Inside Tractebel 2014

São Paulo – July 28, 2014

Questions and answers for the talk show on the subject of "*Operation and Maintenance of Thermoelectric Power Plants under High Demand Conditions*".

1. *What has been the response of Tractebel Energia's thermoelectric plants under the intense and continuous operating conditions prevailing since the end of 2012?*

In 2013, the following conditions were experienced:

- the most intense period of generation in the history of the Jorge Lacerda A Thermoelectric Power Plant (UTLA) - in operation for 48 years;
- the second most intense period of generation in the history of the Jorge Lacerda B Thermoelectric Power Plant (UTLB), the first being in 2012. This plant has been in operation for 34 years;
- the most intense period of generation in the history of the Jorge Lacerda C Thermoelectric Power Plant (UTLC) - in operation for 16 years.

In 2012, the Charqueadas Thermoelectric Power Plant (UTCH) reached its nominal capacity (72 MW) during mandatory tests under National Electric Energy Agency's (Aneel) Resolution 420/2010 for validating the installed and net capacity. As of that year, the plant had been in operation for 50 years.

In the first half of 2014, the William Arjona Thermoelectric Power Plant (UTWA) registered an all-time record in terms of generation. This plant has been in operation for 15 years.

In recent years, the following unit overhauls were undertaken:

- Year 2013:

Maintenance executed: Lages Cogeneration Plant (UCLA) – Short Term Shutdown (PCD) 15 days, Ibitiúva Energética Thermoelectric Power Plant (UTIB) – offseason overhaul, UTLA U#2 – PCD 23 days, UTLA U#4 – PCD 25 days, UTLB U#5 – PCD 30 days, UTLB U#6 – PCD 28 days.

- Year 2014:

Maintenance executed: UTIB – offseason overhaul, UTLB U#5 – PCD 18 days, UTLB U#6 – PCD 13 days, UTLC – PCD 27 days;

Scheduled maintenance: UTLA U#3 – General Overhaul 60 days, UCLA – PCD 15 days, UTCH D3/CD3 – 60 days, UTCH CD4 – PCD 15 days, UTCH CF1 – 30 days.

2. *How does Tractebel Energia endeavor to maximize its generation and uptime?*

We adopt a preventive and predictive maintenance plan and have an operational and maintenance team with the appropriate professional training and knowledge of the generator units. Tractebel Energia closely monitors the operational performance of the main equipment comprising the units, scheduling the maintenance of these in the periods when the demand for thermal generation is low such that these same units are in perfect operational conditions when they are deployed.

In addition, the Company is constantly evaluating the acquisition of replacement parts of the equipment as well as components which are critical to the installation so plant operations can be rapidly reestablished following damage or a fault in equipment (transformers, boiler piping, roller crushers, turbine and generator parts and components, etc.).

Tractebel Energia has a further advantage in that all its plants are certified in their Operational and Maintenance processes under NBR ISO 9001 (product quality), NBR ISO 14001 (environmental) and OHSAS 18001 (occupational safety) standards. In addition, we are in the process of obtaining NBR ISO 50001 standard certification (energy efficiency) for the coal-fired thermoelectric plants.

3. *What are the principal and the most frequent problems that occur in a thermoelectric plant?*

Natural gas-fired thermoelectric plants: if the scheduled maintenance programs are executed appropriately, there are practically no operational problems, thus ensuring that uptime for these plants is extremely high.

Biomass-fired thermoelectric plants (wood chips, saw dust, sugarcane bagasse): low occurrence of problems, resulting in a high level of uptime. Eventual problems that may arise are normally related to fuel quality.

Coal-fired thermoelectric plants: since domestic mineral coal used in our thermoelectric power plants contains a high ash content (ranging from 43% in the Jorge Lacerda Thermoelectric Power Plant (CTJL) and 56% in UTCH), the internal components of the boiler (piping) are subject to accentuated mechanical wear due to the abrasive effect of ash existing in the flow of gases emanating from the burning of coal. This process corrodes the surface of the piping in certain parts of the boiler, thus reducing the thickness of the piping and leading to eventual perforations in the boiler and rendering the unit inoperable. Due to environmental issues, problems in the electrostatic precipitators (filters that retain the fly ash released from the chimney) may also reduce generation or cause a shutdown of the unit so that emissions do not surpass the parameters permitted under the environmental legislation.

