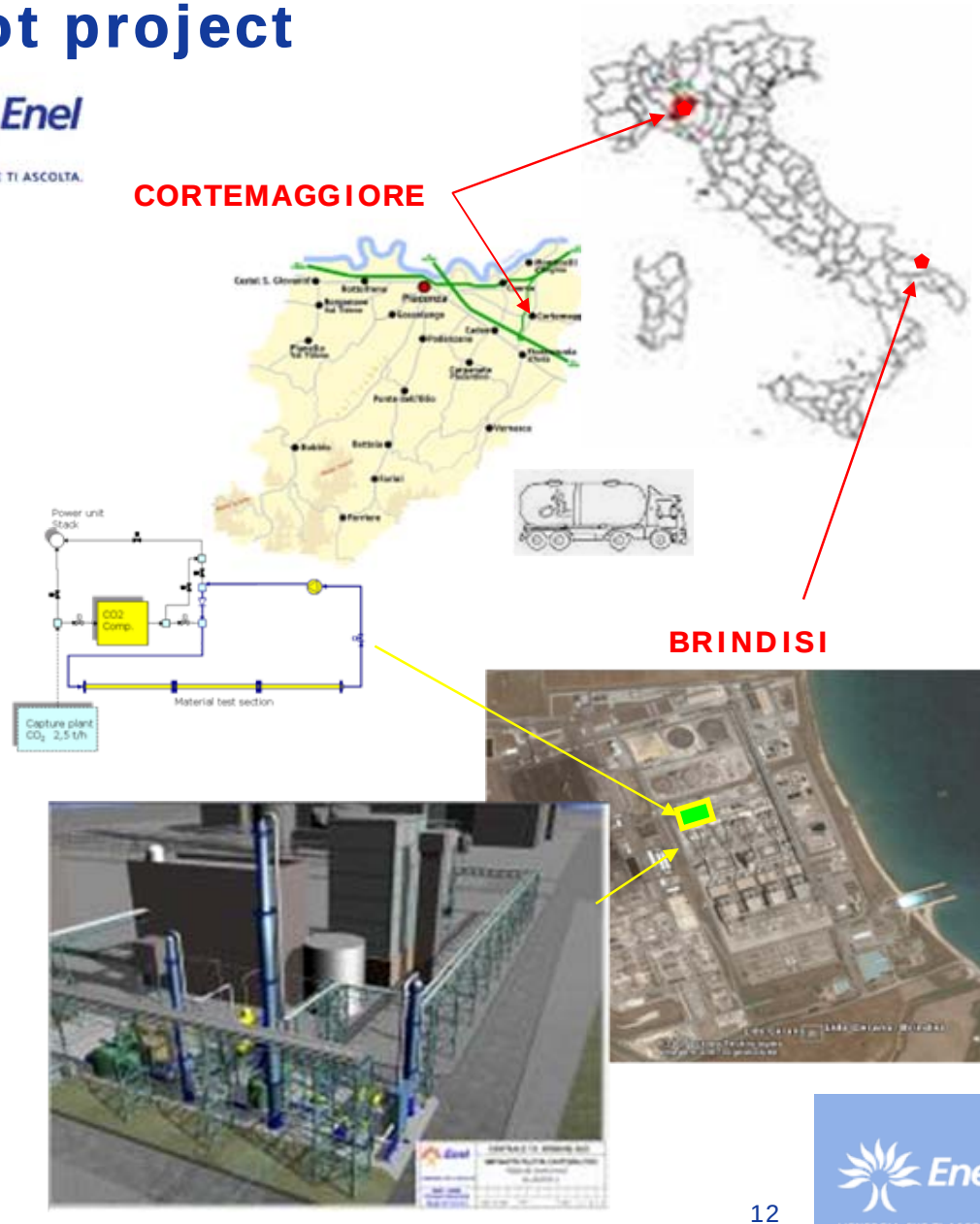
Specification compl.	**Jun 07**
Contract award	**Apr 08**
Start site works	**Feb 09**
Plant completion	**Dec 09**

