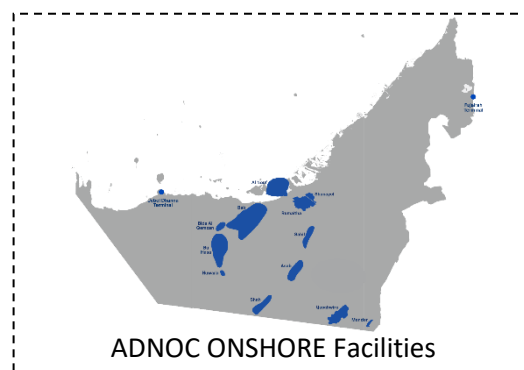


ADNOC ONSHORE

ADNOC ONSHORE is a leading ISO 50001-2018 certified Oil and Gas Company in Energy Management System with an excellent track record in achieving continual improvement of energy performance, best possible energy efficiency and reduction in GHG emissions.



Case Study Snapshot

Industry	Upstream Oil and Gas
Product/Service	Crude oil, Associate and Non-Associate gas and condensate
Location	Abu Dhabi Emirate, UAE
Energy performance improvement percentage (over the improvement period)	19.2% in MJ/BO 2011-2015 wrt baseline 2010 10.1% in GJ/mnBOE 2016-2020 wrt to baseline 2015 0.43% in GJ/mnBOE 2021 wrt baseline 2018
Total energy cost savings (over the improvement period)	USD 55,230,396
Cost to implement Energy Management System (EnMS)	USD 18,427,769
Total energy savings (over the improvement period)	55,230,396 GJ
Total CO₂-e emission reduction (over the improvement period)	1,065,386 Metric Tons

Organization Profile / Business Case

ADNOC ONSHORE is the largest oil producer within the ADNOC Group, accounting for over half of ADNOC's total oil production. ADNOC ONSHORE's concession area spans 12,000 km², operates 11 oil and gas fields and two export terminals, as well as a vast pipeline network through which oil is transported from the oil fields. As a global industry leader in environmental sustainability, ADNOC ONSHORE is the first in the world to capture carbon from the iron and steel industry. Carbon Capture, Utilization, and Storage (CCUS) facility at Al Reyadah has the capacity to capture 800,000 tons of carbon dioxide (CO₂) from Emirates Steel Industries (ESI) each year, for injection use to support reservoirs Enhanced Oil Recovery (EOR).

ADNOC ONSHORE continues to responsibly supply the world's energy needs, with an ambition to create value for the UAE and the world as one of the most carbon efficient oil and gas producers. This ambition is underpinned by ADNOC 2030 Strategy, which is focused on maximizing value from available resources and supported by key strategic pillars focused on SUSTAINABILITY, PEOPLE and PROFITABILITY.

ADNOC ONSHORE established Energy Management System in compliance with ISO-50001 since the year 2013 to support our strategic pillars of SUSTAINABILITY, PEOPLE and PROFITABILITY by driving highest possible energy efficiencies to achieve a lower cost per barrel and reduction in GHG emissions to protect the environment. ISO-50001 has played an instrumental role in establishing systems and processes necessary to continually improve energy performance and achieve organization strategic goals and objectives.

ISO 50001 Energy Management System – Case Study

2022

United Arab Emirates

Energy Management System at ADNOC ONSHORE has an evolution history over one decade with the major milestones achieved as below:



“I am glad to announce the ADNOC Onshore 2030 sustainability strategy, which focuses on climate, emissions, energy, and local environment.

We are ISO 14001:2014 and ISO 50001:2018 certified company since many years with excellent performance in environment management and energy efficiency.”

—Omar Obaid Al Nasri, Chief Executive Officer – ADNOC ONSHORE

Business Benefits

Establishing Energy Management System in compliance with ISO-50001 have immensely proved both tangible and intangible business benefits for ADNOC ONSHORE as described below.

