

ISO 50001 Energy Management System Case Study

2021

Argentina

YPF LUZ

*Reliable and sustainable power generation
that optimizes natural resources*



Organization Profile & Business Case

YPF Energía Eléctrica S.A. (YPF Luz) is a leading Argentine power generation company, dedicated to the electric power generation since 2013, from conventional (thermal) and renewable sources. Our mission is to be a profitable, efficient and sustainable power company, focused on optimizing natural resources and contributing to the energy development of Argentina. Our vision is to become one of the leading companies in the power generation sector, a leader in renewable energy, operating with world-class technology, efficiency and quality standards.

Today YPF Luz operates 10 thermal plants and 2 wind farms, with a total installed capacity of 2,360 MW. It is finalizing the construction of an additional wind farm of 123 MW of installed capacity, scheduled to begin operations in 2021.

In line with its mission and values, YPF Luz has established a Quality, Environmental, Health and Safety (QEHS) Policy and an Operational Excellence Policy. These policies are implemented through the QEHS and

El Bracho Snapshot

Industry	Power generation
Product/Service	Power
Location	Argentina
Energy management system	ISO 50001
Energy performance improvement period, in years	2 years (July 2019-July 2021)
Energy Performance Improvement (%) over improvement period	16.9%
Total energy cost savings over improvement period	\$USD 15.22 M
Cost to implement EnMS	\$USD 300M
Total Energy Savings over improvement period	3,349,513.22 GJ
Total CO ₂ -e emission reduction over improvement period	207,575,288,629 Metric tons

Sustainability Committees, which set as an objective the implementation of the Energy Management System (EnMS) under ISO 50001 at all company facilities. At the moment, YPF Luz has certified ISO 50001 for six thermal power plants located in three sites:

- The Loma Campana Complex, in Neuquén Province, operates three power plants of 229 MW under a single Energy Management System.
- La Plata Cogeneración (LPC), in Buenos Aires Province, has an installed capacity of 218 MW and produces 400 tons of steam per hour. It is located within La Plata Industrial Complex (CILP), owned by YPF.
- The Tucumán Power Generation Complex (CGT), in Tucumán Province, with a total installed capacity of 1,302 MW. It consists of 3 combined cycles: El Bracho

(CTEB) of 473 MW, San Miguel de Tucumán (CTSMT) of 382MW and Tucumán (CTT) of 447 MW.

This case will review the implementation of the Energy Management System (EnMS) at CTEB, from July 2019 to July 2021, demonstrating the benefits of the ISO 50001 certification. It details the transition of the operation of CTEB as an open cycle gas plant (CTEB-OC) in July 2019, to the final configuration as a combined cycle power plant (CTEB-CC) in October 2020, which required the addition of a facility to extract heat from the exhaust gases of the gas turbine by means of a heat recovery steam generator that generates steam to produce more energy, thus making a more efficient use of the natural resources as fuel and air. At CTEB, as in other thermal power plants, ISO 50001 is a key tool to optimize the use of the natural gas, which is the main input in the production of our final product: electrical power.

“The energy management principles helped us realize that the investment in a combined cycle would offset natural gas usage in 5 years, an important contribution to the sustainability.”

—Martín Mandarano, CEO of YPF luz

Business Benefits

The implementation of the Energy Management System (EnMS) with ISO 50,001 standards at El Bracho Thermal Power Plant (CTEB) resulted in a 36.3% improvement in energy performance in 2020 [GJ/kWh], compared to the plant's initial efficiency. The power generated after the technological change of CTEB led to savings in the gas consumption of the Argentine electricity market. CTEB's Heat Rate of 1,537 kcal/kWh is now 16.9% better than the market average¹ of 1.851 kcal/kWh, achieving an natural gas saving of 95810.48 kNm³ equivalent to 3,349,513.22 GJ not consumed, which represents an energy cost saving of \$USD 15,228,505 and a reduction of 207,575,288,629 metric tons of CO₂ eq. emissions.