4. *What are the principal differences between scheduled and unscheduled maintenance? What is the definition of scheduled maintenance?*

Scheduled maintenance: is related to the unit maintenance plan. In other words, each item of equipment of the unit has its own maintenance plan (preventive or predictive) and maintenance is undertaken in accordance with periodicity and/or the number of hours of operation established in the maintenance plan. The maintenance plan provides a schedule of events of what must be done and when.

Unscheduled maintenance: is related to untimely events, that is unexpected faults in equipment. Being untimely, clearly there is no way in which they can be predicted. Based on its long experience of thermoelectric generation units, Tractebel Energia acts preventively to mitigate the occurrence of this type of event and thus increase generator unit uptime.

5. *How long does a scheduled shutdown last? How many people are involved? Are maintenance crews sent from overseas for the purpose?*

The principal scheduled stoppages are for undertaking unit overhauls.

Natural gas-fired thermoelectric power plants: In accordance with manufacturers' instructions, gas-fired generation units undergo three kinds of unit overhaul, which are directly related to the number of hours of operation. Each overhaul involves approximately from 40 to 50 people, between 10 and 15 of them from Tractebel Energia and the remainder from outsourced maintenance contractors. Overseas consultants are used in special situations only and are normally recommended by the turbine manufacturer.

- CCI (combustion chamber inspection) -type overhaul: undertaken for every 8,000 hours of operation with the maintenance process being executed in 8 days;

- HGPI (hot gas path inspection) -type overhaul: undertaken every 24,000 hours of operation and with the maintenance process being executed in 20 days;

- MI (major inspection) -type overhaul: takes place every 48,000 hours of operations with the maintenance process executed in 30 days;

Biomass- and coal-fired thermoelectric plants (wood working waste and sugarcane bagasse): in the case of the biomass-fired plants, maintenance involves between approximately 80 to 100 people, of which from 10 to 20 from Tractebel Energia and the remainder from contracted maintenance companies.

In the case of the coal-fired thermoelectric plants, maintenance involves between 500 and 600 people, of which 80 to 100 from Tractebel Energia and the remainder from contracted maintenance companies. In special situations, foreign specialists are hired, normally representing the manufacturers of the principal items of equipment (turbine, generator and boiler).

There are basically three types of unit overhaul:

- short duration shutdowns: conducted annually and involving a maintenance period of between 15 and 21 days;
- partial unit overhaul: every 20,000 hours of operation (3 to 4 years) involving a maintenance period of 45 to 60 days;
- general overhaul: every 60,000 hours of operation (6 to 8 years) involving a maintenance period of 75 to 90 days.

6. *How does Tractebel Energia guarantee the execution of scheduled maintenance if this has to be either anticipated or postponed?*

Details of the overhauls, their respective periods for execution and principal scope of the services involved are all set out in the Multi-Annual Unit Overhaul Program. Based on this data, the Company puts the work out to tender in order to choose the companies providing the services for each one of the principal activities. Should there be a need to anticipate or postpone the unit overhauls, Tractebel Energia is required to provide notice at least three weeks prior to the beginning of maintenance so that the contracted companies have sufficient time to mobilize or demobilize manpower.

7. *How far does a thermoelectric plant have the flexibility to postpone a shutdown? Is it true that insurance companies do not cover claims for events after the final date established for a given scheduled stoppage? Which equipment is most susceptible to claims for damage/faults?*

Executed annually at the main thermoelectric plants, the focus of Short Duration Shutdowns (PCD) is on equipment which causes the greatest unit downtime. Thanks to this maintenance, equipment of this nature is maintained in the best possible operational condition, thus permitting greater flexibility in postponing shutdowns.

Tractebel Energia endeavors to adhere to the maintenance plan established by the manufacturers with small variations in date, more or less as a function of the conditions prevailing in the National Interconnected System (SIN) and subject to authorization from the National Electric System Operator (ONS) for shutting down a unit for maintenance. Factors such as the time involved for acquisition/release of equipment/imported materials, prioritization of large scale units (with a significant impact on the SIN) when maintenance periods coincide with others of a less significant scale, can also interfere in scheduled stoppages. Out of the limited number of claims reported to the present time, the insurance companies have never created any obstacles in relation to variations in the eventual execution of maintenance plans.