Tangible Business Benefits:

- Total 67 nos of energy improvement opportunities were implemented during years 2014 to 2021. Which resulted in savings of 3,231 TJ of energy, 21.4 mnUS\$ of energy cost and GHG emission of 264,280 T/yr. Furthermore, the following are major energy improvement opportunities implemented at various fields:
 - Phasing out of less efficient open cycle self-generation.
 - Introduction of produced water Re-injection.
 - Commissioning of Vapor Recovery Compressor system to avoid flaring of blanketing gas.
 - Optimization of compressor discharge pressure.
 - Optimization of number of running pumps in main Oil Line system, water injection system and produced water disposal system in all fields.
 - Optimization of excess oxygen in all process heaters.
- Improvement in Energy Performance (GJ/MnBOE) by 10.1% with respect year 2015 baseline during year 2015-2020 and by 0.43% with respect year 2018 baseline during year 2021.
- Improvement in Energy Performance (MJ/BO) by 25.99% with respect to base line 2010 was achieved by 2019.
- Total 40 energy reviews for projects at various stages like concept, FEED and EPC phase were performed to ensure energy efficient design. Major best available technologies such as Turbo Expander Generator, Vapor recovery using water, application of Variable Speed Drives for Water Injection System pumps and Crude oil transfer pumps etc. were studied and considered for implementation in project.

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Intangible Business Benefits:

- Achieved cultural shift the way ADNOC ONSHORE manages energy due to intensive focus from top management, creating widespread awareness and elevating competence of the employees related to energy conservation, who consistently contribute to improve energy performance and savings.
- Continual improvement of energy performance with systematic approach towards energy management and implementing robust process to manage energy use.

Plan

ADNOC and ADNOC ONSHORE both are ISO-50001 certified company. ADNOC persistently provides guidance, directives, and governance related to Energy Management System (EnMS) to ADNOC ONSHORE. EnMS at ADNOC ONSHORE enjoys extensive support and commitment from Executive Team led by that company CEO, which is evident from Energy Policy, Energy organization and EnMS framework that have been established and evolved for more than a decade. Management Review Meeting is held once in a year to evaluate effectiveness of EnMS and its alignment with strategic direction of ADNOC.

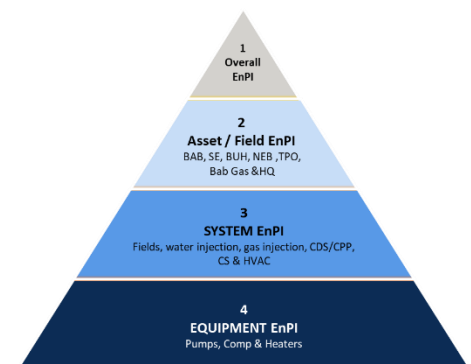
EnMS of ADNOC ONSHORE covers 11 oil fields, export terminals, pumping stations and headquarter building located across a vast geographical area at United Arab Emirates. EnMS involves Team of seven full time energy engineers. The Energy team is supported by energy focal point/team and SMEs from each plant and function. The average hourly demand of electricity is 519MW and gas consumption is 42MMSCFD which is equivalent to primary energy consumption of 134TJ/d at ADNOC ONSHORE facilities as per year 2021 energy statistics.

ADNOC ONSHORE Energy Management System is established in compliance with ISO-50001-2018, Energy policy and developed 25 nos. documented information in the form of manuals, procedures, guidelines, and records.

Energy Monitoring:

ADNOC ONSHORE has implemented comprehensive Energy Monitoring System at different levels.

- Level – 1 monitoring is defined at overall ADNOC ONSHORE whereas Level – 2 monitoring is performed at each individual asset and field level.
 - Energy Performance Indicators (EnPI) at Level – 1 and Level – 2 are MJ/BO (Energy consumed to produce one Barrel of Oil), GJ/mnBOE (Energy consumed to produce one Million Barrel of Oil equivalent) and US\$/BO (Cost of energy to produce one Barrel of Oil)
- Level – 3 monitoring considers significant energy consuming systems such as Water Injection, Gas Injection / Compression, Oil Processing, Transport and Export, Accommodation / Admin buildings, etc. Total 55 systems at various plant are being monitored.
 - EnPI for Level – 3 are kWh/BW for water injection system, kWh/MMSCF or MMSCF/MMSCF for gas compression system, kWh/BO for oil export system, etc.
- Level – 4 monitoring includes 63 nos. Significant Energy User (SEU) equipment such as Compressors, Pumps, Heaters and Gas Turbine Generators.