CTEB was conceived in 2016 as an open-cycle thermoelectric power plant, that is, with a natural gas turbine, which began operations in 2018. In line with the mission and values of YPF Luz, the company implemented from the outset an EnMS to improve the plant's operational efficiency. It became clear that one of the many benefits from the conversion of CTEB to a combined cycle plant would result be higher energy efficiency in terms of use of natural gas, and a reduction in emissions.

The project consisted in the addition of a steam cycle to CTEB, which improved the plant's performance (heat rate) from 38% when the open cycle gas turbine would release heat to the atmosphere, to approximately 57% (depending on atmospheric conditions), with the installation of a Heat Recovery Steam Generator ("HRSG") to capture a major part of the heat of the exhaust gases of the gas turbine to produce steam and use it to generate more electrical energy in a steam turbine, achieving one of the highest efficiencies in the global electricity market as a "Combined cycle" plant.

The combined cycle plant improved efficiency, allowing to produce each MWh of energy with 36.31% less natural gas. The source of this recovery is the heat capture from the exhaust gases that reduces their temperature from 590°C to 78°C, thus allowing to use this heat to produce steam and more energy with a steam turbine.

This represents a better use of atmospheric air. The gas turbine as an open cycle plant consumes 620 kg/s of filtered air to generate 268MW, equivalent to 8,328 kg/MWh. As a combined cycle power plant, it uses 4,862 kg/MWh, reducing 58.4% the use of air per MWh.

Plan

Since Complejo Generación Tucumán (CGT) had already certified ISO 9001, 14001 and 45001, management realized that ISO 50001 could be successfully incorporated into its Integrated Management System

¹ Wholesale Electricity Market (MEM), CAMMESA, 2020

allowing significant opportunities for improvement in energy use aligned with the company's mission.

ISO 50001 was an advantage because the construction of the CTEB combined cycle was carried out with bank financing which included periodic audits to demonstrate the degree of compliance with works progress and environmental and safety issues, following IFC and ISO Standards.

Within this framework, CGT formed an Energy Management Committee (EMC) with representatives of each area of the complex, led by the Regional Operations Manager. The EMC was trained and advised by a specialized consultant and focused on the improvement of energy management starting in January 2018.

Firstly, the EMC determined all energy sources used in the power generation process, quantified them and defined their uses. The EMC then determined which variables needed to be monitored, since what is not measured is not quantified, and what is not quantified cannot be improved.

After numerous meetings, the EMC defined two criteria for the determination of Significant Energy Uses (SEUs):

1. Any use or consumption that represents more than 80% of the total energy consumed.
2. Any use or consumption with potential savings to improve energy performance.

Based on these criteria, the EMC defined three SEUs for CTEB:

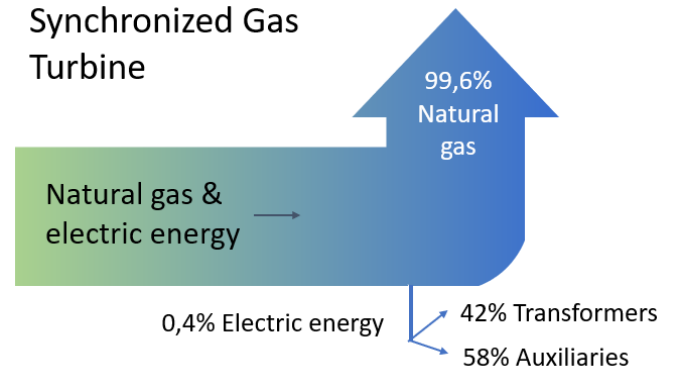
1. Energy for power generation
2. Energy for startup
3. Electrical energy in auxiliary services

The EMC identified that a very important SEU for the power plant was natural gas consumption when the gas turbine was in service (generating electrical energy) and recommended to focus efforts in this area.

