Standardization and benchmark initiatives for emission reduction in the petroleum industry

http://dx.doi.org/10.1590/0370-44672023770125

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Abstract

The Oil and Gas (O&G) sector is facing unprecedented challenges regarding greenhouse gas (GHG) emissions, urging rapid decarbonization actions in line with global imperatives. This comprehensive review article delves into the crucial role of industry standards in spearheading transformative efforts. It synthesizes findings from a literature review, offering insights into real-world implementation cases within the O&G industry, and integrates perspectives from specialists through qualitative research. Key standards from the International Organization for Standardization (ISO), notably TC 301 and ISO 50001, are highlighted for their pivotal role in promoting energy management systems as essential tools for GHG mitigation. These standards not only advocate for energy-saving practices but also emphasize structured energy management to effectively reduce greenhouse gas (GHG) emissions. Additionally, the influential ISO/TC 67 orchestrates a comprehensive suite of standards tailored for the O&G industry, facilitating its adaptation to evolving technological and environmental landscapes. Complementary collaborative initiatives such as IPIECA, OGCI, and IOGP emerge as vital forces in promoting operational and strategic solutions. Through this review study, the intertwined relationship between energy management and GHG emission reductions is elucidated, underscoring how industry standards and collective efforts can drive the O&G sector towards a more sustainable future in alignment with global environmental ambitions.

Keywords: oil and gas; standard; energy efficiency; greenhouse gas emissions; offshore production.

1. Introduction

The Oil and Gas (O&G) industry has been the backbone of global energy supply for several decades, playing an indispensable role in powering economies and ensuring energy security. Yet, as the clarion call for environmental responsibility grows louder, there's an imperative to address the rising levels of greenhouse gas (GHG) emissions, urging the sector to embrace significant changes (IOGP, 2023a).

GHG emissions from the O&G sector contribute notably to global emissions, signifying an urgent requirement for robust mitigation strategies. Amidst this backdrop, organizations like the International Association of Oil & Gas Producers(IOGP), the Oil and Gas Climate Initiative (OGCI), and International Petroleum Industry Environmental Conservation Association (IPIECA) have emphasized the pressing need to intertwine environmental sustainability with the O&G industry's economic objectives.

Recognizing the magnitude of this challenge, an array of entities – from governmental bodies to international consortiums – have rallied to devise standards and guidelines aimed at curbing GHG emissions. Standards and certification bodies have emerged as pivotal players, fostering best practices and sustainability benchmarks, as evidenced by initiatives like ISO TC 301 and ISO TC 67 (ISO, 2023a, 2023b).

At the helm of standardization, the International Organization for Standardization (ISO) has consistently paved the way, crafting guidelines that resonate across varied industries. For the O&G domain, the ISO 50001 standard on energy management emerges as a beacon, accentuating the merits of energy efficiency and tangible GHG mitigation (ISO, 2018).

Beyond merely setting standards, the true essence lies in operationalizing them. The Energy Management Systems (EnMS) blueprint, as encapsulated in ISO 50001, serves as a methodical conduit for industries to optimize energy consumption, translating into tangible GHG emission reductions. Such concerted efforts echo the indispensability of a regimented and coherent energy efficiency strategy (ISO, 2018).

However, in a grand variety of standards like ISO 50001, the real test is in the domain of implementation. Entrusted to individual companies and stakeholders, the uptake and integration of these benchmarks vary vastly, swayed by an ensemble of factors from regulatory frameworks to economic

imperatives (Fuchs; Aghajanzadeh; Therkelsen, 2020; Sousa Lira; Salgado; Beijo, 2019).

As a literature review, this study explores the diverse standards, references, and initiatives laser-focused on GHG abatement in the O&G sector. By scrutinizing their tangible impact, adoption impediments, and the trajectory forward, it aspires to shed light on the dynamic terrain of energy stewardship within the O&G universe.

2. Materials and methods

The methodological framework of this article integrates an extensive literature review primarily focused on standardization in energy management within the O&G sector. Complementing this review, industry-specific case studies were selected to provide additional context and depth to the research.