Phase 2 - Integrated pilot project

Eni - Enel cooperation

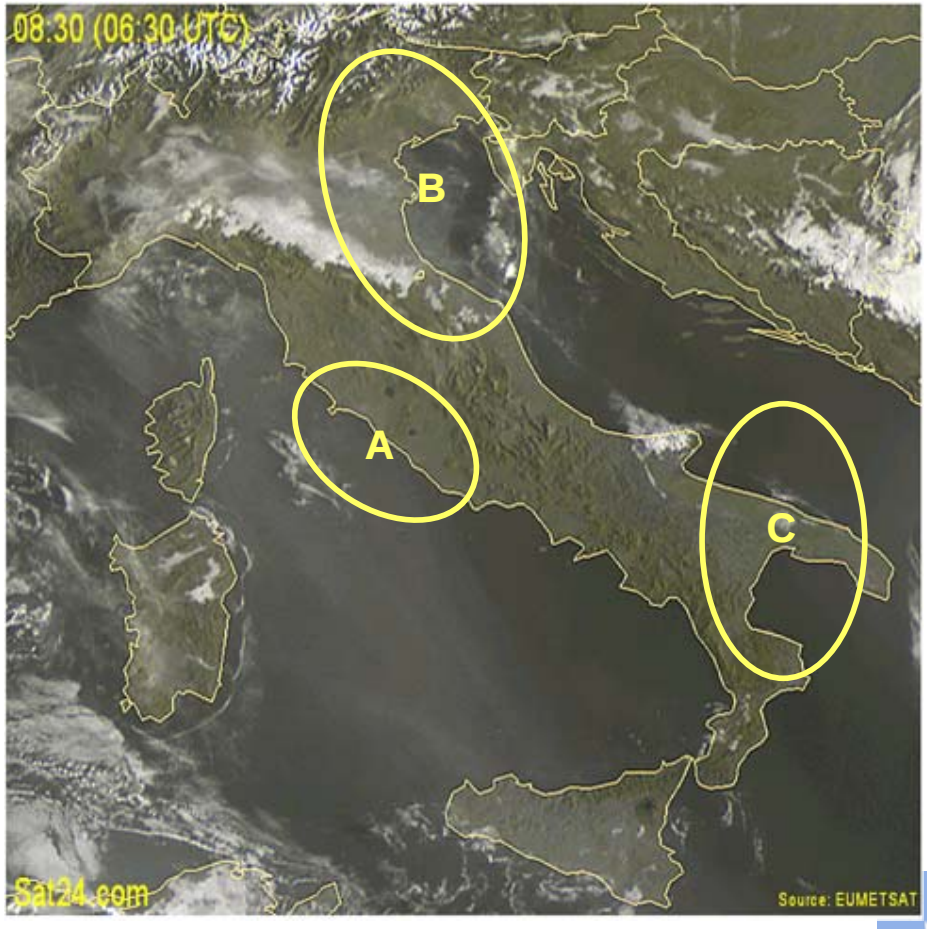
Agreement: October 21st, 2008

- **Capture** – Brindisi pilot plant for post-combustion capture (flue gas flow rate of 10.000 Nm^3/h) starting operation in December 2009. CO_2 captured: 20.000 t/year
- **Liquefaction** – A CO_2 liquefaction system with cryogenic storage will be installed in Brindisi for the storage of the CO_2 captured by the pilot plant
- **Transport** – Pilot line to test pipeline CO_2 transport to be installed in Brindisi. Transport to Cortemaggiore: ~230 trucks/year
- **CO_2 Injection** – CO_2 produced in Brindisi will be injected in Eni-Stogit gas field of Cortemaggiore starting from October 2010. Total injected CO_2: 24.000 ton



Phase 3 - Storage site selection

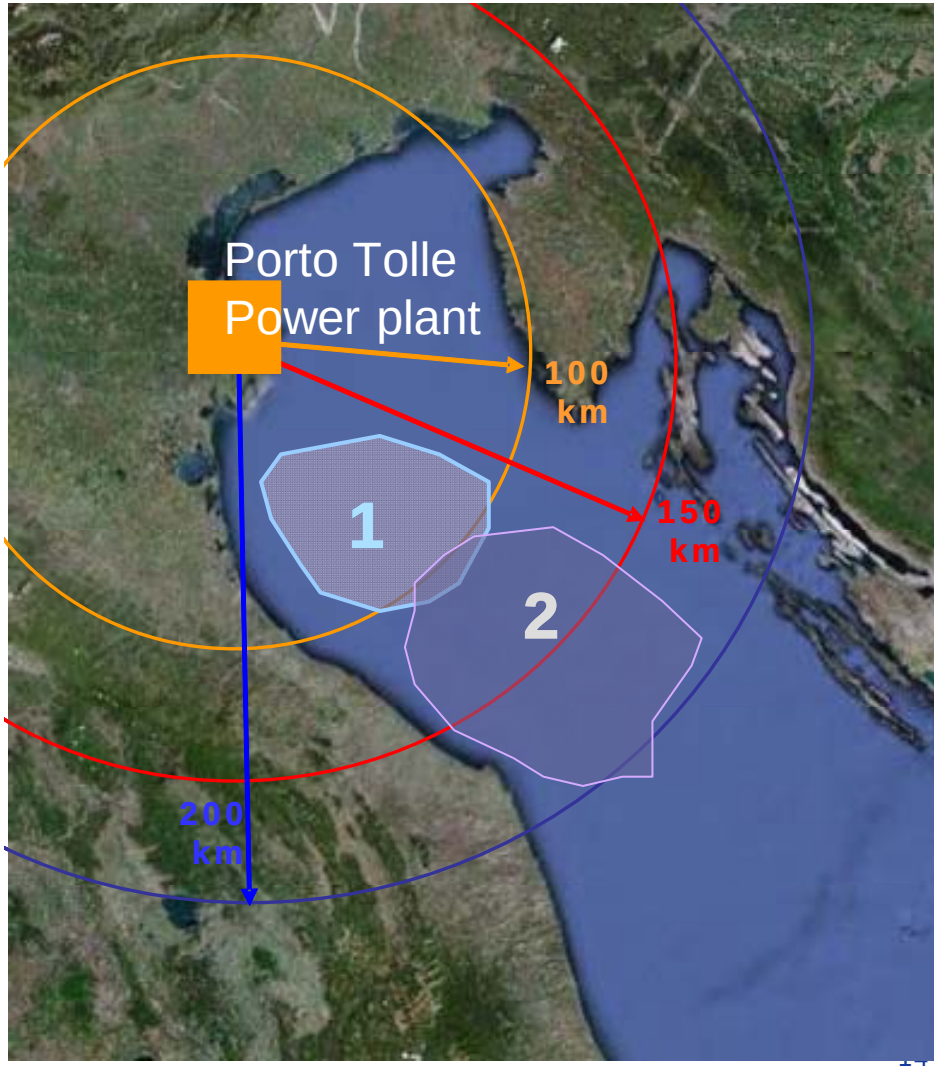
- Italy has theoretically a significant potential for CO_2 geological storage into deep saline aquifers
- Since 2006 Enel is evaluating in detail the storage potential in areas A, B and C that are the areas surrounding possible sites for the post-combustion capture demo. Studies are carried out in cooperation 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 CO_2) is shown by off-shore saline formations about 150-200 km south-east of the Porto Tolle power plant.