When analyzing the investment of installing a HRSG to increase power sale as an expansion of the business, we noted how positive it would be in terms of energy efficiency based on Sankey's diagram. The most consistent opportunity with our EnMS consisted in making a more efficient use of natural gas, which shows

that one of the many beneficial outcomes of the

Synchronized Gas Turbine



CTEB Gas Turbine Sankey Diagram - Analysis for March- August 2018

combined cycle project is a much better use of air and natural gas per MWh produced. Additionally, since the Argentine market prioritizes efficient generation, the HRSG would also increase the total energy sold.

The Heat Rate is the indicator that evidences this improvement, which relates:

$$HR \left[\frac{kcal}{kWh} \right] = \frac{\text{natural gas consumption}}{\text{electric power generated}}$$

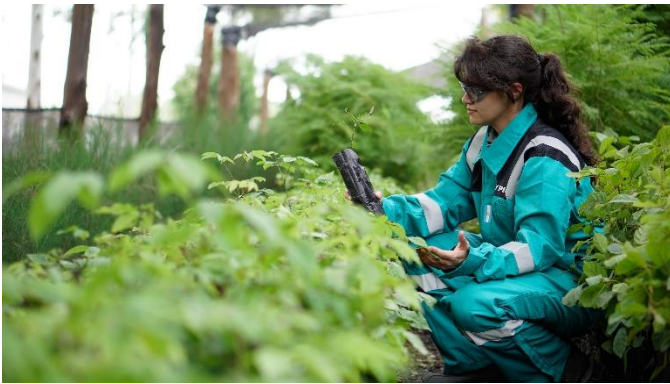
To track energy performance, in 2019 the EMC defined the following Energy Performance Indicators (EnPIs) and Energy Baseline (EnBs) for CTEB:

1. Energy Consumption (natural gas and electricity) during gas turbine startups
2. Electrical Energy Consumption in auxiliary services when the gas turbine is out of service
3. Energy Consumption (natural gas and electricity) and Power Generation, over time.

After the implementation of the combined cycle project (installation of a HRSG and steam turbine), there were significant changes in the operating configuration and profile of the plant. For this reason, in 2021, a new energy review defined the EnPIs and EnBs for the CTEB CC:

1. Energy Consumption (natural gas and electricity) during gas turbine starts
2. Heat Rate Operating Under Combined Cycle
3. Energy Consumption (natural gas and electricity) and Power Generation, over time

4. Compressor efficiency of the Gas Turbine



Greenhouse at CGT 1

Finally, in addition to the incorporation of a heat recovery facility for the use of exhaust gases from the combustion of the gas turbine, for CTEB, YPF Luz assumed a commitment with the Province of Tucumán to contribute to the capture of CO₂ through the plantation of 1,090,000 trees over a 10 year period.

Between July 2019 and July 2021, CGT produced 300,000 trees. Considering that a tree can capture an estimated average of 15 kg of CO₂ per year (the amount depends on tree type, age, soil type, irrigation, temperature, etc), YPF Luz has contributed with the capture of approximately 16.7 tnm³/day of CO₂ in this period (this is an estimation, not included in our CO₂ calculation).

Do, Check, Act



CGT Control Room

EnMS initial implementation

The implementation of an effective EnMS was achieved with the contribution of all areas to the EMC, communication and fluid interactions between the different areas of CGT.

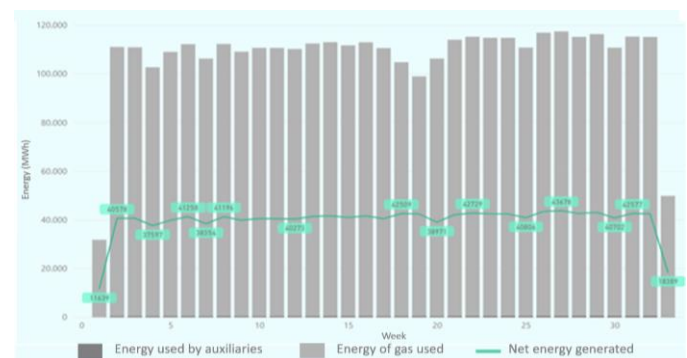
Recurring complexity surrounded two major themes:

1. Little historical data for the construction of energy baselines that could be used in the EnMS (baselines for a new thermoelectric plant in its open cycle).
2. Identification of potential improvements in a new open-cycle power plant using latest technology.

