DEVELOPMENT OF DISTRICT HEATING LINKED TO THE COGENERATION POWER PLANTS IN TURIN AREA

The 34th Congress of Euroheat & Power

Venice, 26/05/2009

Antonio ROSSI – Gianpaolo ROBUSTI
WHERE IS TURIN?
DISTRICT HEATING: EXISTING SITUATION

- SOUTH TURIN DH: 27,0 Mm³
- CENTRE TURIN DH: 9,0 Mm³
- LE VALLETTE DH: 3,0 Mm³
- IRIDE DH SYSTEMS: 39,0 Mm³
- NORTH-WEST AREA DH: 3,6 Mm³
- NORTH-EAST AREA DH: 1,4 Mm³
- OTHER DH SYSTEMS: 5,0 Mm³
- TOTAL DH SYSTEMS: 44,0 Mm³
## EXISTING SITUATION – GENERAL DATA

<table>
<thead>
<tr>
<th>Area</th>
<th>SPACE HEATED (Mm³)</th>
<th>CITIZENS (num)</th>
<th>NOMINAL THERMAL PEAK (MW)</th>
<th>THERMAL ENERGY (GWh/y)</th>
<th>PIPELINES (km)</th>
<th>HEAT EXCHANGER (num)</th>
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<tr>
<td>SOUTH TURIN DH</td>
<td>27,0</td>
<td>250,000</td>
<td>675</td>
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<td>960</td>
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<td>3,050</td>
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<td>430,000</td>
<td>1,080</td>
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<td>3,740</td>
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13th JANUARY 2009 – THERMAL SEASON PEAK

- CHP
- HOB
- ACCUMULATORS DISCHARGE
- ACCUMULATORS CHARGE
SOUTH AND CENTRE TURIN DH - THERMAL ENERGY

- CHP 89%
- HOB 10%
- Accumulators 1%
SOUTH AND CENTRE TURIN DH – PRESSURE LEVEL

DH CENTRE TURIN - Connected Volume 36.4 Mmc - 880 MW
Path CTM-RP1V-RP2M-CMN

Legend
- Profile - supply
- Profile - return
- Level

Pressure level [mwc]

Length [m]
DISTRICT HEATING PLANNING: STEP 0

EXISTING IRIDE DH: 39,0 Mm$^3$
NORTH TURIN: 15,0 Mm$^3$
NICHELINO DH: 2,0 Mm$^3$
MONCALIERI DH: 0,5 Mm$^3$
IRIDE DH STEP 0: 56,5 Mm$^3$

EXISTING OTHER DH: 5,0 Mm$^3$
NEW NORTH-EAST DH: 3,5 Mm$^3$
OTHER DH STEP 0: 8,5 Mm$^3$

TOTAL DH SYSTEMS STEP 0: 65,0 Mm$^3$
## STEP 0 – GENERAL DATA

<table>
<thead>
<tr>
<th>SPACE HEATED</th>
<th>CITIZENS</th>
<th>NOMINAL THERMAL PEAK</th>
<th>THERMAL ENERGY</th>
<th>PIPELINES</th>
<th>HEAT EXCHANGER</th>
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<tr>
<td>Mm³</td>
<td>num</td>
<td>MW</td>
<td>GWh/y</td>
<td>km</td>
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<td><strong>EXISTING IRIDE DH</strong></td>
<td>39,0</td>
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<tr>
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<td>80</td>
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<td><strong>MONCALIERI DH</strong></td>
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<td>5.000</td>
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<tr>
<td><strong>IRIDE DH STEP 0</strong></td>
<td>56,5</td>
<td>575.000</td>
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<td><strong>EXISTING OTHER DH</strong></td>
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<td>30.000</td>
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<td><strong>NEW NORTH-EAST AREA DH</strong></td>
<td>3,5</td>
<td>20.000</td>
<td>87</td>
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<td>625.000</td>
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<td>2.675</td>
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IRIDE DH SYSTEM STEP 0 - DAILY THERMAL LOAD

THERMAL SEASON PEAK

THERMAL POWER [MW]

