The Porto Tolle CCS demonstration project

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CSLF Technical Group Meeting

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- The Porto Tolle CCS demonstration project: objectives and status
- The R&D activities supporting the development of Porto Tolle demo
- Regulatory and financial challenges in demostrating CCS

The Porto Tolle CCS demonstration project
Objectives and status

The Porto Tolle power plant conversion project

Old Plant	New Plant	
•Gross power output (MW)	2640	1980
•Net efficiency (LHV)	39%	45%
•Fuel	Oil (0,25% S)	Coal
•Emissions SO2/NOx/Dust (mg/Nm3)	400/200/50	80/80/7 (daily basis)

✓**New main components:**

- USC boilers
- Steam turbines
- SCR denitrification system
- FGD plants
- Fabric filters
- 2 domes for coal storage

✓**Biomass co-firing capability**

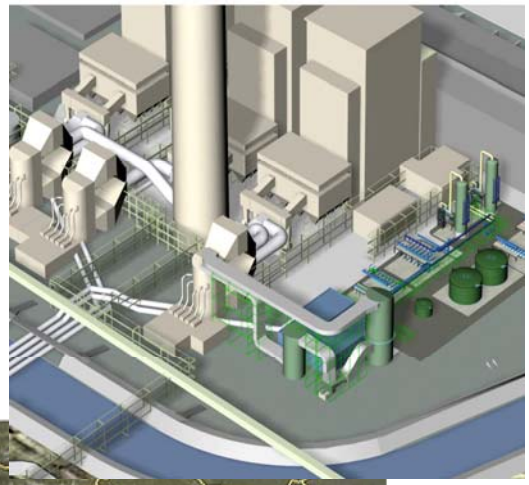
Construction permit for the new plant issued Jan 5, 2011

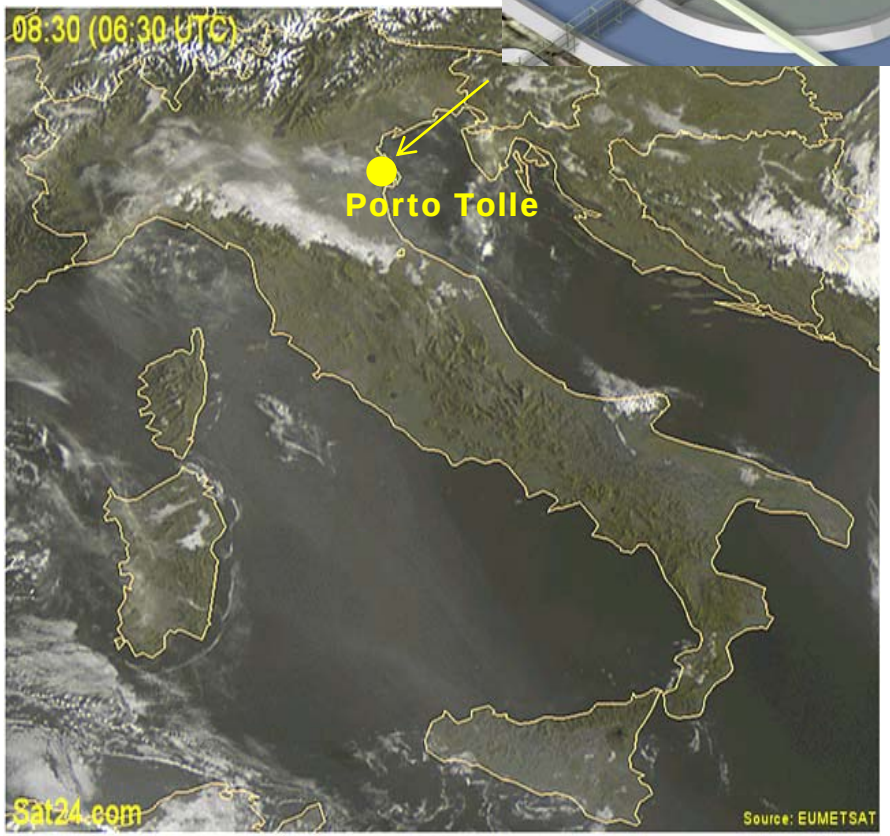
ZEPT- Zero Emission Porto Tolle

The Enel's CCS demo project

Project goal

To retrofit one 660 MW_e coal fired unit of Porto Tolle power station with CO_2 post combustion capture equipment and start CO_2 underground storage in an off-shore saline aquifer by 2015

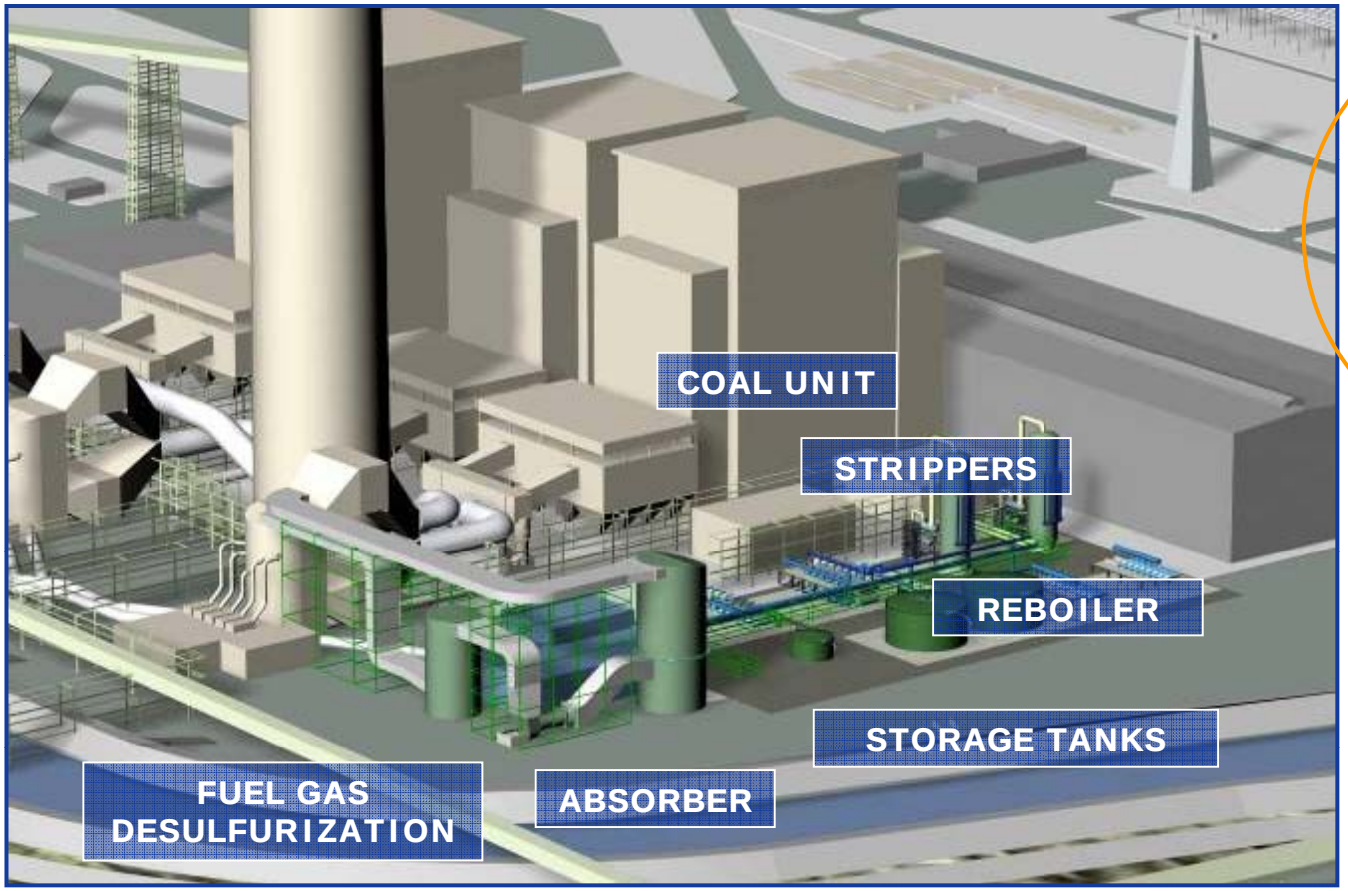




ZEPT- Zero Emission Porto Tolle

CCS demo plant lay-out

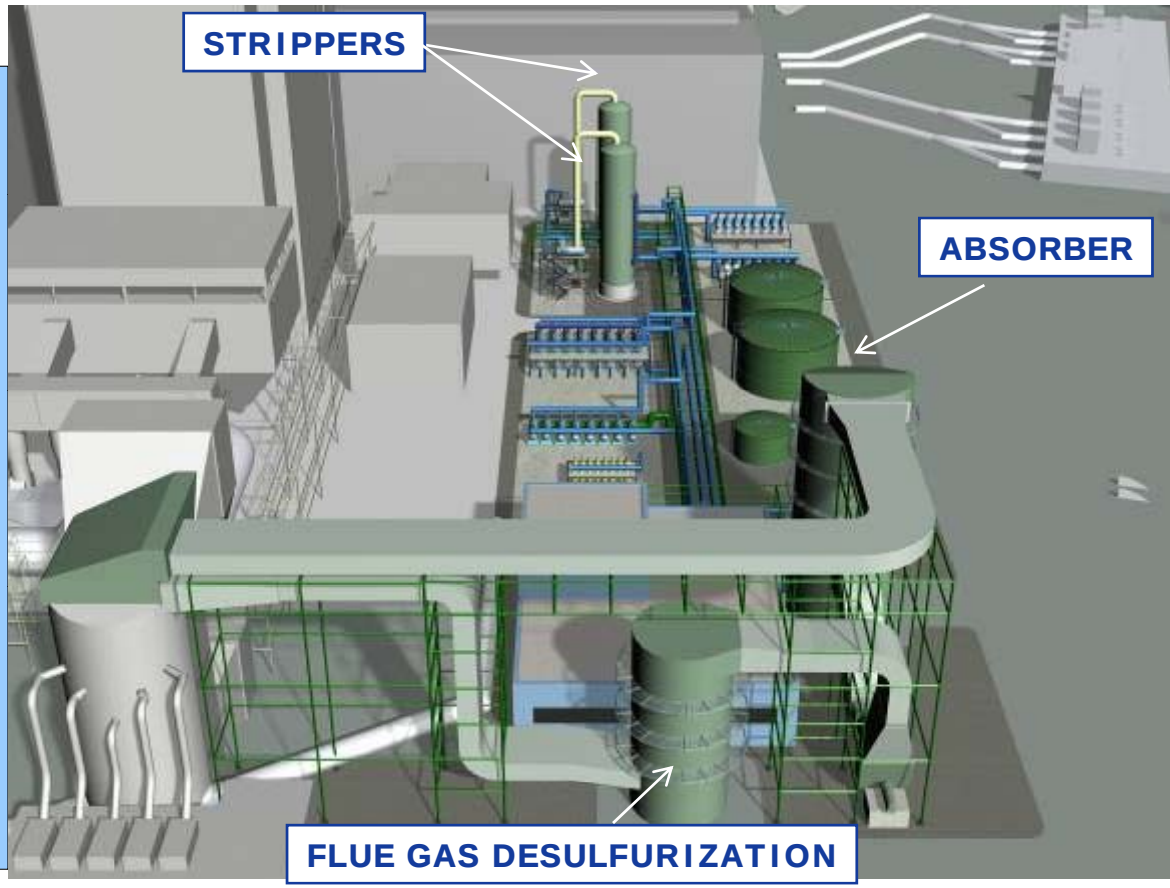
Porto Tolle power plant



CO_2 storage area (light-blue)