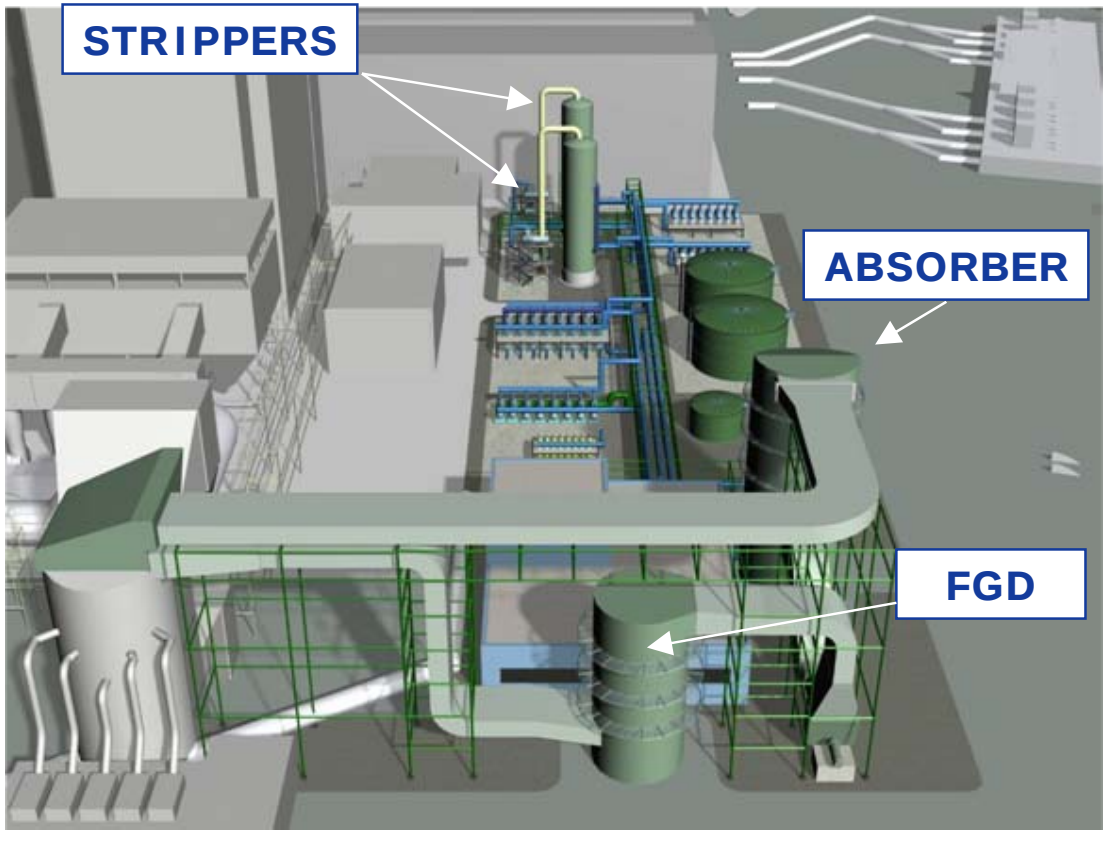


Phase 4 – Porto Tolle post-combustion demo plant

Demo main features

Type of Project	**Retrofit**
Plant location	**Porto Tolle**
Power generation	**660 MWe**
Primary fuel	**Bituminous coal**
Power Generation Tech	**SC PCC**
% 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	**85%**
CO_2 Storage solution	**Deep saline aquifer**
Storage location	**To be decided**
CO_2 value chain	**Pure storage**