0 2 4 6 8 10 12 14 16 18 20 22

CHP
HOB
ACCUMULATORS DISCHARGE
ACCUMULATORS CHARGE
IRIDE DH STEP 0 - THERMAL ENERGY

- CHP 87%
- HOB 11%
- Accumulators 2%
DISTRIBUTION HEATING PLANNING: STEP 1

SPACE HEATED

IRIDE DH STEP 0: 56,5 Mm³
BORGO VITTORIA DH: 3,0 Mm³
VENARIA REALE DH: 1,2 Mm³
IRIDE DH STEP 1: 60,7 Mm³

OTHER DH STEP 0: 8,5 Mm³
NEW NORTH-WEST AREA: 4,3 Mm³
BEINASCO DH: 0,5 Mm³
OTHER DH STEP 1: 13,3 Mm³

TOTAL DH SYSTEMS STEP 1: 74,0 Mm³
## STEP 1 - GENERAL DATA

<table>
<thead>
<tr>
<th></th>
<th>SPACE HEATED</th>
<th>CITIZENS</th>
<th>NOMINAL THERMAL PEAK</th>
<th>THERMAL ENERGY</th>
<th>PIPELINES</th>
<th>HEAT EXCHANGER</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mm$^3$</td>
<td>num</td>
<td>MW</td>
<td>GWh/y</td>
<td>km</td>
<td>num</td>
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<td>5.100</td>
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<tr>
<td>BORGO VITTORIA DH</td>
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<td>30.000</td>
<td>72</td>
<td>120</td>
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<tr>
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<td>2.595</td>
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<td>18</td>
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<td>100</td>
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<tr>
<td>TOTAL DH STEP 1</td>
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<td>1.825</td>
<td>2.995</td>
<td>750</td>
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IRIDE DH STEP 1 - THERMAL ENERGY

- CHP 80%
- HOB 10%
- WTE 6%
- Accumulators 4%
DISTRIBUTE HEATING PLANNING: STEP 2

IRIDE DH STEP 1: 60,7 Mm³
NORTH-EAST TURIN DH: 10,0 Mm³
IRIDE DH STEP 2: 70,7 Mm³
OTHER DH STEP 1: 13,3 Mm³
TOTAL DH SYSTEMS STEP 2: 84,0 Mm³
## STEP 2 – GENERAL DATA

<table>
<thead>
<tr>
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<th>SPACE HEATED</th>
<th>CITIZENS</th>
<th>NOMINAL THERMAL PEAK</th>
<th>THERMAL ENERGY</th>
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<tr>
<td></td>
<td>Mm$^3$</td>
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<td>MW</td>
<td>GWh/y</td>
<td>km</td>
<td>num</td>
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<td>615.000</td>
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<td>2.595</td>
<td>570</td>
<td>5.950</td>
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<td>NORTH-EAST TURIN DH</td>
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<td>690</td>
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<td>400</td>
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<td>785.000</td>
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<td>3.415</td>
<td>870</td>
<td>9.940</td>
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IRIDE DH SYSTEM STEP 2 - THERMAL ENERGY

- CHP 80%
- WTE 6%
- Accumulators 4%
- HOB 10%
THE NEW FACE OF MONCALIERI CHP PLANT FOR TURIN DH
MONCALIERI CHP PLANT BEFORE REPOWERING

- an Hydraulic Unit ("HU") of 4,5 MWe;
- a traditional steam Thermoelectric Unit ("1° GT") of 35 MWe;
- a traditional steam CHP Unit ("2° GT") of 141 MWe (100 MWe + 200 MWt);
- a GT Unit ("TG") of 35 MWe + 70 MWt;
- a HOB Plant, as Integration and Reserve ("HOB") of 141 MWt;
- the DH system: pumps station, pressurization, expansion, demi water feeder system, filtration and conditioning system;
- auxiliary systems.

~ 215 MWe ~ 410 MWt
• an Hydraulic Unit ("HU") of 4.5 MWe;
• a traditional steam Thermoelectric Unit ("1° GT") of 35 MWe; **ELIMINATED**
• a CHP GTCC Unit ("RPW2° GT") of 395 MWe (345 MWe + 260 MWt); **REPOWERED**
• a GT Unit ("TG") of 35 MWe + 70 MWt; **ELIMINATED**
• a HOB Plant, as Integration and Reserve ("HOB") of 141 MWt;
• the DH system: pumps station, pressurization, expansion, demi water feeder system, filtration and conditioning system;
• auxiliary systems;
• a CHP GTCC Unit ("3° GT") of 383 MWe (322 MWe + 260 MWt). **NEW**

