

Saudi Aramco’s Uthmaniyah Gas Plant

Ground breaking Energy Efficiency records followed by Saudi Aramco corporate recognition since the implementation of ISO 50001.



Figure 1: Uthmaniyah Gas Plant

Case Study Snapshot	
Industry	Oil and Gas
Product/Service	Multiple/Gas Processing
Location	~177 km southwest of Dhahran in the Eastern Province of Saudi Arabia
Energy performance improvement percentage (2020-2022)	13.11 % improvement in energy consumption compared to expectation. (Baseline 2020-2021)
Total energy cost savings (2020-2022)	USD 72,546,755
Cost to implement Energy Management System (EnMS)	USD 98,585
Total energy savings (2020-2022)	5,581,357 MWh
Total CO₂-e emission reduction (2020-2022)	948,397 Metric Tons

Organization Profile / Business Case

As one of the world’s largest integrated energy and chemicals companies, Saudi Aramco is playing an active role in building a lower carbon economy, while delivering the energy and materials needed to support the growth and societal well-being globally. Saudi Aramco supports the objectives set by the Paris Agreement, which aims to strengthen the global response to the threat of climate change. Saudi Aramco is a founding member of the Oil and Gas Climate Initiative (OGCI), and is working to shape the global pathway to a low carbon future. Aramco recognizes the need to maintain its position as a leader in upstream carbon intensity, with one of the lowest carbon footprints per unit of hydrocarbons produced and to decarbonize its own operations. In October 2021, the Company announced its ambition to achieve net-zero greenhouse gas emissions across its wholly-owned operated assets by 2050. This complements the Kingdom of Saudi Arabia’s aim to reach net-zero emissions by 2060, announced as part of the Saudi Green Initiative.

This business case is for one of the largest Saudi Aramco gas processing plants, the Uthmaniyah Gas Plant (UGP), located ~177 km southwest from the company headquarters at Dhahran city in the Eastern Province of Saudi Arabia. UGP was commissioned in 1981 as part of Saudi Aramco’s Master Gas System to process natural gas from oil wells. UGP has been recognized by the World Economic Forum as a “Lighthouse” manufacturing facility, and a leader in technology applications of the Fourth Industrial Revolution.

UGP’s pursuit of excellence in maximizing energy efficiency has been the driving force for many projects, investments, technology adaptation and initiatives. The main driver is the corporate Operation Excellence program’s expectations for UGP to be in alignment with the Corporate Policy on Energy Performance Improvement, Energy Management Steering Committee (EMSC) outlooks and internationally recognized Energy Management Systems (ISO50001:2018). The EMSC has established an Annual Energy Efficiency Awards program that sets a positive competition among facilities

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to push the wheel of continuous improvement towards a solid energy efficiency program and GHG reduction across the company.

Furthermore, UGP has established innovation and technology deployment program that manages idea creation for industrial applications, including energy savings ideas. The facility has filed and granted many patents in US Patent Office over the past years. Since 2020, the facility filed/granted 14 new patents to US Office. Examples of energy management related patents: Optimized NGL Control System with Actual Flow and Set Point Tracking – 17/340732, Intelligent Prediction of Boiler Blowdown – 17/709135, Enhanced Hydrocarbon Recovery – 17/873459 and Utilize the Catalytic Converters at Boiler Stack – 17/932923.

“ISO 50001 is a lead by example, effective and sustainable long-term approach that had helped the organization to optimize the facility Energy Efficiency and demonstrate our commitment to leadership in Energy Management Excellence”

—Fahad S. Dossary, Director
Uthmaniyah Gas Plant Department
Saudi Aramco

Business Benefits

Uthmaniyah Gas Plant Department successfully implemented ISO 50001:2011 for the first time in September, 2019. At the time, the certification process went smoothly with only minor tweaks required on UGP’s Energy Management System (EnMS). The corporate guidelines for facilities energy efficiency program was already aligned with ISO 50001 which facilitated the certification process in Uthmaniyah. Later on, in 2020, the department upgraded its EnMS to the latest standard, ISO 50001:2018. This upgrade introduced further enhancement to the EnMS at UGP and thus, the period following ISO upgrade was chosen to define the case study. The period will be covering plant’s performance and key achievement from 2020 until 2022; 2020-2021 being the baseline while the improvement calculation period is 2022 (over 12 months).