As to cutoff dates for maintenance, restrictions are greatest when the equipment is still under guarantee, the latter subject to being declared invalid should maintenance not be executed in the period established by the manufacturer.

As a rule, the thermoelectric plant's turbo-alternator and the principal transformer are the items of equipment where damage can result in a claim against an insurance policy given that the unit costs involved normally exceed the deductible. While the boiler as a whole is the largest piece of equipment of a thermoelectric plant, it is made up of a series of smaller component parts, the unit value for repair of which is normally smaller than the policy's deductible rendering any claim uneconomic. Figures 1, 2 and 3, below, show a turbo-alternator, a principal transformer and a boiler, respectively.



Figure 1: Turbo-alternator.



Figure 2: Principal transformer.



Figure 3: Boiler.

The probability of an occurrence of a major fault in the boilers is reduced thanks to a control and protection system. In all the CTJL units, there are cameras to monitor the furnace and flame sensors installed at UTLB and UTLC, equipment showed below in the figures 4 and 5, respectively.



Figure 4: Camera to monitor the furnace.



Figure 5: Flame sensors.

Normally, insurance company requirements in the case of principal transformers are focused on the installed equipment monitoring system, temperature measurements, the analysis of the gases generated from the oil and refrigeration system etc. There is no specific limitation on the number of hours of operation after which the policy becomes

inoperative. In the event of a claim, the insurers request a statement of all operational conditions and a maintenance record of the equipment. It is then that the amounts measured from electrical trials, insulation oil tests and tendencies identified from monitoring are critical for demonstrating the conditions of the equipment.

The operating risk policy does not provide for a specific maintenance schedule but rather requires that maintenance be conducted in accordance with the schedule established by the equipment manufacturers.

Tractebel Energia's maintenance program is designed to optimize the Company's resources and to adhere to the recommendations of the equipment manufacturers, in this way guaranteeing the full coverage of the contracted risks in the insurance policies.

8. *How does Tractebel Energia act in the event of an unscheduled shutdown? What is done to minimize the events of such an unwanted stoppage?*

The maintenance crews act promptly to repair the equipment which has failed with a view to the speedy reestablishment of the unit in a secure manner. In parallel, the operating and maintenance teams check the work orders which were awaiting the next scheduled shutdown of the unit and use the unscheduled stoppage to execute these maintenance services. In conjunction with maintenance engineering, the maintenance crews analyze the principal occurrences to determine the root cause of the events. Preventative measures are then adopted in accordance with the best practices of international benchmark entities such as for example the United States' Electric Power Research Institute (EPRI).

Coincidentally, we are currently repairing two machine defects: the breakage of the blades in a 50 MW turbine (UTLA 1), illustrated in the Figure 6, and a short circuit in a 131 MW generator (UTLB 6), which image is showed in the Figure 7. UTLA 1 is expected to resume operations before the end of August while UTLB 6 is expected to be back on stream in the fourth trimester of 2014.



Figure 6: Breakage of the blades in UTLA 1.