Energy reviews:

During the journey of Energy Management at ADNOC ONSHORE, comprehensive energy reviews were conducted at regular intervals and when major facilities were introduced, as listed in below table.

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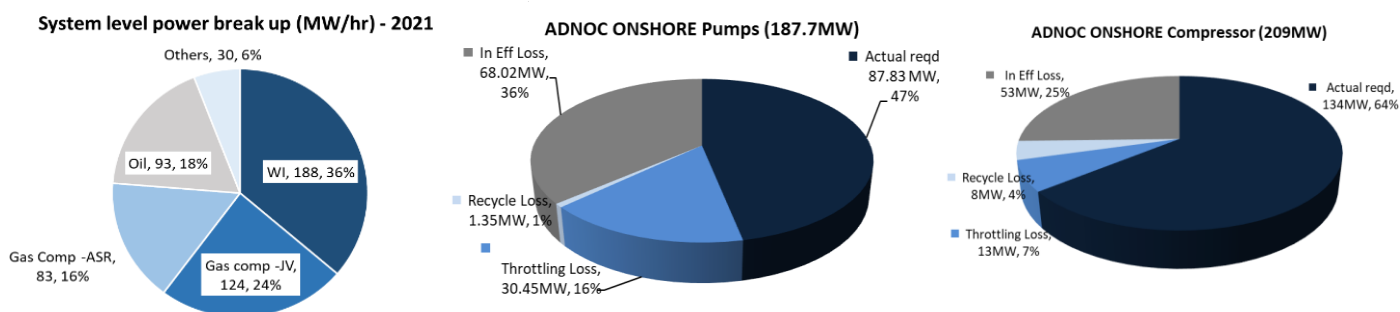
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Description	Consultant	Year
Energy Management Strategic study for ADNOC Group Cos.	Genesis oil and gas consultants Ltd.	2009-10
Energy Efficiency Improvement Study	Performance Improvement (PI) Ltd.	2011-12
Energy Efficiency Improvement Study – SE asset	Blue Sea Engg. Consultants Ltd.	2015
Comprehensive Energy Study	By ADNOC ONSHORE Energy Team	2017-18

Above energy reviews assisted in developing objectives and targets, evaluating energy usages and consumption, identifying energy losses, energy improvement opportunities to mitigate energy losses and determining Significant Energy Uses – Systems and Equipment and their performance indicators as listed under Energy monitoring System. With that said, around 67 numbers of Energy Improvement Opportunities identified during energy reviews have been implemented.

Example of energy usages and consumption, energy losses evaluation for pumps and compressors (which is 90% of ADNOC ONSHORE energy consumption) is illustrated below. Identification energy usage and losses facilitated in determining energy improvement opportunities and their priorities, which led to energy saving and improved energy performance.



Energy Management Objectives and Targets:

ADNOC ONSHORE Targets	Improve energy efficiency of existing facilities by 25% from the baseline of 2010 by end of 2025.	25.99% saving achieved by 2019
	Increase dependence on renewable energy sources to achieve 2% share of total energy use by 2025.	Achieved 1.35%
	Ensure implementation of Best Available Techniques (BAT) in energy efficiency in the future facilities.	40 Energy reviews conducted.
	10% improvement in energy efficiency from 2015 to 2020 from the baseline year 2015 (Completed)	Achieved 10.1%
ADNOC Targets	5% improvement in energy efficiency for the upcoming five years (2021-2025) from the baseline year 2018.	0.43% achieved in year 2021
	25% Reduction in GHG emission intensity by 2030 from the baseline year 2018.	Task force set up and roadmap is in place