ZEPT- Zero Emission Porto Tolle

Demo main features

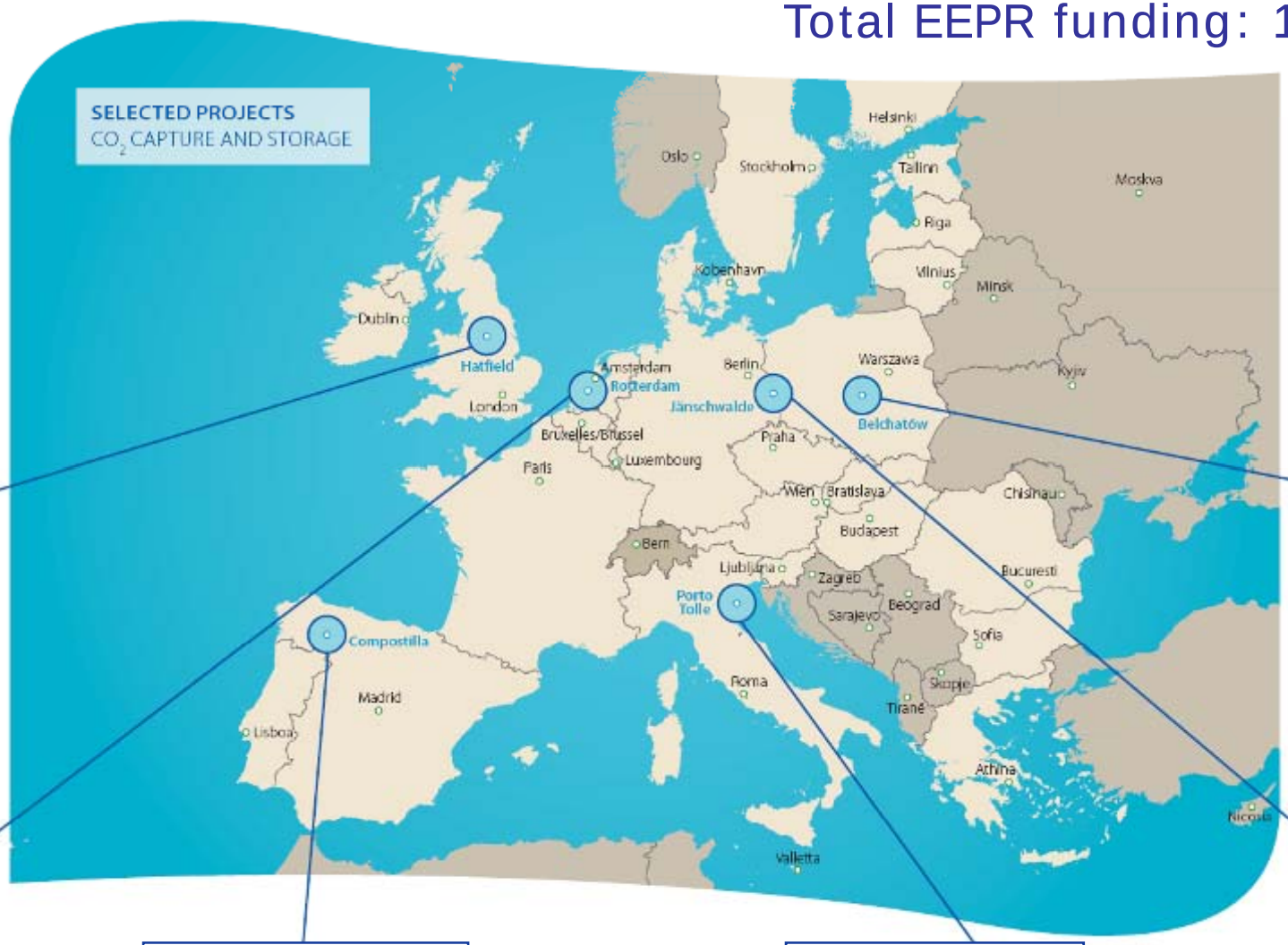


Co-financed by the European Union
European Energy Programme for Recovery

ZEPT- Zero Emission Porto Tolle

One of the six EEPR projects

Total EEPR funding: 1 b€



IGCC
Off-shore
gas field

Post-combustion
On shore saline aq

Post-combustion
ff-shore gas field

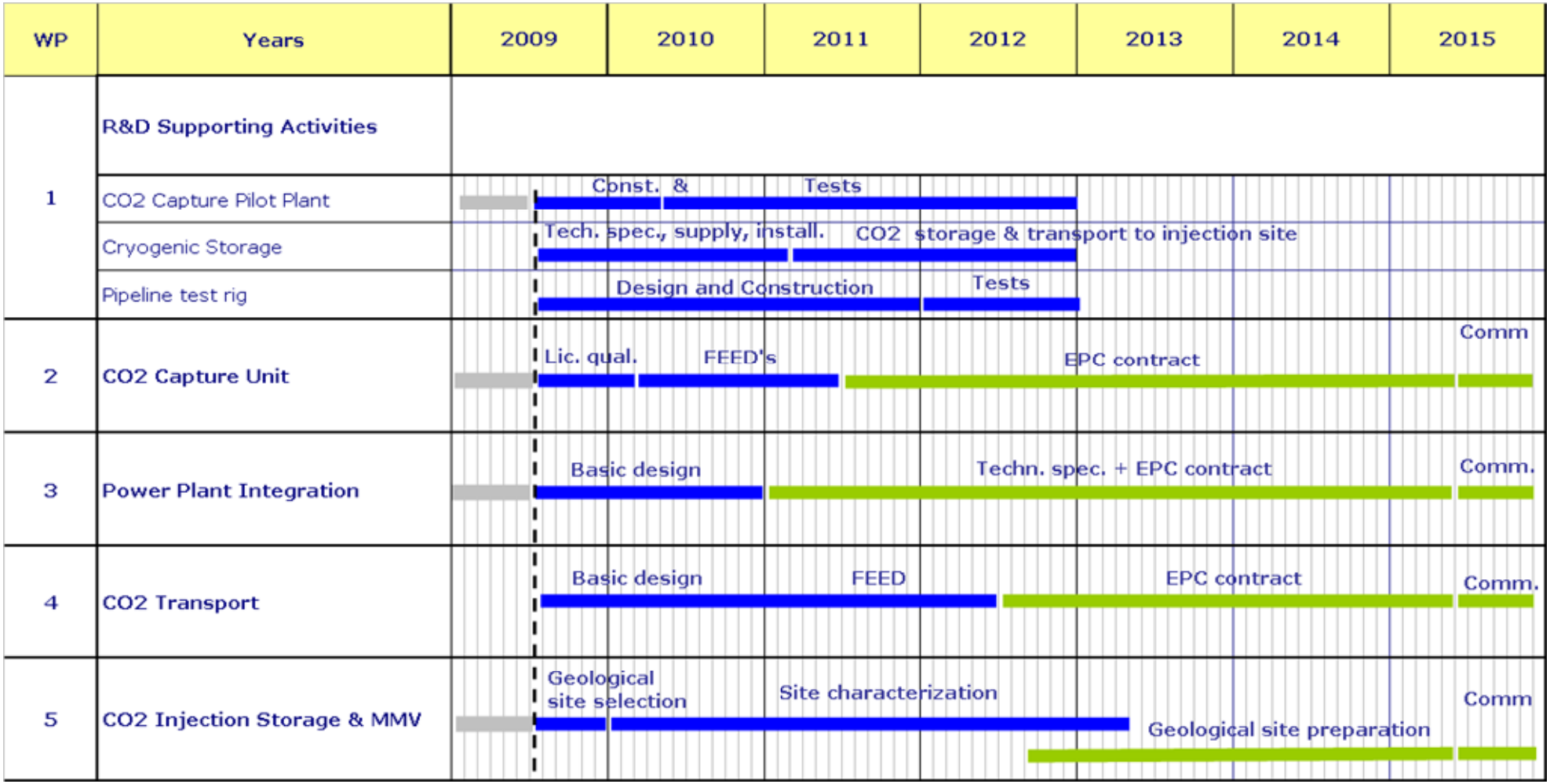
Oxy-fuel CFB
On shore saline aq.

Porto Tolle
Post-combustion
Off-shore saline aq.