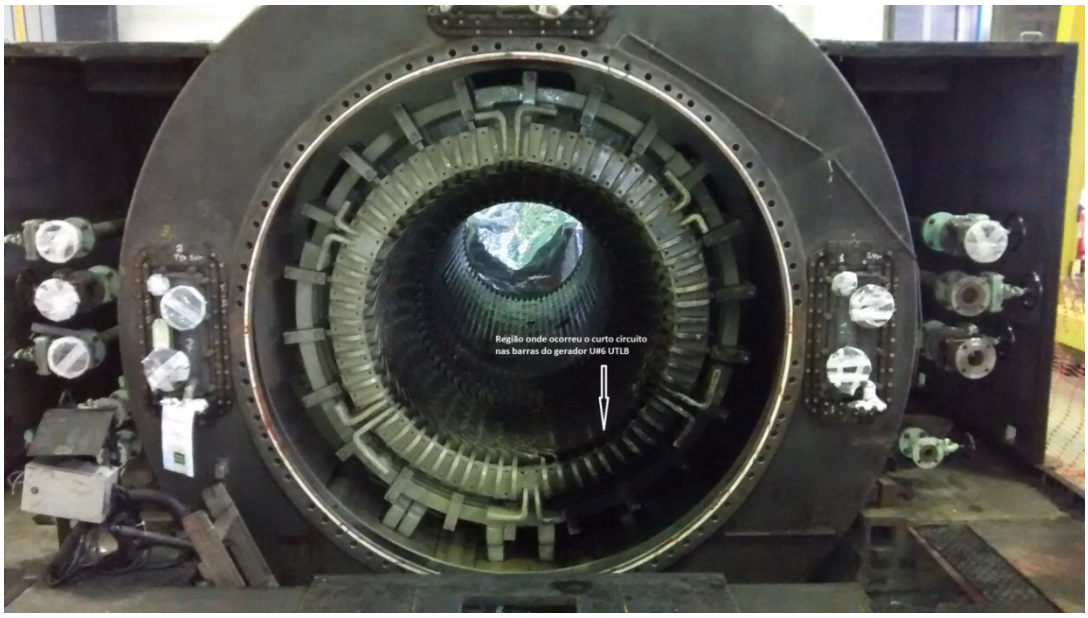


Figure 7: Short circuit in the bar of generator, in UTLB 6.

Unfortunately, defects occur in spite of good maintenance plans. We are also able to learn from these untimely events which serve as a means for improving our maintenance planning and equipment inspection. However, over the long term even with the occurrence of such events, our uptime ratios show that we surpass the average for the market as a whole.

9. *With respect to benchmarking, how does the performance of Tractebel Energia's performance compare with the plants elsewhere in the world?*

The Jorge Lacerda Thermoelectric Complex (UTLA, UTLB and UTLC) has seen a high level of deployment since July 2012 and prospects are that this situation will persist until next year. The current capacity factor (CF) is 34% above the statistical average for the CTJL (2008 to 2012) and 25% more than the average for the North American Electric Reliability Corporation (NERC) for coal-fired plants with the same installed capacity range.

The following graph (Figure 8) compares the capacity factor (CF) of the CTJL and the average for the North American market monitored by the NERC.

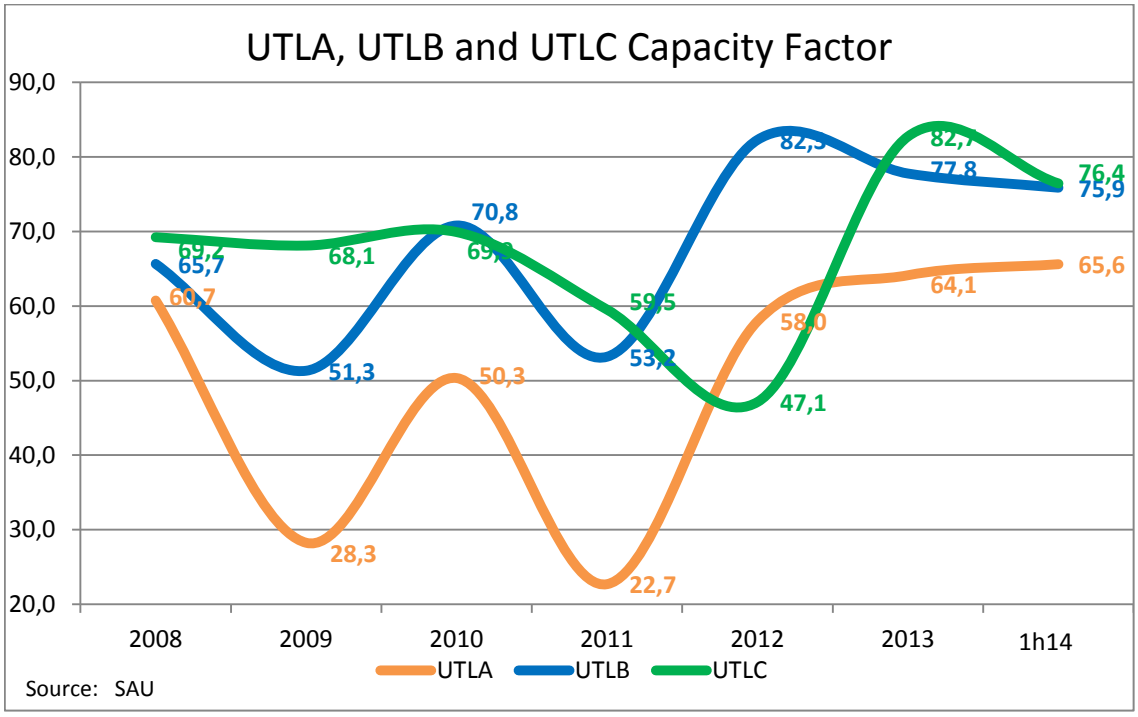


Figure 8: CTJL plants' capacity factor (CF) between 2008 and June 2014.