UGP is a gas processing facility with dynamic energy performance that is heavily impacted by the facility utilization (throughput), which varies across the year based on customer demand. Therefore, energy performance targets, such as energy intensity & energy consumption, are being set based on demand forecast produced by the corporate planning entity and energy consumption prediction models. The target is then set with extensive revision by energy team at a plant level, and by EMSC at a corporate level.

Over the study period, UGP has managed to reduce its energy consumption by **5,581,357 MWh** (2,416,957 MWh reoccurring per year + 3,164,400 MWh one-time reduction) which consist of power and fuel gas reduction from optimizing plant operation & implementing energy efficient projects and initiatives compared to expected energy consumption. This translates to an energy saving of **\$72.5MM** (\$53.6MM reoccurring per year + \$18.9MM one-time saving) and a reduction in carbon emissions of almost **1 million tonnes of CO_{2e}** (376,969 tonnes of CO_{2e} reoccurring per year + 571,428 tonnes of CO_{2e} one-time reduction).

This was made possible by implementing energy efficiency projects and initiatives, with the following major contributors:

Ethane Deep Recovery Project Energy Enhancement (2020): Energy optimization have been incorporated in the early stages of the design, enabling improved energy consumption and cost optimization well in advance. Examples of implemented improvement are; Recycle Split Vapor (RSV) technology adaptation, elimination of propane refrigerant system, thermosyphon reboilers, storage vent gas heat integration, regen gas-gas exchanger implementation and many other design modification and technologies adaptation. The implemented operational energy optimization has contributed to \$21.8MM/year of operational energy saving.



Figure 2: Ethane Recovery Unit

Natural Gas Liquid (NGL) Train Zero Carbon Emission During Start-up (2020): It is typical for NGL trains to undergo the dry-out step during unit start-up to remove moisture with dry gas, which is normally is sent to flare. Through design enhancement of Ethane Recovery Unit, dry-out gas was made to be recycled back to the unit feed achieving zero gas flaring during unit dry-out step. This promotes recycling of gas and lower GHG emissions, by avoiding gas flaring. This resulted in cost avoidance of \$18.9MM and avoided emissions of 571,428 tonnes of CO_{2e} during the unit initial start-up in 2020.

UGP’s EnMS has also expanded its focus on decarbonization projects and initiatives aligning the plant with the corporate green goal of net-zero emission. Examples:

- **Flare Gas Recovery (FGR):** The objective of the system is to recover a portion of flare gas by compressing the gas to match the feed pressure, which allows that portion to be recovered and further processed in the plant. In 2022, FGR has resulted in reduction of 37,431 MWh in energy and of GHG emissions by 6,759 tonnes of CO_{2e}.
- **Wet Hydrocarbon Recovery (WHCR):** The system is designed to recover waste liquid hydrocarbon during routine operation. The recovered liquid hydrocarbon is then sent to another plant for further processing. During 2022, the plant managed to save \$6.0MM and reduce GHG emissions by 25,911 tonnes of CO_{2e}.



Figure 3: Steam Turbine Generator (STG)

At utilities front, EnMS also looked at opportunities to save energy and reduce carbon footprint, with the following key project and initiative:

Steam Turbine Generator (STG) Project (2022): The project aims to recover excess low-pressure steam and generates useful power. In 2022, the total net power generated by STG alone was 142,788 MWh, with its associated carbon emission reduction (57,115 tonnes of CO_{2e}).

Data Driven Steam Network Optimization (2022): Steam network parameters such as steam demand are linked with the plant load via mathematical representation. At the same time, economical functions are fed into the model with optimization levers to advise EnMS with best mode of operation. This tool resulted in energy saving of \$1.4MM during 2022 (52,142 tonnes of CO_{2e}).

Other benefit: In addition to aforementioned added value of implementing ISO 50001, there are other benefit that the department has felt in the past years. Namely, the EnMS overall structure improvement and assisting the plant in building energy efficiency and decarbonization culture amongst many employees from different backgrounds.