Oxy-fuel and
post-combustion
On shore storage

ZEPT- Zero Emission Porto Tolle

Project time schedule



Activities carried out in the frame of the EEPR Grant Agreement signed in December 2009 with European Commission

CCS demo workflow strategy - 1
Capture

Lab scale
Research center - Brindisi

Flue gas: 2 Nm3/h

CO_2: 0.4 kg/h

- Process evaluation
- Analytical protocols development

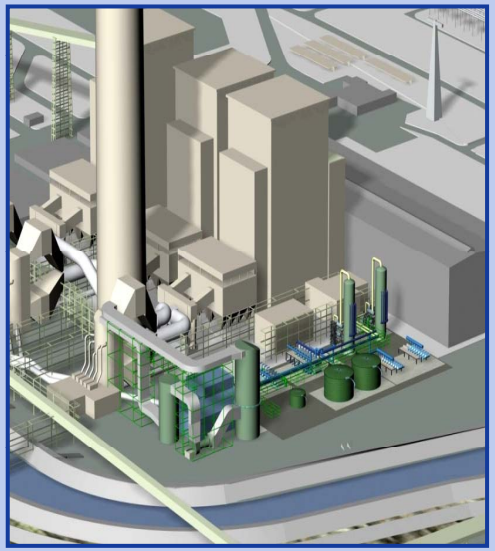
Pilot scale
Power plant - Brindisi

Flue gas: 10'000 Nm3/h

CO_2: 2'500 kg/h

- Performance evaluation
- Emission analysis
- Tests on innovative process

Demo scale
Power plant – Porto Tolle



Flue gas:810'000 Nm3/h

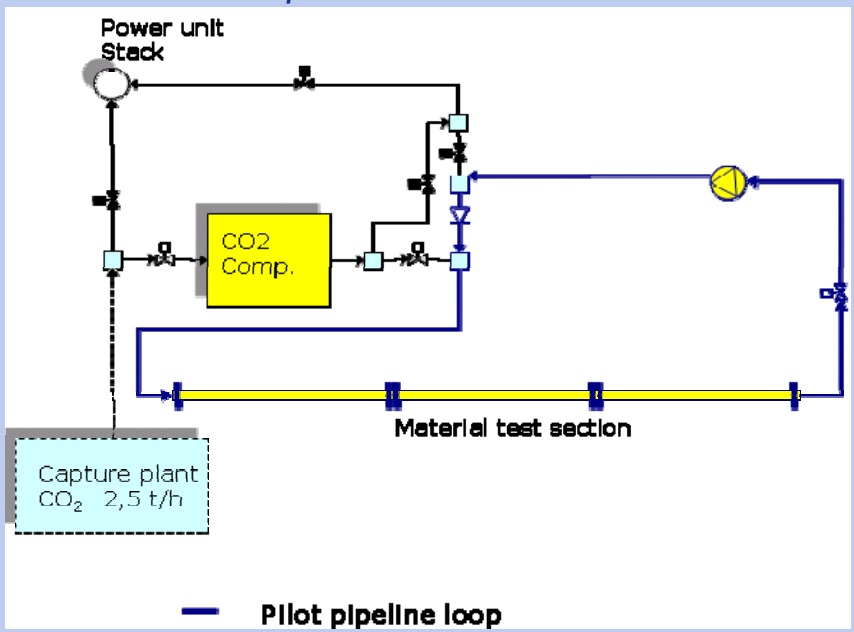
CO_2: 180'000 kg/h

- Technology scale up

CCS demo workflow strategy - 2
Transport

Pilot scale

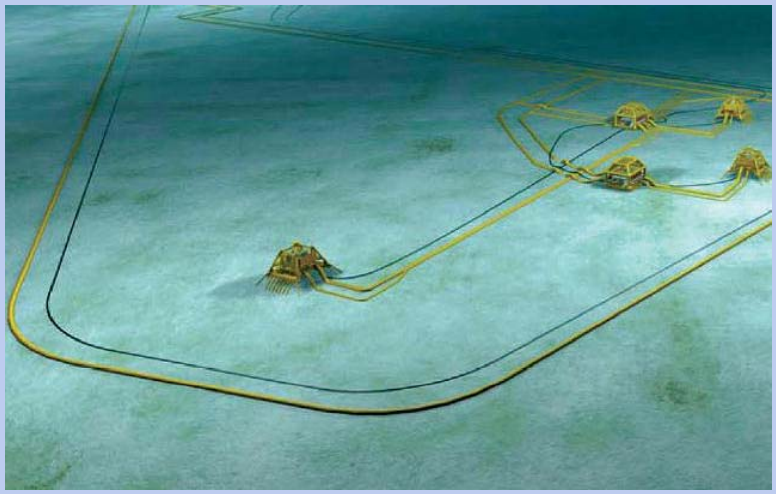
Power plant - Brindisi



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

Demo scale

Power plant – Porto Tolle



- Subsea pipeline ~100 km

CCS demo workflow strategy - 3
Storage

Basin scale
Italy

Estimation of the CO2 geological storage potential in Italy, focusing on the areas next to main CO2 source.

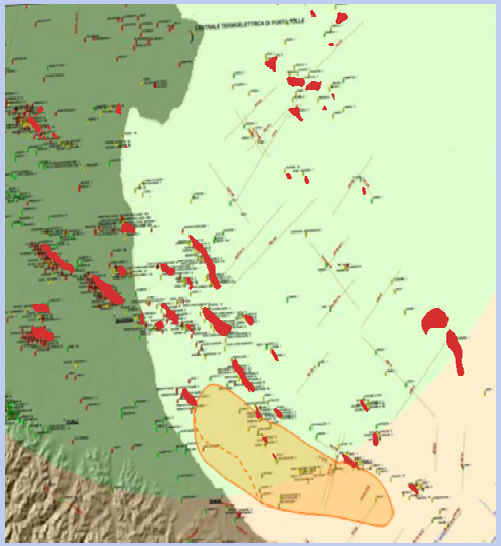
- Cesi Ricerca project
- GeoCapacity EU project

Regional scale
Northen Adriatic sea

The correlation between the borehole information and the available seismic lines led to the mapping of the reservoir and caprock depth.

- Public data

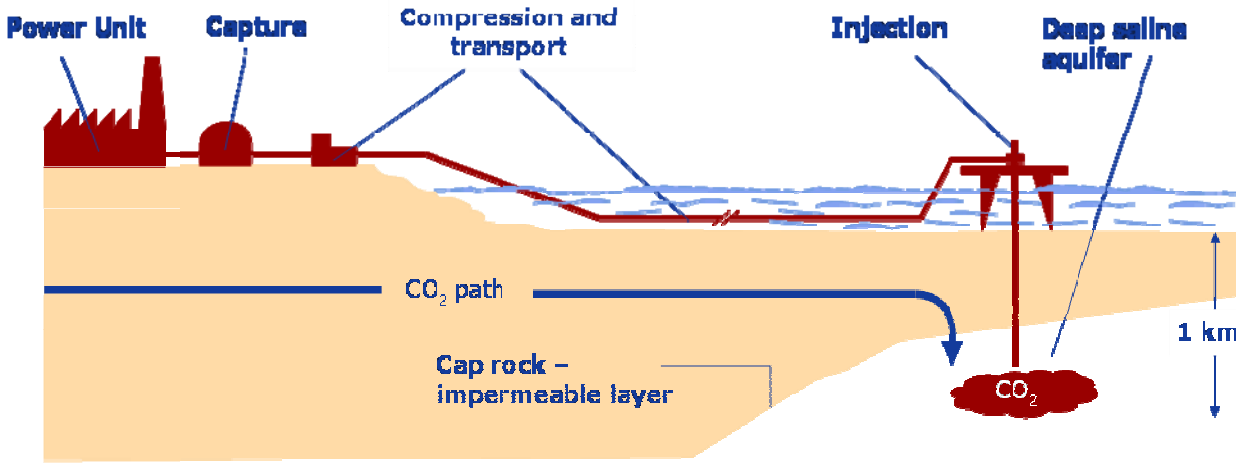
Local scale
Storage structures



A characterization of the selected area was performed revealing that it is constituted by several structures.
Static and dynamic modelling are ongoing

- Property data
- Field data

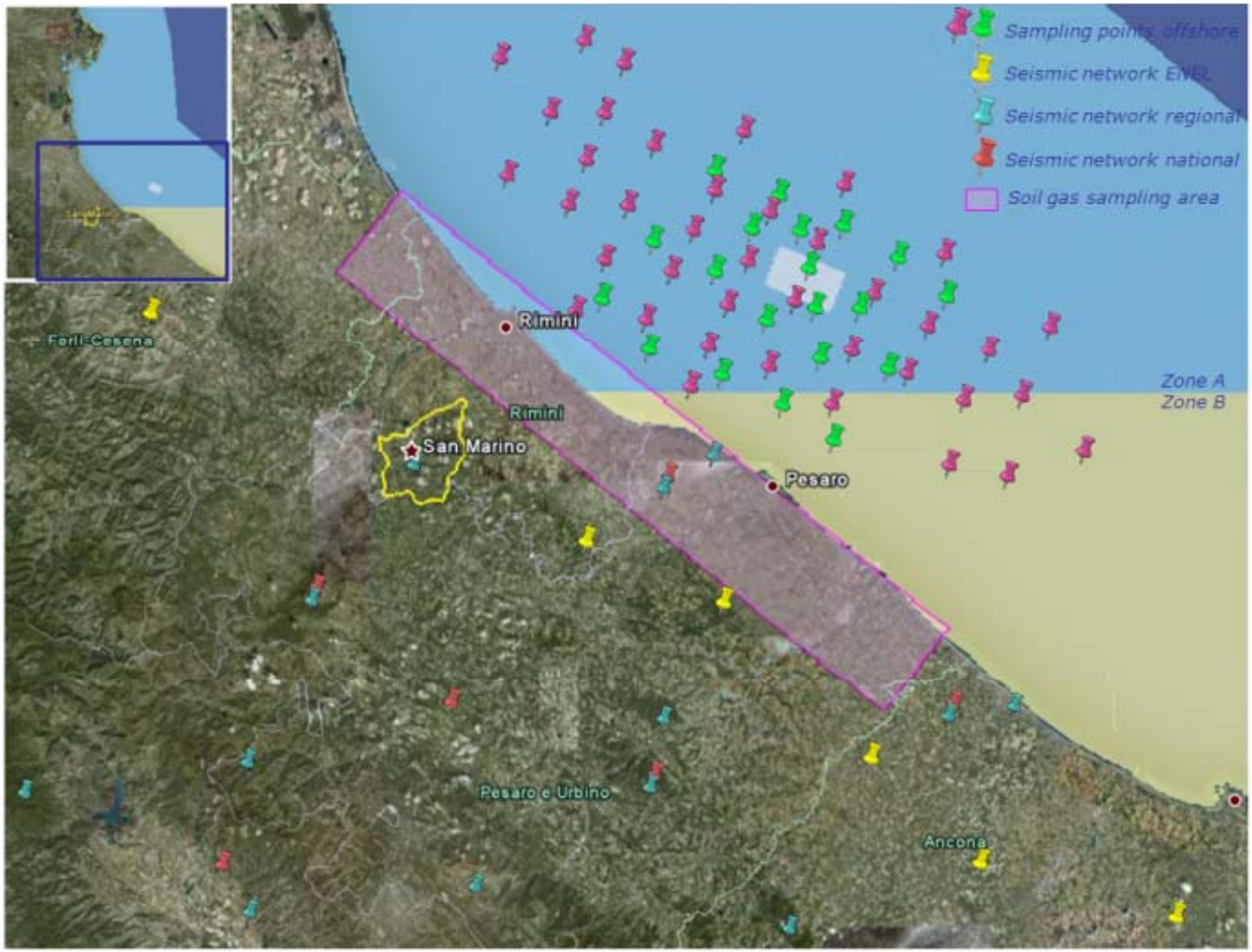
ZEPT – CCS Demo Activities



Activities in progress:

- Selection of the CO_2 capture technology : execution of 4 parallel FEED's under way (completion Apr. 2011; selection Jun. 2011)
- Development of the FEED for transport pipeline and injection infrastructure (contract award Jun. 2011)
- Selection and assessment of the storage site : geological site modelling, appraisal well design and monitoring plan in progress
- Development of the financial plan

Enel project
Baseline surveys



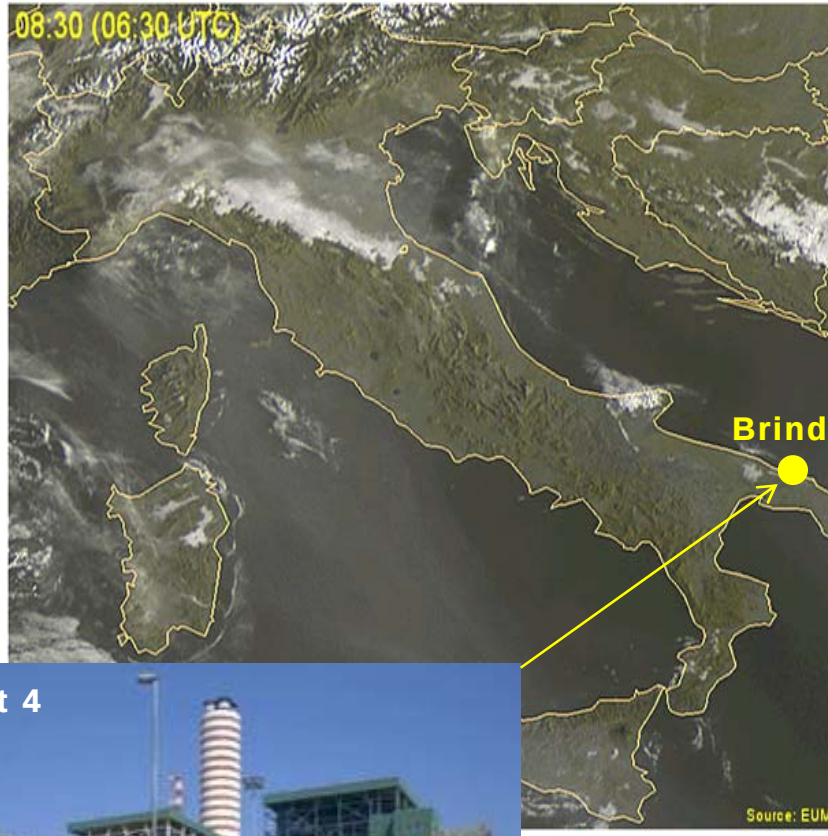
Based on request of European Directive on CO_2 geological storage it was planned to evaluate CO_2 baseline before injection.

R&D activities supporting the development of Porto Tolle demo

ZEPT- R&D Supporting Activities

CO_2 capture pilot plant

- At the site of **Brindisi** coal fired power station a pilot plant for CO_2 separation via amine scrubbing was built and is now in operation. The pilot plant is installed on the Unit 4.
- The pilot plant is composed by a flue gas pre-treatment section (able to remove completely the particulate and the SO_3 and to reduce SO_2 level below 20 mg/Nm^3) and by a CO_2 separation unit
- The plant size is **10.000 Nm³/h** of flue gas, capturing up to **2,5 t/h of CO_2**
- Goal: to gain experience in CCU designing and operation, and to assess the environmental impact of the process



ZEPT- CO_2 capture pilot plant

- ✓ About one year for site construction activities
- ✓ Less than 2 years to first CO2 separation since detailed engineering start
- ✓ Operation start: **Oct 2010**

ZEPT- CO2 capture pilot plant

Research Program Objectives

- **Develop operational experience (MEA 20%- 30%-40% + inhibitors)**

➢Assessment of the MEA absorption technology: reliability, environmental impact, power consumption and capture performance

➢Definition of operating procedures, management

➢Cost evaluation at different operating conditions for retrofit application: solvent consumption, inhibitors, waste treatment management

➢Flue gas composition: CO2 stream and emissions

- **Test advanced solvents and inhibitors**

➢Reduction of power consumption (reduction of operating cost)

➢Solvent degradation (reduction of operating cost)

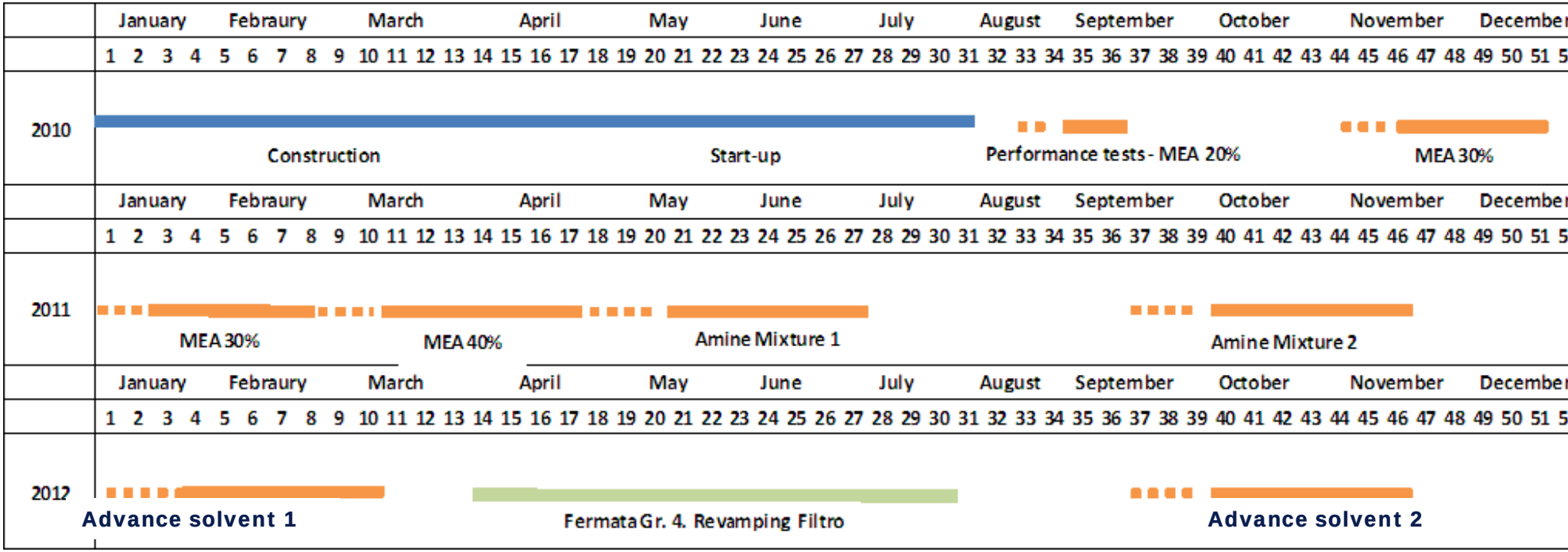
➢Assessment of corrosion (reduction of capital cost)

➢Reaction rate (check of design parameters)

➢Environmental performances

ZEPT- CO2 capture pilot plant

Tests schedule



- 2011 → 4000 hr continuous operation; ~ 8000 ton of separated CO_2
- 2012 → 3000 hr continuous operation; ~ 6000 ton of separated CO_2