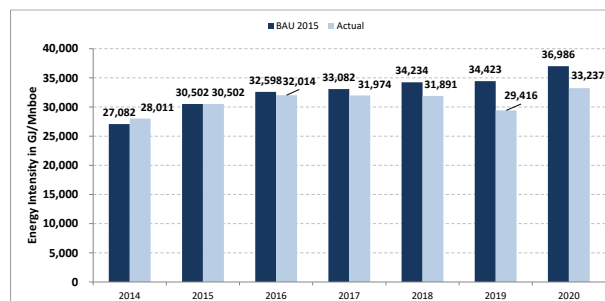
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“ADNOC ONSHORE is committed to utilize the energy resources responsibly, constantly monitor and improve energy efficiency in our design and operations. ISO-50001 has assisted and guided enormously in developing Energy Management System at ADNOC ONSHORE”

Sami Al Ankar, Vice President, Technical Center (Engineering),
ADNOC ONSHORE



Improved EnPI(GJ/mnBOE) by 10.1% by 2020 wrt 2015 baseline

Do, Check, and Act

Energy Saving and Performance Improvement Campaigns:

Various campaigns undertaken by ADNOC ONSHORE Top Management to stimulate and encourage energy saving and energy performance improvement as listed below.

Energy Must DO:

Launched in year 2014 with an objective to “Identify and Implement Energy Improvement Opportunities (EIO) to reduce ADNOC ONSHORE 's energy consumption per barrel of exported oil by 5% by 2016 from 2010 baseline.” Total 2,820TJ energy saved which was 13.5% from 2010 base line and reduced energy cost of 7.97mnUS\$.

ADNOC ONSHORE Cost Efficiency (ACE) Drive:

ADNOC ONSHORE Cost Efficiency (ACE) drive was initiated in year 2017 with an objective to reduce Crude Oil production cost. Energy Management System was one of the major contributing stake holders in that drive.

Develop Energy Efficient Initiatives:

As part of the annual Corporate Performance Scorecard, various Key Strategic Initiatives (KSI) were introduced in year 2020. One of those KSIs was “Develop Energy Efficient Initiatives” with a weightage of 3% in performance score card. All identified activities as part of the KSI were completed and desired objectives were achieved.

ADNOC ONSHORE 2030 Sustainability Strategy:

ADNOC ONSHORE management has announced 2030 sustainability strategy, which focuses on climate, emissions, energy, and local environment. ADNOC ONSHORE targets to be #1 Energy Efficient Oil and Gas Operator by year 2030.

Implementation of planned Energy Improvement Opportunities (EIOs):

Various energy reviews conducted throughout energy management journey as listed above, suggested energy usages and systems / equipment where energy losses were identified. Above reviews together with ideas and suggestions from employees assisted in developing Energy Opportunity Register. According to assessment of tech-economic feasibility studies and priorities, EIOs implementation were planned and reflected in the corporate business plan.

At individual Asset / Field, for individual or group of EIOs, a team comprising of Subject Matter Experts (SMEs) were formed to implement EIOs. The Management of Change (MOC) procedure was followed to obtain necessary approval from for implementation. The financial proposals were generated to secure required budget and sought management

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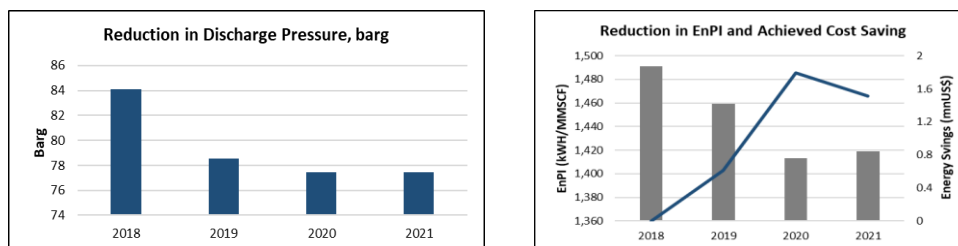
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approval where applicable. After successful implementation of EIOs, measurement and verification were performed to ascertain the actual energy saving achieved.