~ 780 MWe  ~ 660 MWt
GOALS

+ POWER

- POLLUTION

ELECTRIC HEAT (combined)

BETTER EFFICIENCY

Competitiveness &

BETTER USE OF PRIMARY SOURCES

Environment
Carefull
DEVELOPMENT

PARTICULAR CARE OF ARCHITECTURAL AND ACUSTIC IMPACT
COMBINED PRODUCTION = ELECTRIC POWER + HEAT

CHP GT COMBINED CYCLE (with 3 levels of pressure and REHEATER)

GT

HRSG

ST

DH
TRADITIONAL STEAM CYCLE
(with REHEATER and FEEDER WATER STEAM PREHEATER)

\[ \eta = 38 - 40 \% \]

GT UNIT (OPEN CYCLE)

\[ \eta = 33 - 39 \% \]

GTCC (with 3 levels of pressure and REHEATER)

\[ \eta = 57 - 58 \% \]

CHP GTCC (with 3 levels of pressure and REHEATER)

U.F.F. = 87 - 90 %

better use of primary sources

Less pollution and greenhouse gas emission
MONCALIERI POWER PLANT REPOWERING PROJECT

1st PHASE  FINISHED (MAY 2005)
New CHP GTCC (“3° GT”)

383 MWe (322 MWe + 260 MWt)

2nd PHASE  FINISHED (OCTOBER 2008)
Repowering of the CHP 2° GT as a CHP GTCC (“RPW 2° GT”)

395 MWe (345 MWe + 260 MWt)
The NEW CHP GTCC, installed in the Moncalieri CHP Power Plant, is made by the following main equipment:

1. a SIEMENS GT, fed only by natural gas;
2. an Ansaldo Caldaie HRSG, fed by the GT exhaust;
3. a SIEMENS ST, with a river condenser and a steam extraction for the district heating.

The performances of the new Unit are the following:

MAX Net Electric Power: 383 MW (without DH), 322 MW (with DH)

MAX HEAT available for DH: 260 MWt;

Efficiency in electric operation: 57 %;
Efficiency in combined operation: 88 %;

EMISSIONS: CO < 30 mg/Nm³, NOx < 50 mg/Nm³

(Ref. 15% of O₂ dry, between minimum load and 100%)
MAIN FEATURES:

MODEL: **SIEMENS V94 3A2, 260 MW** (ISO conditions), singleshaft;
Axial turbine with 4 STAGES (ceramic coating);
Axial compressor with 15 STAGES;
Double air filtration STAGES;
Hollow rotor made by disks interlocked via Hirth serrations fixed via one central tie bolt;
2 radial bearings at the ends (axial beering at compressor side);
Generator coupling at cold end drive;
Axial flow exhaust.

Annular combustion chamber, with **24 Dry-Low-Nox**, fed only by natural gas and protected by ceramic and metallic heat shields (ISO inlet turbine temperature **1,230 °C**);
Turbine blades internally cooled by air and externally protected by cooling air films and ceramic coatings.
GAS TURBINE

MAIN FEATURES:

Variable Inlet compressor Vanes (IGV) to control the air flow;

3 Combustion MODES:

- **DIFFUSION**, from 0 to 50 Hz;
- **PREMIX**, from 0% to 100% LOAD;
- **PYLOT**, from 0 Hz to 100% LOAD to stabilize the flame

Size of the GT building: **43 m x 38 m x H20/14 m**.
The building is provided with a 130 ton crane.

The **SIEMENS** GT generator **TLRI 115/52**, air cooled, has a nominal power of **280 MVA**.
V94.3A Econopac

- Speed: 3000 rpm
- Frequency: 50 Hz
- Net Power Output: 260 MW
- Net Efficiency: 39.0%
- Net Heat Rate: 9,231 kJ/kWh
- Exhaust Temperature: 585 °C
- Exhaust Flow: 665 kg/s

Start-Up Times
- to full speed: ~ 6 min.
- to full load: ~ 26 min.