  Tests with advanced solvents

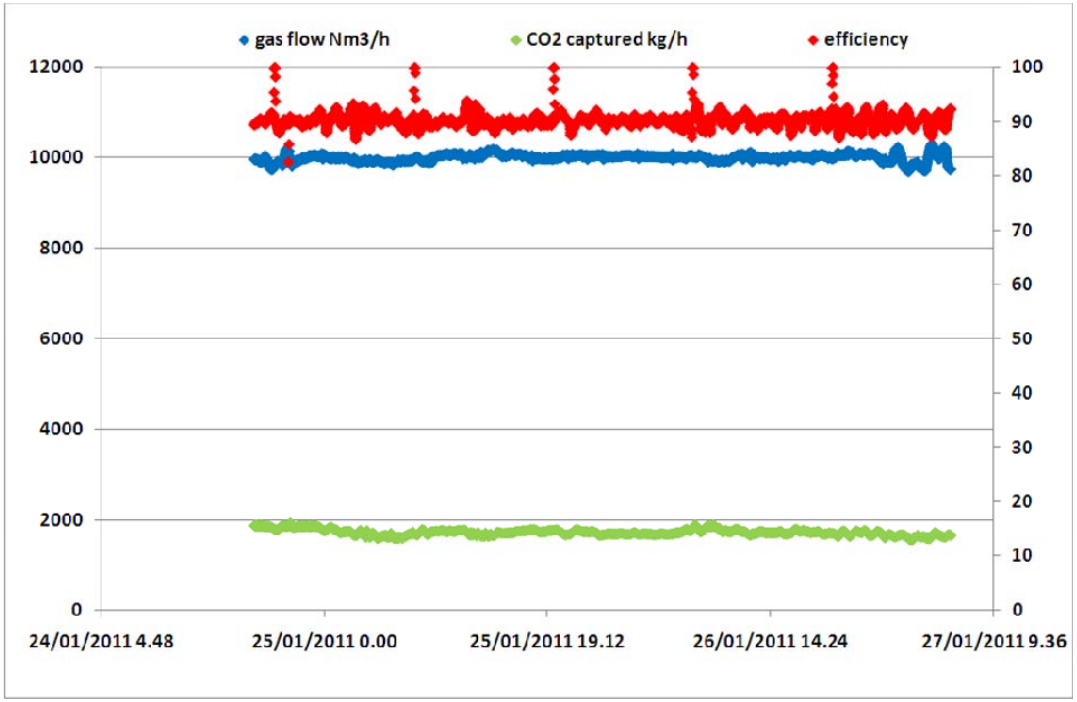
ZEPT- CO_2 capture pilot plant

Test campaign with 30% MEA

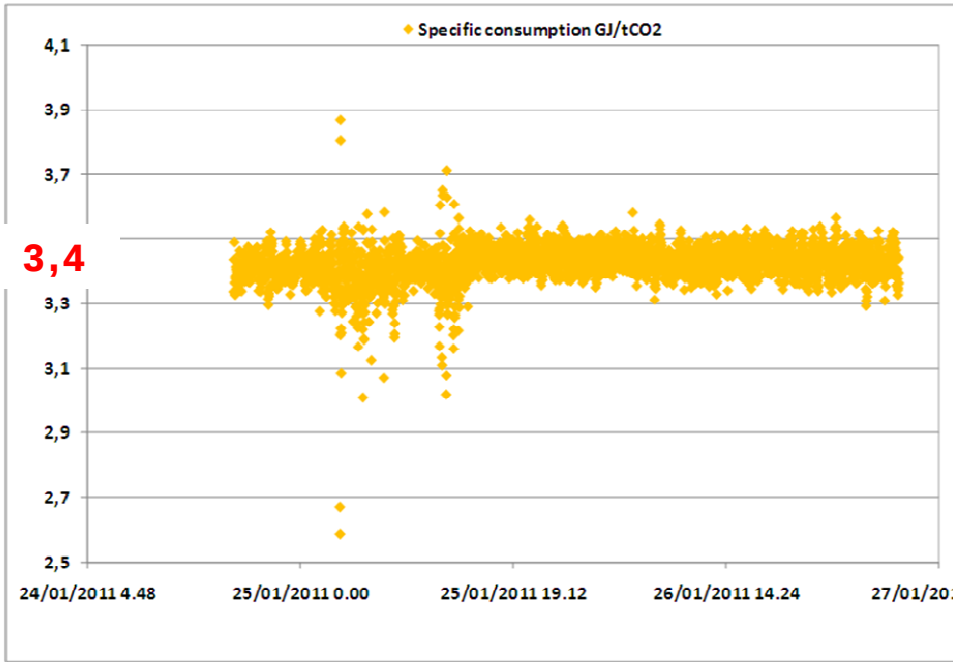
The following settings have been applied in the 500 hours test (Jan 07 – Feb 11; continuous operation):

- Flue gas flow: 10.000 Nmc/h
- Solvent flow: 30 mc/h
- Stripper pressure: 0.8 barg
- Corrosion coupons are installed:

CS 018; SS 316; SS 304



Steam consumption: ~ 3.4 GJ/t CO_2



Average CO_2 capture: ~ 90 %

CO_2 capture pilot plant

ZEPT - CO2 capture pilot plant

ZEPT – R&D Supporting Activities

Integrated CCS pilot project

- The first Italian integrated CCS pilot project is under development in the frame of the Eni - Enel cooperation agreement signed in 2008. It will include:

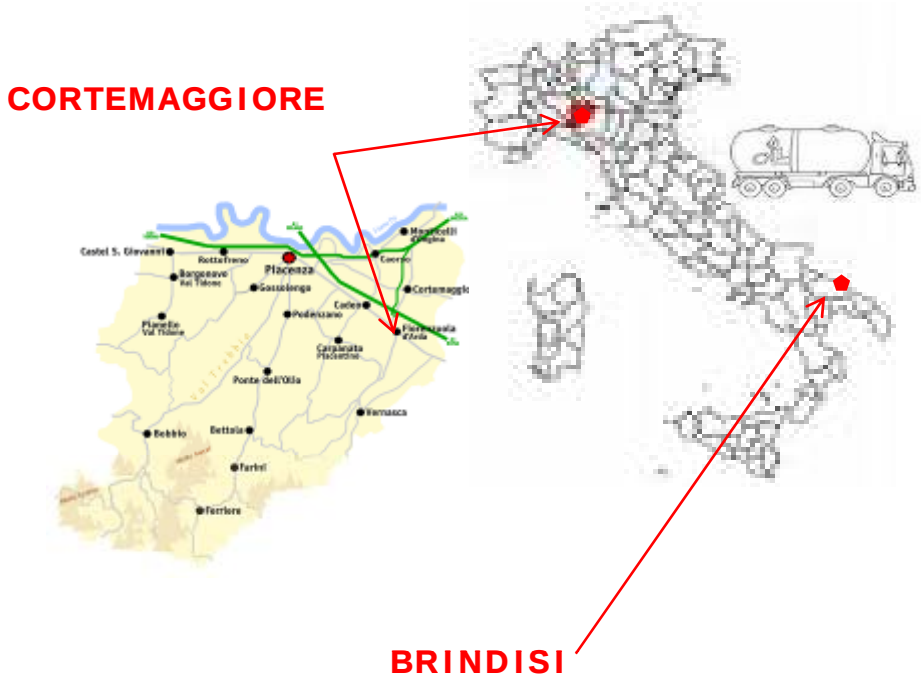
✓**Capture** – Enel's post-combustion capture pilot plant in Brindisi in operation from Oct. 2010 and separating at least 5000 tCO_2/y

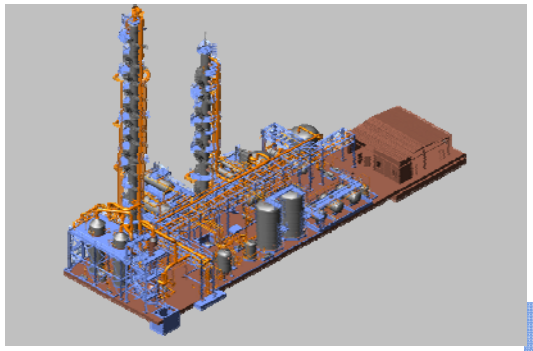
✓**Liquefaction** – CO_2 liquefaction and criogenic storage system to be built in Brindisi treating the CO_2 produced by the pilot capture plant

✓**Transport** – by truck

✓**Storage** – Eni's pilot CO_2 injection project in an exhausted gas field in Cortemaggiore (Piacenza).
Injection start: summer 2012.
Total CO_2 injected: 24000 ton

- It is also foreseen to build in Brindisi a closed loop CO_2 pilot pipeline to develop knowledge to be used in the demo transport system design.



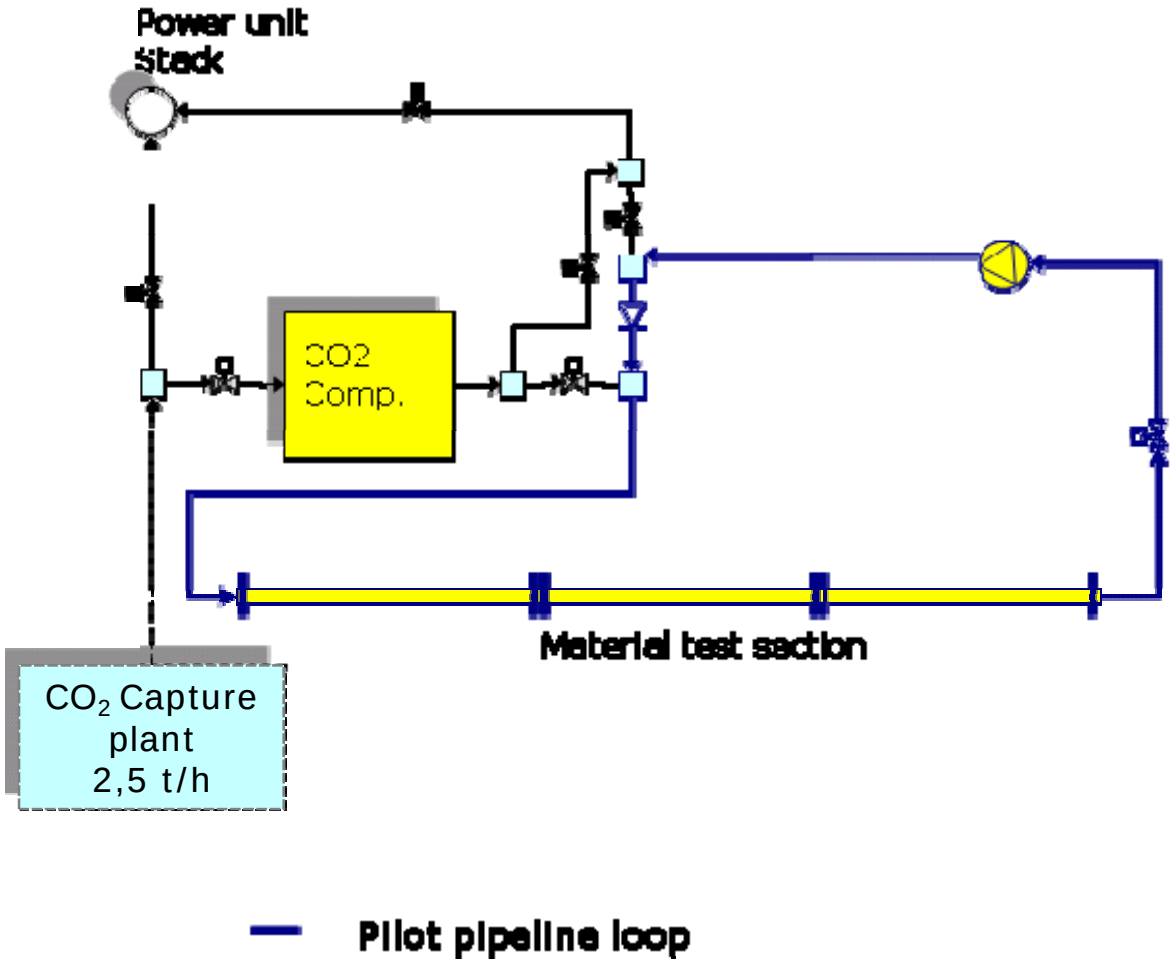


ZEPT – R&D supporting activities

CO_2 pilot pipeline

This will allow to collect experimental data to be used to:

- Validate design models (both stationary and dynamic) of the CO_2 transport line
- Optimize operating procedures
- Study corrosion problems related to the presence of impurities in the CO_2 stream



FEED completed in Feb. 2011. Permitting under way, order to be issued 2H 2011. Expected operation start in 2012

Regulatory and financial challenges in demonstrating CCS

Italian regulatory framework

The trasposition of the European Directive 2009/31/EC on CO2 geological storage into the Italian legislation is well advanced:

- **The tool used is a Legislative decree.** This is an act from the Government which was empowered by a vote of the Parliament (Law 96/2010, the so-called “Legge comunitaria 2009”).

