From clean coal to zero emissions

Pietro Barbucci
Enel - Engineering & Innovation Division

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Forum on Clean Electricity Investments and the Financial Crisis

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Content

- Achievements so far in the environmental field
- Coal power plants in Italy
- Clean coal projects in Italy
  - Torrevaldaliga Nord conversion project
  - Porto Tolle conversion project
- Zero Emission Porto Tolle
Achievements so far

in the environmental field
Enel’s achievements in pollutant reduction

- **SO₂**: - 64%
- **NOₓ**: - 33%
- **Dust**: - 70%

Enel has invested 4 billion Euro since the ‘90s to improve environmental performance of thermal power plants.
Enel commitment to reduce CO₂ emissions
Voluntary agreement signed with the Italian Government in 2000

Enel committed itself to reducing its specific emission to 510 g CO₂/kWh by 2006

Enel's total emission (Mton)

- 2000: 68
- 2005: 56

Enel specific emission trend gCO₂/kWh

- 1990: 618
- 2005: 501
- 2006: <500

Target 510
Changing generation mix while reducing CO₂ emissions

- Increasing renewable share
- Eliminating oil as a fuel
- Using NG only in high efficiency CCGT
- Building new coal capacity using best available technologies

Enel Italian generation mix
Enel’s domestic coal capacity

- 7 power plants, 18 units
- 1 power plant under construction, 3 units
- 1 power plant under permitting, 3 units

Total capacity \( \sim 5.000 \text{ MW}_e \)
+ 2,000 MWe in erection phase
Clean coal projects in Italy

- Torrevaldaliga Nord conversion project
- Porto Tolle conversion project
Torrevaldaliga Nord conversion project
One of the cleanest and most efficient coal fired power stations worldwide

**Termal cycle characteristics:**
- $\eta$ (net, LHV) 45%
- SH steam temperature at turbine inlet 600° C
- RH steam temperature at turbine inlet 610° C

**Emission limits** (mg/Nm$^3$ hourly basis)

<table>
<thead>
<tr>
<th></th>
<th>Design values</th>
<th>European limits</th>
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<tbody>
<tr>
<td>NOx</td>
<td>100 (80)$^1$</td>
<td>200</td>
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<tr>
<td>SO$_2$</td>
<td>100 (85)$^1$</td>
<td>200</td>
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<tr>
<td>Particulate</td>
<td>15 (9)$^1$</td>
<td>30</td>
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</table>

$^1$ Monthly basis
Clean coal conversion projects

The strategy:
- To replace old oil-fired power plants with clean coal unit using BAT’S (Torrevaldaliga Nord, Porto Tolle power plants)

The design approach:
- “Brown field” conversion, in order to reuse:
  - existing site
  - stacks
  - turbine building
  - logistical buildings
  - electrical substation and high voltage transport lines
  - sea water cooling civil structures
  - process water discharge civil structures.
Torrevaldaliga Nord conversion project

Previous fuel oil power plant

Present clean coal power plant
Main Interventions

- Replacement of the boilers with new coal fired ones (250 bar/604° C/612° C)

- Replacement of the steam turbines with new ones

- Installation of a completely new flue gas cleaning train

- Construction of a seaport with a new main jetty for coal unshipping and a secondary jetty for limestone unloading, and ash and gypsum loading

- Construction of fully enclosed ship un-loader, belts and covered storage for coal (two 150,000 ton capacity dome type stockyards), limestone, gypsum and ash

- Installation of a new demineralization plant for sea water desalination, and a FGD blow-down ZLD system.
MCR (Max Continuous Rating)
- \( T_{SH} = 604^\circ C \) \( T_{HRH} = 612^\circ C \)
- \( T_{ECO} = 312,7^\circ C \)
- \( F_{SH} = 532,8 \text{ kg/s} \) \( F_{RH} = 442,3 \text{ kg/s} \)
- \( P_{SH} = 252,7 \text{ bara} \) \( P_{HRH} = 57,8 \text{ bara} \)

- Gas Flow Biasing (RH temp control)
- Spiral Wall Furnace
- Low NOx Burners
  NOx at boiler outlet \( \leq 400 \text{ mg/Nm3} \)
  - Natural gas used for start up only
  - Unburned particles in ash \( \leq 5\% \)

- Variable Pressure Operation
  - 60\% capacity steam by-pass
  - Boiler Efficiency > 94%
**Torrevaldaliga Nord conversion project**

The flue gas treatment line

- **NOx**
  - Advanced combustion system
  - High dust SCR
  - Urea to ammonia Plant (Ammogen)

- **Particulate**
  - Fabric Filter

- **SOx**
  - GGH zero-leakeage
  - Wet FGD limestone-gypsum
  - SOx removal efficiency > 97%
Torrevaldaliga Nord conversion project

Environmental benefits

Emissions related to 6,500 operating hours (ktons/year)

- SO₂: 17.7 ktons/year, 88% reduction
- NOx: 8.8 ktons/year, 61% reduction
- Particulates: 2.2 ktons/year, 88% reduction