NOx Emissions
- Natural Gas (dry): 25 ppm / 15 ppm at lower turbine inlet temperature
- Fuel Oil (dry): 73 ppm / 58 ppm lower turbine inlet temperature
- Fuel Oil (water): 42 ppm

Conditions for Performance Data
- ISO Ambient Temperature: 15 °C/59 °F
- ISO Barometric Pressure: 1.013 bar/14.7 psia
- ISO Relative Humidity: 60%
- Fuel: Natural Gas
- Inlet/Exhaust Pressure Losses: 9/10 mbar
- Injection of Water: No
**Main Features:**

Manufacturer: **ANSALDO CALDAIE**  
Type: **HORIZONTAL** with 3 levels of pressure, LP integrated deaerator and REHEATER  
**NATURAL CIRCULATION** evaporators  
HP (105 bar), IP (30 bar), LP (7.5 bar)  
2 feedwater pumps (2 x 100%)

**Steam by-pass for District Heating** in case of ST trip.  
**No GT exhaust by-pass**

Size of the HRSG building: **25 m x 21 m x H37 m**. The chimney is 60 mt high.
STEAM TURBINE

MAIN FEATURES:

MODEL: SIEMENS HMN, nominal power 138 MW, river condenser with extractions for DH
3 SECTIONS: HP (104 bar / 550 °C), IP (28 bar / 560 °C), LP (3 bar / 250 °C)
TURBINE BLADES designed via 3-dimensional flow optimization
OPPOSED HP/IP FLOWS, 2 LP OPPOSED FLOWS

2 STEAM EXTRACTIONS in IP section for DH (260 MWt)

Size of the ST building: 48 m x 25 m x H35,7 m.
The building is provided with a 150 ton crane.

The SIEMENS ST generator TLRI 100/36, air cooled, has a nominal power of 155 MVA.
Moncalieri
Longitudinal Section

STEAM TURBINE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Rated Capacity</td>
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<tr>
<td>Speed</td>
<td>50 s⁻¹</td>
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<tr>
<td>Steam Pressure</td>
<td>103.9 bar</td>
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<tr>
<td>Steam Temperature</td>
<td>550°C</td>
</tr>
<tr>
<td>Exhaust Pressure</td>
<td>0.038 bar</td>
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HP

IP

LP

H30-25

M30-25

N30-2x8m²
THE REPOERED CHP GTCC "2° GT"

The traditional steam cycle CHP 2°GT of the Moncalieri CHP Power Plant has been repowered as a CHP GTCC NEW CHP GTCC. This Unit is made by the following main equipment:

1. an Ansaldo Energia GT, fed only by natural gas;
2. an Ansaldo Caldaie HRSG, fed by the GT exhaust;
3. a ALSTOM ST, with a river condenser and a steam extraction for the district heating.

The old FRANCO TOSI boiler (420 ton/h) has been kept as reserve.

The performances of the repowered Unit are the following:

**MAX Net Electric Power:** 395 MW (without DH), 345 MW (with DH)  
**MAX HEAT available for DH:** 260 MWt;

- Efficiency in electric operation: 58 %;
- Efficiency in combined operation: 90 %;

**EMISSIONS:**  
CO < 30 mg/Nm$^3$  
NOx < 30 mg/Nm$^3$  
(Ref. 15% of O$_2$ dry, between minimum load and 100%)
MAIN DIFFERENCES RPW2°GT - 3° GT

GT MODEL V94.3A4 instead V94.3A2:
- + 8% ELECTRIC POWER with the same efficiency
- AXIAL CLEARENCES hydraulic recovery AT COMPRESSOR SIDE BEARING
- HYDRAULIC IGV rather than electric
DE-ICEING SYSTEM with DH water / air heat exchanger

LOW NOx EMISSIONS: 30 mg/Nm³ rather than 50 mg/Nm³

HRSG designed for SCR (NOx)

CHANGES TO THE existing ALSTOM STEAM TURBINE:
NEW AIR cooled generator rather than HYDROGEN cooled old generator
NEW PIPES for the CONDENSER
NEW ST ACUSTIC ENCLOSURE
1 NEW 3-phases TRANSFORMER rather than 3 single-phase TRANSFORMERS
NEW 15,75 kV DUCT without UNIT BREAKER
NEW DH HEAT EXCHANGER (260 MWt rather than 200 MWt)
NEW MONCALIERI AIR COOLER

binding: MAX $\Delta T$ 3 °C of the river water

goal = INCREASE the availability of the 2 GTCC Units in SUMMER

MAX thermal power exchanged **340 MWt**

DH water inlet temperature 110 °C
DH water outlet temperature 70 °C
Ambient temperature 30 °C
MORE ELECTRIC PRODUCTION