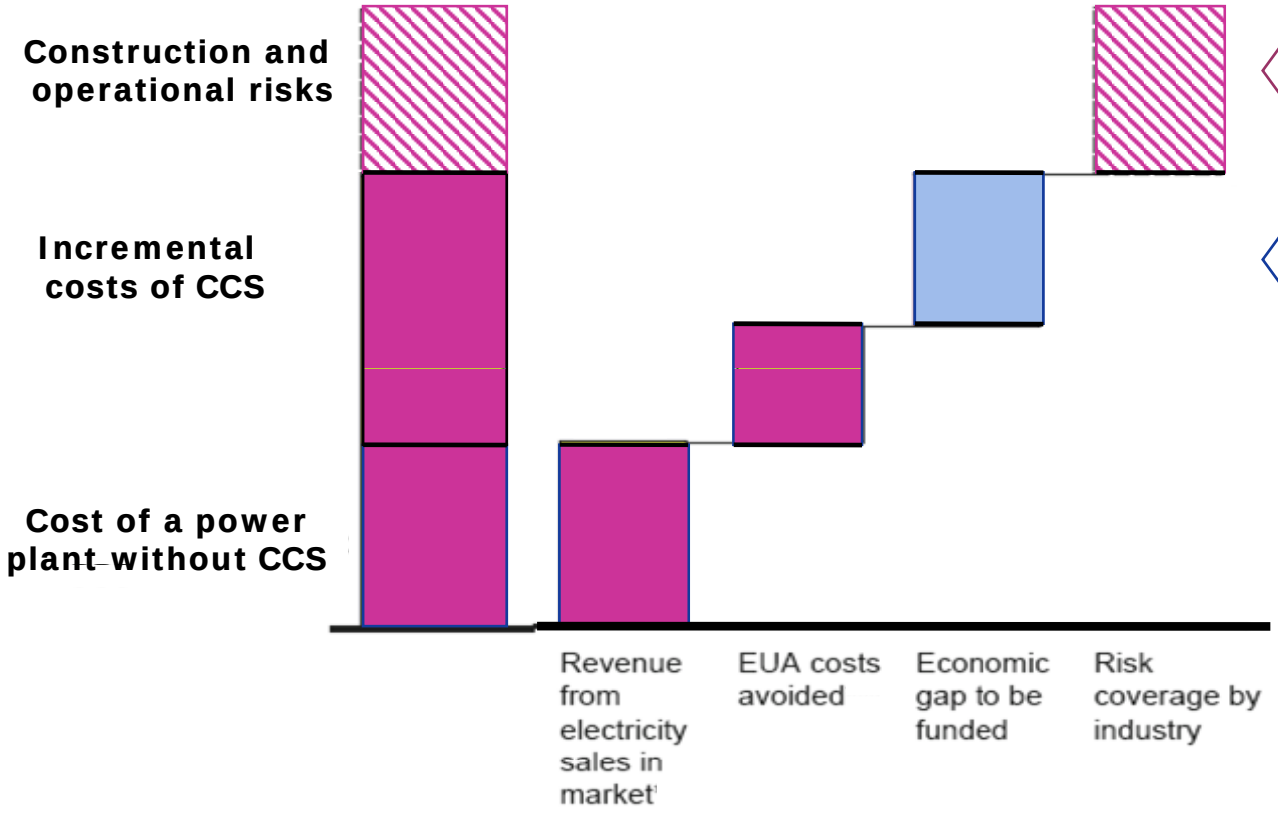
- **Process status**

May 2010	First draft of the decree
Jun - Oct 2010	Stakeholders consultation
Nov 2010 - Feb 2011	Legal review
23 Mar 2011	Approval by Council of Ministers
By end May 2011	Opinion from Parliament Commissions
Mid June 2011 (expec.)	Final approval and publication

- According to the draft text **the competent authority** in the permitting process is the **Ministry of the Economic Development** in concert with the **Ministry of the Environment.**

- Details about the implementation of some articles will be contained in ministerial decrees to be issued within 6 months from the publication of the legislative decree.

Financial feasibility of CCS demos



- Project promoters are bearing relevant constructions and operational risks
- Public needs to cover most of the economic gap

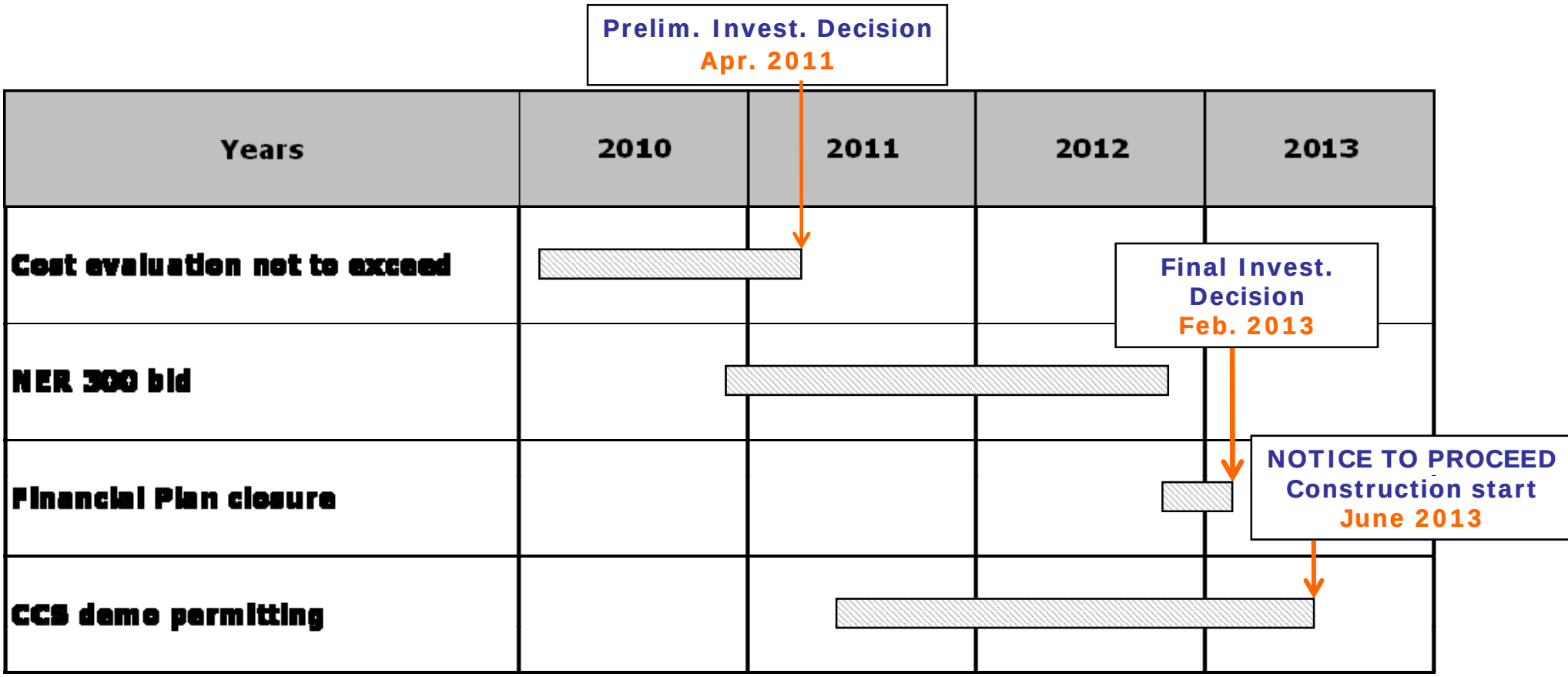
Not at scale

The economic gap for a typical CCS demo project is of the order of 1b €

Public funding assumptions for ZEPT demo

- A grant from the **EEPR** fund → 100 M€ under the Grant Agreement signed in Dec. 2009
- A substantial contribution from **NER 300** fund → Proposal presented by the Italian Government on May 9, 2011; process ongoing
- A significant funding from **Italian Government** → Under discussion. Legal basis: Law 99/2009, Law 111/2010