Case Studies – Few Success Stories of Implemented Energy Improvement Opportunities:

Gas Discharge Pressure Optimization at GAS (ASR) Asset:

GAS Asset (ASR-ADNOC ONSHORE Sole Responsibility) produces Gas and Condensates from depleting and recycle gas reservoirs. The Gas from depleting reservoirs is compressed through 12nos. Gas Compressors located at 4 Compressor Stations. Each compressor is a Significant Energy User with rated power of 12.5MW. Up to 2018, the compressors were operated at higher discharge pressure. It was identified possible optimization to reduce compressor discharge pressure / Pressure ratio. Necessary trial runs were performed to verify process requirements and gradually the discharge pressure reduced which earned a substantial savings. The history of operation parameters, EnPI and energy savings is depicted in below graphs.



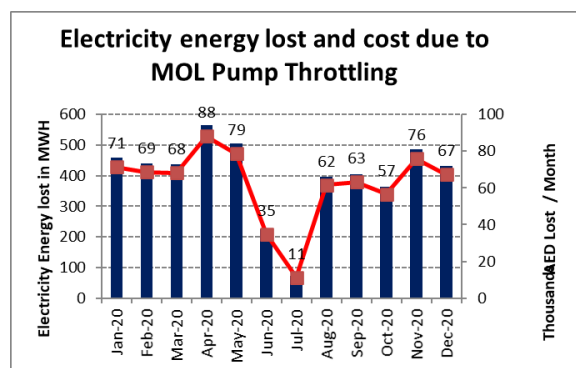
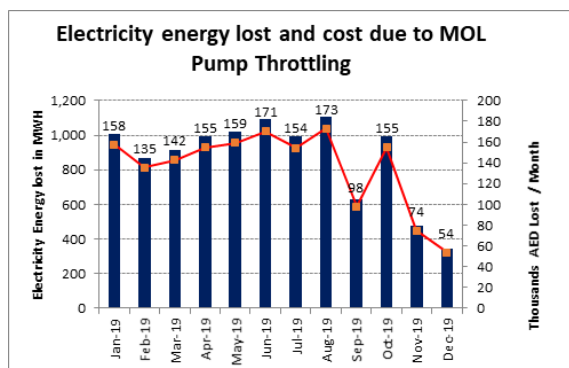
In Year 2022, the discharge pressure is planned to further reduce to 73 BarG, for which studies and trial run is underway to yield significant energy savings.

Switching off one MOL pump:

The interrelated plant operation demands for close coordination among teams within different plants and boundaries. The oil produced was transported to export terminals through Main Oil Line (MOL) pumps which consumes 4.4MW/hr of electricity. The detailed study revealed that system has losses of greater than 20% which was deterrent to ADNOC ONSHORE Profitability Pillar. With a goal to eliminate the losses, improve energy efficiency and increase profitability, the deliberated efforts suggested that one MOL pump could be switched off without affecting production and integrity of operations if MP-21 (part of Terminals and Pipelines Asset) operating pressure is reduced. The Energy Improvement Opportunity was implemented with close coordination among different facilities and functions. It could be evident from below charts that energy loss due to excess head developed has been reduced considerably and switching off of one Main Oil Line pump has yielded enormous energy saving.

Year 2019 energy loss: (1 pump switched off Oct. 2019)

Year 2020 energy loss: (1 pump switched off)



- Total Energy loss for duration Jan to Oct 2019: 9,624MWH (Before implementation of EIO)
- Total Energy loss for duration Jan to Oct 2020: 3,867 MWH (Before implementation of EIO)
- Total Saving in 10 months = 5,757 MWH equivalent to 242,160US\$ and 2590T/Yr CO₂

Energy Performance and Savings Measurement:

Overall Energy performance measurement at ADNOC ONSHORE is performed with Energy Performance Indicators (EnPIs) – MJ/BO (Energy consumed to produce one Barrel of Oil) and GJ/MnBOE (Energy consumed to produce one Million Barrel of Oil equivalent – considering all hydrocarbon production). The base line years for the measurement are years 2010, 2015 and 2018.