### Electric energy production

<table>
<thead>
<tr>
<th>Year</th>
<th>Gruppo Idraul.</th>
<th>1° GT</th>
<th>2° GT</th>
<th>RPW2°GT</th>
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</thead>
<tbody>
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<td>2004</td>
<td>1721.4</td>
<td>20.0</td>
<td></td>
<td></td>
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<tr>
<td>2005</td>
<td>1793.4</td>
<td>635.8</td>
<td></td>
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<tr>
<td>2006</td>
<td>569.4</td>
<td>234.7</td>
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<tr>
<td>2007</td>
<td>470.4</td>
<td>1877.7</td>
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<tr>
<td>2008</td>
<td>163.4</td>
<td>629.0</td>
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MORE HEAT

DH thermal energy production

GWh

2004 2005 2006 2007 2008

2° GT 3° GT RPW 2° GT

Cald. int e ris.

FIRST RESULTS

3° GT

RPW 2° GT
**FIRST RESULTS**

**BETTER EFFICIENCY**

<table>
<thead>
<tr>
<th>Year</th>
<th>Specific Fuel Consumption (kcal/kWh)</th>
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<td>1567</td>
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<tr>
<td>2005</td>
<td>1431</td>
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<tr>
<td>2006</td>
<td>1325</td>
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<td>2007</td>
<td>1256</td>
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<tr>
<td>2008</td>
<td>1199</td>
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**Graph:**

- 3° GT
- RP2°GT

Specific fuel consumption cogeneration units
LESS POLLUTION

**Specific atmospheric pollutions: NOx**

<table>
<thead>
<tr>
<th>Year</th>
<th>RPW 2° GT</th>
<th>3° GT</th>
<th>2° GT</th>
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<tbody>
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<td>2005</td>
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</tr>
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<td>2006</td>
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<td>0.11</td>
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</tr>
<tr>
<td>2007</td>
<td>0.11</td>
<td>0.29</td>
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</tr>
<tr>
<td>2008</td>
<td>0.10</td>
<td>0.11</td>
<td>0.25</td>
</tr>
</tbody>
</table>
FIRST RESULTS

LESS POLLUTION

Specific atmospheric pollutions: CO

<table>
<thead>
<tr>
<th>Year</th>
<th>3° GT</th>
<th>RPW 2° GT</th>
<th>2° GT</th>
</tr>
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<tbody>
<tr>
<td>2004</td>
<td>0.03</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>2005</td>
<td>0.05</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>2006</td>
<td>0.04</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>2007</td>
<td>0.03</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>2008</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>
TORINO NORD POWER PLANT

- ST
- GT
- HRSG
- ACC
- HOB
- Accumulators
- Aux. Systems
### TORINO NORD POWER PLANT – TECHNICAL DATA

#### CCGT

<table>
<thead>
<tr>
<th></th>
<th>Electric mode</th>
<th>Combined mode</th>
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</thead>
<tbody>
<tr>
<td>ELECTRIC POWER</td>
<td>390 MW</td>
<td>340 MW</td>
</tr>
<tr>
<td>HEAT</td>
<td>0 MW</td>
<td>220 MW</td>
</tr>
<tr>
<td>EFFICIENCY</td>
<td>56 %</td>
<td>87 %</td>
</tr>
<tr>
<td>FUEL</td>
<td></td>
<td>NATURAL GAS</td>
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</table>

#### HEAT ONLY BOILERS

<table>
<thead>
<tr>
<th></th>
<th>Thermal mode</th>
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</thead>
<tbody>
<tr>
<td>HEAT</td>
<td>340 MW</td>
</tr>
<tr>
<td>EFFICIENCY</td>
<td>92 %</td>
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<tr>
<td>FUEL</td>
<td>NATURAL GAS</td>
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</table>

#### HEAT STORAGE SYSTEM

<table>
<thead>
<tr>
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<th>Thermal mode</th>
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</thead>
<tbody>
<tr>
<td>WATER SPACE</td>
<td>5.000 m³</td>
</tr>
<tr>
<td>HEAT AT PEAK</td>
<td>150 MW</td>
</tr>
</tbody>
</table>
- Energy saving 100,000 tep/year
- Emissions avoided of CO$_2$ 300,000 t/year
- Emissions avoided of NO$_x$ 134 t/year
- Emissions avoided of SO$_2$ 400 t/year

Decommissioning “Le Vallette” Power Plant
Thank you for your attention!