Commissioning: 2015

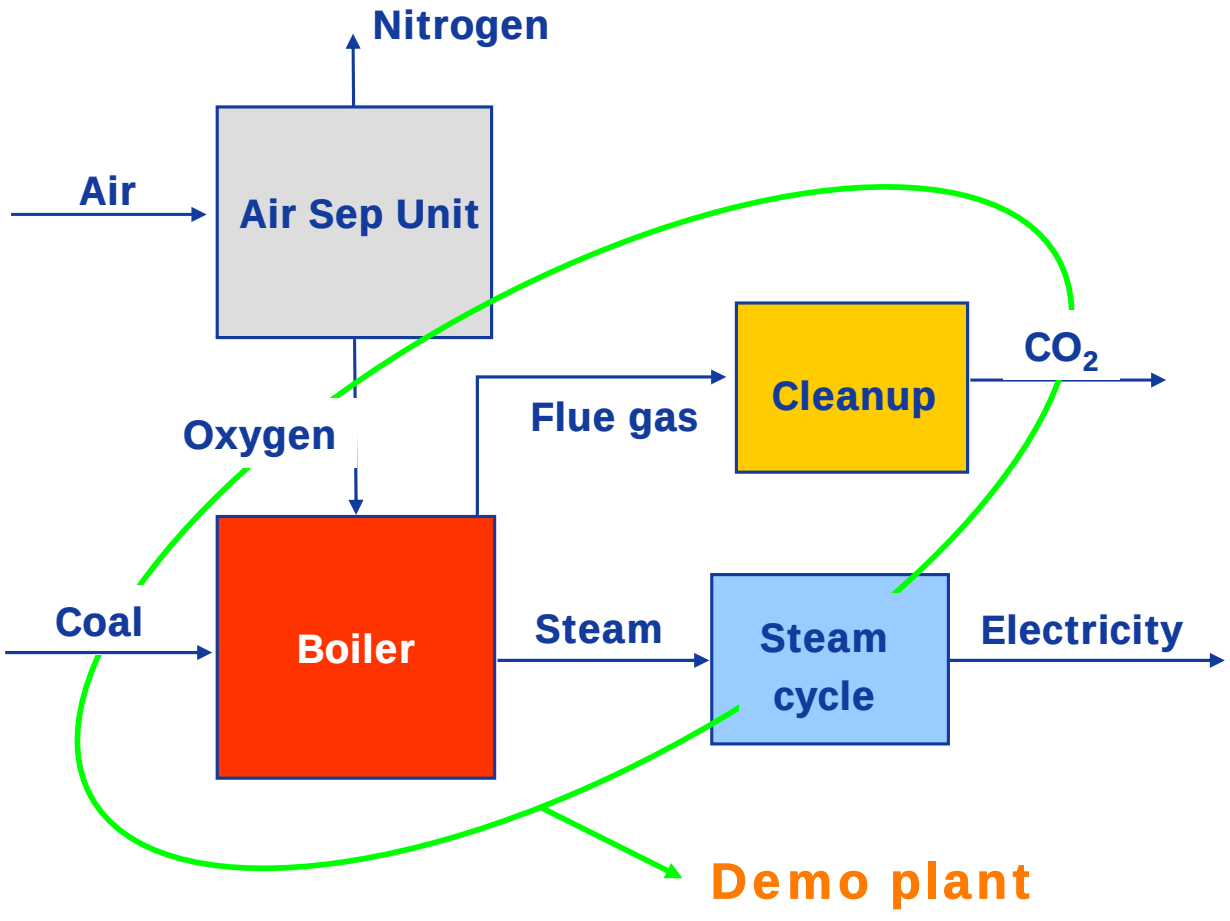


Enel will candidate this project for the "European Flagship Programme"