To bolster the research foundation, qualitative research methods were employed, particularly seeking insights from sector experts. A questionnaire containing specific inquiries on the subject matter was distributed to specialists from O&G production companies and standardization-linked enterprises. This qualitative inquiry, conducted between December 2023 and May 2024, incorporated selected responses into this article. It is crucial to note that the survey findings do not necessarily reflect the views of the companies themselves.

According to Swanson & Holton (2005), case study research examines dynamics within unique contexts, offering empirical observations without providing formal theoretical interpretations. However, it contributes to theory development by elucidating the dynamics of phenomena within case settings.

The discussion on implementation facilitates the evaluation of paths pursued in the case study, delineating four discernible phases: 1) delineation of the unit of analysis; 2) data collection; 3) selection, analysis, and interpretation of the data; 4) compilation of the report (Ventura, 2007).

Qualitative research plays a pivotal role in conceptual development and operationalization, employing exploratory approaches to understand constructs and their interconnections. Essential techniques for qualitative data collection include fieldwork, observation, interviews, and document analysis (Creswell, 2003; Khan, 2014).

Operating within a poststructuralist paradigm, qualitative research embraces a holistic approach, aiming to uncover intricate experiences within natural settings. It accentuates participants' perspectives and employs less structured narratives to engender novel theoretical insights (Creswell, 2003; Leedy; Ormrod, 2001).

3. Review of Literature

3.1 Energy management initiatives references

3.1.1 ISO TC 301

The ISO Technical Committee 301 (TC 301) plays a pivotal role in crafting international standards that address energy management challenges across various sectors. Originally established to concentrate on energy management and savings, its keystone is the ISO 50001 standard, which offers a robust framework for establishing, implementing, maintaining, and improving an energy management system (EnMS) (ISO, 2018).

The significance of energy management within international standardization has been underscored by scholars. Over time, a comprehensive set of standards has been meticulously developed by experts to guide the global community towards sustainable practices. As the front runner in energy management standardization, ISO/TC 301 has significantly contributed to the ISO 50000 series. This suite includes the foundational EnMS standard ISO 50001 (Energy Management Systems) and essential guidance documents like ISO 50004 (Energy Management System Guidance) and ISO 50006 (Energy Baseline and Energy Performance Indicators), which provide insights into the execution of the energy management system and the metrics of energy performance, respectively (Barros Gallo, 2023; Mckane *et al*., 2009).

Expanding its scope, ISO/TC 301 has delved into the realm of Net Zero. ISO/PAS 50010, for instance, offers guidance on achieving net zero energy operations within the ISO 50001 framework. Moreover, ISO/IWA 42, which provides Net Zero guidelines, had the opportunity to be showcased at COP 27 (Barros Gallo, 2023; ISO, 2023b)

As articulated by ISO (2023), ISO/TC 301's multifaceted mission encompasses the ongoing improvement of energy performance, informed decision-making regarding varied energy sources, the proficient use of data, and the creation of tools for EnMS implementation. Central to its mission is the standardized approach to measuring, monitoring, validating energy savings, and transparently reporting improvements in energy performance (Thollander; Dotzauer, 2010).

Characterizing ISO/TC 301's strategy is its commitment to nurturing an adept workforce in energy management, endorsing stringent assessment methods, and refining energy performance. As global sustainability initiatives gain traction, TC 301's role becomes ever more crucial. Its strategic direction aligns perfectly with the global objectives of energy transition and broader sustainable development goals. Such alignment suggests profound implications for organizations, governments, and entire industries, touching upon enhanced energy efficiency, reduced carbon footprints, and bolstered economic competitiveness (ISO, 2023b).

TC 301's contributions to energy management standards have considerably shaped sustainability and efficiency across various sectors. Emphasizing collaboration, standardization, and constant evolution, TC 301 has left an indelible mark on the global energy paradigm. Future challenges and opportunities will solidify TC 301's position as a central figure in the narrative of global sustainable energy transition with standards solutions that empower organizations in their quest to optimize energy consumption and curtail greenhouse gas emissions.

This segment explores case studies and empirical data that elucidate how ISO standards have recalibrated energy consumption behaviors, spurred enhancements in energy efficiency, and led to tangible economic and environmental gains. Organizations that align with TC 301's standards reap rewards in the form of ef-

ficient resource management, adherence to regulatory mandates, and enhanced public confidence (ISO, 2023a).