4 fuel oil units vs. 3 coal units
Torrevaldaliga Nord conversion project

The new jetty for coal unloading
Torrevaldaliga Nord conversion project

Coal handling system
Torrevaldaliga Nord conversion project

Coal storage

Dome type to limit dust emissions in atmosphere

2x150,000 tons storage capacity
Torrevaldaliga Nord conversion project

Site works overview

Boiler Unit 2

Desox units 3 and 4
Porto Tolle conversion project

- Gross power output (MW)
  - Old Plant: 2640
  - New Plant: 1980 (*)
- Net efficiency
  - Old Plant: 39%
  - New Plant: 45%
- Fuel
  - Old Plant: Oil (0.25% S)
  - New Plant: Coal
- Emission $\text{SO}_2/\text{NO}_x/\text{Dust} (\text{mg}/\text{Nm}^3)$
  - Old Plant: 400/200/50
  - New Plant: 100/100/15 (hourly basis)

**New main components:**
- USC boilers
- SCR denitrification system
- FGD plants
- Fabric filters
- 2 domes for coal storage

- Cofiring coal–biomass is possible for 2 units

**Coal Logistic:**
- Transhipment from Panamax to “storage ship” in the Adriatic Sea (Porto Levante) + barges to and from Porto Tolle
Porto Tolle conversion project

Present status

Future plant

To be demolished

New buildings
Towards Zero Emissions
The challenge of climate change
A technology revolution required

Source: IEA – Energy Technology Perspectives 2008
ZEPT - Zero Emission Porto Tolle

Post-combustion capture and storage demo project
Project goal

To retrofit one 660 MW\textsubscript{e} coal fired unit of Porto Tolle power station with CO\textsubscript{2} capture equipment and start CO\textsubscript{2} underground storage by 2015.
## ZEPT- Zero Emission Porto Tolle

### Time schedule

<table>
<thead>
<tr>
<th>Phase</th>
<th>Year</th>
<th>2006</th>
<th>2007</th>
<th>2008</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. Lab</td>
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<td>Capture process tests at lab scale</td>
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<td>Geological storage site characterization and preparation</td>
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<td>4. Demo</td>
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- **2006**: Capture process tests at lab scale
- **2007**: Design and construction of a 10,000 Nm$^3$/h pilot plant
- **2008**: Operation of the capture pilot plant and pilot tests on transport & injection
- **2009**: Technology follow-up
- **2010**: Geological studies for site selection
- **2011**: Geological storage site characterization and preparation
- **2012**: Feasibility study, design and construction of a CCS demo plant
At the site of Brindisi coal fired power station a pilot plant for CO$_2$ separation via ammine scrubbing is under construction. The plant is installed on the Unit 4.

The 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**, capturing about **2.5 t/h of CO$_2$**.

Target: gain experience in CCU designing and operation, and assess the environmental impact of the process.
ZEPT - Zero Emission Porto Tolle
Phase 2 - CO₂ capture pilot plant

Work in progress at site - October 2009

Plant completion expected by Feb 2010
ZEPT - Zero Emission Porto Tolle
The technological network

• ENI
In October 2008, Eni and Enel signed a Strategic Cooperation Agreement to develop technologies for CO$_2$ capture, transport and geological sequestration and to accelerate the deployment of CCS. Specific goals of the cooperation program are:

✔ To build the first integrated pilot project in Italy
✔ To carry out a detailed feasibility study for the Porto Tolle CCS demo plant
✔ To jointly evaluate the CO$_2$ storage potential in Italy

• IFP
In January 2009 IFP and Enel have signed a MoU to test an IFP proprietary technology for flue gas scrubbing using chemical solvents, in Enel’s Brindisi pilot plant.
A pilot covering the entire CO₂ chain:

An integrated capture-injection project where the Enel’s CO₂ capture pilot plant in Brindisi will provide CO₂ for the Eni’s pilot injection project in an exhausted gas field at Cortemaggiore (Piacenza). The start of the CO₂ injection (8,000 t/y) is scheduled for the end of 2010.

A CO₂ pilot pipeline to be built in Brindisi to validate design models of CO₂ transport lines, to optimize operating procedures and to study corrosion problems.
ZEPT - Zero Emission Porto Tolle
Phase 4 – Porto Tolle post-combustion demo plant

Porto Tolle power plant

CO2 storage area
**ZEPT - Zero Emission Porto Tolle**

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**: 40%
- **CO₂ Capture Tech**: Post Combustion Capture with Amine
- **Stored CO₂**: Up to 1 Mt/y
- **CO₂ Capture rate**: 90%
- **CO₂ Storage solution**: Deep saline aquifer
- **Storage location**: 100 km South-East – Nord Adriatic Sea
- **CO₂ value chain**: Pure storage

This is one of the 6 demo projects proposed for funding under the EEPR (European Energy Programme for Recovery).
ZEPT - Zero Emission Porto Tolle
Phase 4 - Porto Tolle post-combustion demo plant

Time schedule

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- Detailed identification of injection area
- Pre-feasibility study completion
- Investment decision
- NTP-Construction start
- CO₂ injection start
Thank you
for your kind attention