Enel CCS2

The oxy-coal combustion project

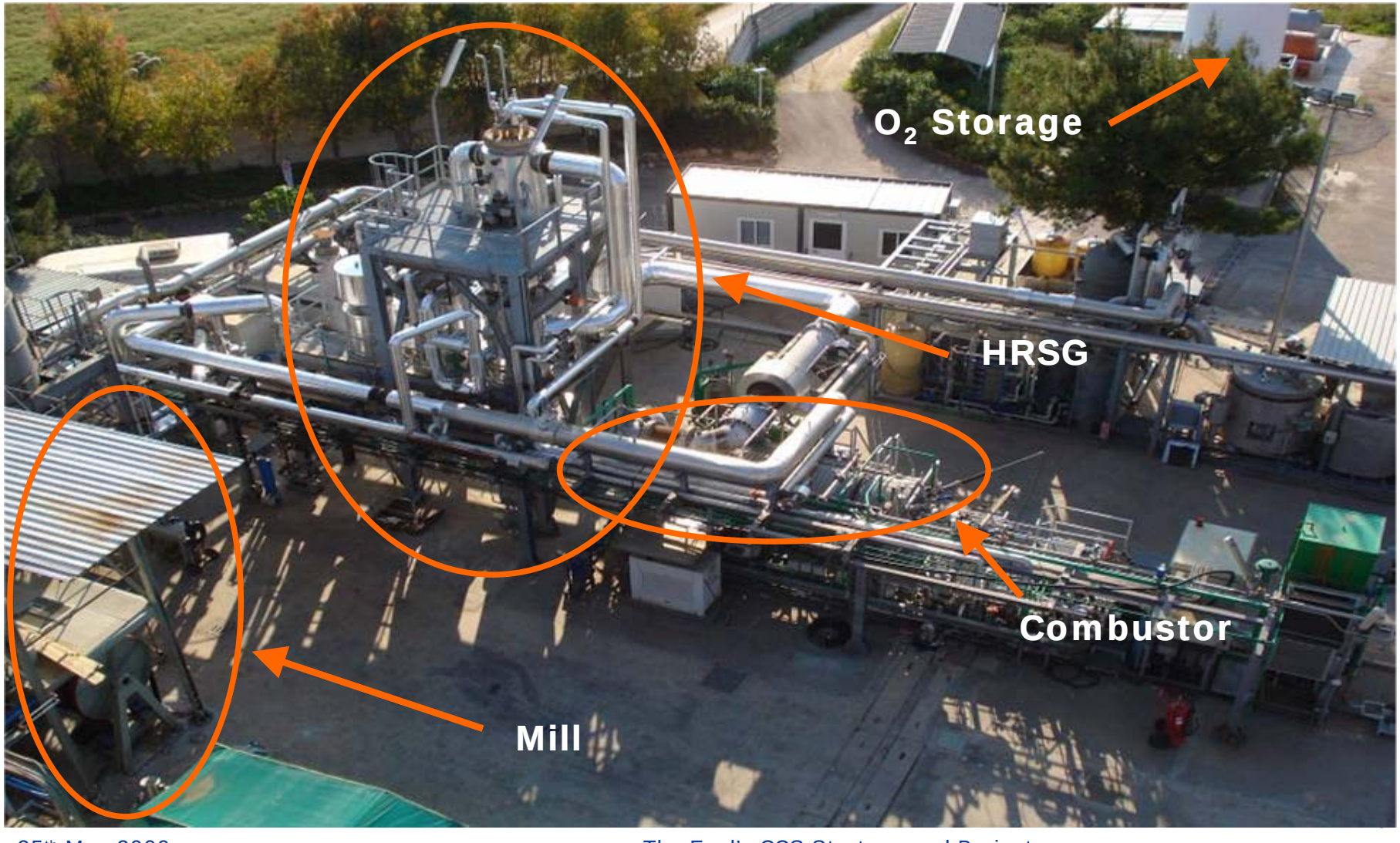
Pressurized oxy-coal combustion project



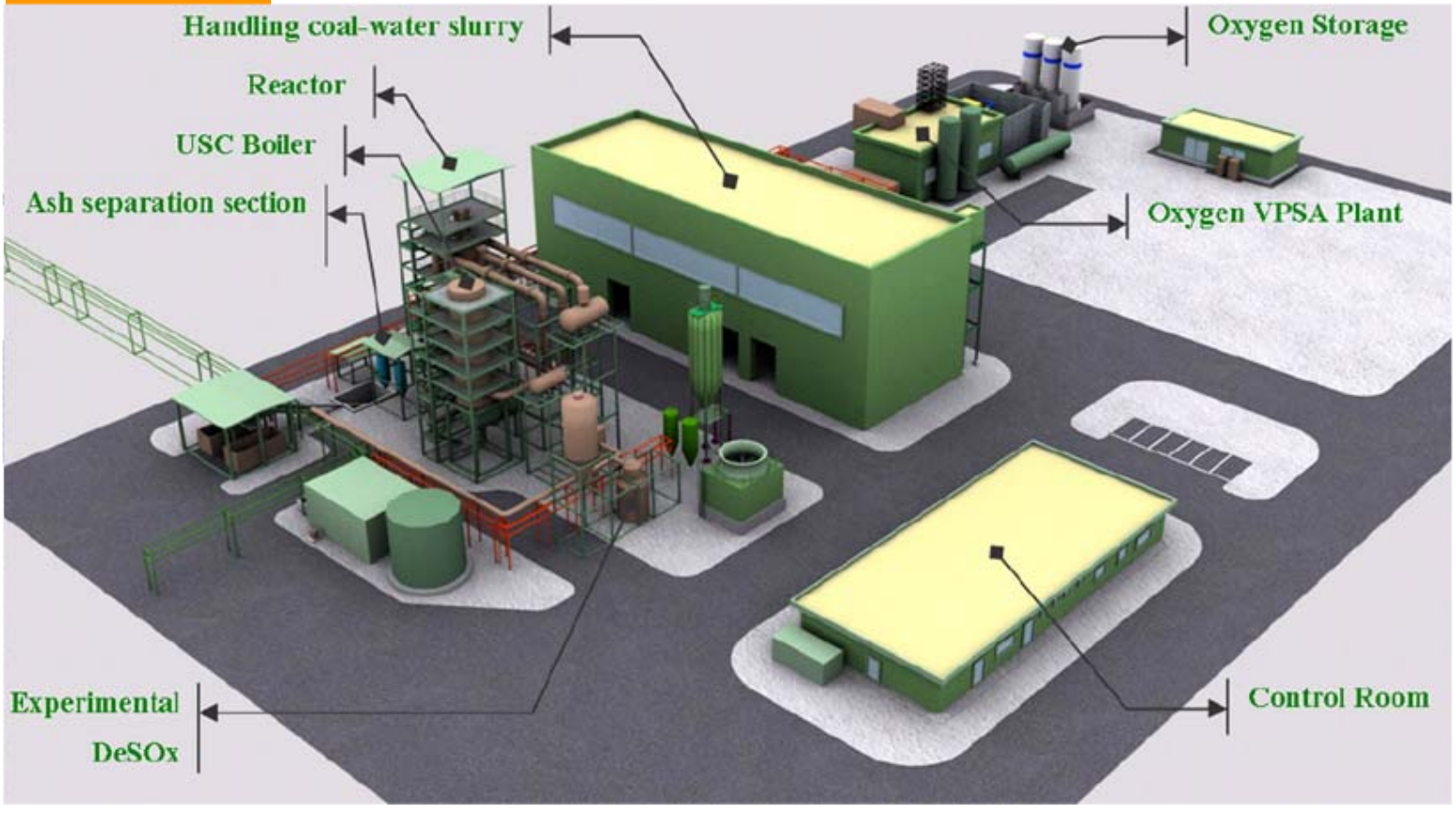
Construction by 2011 of a small (~50 MW_t) zero emission coal fired power plant based on a pressurized oxy-combustion technology already proven at pilot scale