Furthermore, the standards developed by TC 301 have served as a beacon for organizations seeking a structured approach to energy management. They offer a clear roadmap, providing the tools and methodologies that organizations require to measure, manage, and continually improve their energy performance. This approach not only aligns with global environmental imperatives but also offers economic advantages by optimizing energy usage, thereby leading to cost savings (Thollander; Dotzauer, 2010).

One must also consider the strategic relevance of TC 301 in the broader context of international climate change commitments. With countries around the world pledging to reduce their carbon footprints, having a consistent set of standards is instrumental. By adhering to ISO standards, governments, and industries can ensure that their energy management practices are both effective and aligned with global best practices (Boiral, 2011).

Moreover, TC 301's commitment to continuous improvement is evident in its iterative approach to standard development. By regularly revisiting and updating its standards, the committee ensures that they remain relevant in the face of evolving challenges and technological advancements in the energy sector (Vine, 2008).

Feedback from organizations that have adopted TC 301's standards further emphasizes their utility. Many reports enhanced operational efficiencies, reduced energy costs, and an improved public image, which underscores the benefits of integrating standardized energy management practices into organizational strategy.

In summation, the ISO Technical Committee 301 has undoubtedly left a mark on the global energy landscape. Its standards have acted as a linchpin, ensuring that energy management remains a focal point in global sustainability efforts. As the world grapples with the pressing need to transition to cleaner energy sources and reduce emissions, the role of TC 301 and its standards becomes ever more crucial. Their continued evolution and adoption will undeniably play a pivotal role in steering the world towards a sustainable energy future.

3.1.2 ISO 50001

In the escalating pursuit of energy efficiency and sustainability, especially in the O&G sector, standardization efforts have gained prominence. Leading these endeavours is the International Organization for Standardization (ISO) through ISO 50001. Introduced in 2011, ISO 50001 aims to offer companies, regardless of their size or operational nature, a framework for enhancing energy utilization and consequently reducing greenhouse gas (GHG) emissions. This standard fosters a comprehensive approach, integrating seamlessly with existing systems (Sousa Lira; Salgado; Beijo, 2019).

The concept of Energy Management Systems (EnMS) stands central to this dialogue. EnMS, integral to ISO 50001, are designed to make industries' productive activities more energy-efficient, leading to both financial savings and marked reductions in GHG emissions (Sousa Lira; Salgado; Beijo, 2019). Further accentuating the importance of EnMS, McKane *et al.* (2017a) illuminate how an effective EnMS transcends being just a tool, acting as a strategy that can bring about transformative shifts in energy consumption patterns across the O&G sector.

Yet, while the potential advantages of ISO 50001 are undeniable, factors influencing its adoption are multifaceted. Lira *et al.* (2019) pinpoint elements tied to energy consumption, supply, and impacts as crucial. The situation is further muddled by the misalignment between available indicators and the diffusion of ISO 50001, a concern underscored by Fuchs *et al.* (2020). Such indicators encompass environmental aspects like total natural resources rents and economic metrics such as energy depletion relative to Gross National Income.

However, it is the challenges in the diffusion and adoption of these standards that often take center stage. Fuchs *et al.* (2020) examine these challenges, drawing attention to the relationship between the spread of ISO 50001 and countries' regulatory climates. Notably, while countries like Germany, Denmark, and Sweden have advanced significantly, others are still navigating the intricacies of standard incorporation. Recognizing that this diffusion isn't just anchored to the ISO's framework but is also influenced by a combination of regional and global factors is paramount.

Lira *et al.* (2019) spotlight the adaptability of ISO 50001. Given the dynamic nature of the O&G sector where technological and operational practices continually evolve, the framework's adaptability assures its ongoing relevance. It aligns with the industry's goals and provides a versatile model that can adapt to advancements in energy technologies and procedures.

McKane *et al.* (2017b) offer a business vantage point, proposing that beyond regulatory incentives, O&G companies are increasingly acknowledging the sustained viability and profitability of green energy practices. In this scenario, ISO 50001 emerges not just as an energy management guide but as a conduit to competitive advantages in a progressively resource-aware global market.

