The Porto Tolle CCS demonstration project

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Enel - Engineering & Innovation Division

CO₂ Capture and Storage – Response to Climate change
Regional Awareness-Raising Workshop

Vilnius, 13-14 April 2011
The Porto Tolle CCS demonstration project: objectives and status

The R&D activities supporting the development of Porto Tolle demo

Italian policy framework

Financial challenges in demonstrating CCS
The Porto Tolle CCS demonstration project

Objectives and status
The Porto Tolle power plant conversion project

- Gross power output (MW)
  - Old Plant: 2640
  - New Plant: 1980
- Net efficiency (LHV)
  - Old Plant: 39%
  - New Plant: 45%
- Fuel
  - Old Plant: Oil (0.25% S)
  - New Plant: Coal
- Emissions SO2/NOx/Dust (mg/Nm3)
  - Old Plant: 400/200/50
  - New Plant: 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
Project goal

To retrofit one 660 MWₑ coal fired unit of Porto Tolle power station with CO₂ post combustion capture equipment and start CO₂ underground storage in an off-shore saline aquifer by 2015.
ZEPT- Zero Emission Porto Tolle
CCS demo plant lay-out

Porto Tolle power plant

CO₂ storage area (light-blue)
ZEPT- Zero Emission Porto Tolle

Demo main features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
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<tbody>
<tr>
<td>Type of Project</td>
<td>Retrofit</td>
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<tr>
<td>Power generation</td>
<td>660 MWe</td>
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<tr>
<td>Primary fuel</td>
<td>Bituminous coal</td>
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<tr>
<td>Secondary fuel</td>
<td>Biomass</td>
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<tr>
<td>Power Generation Tech</td>
<td>USC-PC</td>
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<tr>
<td>% of flue gas treated</td>
<td>40%</td>
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<tr>
<td>CO$_2$ Capture Tech</td>
<td>Post Combustion Capture with Amine</td>
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<tr>
<td>Stored CO$_2$</td>
<td>Up to 1 Mt/y</td>
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<tr>
<td>CO$_2$ Capture rate</td>
<td>90%</td>
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<tr>
<td>CO$_2$ Storage solution</td>
<td>Deep saline aquifer</td>
</tr>
<tr>
<td>Storage location</td>
<td>North Adriatic Sea</td>
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<tr>
<td>CO$_2$ value chain</td>
<td>Pure storage</td>
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</tbody>
</table>

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€
# ZEPT- Zero Emission Porto Tolle

## Project time schedule

<table>
<thead>
<tr>
<th>WP</th>
<th>Years</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
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<tbody>
<tr>
<td>1</td>
<td>R&amp;D Supporting Activities</td>
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<td>Const. &amp; Tests</td>
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<tr>
<td></td>
<td>CO2 Capture Pilot Plant</td>
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<td></td>
<td>Cryogenic Storage</td>
<td>Tech. spec, supply, install. CO2 storage &amp; transport to injection site</td>
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<td></td>
<td>Pipeline test rig</td>
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<td>Design &amp; Construction Tests</td>
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<tr>
<td>2</td>
<td>CO2 Capture Unit</td>
<td>Lic. qual. FEED’s</td>
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<td>EPC contract</td>
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<tr>
<td>3</td>
<td>Power Plant Integration</td>
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<td>Basic design</td>
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<td>Techn. spec. + EPC contract</td>
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<td>4</td>
<td>CO2 Transport</td>
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<td>Basic design</td>
<td>FEED</td>
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<tr>
<td>5</td>
<td>CO2 Injection Storage &amp; MMV</td>
<td></td>
<td>Geological site selection</td>
<td>Site characterization</td>
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<td>Geological site preparation</td>
</tr>
</tbody>
</table>

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

- Selection of the CO₂ 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 and appraisal well design in progress
- Development of the financial plan
R&D activities supporting the development of Porto Tolle demo
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 Nm\(^3\)/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- 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.
ZEPT- CO₂ capture pilot plant

CO₂ separation unit

Absorber
- 1.5 m internal diameter
- 3 structured packing sections (22 m total)
- Solvent flow rate: 20 to 80 m³/h

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

<table>
<thead>
<tr>
<th>Month</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
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<tr>
<td>2010</td>
<td>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52</td>
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<tr>
<td></td>
<td>Construction</td>
<td>Start-up</td>
<td>Performance tests - MEA 20%</td>
<td>MEA 30%</td>
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<td></td>
<td>MEA 30%</td>
<td>MEA 40%</td>
<td>Amine Mixture 1</td>
<td>Amine Mixture 2</td>
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<td></td>
<td>Advance solvent 1</td>
<td>Fermata Gr. 4. Revamping Filtro</td>
<td>Advance solvent 2</td>
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- **2011 → 4000 hr continuos operation; ~ 8000 ton of separated CO₂**
- **2012 → 3000 hr continuos operation; ~ 6000 ton of separated CO₂**

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: $\approx 3.4$ GJ/t CO$_2$

Average CO$_2$ capture: $\approx 90\%$
- CO₂ capture pilot plant
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 tCO₂/y
- **Liquefaction** – CO₂ liquefaction and cryogenic storage system to be built in Brindisi treating the CO₂ produced by the pilot capture plant
- **Transport** – by truck
- **Storage** – Eni’s pilot CO₂ injection project in an exhausted gas field in Cortemaggiore (Piacenza). Injection start: summer 2012. Total CO₂ injected: 24000 ton

It is also foreseen to build in Brindisi a closed loop CO₂ pilot pipeline to develop knowledge to be used in the demo transport system design.
ZEPT – R&D supporting activities

CO₂ pilot pipeline

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

- 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

Italian policy framework
The Italian energy strategy

The role of CCS

- **Coal is a key element** of the Italian energy sources diversification policy. The strategy for new coal is based on the use of BAT’s while promoting the transition to near-zero emissions (advanced materials, ultra-high efficiency systems, **CCS**).

- **The transposition of the European directive on CO\(_2\) geological storage** in the Italian legislation will be realised through a base decree followed by various administrative acts (see next slide).

- **Law 99/2009 (New energy strategy)** includes provisions for the promotion of innovation in the energy sector. Priority fields for R&D&D are CCS, nuclear and distributed generation. Financial support to the realisation of CCS demo projects is also foreseen (source of funds not specified).

- **Law 111/2010** provides for the use of revenues of the auctioning of ETS allowances for the aims quoted in art 10.3 of the European directive 2009/29/EC, which include “the environmentally safe capture and geological storage of CO\(_2\)...”
The trasposition of the European directive 2009/31/EC on CO2 geological storage into the Italian legislation is in progress:

- **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 mid- May 2011: Opinion from Parliament Commissions
  - End May 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 challenges in demonstrating CCS
Financial feasibility of CCS demos

- Construction and operational risks
  - Project promoters are bearing relevant constructions and operational risks
- Incremental costs of CCS
  - Public needs to cover most of the economic gap
- Cost of a power plant without CCS

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** → Call for proposal issued Nov. 2010; process ongoing

- **A significant funding from Italian Government** → Under discussion
**ZEPT - Decision gates**

<table>
<thead>
<tr>
<th>Years</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
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<tbody>
<tr>
<td>Cost evaluation not to exceed</td>
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<td>NER 300 bid</td>
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<td>Financial Plan closure</td>
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<tr>
<td>CCS demo permitting</td>
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</tbody>
</table>

- **Prelim. Invest. Decision**
  - Apr. 2011

- **Final Invest. Decision**
  - Feb. 2013

- **NOTICE TO PROCEED**
  - Construction start: June 2013
Thank you for your kind attention