The fault average in Tractebel Energia's thermoelectric plants due to forced stoppages in the boilers is 3.6 faults/boiler/year. This amount is within the Electric Utility Cost Group's (EUCG) range of forced stoppages due to faults in boiler piping for a sample of 219 coal-fired thermoelectric generator units in the USA. The following graph (Figure 9) shows Tractebel Energia with a better performance.

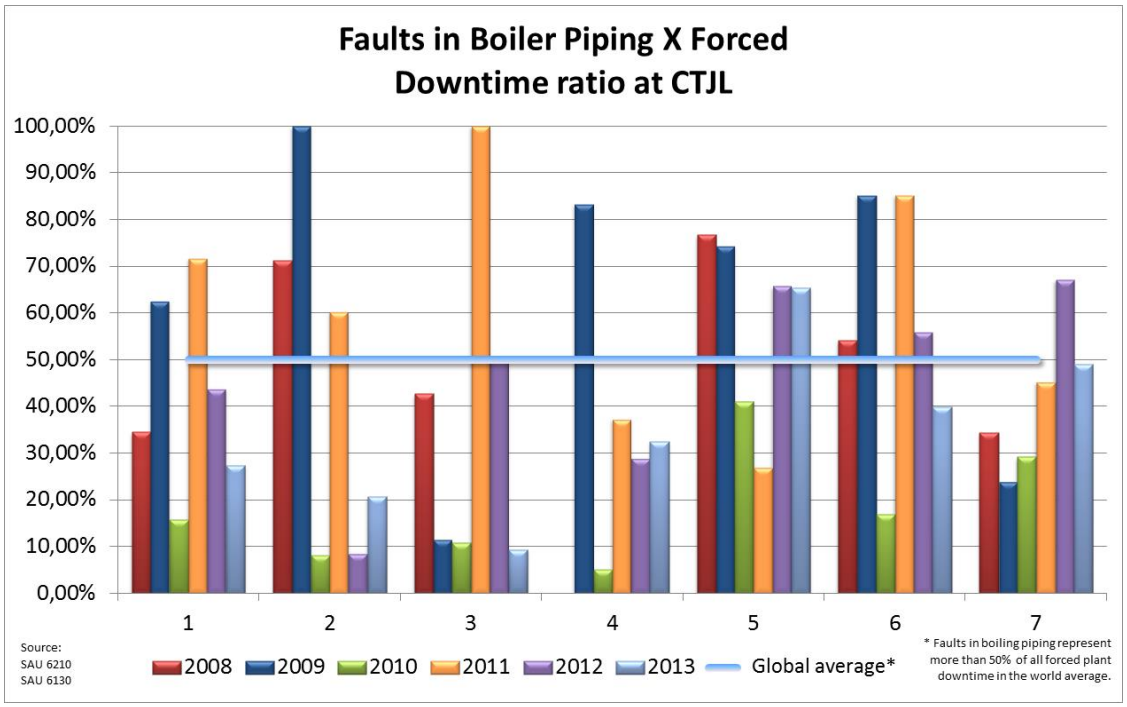


Figure 9: Relation between uptime loss due to boiler faults and the total loss of uptime in thermoelectric plants. The world average is greater than 50% while in the case of Tractebel Energia, it is less.

Among the thermolectrics considered a world benchmark, outstanding is the Unit 1 of the Maasvlakte plant in the Netherlands. This established a world record by operating for 13,000 hours without a defect in boiler piping. Unit 1 of the Maasvlakte plant deserved a mention in the Guinness Book of Records (October 1997 edition) for reaching this level of uninterrupted commercial operations over a protracted period. (Source: *Power Gen 98*, Milan – Italy)

Two notable examples have been reported at CTJL: Unit 4 of the UTLA, which in 2009 recorded 672 days (9,363 hours in operation) without boiler piping faults, and UTLC (Unit 7), which in the period from January to December 2009, was classified as “World Class” based on the Assessment of Utility’s Boiler Tube Failure Reduction Program of the Electric Power Research Institute (ERPI), registering a forced downtime (FD) per boiler fault of less than 0.5% (a single fault in 2009). Figure 10, below, illustrates typical damage in the boiler pipes.