Pressurized oxy-coal combustion project

Gioia del Colle 5 MW_t pilot plant



Pressurized oxy-coal combustion demo plant



Project milestones

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

Combustor power	**48 MW_t**	Oxygen	**cryogenic storage**
Pressure	**10 bar**	Oxygen mass flow rate	**400 t/d @ 90% purity**
Fuel	**coal-water slurry**	Steam generation	**55 t/h @ 240 bar/600° C**
Boiler	**pressurized**	Yearly operating hours	**3000 h**

Enel CCS3

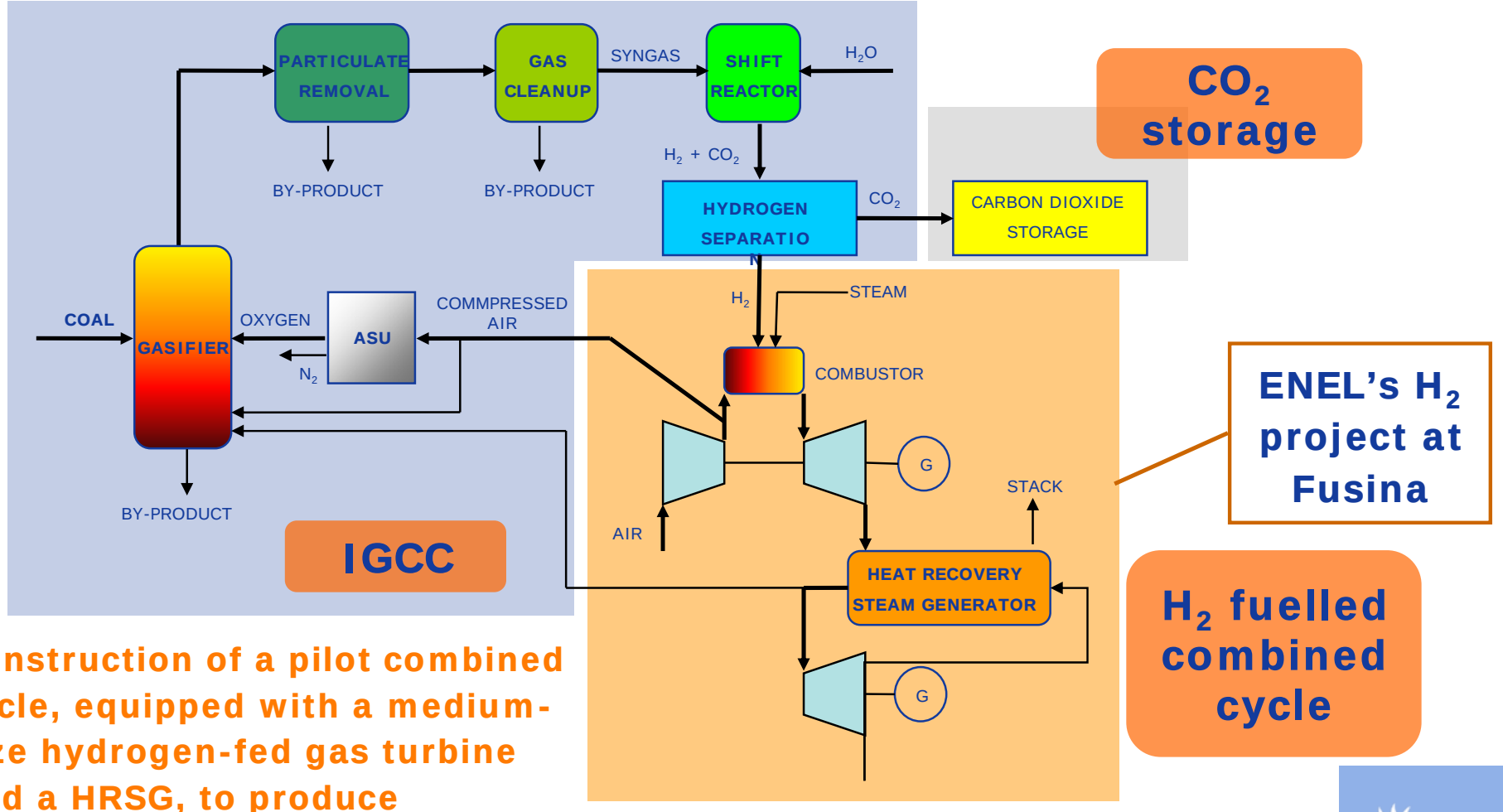
Power from Hydrogen

&