Cost of Implementation: The energy team is led by the assigned energy coordination whom is a certified energy manager (CEM by AEE) and certified in auditing ISO 50001 by third party entity. The coordinator is dedicated, full-time, to monitor, assess and manage UGP energy performance around the clock. The coordination position is crucial; thus, it is assigned to an experienced operation engineer with a minimum of 3 years in his field. Energy team, on the other hand, are assigned part-time with different disciplines providing the required support as seen fit by the coordinator. Therefore, the cost of implementing the ISO 50001 is well managed in terms of manhours and training to maintain optimum results. The total cost of implementation of EnMS is **\$98,585** (which includes manhours, audit and training).

EnMS and GHG Reduction: Energy management system is one of the levers that will support Saudi Aramco to achieve its GHG reduction goals. The Company plans to reduce the carbon intensity kg CO₂-eq/boe by 15% and 51 million Ton of CO₂-eq in scope 1 and 2 by 2035. This can be achieved through several programs including energy efficiency, reductions in methane and flaring and increased use of renewable energy sources. GHG emissions reduction and energy efficiency are not separate from each other. UGP, as a certified ISO 50001 facility, promotes energy efficiency, decarbonization initiatives and optimizations that ultimately led to CO₂ emissions reduction. In 2022, UGP managed to reduce its flaring by **70.4%**, achieving the highest performance amongst all Saudi Aramco facilities.

Energy Awards: UGP's energy performance has been recognized at the corporate level in two occasions in the specified case study period. The facility won the corporate energy efficiency award in 2020 under the facilities energy efficiency initiative award and as a top performer in the energy efficiency in 2022.

Plan

UGP team saw ISO certification as an opportunity to consolidate and benchmark its EnMS internationally. Pitching this idea to the facility management was not hard, as the corporate encourages international benchmarking and positive competition among the organization's facilities. From this point forth, UGP started its journey towards achieving energy excellence and aligning its energy program in preparation for the ISO certification process.

Upon successfully granting ISO50001:2011 certification in 2019, gears of excellence were set in motion. This certification did not only encourage the energy team, but the facility management as well. The whole department was committed to pursue energy excellence through expanding its program to reach all employees and contractors through awareness sessions. This facilitated the fund allocation for engineering studies, initiatives and third-party audits. Additionally, significant efforts were exerted to establish in-house live monitoring dashboard with historian capabilities. Also, a recognition program was created to encourage energy saving ideas submissions to the corporate innovation portal.

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Annually, the department's energy policy and energy team are established to drive continuous improvement and sustainability of the program. The energy team draws the roadmap of the year in order to meet energy intensity key performance indicator targets. These targets are calculated and consolidated with the corporate EMSC in annual basis to align the department with the organization energy vision. The energy team analyzes plant's historical energy data over the past years to understand and link energy consumption with plant utilization (throughput). Power consumption breakdown for individual equipment is filtered and studied to determine the significant energy users (SEUs) as part of the EnMS requirements. Understanding where the majority of the power is consumed allowed the team to concentrate its efforts on systems where the energy reduction is impactful. This approach resulted in targeting equipment that contributed to 90% of the maximum facility power demand.

Quarterly, the energy performance is presented to the management to review the program compliance. It's also an opportunity to present new initiatives for management funding endorsement and track the progress of pending projects and recommendations for support. This is a vital part of the process to achieve continuous improvement throughout the year. This milestone works as a self-auditing opportunity for the plant to look back and reflect upon its EnMS implementation plan.

Furthermore, at the end of the year, the energy team presents all gained opportunities from the energy program implementation to facility management. The plant's energy performance and all implemented initiatives are quantified by their financial benefit and GHG emissions reduction. This analysis is then submitted to the corporate EMSC for further evaluation to qualify for the corporate energy efficiency awards program.

Finally, the department conducts an annual self-assessment for all of its excellence programs including EnMS. The assessment ensures the four corners of operation excellence have been implemented by the energy program which are Plan, Do Check and Adjust. UGP EnMS also undergoes a thorough review against the corporate strategies, standards and guidelines to ensure full aligned with all of them. Any shortcomings are rectified by comprehensive recommendations that measurable, innovative and achievable.