ZEPT- Decision gates



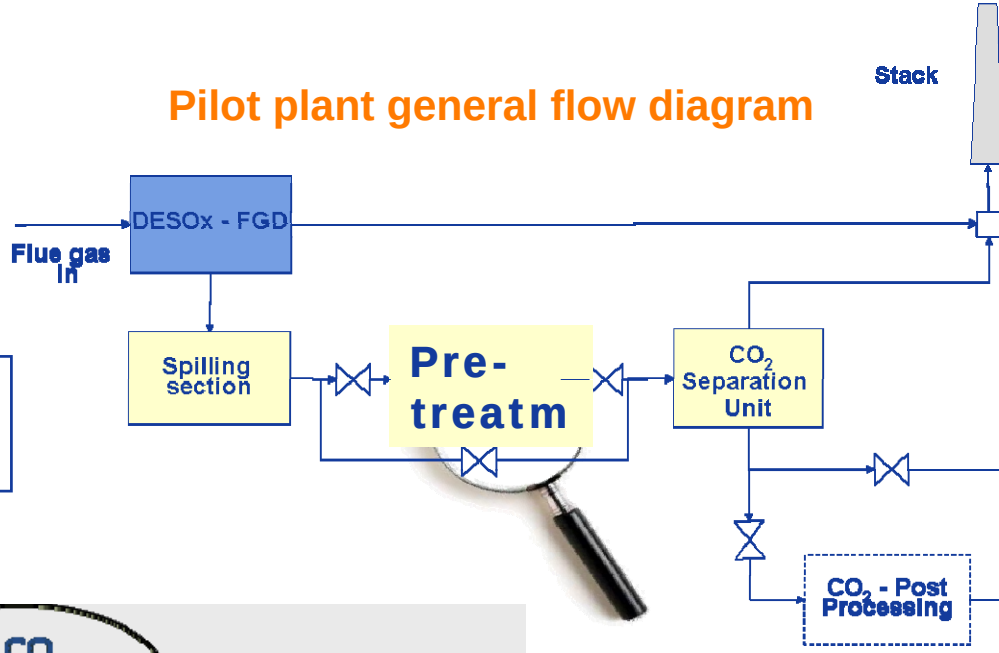

Thank you
for your kind attention

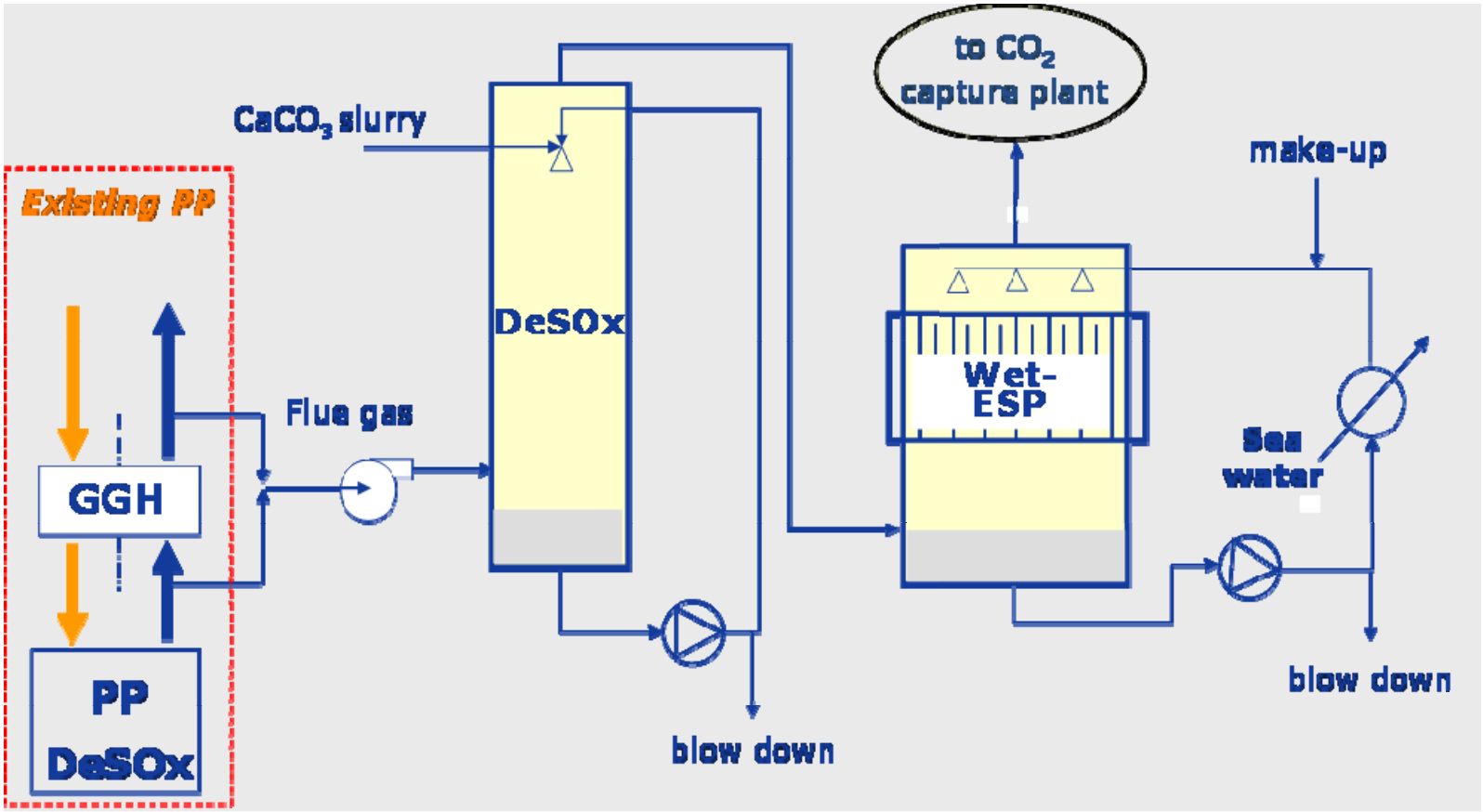
ZEPT- CO_2 capture pilot plant

Flue gas pre-treatment

The pre-treatment system gives the possibility to partially bypass both the WFGD and the WESP

Pilot plant general flow diagram

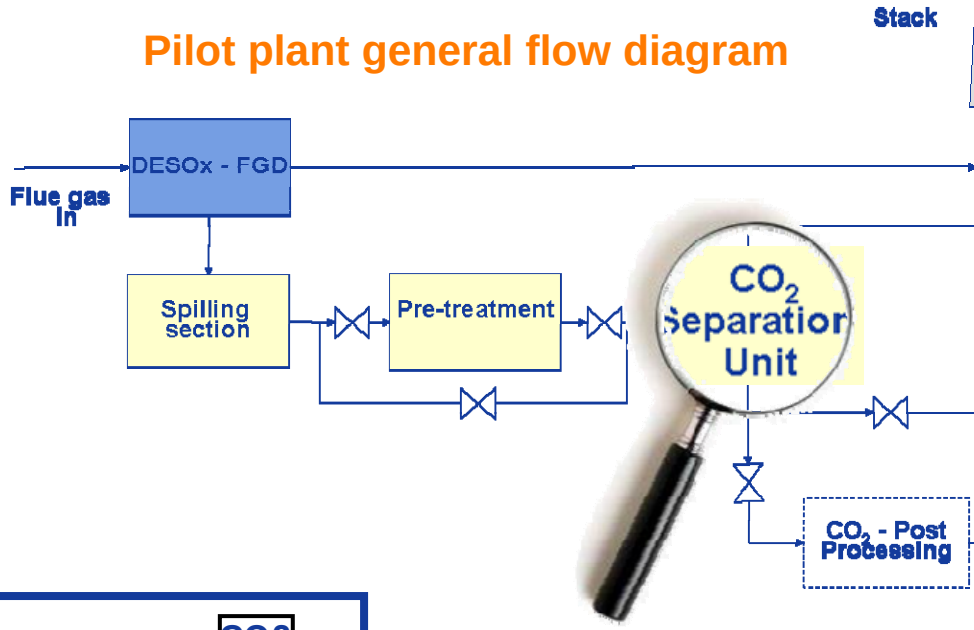




ZEPT- CO_2 capture pilot plant

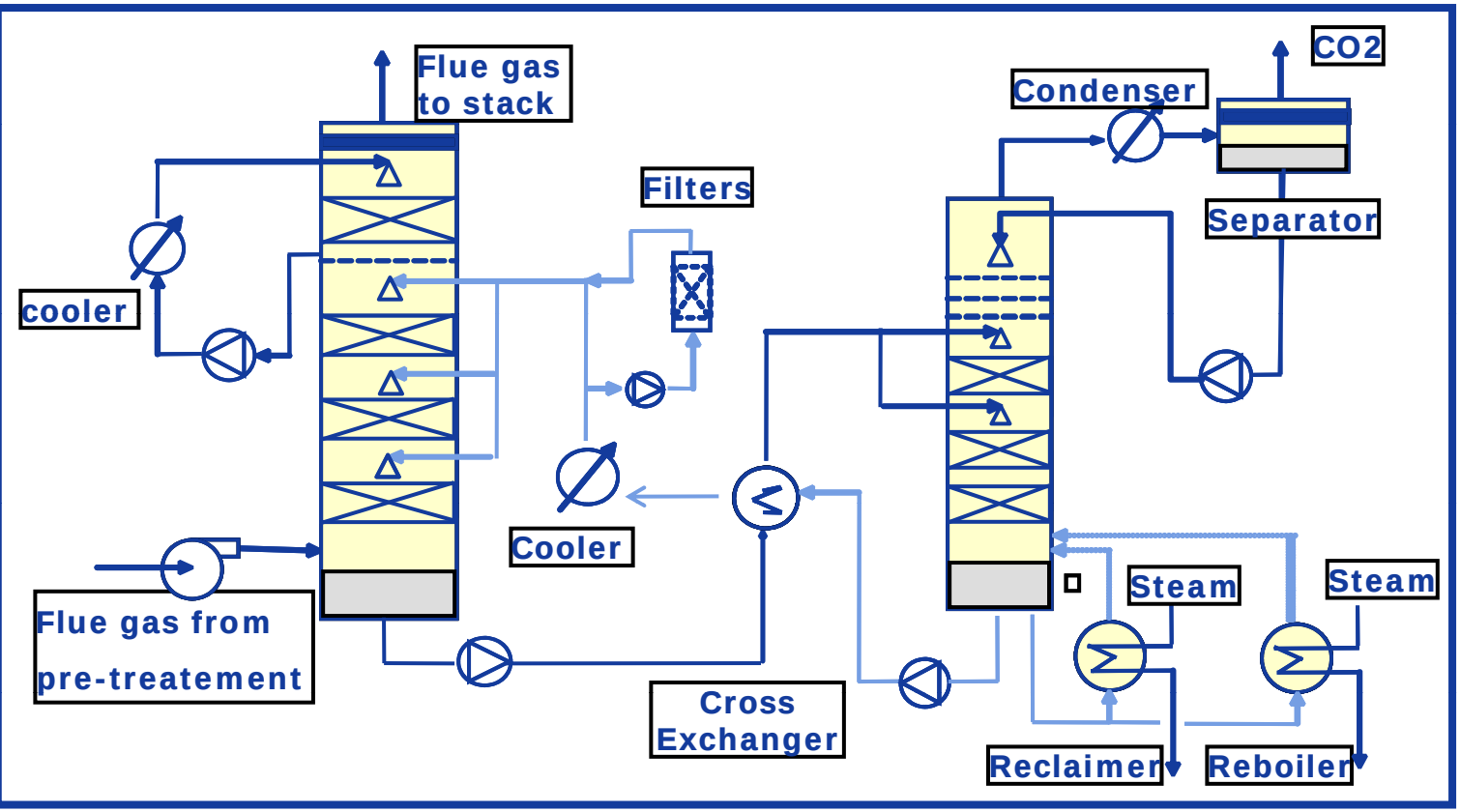
CO_2 separation unit

Pilot plant general flow diagram



Absorber

- 1.5 m internal diameter
- 3 structered packing sections (22 m total)
- Solvent flow rate : 20 to 80 m^3/h