Zero Emission IGCC

Power from hydrogen

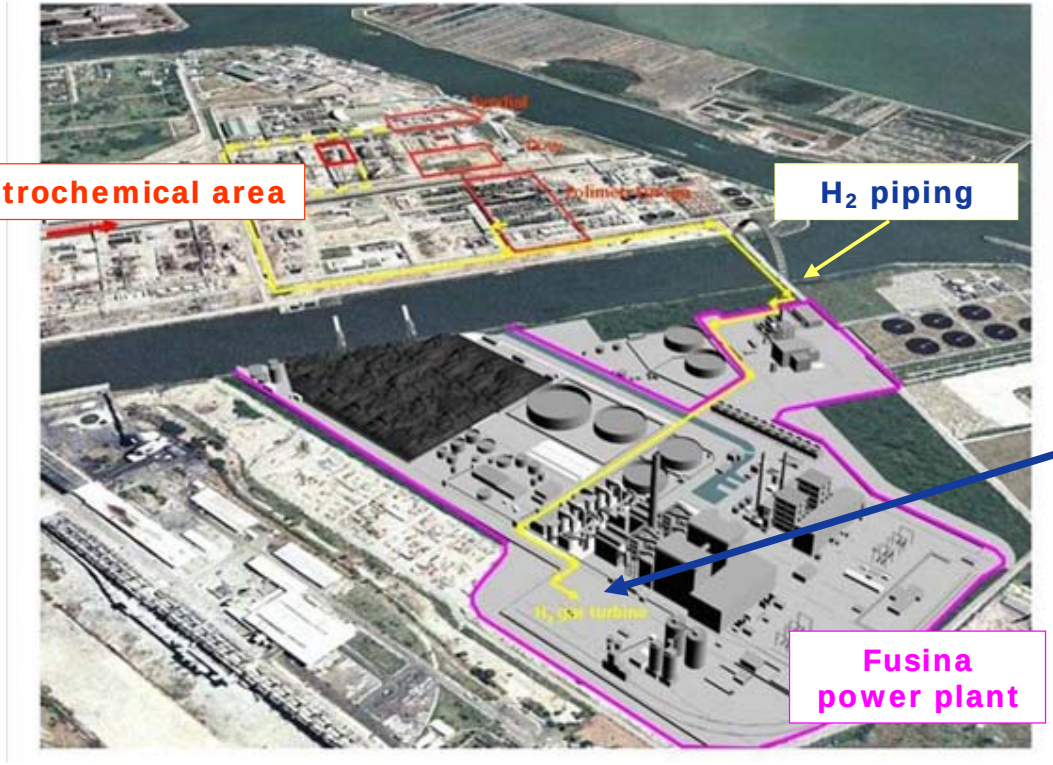
Fuel gasification and H_2 separation



Construction of a pilot combined cycle, equipped with a medium-size hydrogen-fed gas turbine and a HRSG, to produce electricity from hydrogen

The Fusina hydrogen power plant

A 12 MWe combined cycle fed by hydrogen produced by petrochemical industries



Project milestones

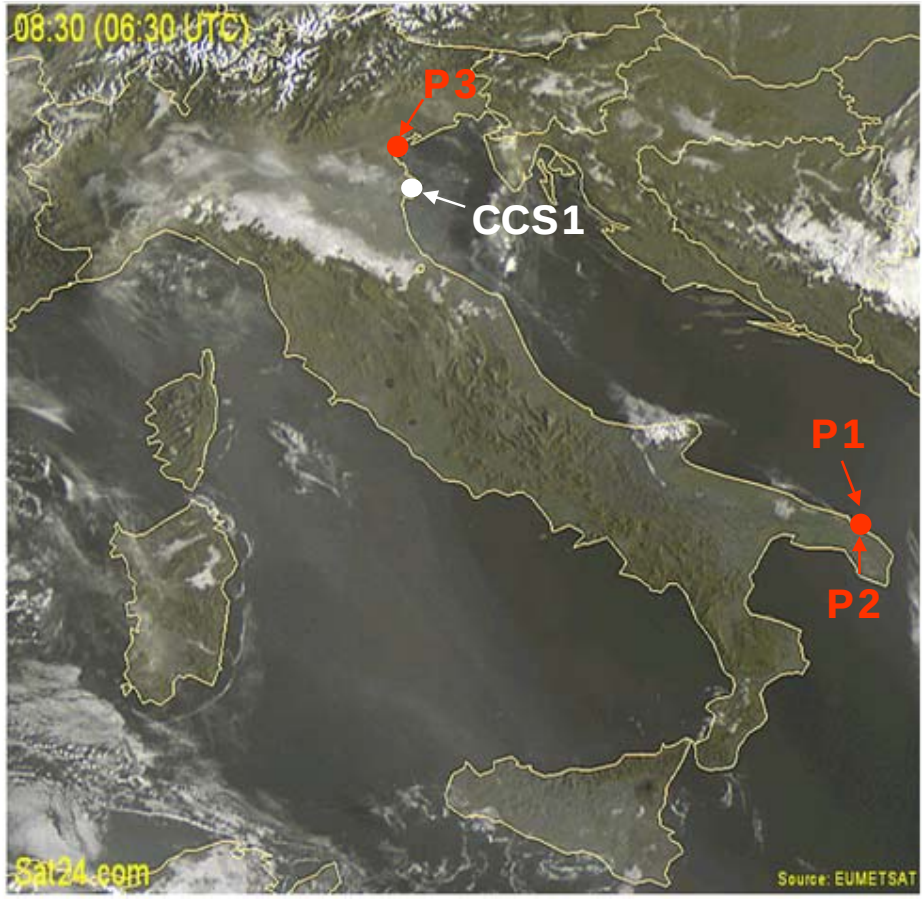
GT order	**Mar. 07**
Combustor tests	**Sep. 07**
Start site works	**Dec. 07**
Plant completion	**July 09**