The first situation was partly countered with the instant digital data for CTEB available at the Control Room, although a validation and audit of this data was required. The second situation was addressed through the conversion of the power plant to a combined cycle plant.

The following additional activities to improve energy performance were implemented:

1. Automation of controls of auxiliary systems and processes impacting energy performance.
2. Maintenance plans of instruments/equipment associated with SEUs within SAP.
3. More detailed monitoring of compressor washing.
4. Energy performance evaluation of new services, products and equipment linked to the SEUs. YPF Luz invites bidders to inform energy improvement information, if available.
5. Implementation of PI System to collect and process data more efficiently on energy performance indicators.
6. The information available in our control room promoted a continuous training of our personnel.
7. Implementation of awareness signage at the plant
8. Continuous audits, both internal and external, to achieve the improvement of the EnMS



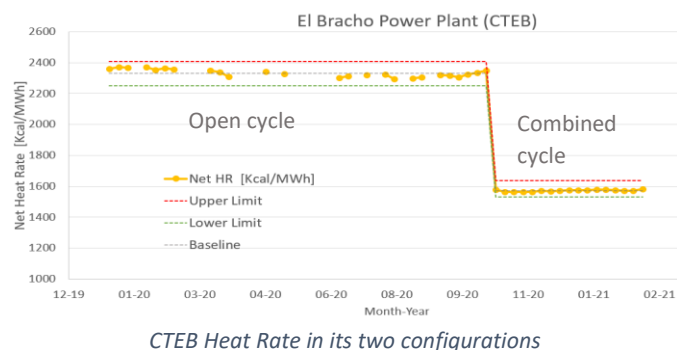
Energy Performance Monitoring with PI System

Heat Rate Tracking

The EMC is responsible for tracking defined EnPIs and EnBs. When a deviation outside the range of the statistical error bands of each of the defined Energy

Baselines is observed, it constitutes a non-conformity to the EnMS. These deviations are recorded and treated by the EMC, on a monthly basis, and compared against annual objectives. This allows to detect deviations and to take the appropriate corrective measures in the short term.

The improvement in CTEB's energy performance can be visualized in the EnBs associated with Heat Rate:



The graph shows that the specific consumption of CTEB improves in its OC vs CC configuration (1,537 kcal/kWh vs 2,414 Kcal/kWh, respectively, considering natural gas with a calorific value of 8,350 kcal/m³).

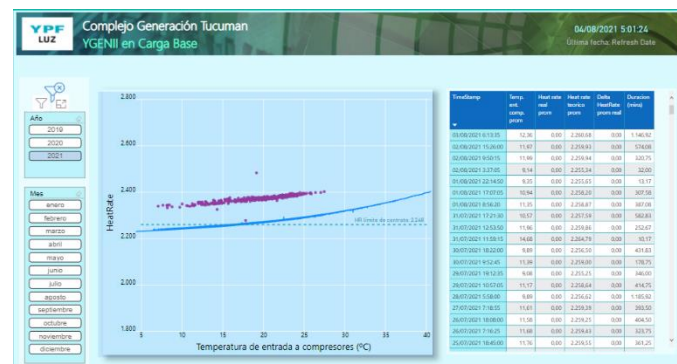
The net energy generated in the CC period was 2,552,126.75 MWh, if CTEB had continued to operate as an open cycle. CAMMESA, which is responsible for dispatch would have had to generate with plants that in 2020 had an average HR of 1,851 [kcal/kWh] to generate the same amount of electricity, instead of consuming 469,963.42 kNm³, it would have consumed 565,746.90 kNm³ (assuming that the dispatch requirement would have been the same).