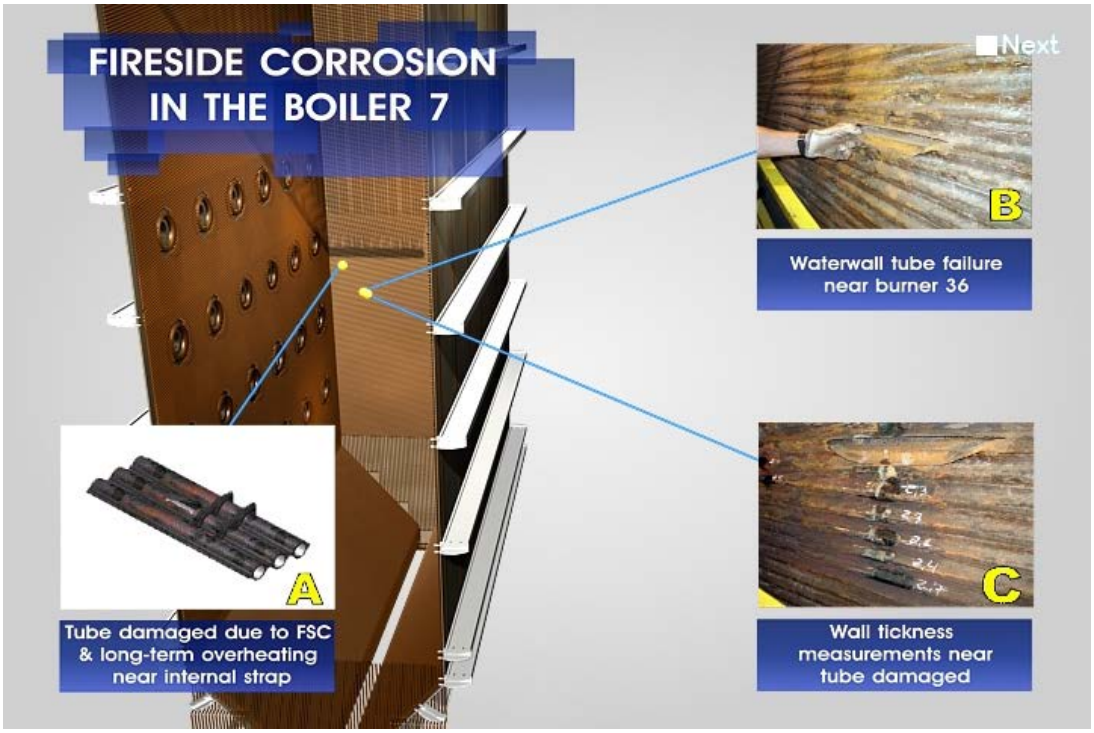


Figure 10: Typical damages in the boiler pipes.

The EPRI criteria for the FD indicator are adopted: less than 2% of loss of uptime due to boiler faults is considered a "goal'". Should the FD exceed 3%, then the ERPI recommends that mitigating actions be taken to reduce this ratio. Benchmarks are considered as anything less than 0.5%. Figure 11, as follows, shows the performance of the CTJL units in this respect.