Fusina hydrogen CCGT plant

Plant erection status

First firing with natural gas: end of April

Summary of Enel's initiatives on CCS



Pilot Plants		Size	Status
P1	Post-combustion capture	2,5 t/h CO_2	Under construction. Commissioning start Feb 10
P2	Pressurized oxy-combustion	48 MW_{th}	Design completed. Ground breaking Sep 09
P3	Hydrogen combined cycle	12 MW_e	Construction completed. Commissioning start Apr 09

CCS demo plants		
CCS1 -Porto Tolle post-combustion demo	330 MW_e (eq.)	Detailed feasibility study under way

International cooperations

EU funded projects

- 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
  - ✓ **SOCRATES,** a project for the feasibility and engineering studies for 2 first-of-a-kind large scale zero emission plant CCS projects (both are potential candidates to the future Flag Ship Program)

EPRI projects (USA)

Enel is partner of:

- **Program 165 - CO_2 Capture and Storage**
  This program provides information about the expected cost, availability, performance, and potential risks of a range of flue gas CO_2 capture processes, as well as the permanence, safety, and environmental acceptability of long-term CO2 storage from any source.

- **Ion Transport Membrane for Low-Cost Oxygen Production**
  The heart of the ITM Oxygen separation process is a nonporous "perovskite" ceramic material which, under a pressure gradient at the proper temperature, electrochemically ionizes oxygen molecules from air and diffuses the ions and electrons through a wafer-type membrane, where they recombine as oxygen molecules on the other side.

Cooperation among MOST (China), MATTM & ENEL (Italy) on Clean Coal Technologies

On May 5, 2008 the Ministry of Science and Technology of the People's Republic of China (MOST), the Italian Ministry for the Environment, Land and Sea (IMELS) and ENEL signed a Memorandum of Understanding (MoU) on the cooperation on clean coal technologies including carbon capture and storage (CCS) and ultra super critical coal fired power plants technologies.

The identified main cooperation areas were:

- Post-Combustion Capture technology
- IGCC and Pre-combustion Capture
- Oxyfuel technology
- CCS demo plant in China

Chinese delegation visiting Enel experimental facility in Sesta

The challenges ahead

Strong industry commitment

But public support essential for demo program

- As shown Enel is strongly committed to the development and demonstration of CCS technologies. More than 200 M€ were already spent or committed for the realization of the different pilot plants and for the related R&D activities
- Enel is carrying out a detailed feasibility study of its Porto Tolle demo in order to carefully evaluate the necessary investment and operational costs. However the dimension of the extra costs of CCS demo plant is so large(*) that the power industry cannot face them on its own
- In order that demo projects materialize is therefore necessary that a large portion of the extra costs is covered by public funds (European and National), taking into account that projects developers already bears all the construction and operational risks

*** The order of magnitude is about 1 billion € per project including both the CCS related investment costs and the extra operating costs mainly due to the strong efficiency penalty connected with CCS**

Time is of essence

Essential first steps were taken, need to complete the work

- In 2008 the foundation stone was laid by the European Institutions through the approval of the CO_2 storage directive and the modification of the ETS regulation in order to cover CO_2 storage and to provide funding (300 million allowances) from New Entrant Reserve
- Now, in order to have CCS demo projects up and running by 2015 the following is needed:
  - ✓ The regulatory framework has to be completed quickly in order to allow the permitting process to start
  - ✓ The rules to allocate the 300 million allowances fund have to be defined by the end of the year and the projects selection process has to be completed by 2010 at the latest
  - ✓ Various sources of funding need to be provided in order to close the financial gap of CCS demo projects
  - ✓ A proper communication plan needs to be developed in order to secure public acceptance of CCS


Thank you
for your kind attention