This difference of 95,810.48 kNm³ (or its equivalent 800,017,488,167.09 Btu) not consumed, translates into an improvement in energy efficiency of:

$$\left[\frac{18,733,772,025,160.60 \text{ Btu} - 15,561,166,672,861.00 \text{ Btu}}{18,733,772,025,160.60 \text{ Btu}} \right] * 100 = 16.9\%$$

The construction of the CTEB CC required an investment of approx. USD 300 million, with the 800,017,488,167.09 Btu of natural gas saved (considering the updated price of natural gas from Bolivia at 4.8 [USD/millBtu] improve in USD 15,228,505 business benefits to pay de contract for de CTEB.

Additionally, as a control measure within the EnMS, we have continued the monitoring of the heat rate of the CTEB gas turbine (at base load):



Screenshot of Power BI with CTEB HR tracking at base load, 2021

Communication

To receive ideas, observations and/or proposals in relation to CGT's Energy Management, the EMC created an email to receive suggestions. The company also has a company-wide suggestions mail and inboxes to channel employee suggestions. All suggestions are evaluated by the EMC to assess the desirability of implementing them and are answered in the short term.

On the other hand, an important milestone for the EnMS was the assignment of the responsibilities of the EMC. *"It is the EMC's responsibility to play a role as a catalyst for the culture of Energy Performance in its areas of work and to promote and implement executively the action plans to improve our energy management"* said the from the North Region Operations Manager. The members of the EMC of CGT were empowered to carry out Energy Management trainings to the rest of the plant and the organization, functioning as leaders in their work sectors.

The success of ISO 50001 at CGT

In 2018, after three months of hard work, CTEB's OC was the first plant of its type to certify under ISO 50001:2011 its main electric power process in the argentine market. After completing the works of the CTEB CC in October 2020, in November of the same year it was certified under the ISO 50001:2018 standard.



EMC members, during an internal audit

The success of implementing ISO 50001 in CGT was due to the involvement of all staff, both internal and external, in the development and transition of the EnMS. At all times, emphasis was placed on awareness posters, internal talks by EMC members in each of their areas, reinforcing the impact of their activities on the indicators, and queries and proposals for improvement were always received and answered.

“The participation in the Energy Management Committee of representatives of all areas of the plant was key to promote a culture of energy improvement.”

—Marcelo Sobico, North Region Operations Manager

Transparency

After receiving the external audit and successfully passing it, all employees of the organization are informed of the news that the CTEB was the first YPF LUZ plant to implement ISO 50001.



EMC members, during an external audit

In 2019 the EMC was invited to participate in the Environment week organized by YPF SA at Y-TEC to share the success story of its EnMS Implementation. On that occasion, two EMC representatives presented to an audience the case of implementation and certification of ISO 50001 in the CTEB Open Cycle.

CTEB's ISO 50.001 certification was also published at our [corporate website](#) and [Linkedin page](#), and mentioned in YPF Luz's [2018](#) and [2019](#) Sustainability Reports. The company has included the certification information in financial reports since it is aware of the importance given by investors to sustainability issues.

What We Would Have Done Differently

The EnMS could be improved if it were contemplated at the conception of a project, which would make it possible to incorporate in the design more energy efficient equipment, according to the site where the work will be implemented: variable speed drives in pumps, analyze which cooling systems is most convenient for the project (forced vs. convectives) etc. The EMC has shared this opportunity to improve with the project development area of the company.

The Energy Management Leadership Awards is an international competition that recognizes leading organizations for sharing high-quality, replicable descriptions of their ISO 50001 implementation and certification experiences. The Clean Energy Ministerial (CEM) began offering these Awards in 2016. For more information, please visit www.cleanenergyministerial.org/EMAwards.