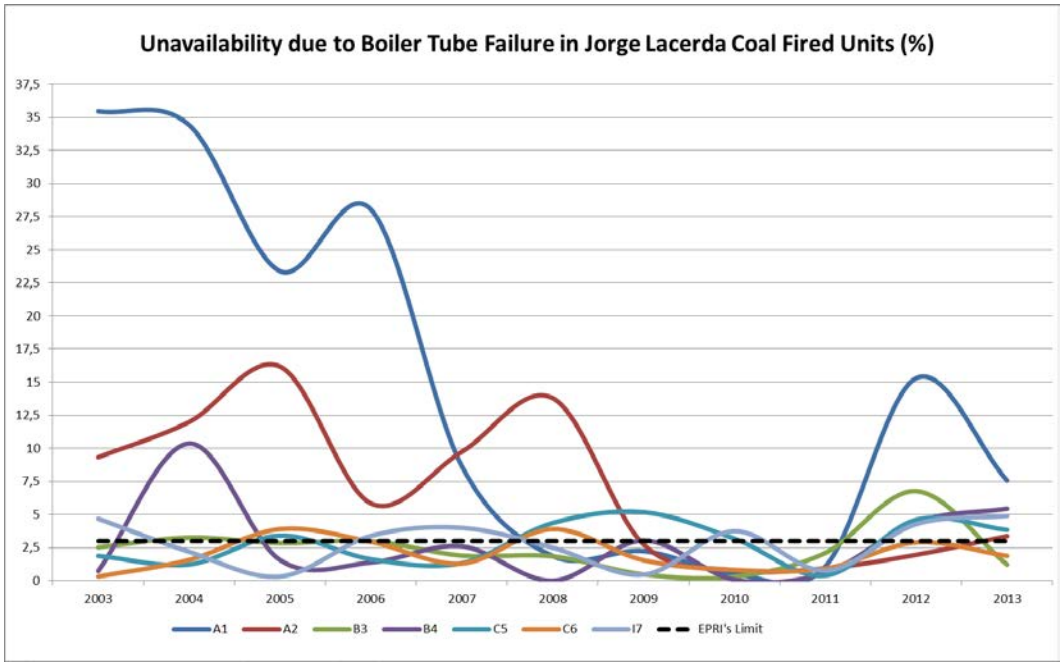


Figure 11: Reduction in downtime at Tractebel Energia's generator units due to boiler corrosion.

10. Still on the subject of benchmarking, how does the performance of Tractebel Energia's thermoelectric power plants compare with the Brazilian electric sector as a whole?

According to the statistics of the Equipment Performance Commission (CDE) of the Brazilian Electric Energy Generator Companies (Abrage), in 2012, Tractebel Energia's thermal generator units posted a higher total uptime than the other thermoelectric power plants in Brazil (see Figure 12 below). In 2013, the average uptime for Tractebel Energia's thermal plants was 90.72%, while the national average was 85.94%.

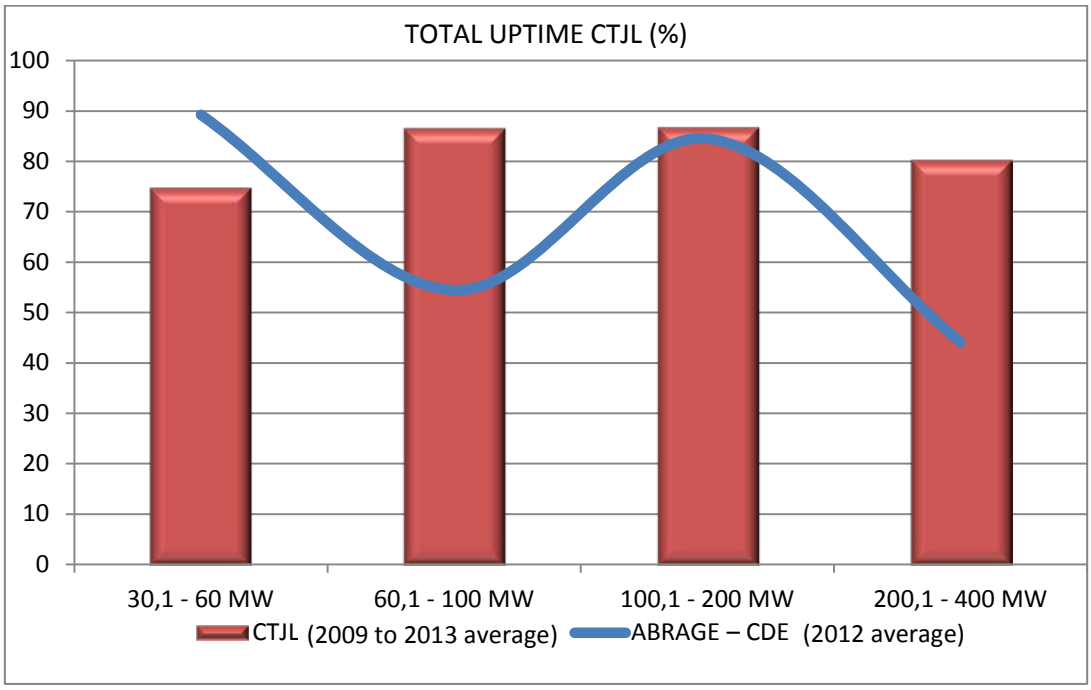


Figure 12: Comparison between the uptime of Tractebel Energia's coal-fired plants and the average for the domestic market by installed capacity range according to Abrage (2012).