“The introduction of ISO 50001 guidelines and methodology has helped the department raising its Energy Management System maturity level, not only in meeting energy efficiency goals, but in GHG emission reduction”

—Abdulaziz A. Albaiz, Process Engineer, CEM, CEA

Do, Check, and Act

The implementation process of EnMS is a one-year cycle that starts in August, right after the energy performance target has been set for the facility. The site energy coordinator, along with assigned energy team from different disciplines, drive the facility towards outperforming the set targets through the operational excellence OE#5.3 “Energy Efficiency”. The execution of OE comes from establishing the annual roadmap through brainstorming sessions to list ideas and initiatives to improve energy performance and finally, presenting the energy performance for the facility to plant's management in quarterly-basis. At the same time, the corporate EMSC receives and audits all sites' energy performance quarterly. By the year end, the facility quantifies all realized benefits in terms of GHG emission and energy reduction.

Motivation and rewards are essential part of the process to incentivize individuals/facilities in energy and decarbonization sector. At a site level, plant management recognize and reward EnMS related accomplishments through UGP quarterly recognition program. On the other hand, at a corporate level, the facilities, teams and individuals are being recognized through the annual Energy Efficiency Award program. At both levels, the EnMS for each facility is motivated to compete with one another, which positively influences the overall corporate EnMS.

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A key part of the energy management program is significant energy users’ management. UGP EnMS team utilizes a Decision Matrix Advisory Model, which is an online advisory tool that evaluates current plant operation (throughput) and finds opportunities to conserve energy by displaying the optimum number of running equipment.

Another key part of the process is the daily monitoring and reporting to all plant’s key personnel, which illustrates the daily energy performance, gained and lost opportunities, recommended actions and analysis. This, in turns, allowed for operational control, as the report is communicated to operation via emails, morning operational briefing and direct communication, in case a recommendation was not implemented. The effective implementation of such program, along with projects and initiatives, allowed the facility to achieve major energy improvement in 2022, meeting the annual targets.

Tools and resources: The corporate provide the facilities with wide ranges of tools and resources. Examples of employed tools (but not limited to): advanced analytical tool, historian system, electronic filing system, operational excellence system and spreadsheet software. A combination of all listed tools and resources allowed the facility to effectively produce results, and communicate the energy performance to UGP team.

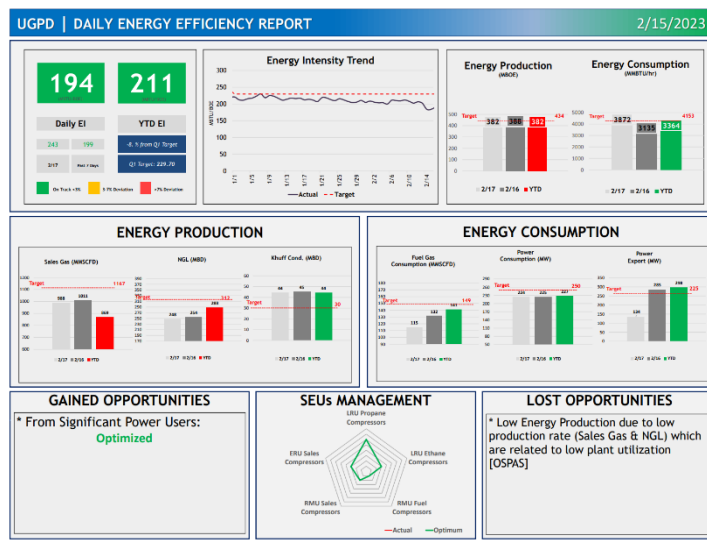


Figure 4: UGP Daily Energy Efficiency Report Display

Energy Performance: As stated, gas plants operations are dynamic such that the plant utilization changes in accordance with costumers’ demand. Therefore, a dynamic energy consumption baseline is set based on plant utilization. The baseline is updated annually with 48 months’ worth of historical data is used to set a challenging energy targets for the facility in the following year (target set by corporate EMSC). The energy performance for UGP is validated and verified by corporate EMSC.

Energy Performance Indicators (EnPIs): At a higher level, the total energy performance for a site is expressed as an energy intensity ratio. This provides a simple form of energy performance that is easily measured and monitored with the following expression:

$$\text{Energy Intensity} \left(\frac{\text{MBTU}}{\text{BOE}} \right) = \left(\frac{\text{Total Energy Consumption (MMBTU/hr)}}{\text{Total Energy Production (MBOE)}} \times 24\text{hr} \right)$$

BOE: barrel oil equivalent.