Stripper

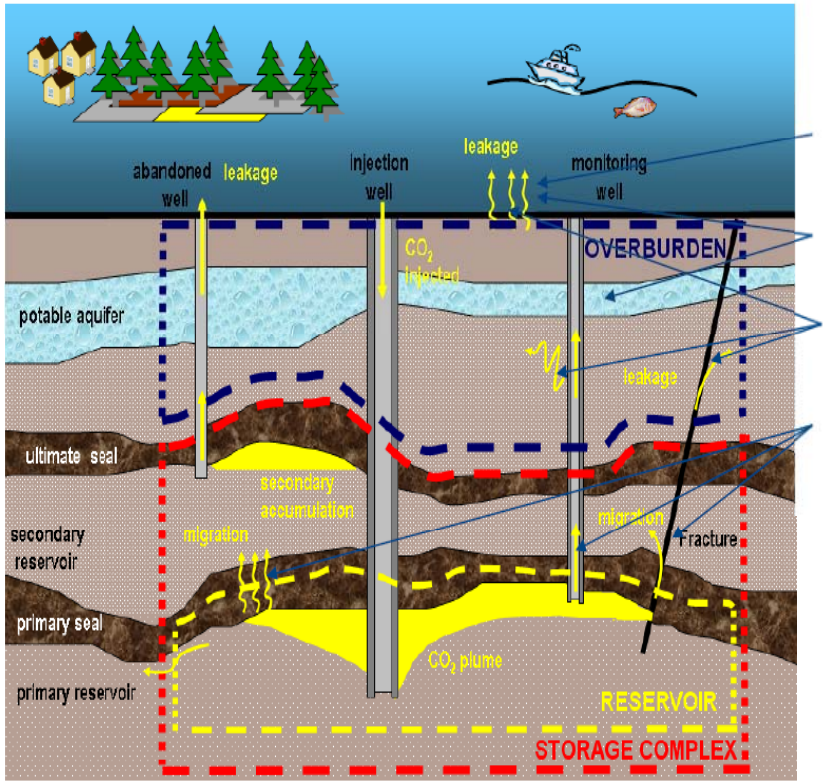
- 1.2 m internal diameter
- 3 random packing sections (10 m total)
- Operative pressure up to 2.5 bar

ZEPT Monitoring Plan
General objectives

✓Operational Monitoring
- Injection operation control
- Quantification of injected CO2

✓Verification Monitoring
- Well Integrity
- Cap Rock / Fault Integrity
- CO2 displacement & fate
- Calibration of predictive models

✓Assurance Monitoring
- Impact: HSE monitoring
- Leakage and associated impact



ZEPT project

Pre-injection off-shore survey

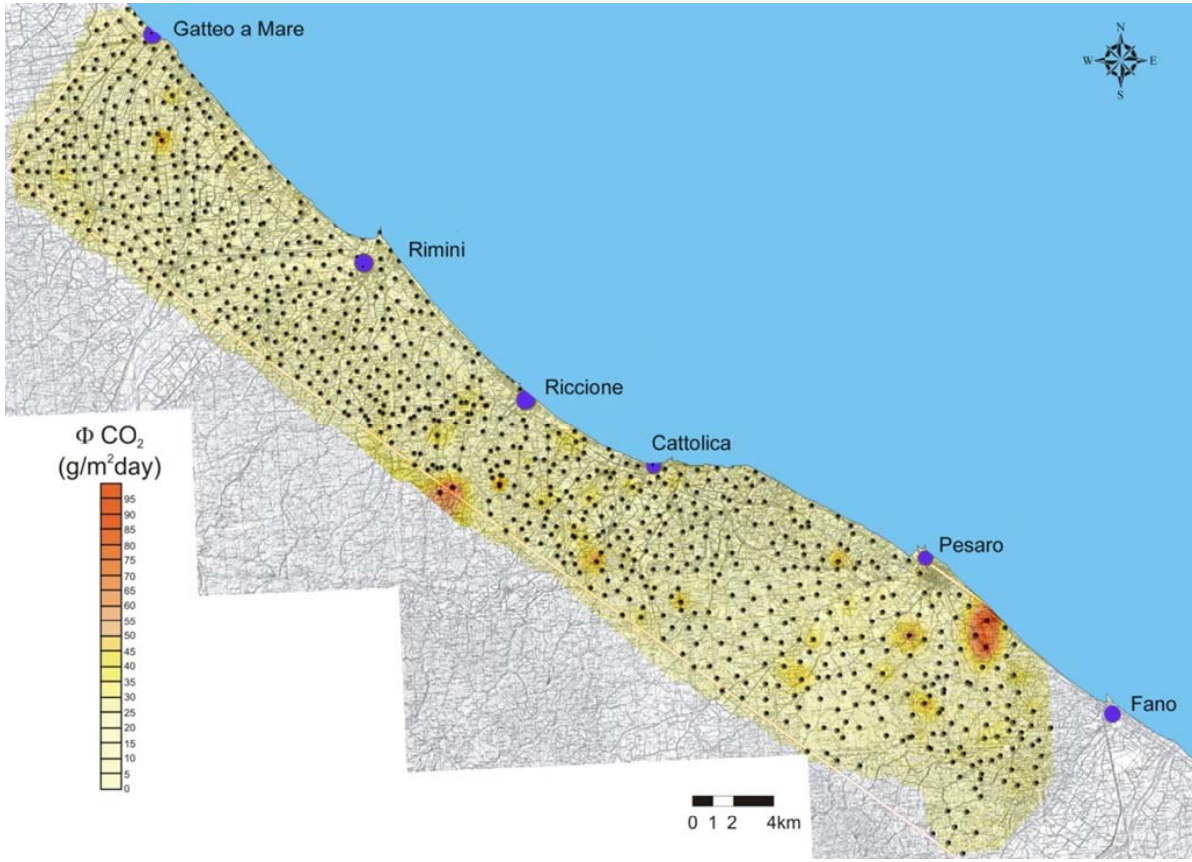
The baseline study covers a 400 km2 area around the more probable injection locations in water depths ranging from 13 to 40 m.

Measurements include chemical, biological and physical analyses of both the water column and the near-surface sediments during four different periods of the year to define the ranges of baseline values in the area, both spatially and temporally.

ZEPT project
Pre-injection on-shore survey

The development of the pre-injection grid was carried out through

- ✓soil geo-gas measurements (CO_2 and CH_4 fluxes)
- ✓geo-gas concentrations (CO_2, CH_4, He, 222Rn, H_2S, CO, H_2, N_2, O_2, and light hydrocarbons)
- ✓shallow and deep aquifer fluids in terms of physico-chemical parameters (temperature, salinity, pH, redox conditions), chemical composition (major, minor and trace elements) and dissolved gases content.



ZEPT project

Evaluation of pre-injection micro-seismicity

Study of historical seismicity of nteresting areas.

The goal of the feasibility studies is the collection f a **new passive seismic dataset**, in order to crease both the seismic behavior and the deep eological and tectonic setting of the area.

The aim of the seismic experiment is to increase he grid of the permanent seismic networks already vailable (Italian National Seismic Network and arche Seismic Network) in order to increase the ensitivity of the networks and locate earthquake ith ML <2.

ZEPT project

Design of an seismic monitoring plan

It consists of a chain of actions involving:

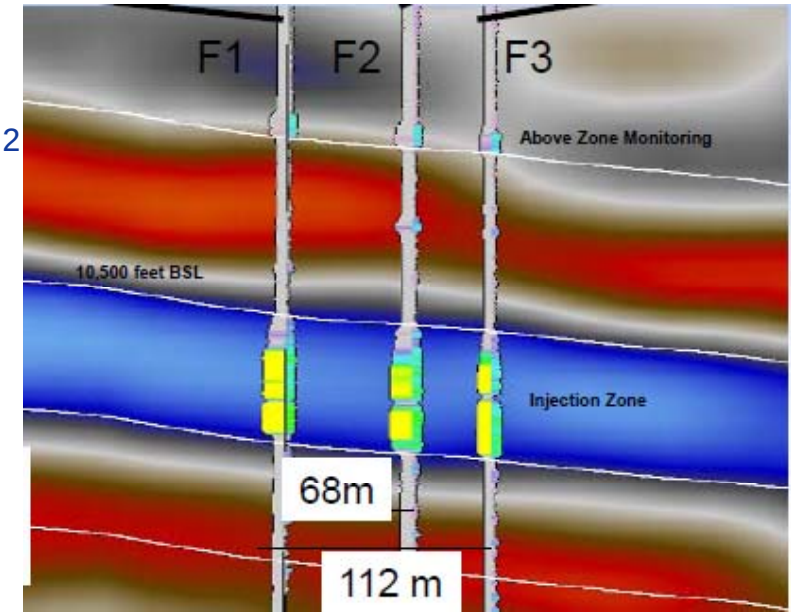
✓Building a model of the physical properties in the rock formations from the surface to the aquifer/reservoir;

✓evaluation of the change in seismic properties varying CO_2 saturation;

✓calculation of synthetic seismograms and topographic modelling;

✓evaluation of delectability of the injected CO_2, both in the hosting formation (CO_2 plume) and in the overlying formations (possible leakages);

✓plan of the most effective seismic acquisition pattern in terms of cost/benefits and lower impact on the investigated areas (planning optimization).



Open questions

- ✓Adaptation to site-specific constraints
- ✓Definition of area of interest
- ✓Guidelines on monitoring tools selection
- ✓Minimum requirements in monitoring plan definition