The Energy Baseline is determined by measuring corresponding energy consumption (ΣC_{MBL}) for the baseline period. In addition, applicable relevant variables such as oil production, water and gas injection, gas lift quantities, power generation, feed crude oil temperature, etc. which have significant impact on energy performance are recorded during the baseline period. The Energy Baseline consumption is normalized using applicable variables (ΣC_V) to derive Business as Usual (BAU) values ($\Sigma C_N = \Sigma C_{MBL} + (\pm \Sigma C_V)$) to compare actual energy consumption of reporting period (ΣC_M) under equivalent conditions of relevant variables.

The improvement / savings is worked out by difference of actual reporting energy consumption value (ΣC_M) and normalized baseline Energy consumption value - BAU value (ΣC_N) and as percentage change of above with help of following equations.

$$(a) \text{ Energy Saving } \Sigma S = (\Sigma C_N - \Sigma C_M)$$

$$(b) \text{ Energy Saving } \% \Sigma S = (\Sigma S \div \Sigma C_N) \times 100$$

Tools and Resources Used:

Energy performance and savings calculations, Energy Performance Indicators (EnPI) for various systems and equipment, etc. are performed in MS Excel work sheets. Real time process parameters are extracted in MS Excel work sheet from Field Data Integration System (FDIS) using PI data link tool. Production Injection and Export System (PIES) data base tool is used to obtain production, gas consumption, Water and Gas Injection, Gas lift data, which are key process variables that affect energy consumption. Electrical Energy consumption for various system and equipment is obtained from electrical SCADA System.

Awareness and Competence:

To enhance awareness and competence of the employees to encourage their participation and contribution to achieve objectives and targets of energy management system, various energy awareness sessions and training programs were developed and delivered as illustrated below.

- Energy awareness sessions - 72 nos., 4,100+ employees participated.
- Energy Management Training – 23nos., 350+ employees participated.
- E-learning energy awareness session is prepared and published in SAP ERP system in December 2021.

Internal and Third-Party Energy Management System Audits:

There is a strategic team of energy auditors and auditees created to look after the Energy Management System requirements as per ISO 50001:2018 standards. They are trained as Internal auditors, Lead Auditors and implementors.

Every year there are internal energy audits, followed by management review meetings. The actions arising from the audits and the review meetings are closed successfully. Third party auditors are invited to conduct the Energy audits as per the requirements of the ISO 50001:2019 standards.

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The third-party audits are conducted by world renowned bodies such as ABS Certification (from 2008 to 2019), by Bureau Veritas quality International which is current certification body and third-party auditors since 2020 onwards and ongoing.

After successfully carried out audit, outcome is reported to the top management for effective communication and implementation.

Transparency

ADNOC publishes Sustainability Report in a public domain where organization activities and achievements are highlighted related to Energy Efficiency improvement and other initiatives related to emission reductions and sustainability.

ADNOC ONSHORE achievements related to energy efficiency and ISO-50001 are referred in ESG (Environment, Social and Governance) strategy statement. It is mentioned that through the implementation of the group wide ISO-50001 certification in energy management, ADNOC ensures best practices and technologies are put in place to achieve energy efficiency. Across its operations, including the Onshore Operating Companies, the ADNOC Group has taken tangible steps in implementing a variety of energy efficiency projects that target both energy supply and demand.

What We Can Do Differently

Being agile and resilient organization, pursuing new technologies and best practices is quite prevalent at ADNOC ONSHORE. Few of many initiatives are being under considerations as listed below to further support improving energy efficiency and reduction in GHG emissions.

- Study and explore possibilities of implementing energy recovery in the plant process and facilities where applicable. Two such concepts of recovering energy through Hydro Pressure Recovery System at Oil export Terminal and installation of Gas Expander Generator to recover pressure energy of reservoir gas is under techno economic study / FEED phase.
- Evaluate other sources of water injection instead of currently used aquifer water injection to optimize energy.
- Consider large scale on grid solar power generation if techno economically feasible.
- Study feasibility and implement centralized real time energy management monitoring system. Apply analytics software with application of Artificial Intelligence and Machine Learning concepts for energy optimization.
- Further increase in Carbon Capture and Utilize System (CCUS) capacity, reaching 5 million tons of CO₂ by 2030.



AL REYADAH CCUS Plant



AL REYADAH CCUS Plant



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.