On a lower level, UGP EnMS tracks significant energy users with its associated EnPIs, depending on the equipment type:

Equipment type	EnPI	Formula
Compressor	Efficiency	Polytropic head / Compressor Work
Boiler	Efficiency	[(Stream rate) x (Enthalpy)] / [(Fuel gas rate) x (Heating value)]
Process Furnace	Fuel intensity	MSCFD (Fuel) /MMSCFD (Process fluid)

Those EnPIs are affected by relevant variables such as weather condition and unplanned equipment shutdowns.

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Energy Performance Normalization: Energy consumption is linked directly with the plant throughput. Therefore, Energy Intensity is used to measure the facilities’ energy performance within the corporate. This normalization method makes it easy to compare the facility performance against others. Additionally, it is a clear indication for any observed abnormalities within the plant, as the intensity will vary significantly.

Moreover, the realized benefits from direct energy performance improvement have been calculated based on linear normalization of energy consumption target (expectation). This linear regression method ensures accurate energy improvement representation, which accounts for actual plant production rate variation.

Employees engagement and training: Part of the EnMS roadmap is employees’ engagement. This comes in various forms, such as flyers, SMS messages, presentations, open discussions, quizzes and energy conventions. Over the recent years, UGP energy team have seen an increase in employees’ participation rate in energy contests. On the training front, a set plan for energy coordinator (and his back up) is established while developing the roadmap. This training plan includes corporate technical courses, such as Combined Heat & Power (CHP) and international certifications, such as certified energy manager & ISO 50001 energy auditor.

Third party audit preparation: The corporate operational excellence (OE) audit and plant’s annual OE self-assessment are both good venues for EnMS 3rd party audit preparation. Since corporate energy OE program is well aligned with ISO 50001, UGP continues its adherence to the ISO requirements.

Transparency

UGP proudly displays all ISO certifications in its administration and engineering buildings publicly. These buildings are attended by out of company visitors, vendors and contractors. Additionally, any obtained ISO certificate is announced and shared with other gas operating facilities through the internal weekly newsletter.

On a different note, UGP has published its ISO 50001 EnMS implementation through corporate media “Aramco Life”, accessible by all employees.



Figure 5: UGP ISO Certificates Display

Furthermore, Saudi Aramco’s efforts in all fronts are demonstrated and showcased in its sustainability report, readily accessible through below link:

<https://www.aramco.com/en/sustainability/sustainability-report>

What We Can Do Differently

Saudi Aramco has always actively promoted energy efficiency at national and global levels, while leveraging latest technologies and investments to reduce its GHG emissions footprint. The specific facility, UGP, has poured its efforts into aligning its projects and initiatives with the corporate climate change targets and ambition. This is demonstrated by the energy and decarbonization driven achievements since the implementation of ISO 50001.

However, UGP acknowledges that there are missed opportunities that could have been captured to enhance EnMS performance:

- **Overlooking non-significant energy users:** The sole focus of the energy team was optimizing the SEUs, while paying less attention to the remaining plant’s energy users. This could have opened many opportunities for reducing energy consumption and GHG emissions by implementing thorough programs covering non-industrial buildings, small industrial equipment and renewable energy solutions.
- **Limiting ISO 50001 awareness to plant personnel:** The awareness program is a corner stone of EnMS but it was limited to the plant scope, in terms of audience and content. We believe the awareness could have been more impactful if we had diversified the audience with every-day-life relatable energy conservation topics.

We admit those were missed opportunities that could have generated more energy saving value to the facility.

Moving forward with ISO 50001 EnMS, UGP plans to capture those missed opportunities as follows:

- **Include non-significant energy user program to EnMS:** UGP plans to closely monitor and optimize non-significant energy users, which include small industrial equipment and non-industrial buildings.
- **Energy awareness outreach:** UGP aims to expand upon its awareness program scope to take ISO 50001 culture to the society. This can be achieved by conducting energy awareness campaigns in community venues such as schools and universities. These campaigns would highlight the impact of reducing energy consumption from urban sources (homes, schools, vehicles, ...etc) on the environment.