Despite the hurdles, numerous countries and corporations have fully embraced ISO 50001. Both ISO (2018) and McKane *et al.* (2017a) emphasize the revolutionary nature of this standard. With an emphasis on continuous refinement over set mandates, ISO 50001 fosters a proactive energy management ethos. As a result, companies are not just adhering to a standard but are actively revamping their energy consumption philosophies and techniques (ISO, 2018).

A challenge worth noting, highlighted by Fuchs *et al.* (2020), is the relative unawareness regarding the tangible advantages of ISO 50001. While businesses are familiar with the theoretical benefits, translating these into concrete metrics, such as cost savings, GHG reductions, and efficiency enhancements often proves challenging. However, when companies witness these quantifiable outcomes firsthand, it stimulates a more pronounced inclination towards adoption and stringent implementation.

The compatibility of ISO 50001 with other ISO management system standards offers a potential for harmonization and process streamlining. This synergy between ISO 50001, ISO 9001 (Quality Management), and ISO 14001 (Environmental Management) facilitates a holistic approach to sustainability and paves the way for enhanced organizational performance (Sousa Lira; Salgado; Beijo, 2019).

As the global community pivots towards a low-carbon future, ISO 50001's significance is amplified. The future trajectory of ISO 50001, its alignment with international energy goals, and possible refinements to address emergent energy challenges are worthy of contemplation. This standard also proposes avenues for

deeper research and innovation in energy management methodologies (ISO, 2018).

Through a meticulous, evidence-driven examination, it's evident that ISO 50001 substantially improves energy performance, cuts costs, and paves the way for a more sustainable future (ISO, 2018).

The universality of ISO 50001's application emphasizes its flexibility and broad relevance. The framework provides not just guidance but also cultivates a culture of proactive energy management, fostering organizations to evolve beyond mere compliance. This spirit of proactiveness is reflected in the ethos of ISO 50001, which champions continuous improvement over mere static benchmarks (ISO, 2018).

In wrapping up, ISO 50001 is more than a standard; it is a tool geared towards energy efficiency and possibly reduced carbon footprints. As organizations, nations, and the global community grapple with the pressing challenges of climate change, tools like ISO 50001 offer solutions. They underscore the potential of collective action, rooted in evidence and structured guidance, to sustainable energy management and a greener future for the industry.

3.2 O&G initiatives references

3.2.1 ISO TC 67

ISO is renowned for its pivotal role in orchestrating standards that not only cater to the global commercial environment but also ensure safety and foster international cooperation. One such crucial committee under the aegis of ISO is the Technical Committee 67 (ISO/TC 67). This committee serves a paramount purpose in harmonizing and managing worldwide standards specifically tailored to the oil and gas industry, with a pronounced aim of achieving international conformity for oil and gas products (ISO, 2023a).

ISO/TC 67 was traditionally titled "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries." However, in keeping with the dynamic shifts in the energy landscape and recognizing the importance of transitioning to sustainable energy sources, the committee underwent a rebranding. As of November 2021, it adopted a more encompassing title: "Oil and gas industries including lower carbon energy," with a broader scope to standardize areas not only in the realm of oil and gas but also encompassing petrochemical and lower carbon energy activities (Hamran *et al*., 2022).

The main characteristic of ISO/TC 67 is further accentuated by its diverse membership, comprising industry professionals from various nations, bringing together a multitude of professional experiences and backgrounds. All members converge on the platform of ISO/TC 67, driven by a collective aspiration for advancements in safety, uniformity, and the international application of their products within the industry (ISO, 2023a). As of January 2022, this committee boasts 35 participating members, supplemented by 27 observing member countries. Their concerted efforts have culminated in the publication of 227 ISO standards, with an additional 39 new or revised ISO standards currently under development (Hamran *et al*., 2022).

Delving deeper into the specifics, ISO/TC 67's scope revolves around the standardization in the oil & gas sector, including petrochemical and lower carbon energy activities. However, it's worth noting certain exclusions, such as aspects related to petroleum products, natural gas, hydrogen technologies, biogas, carbon dioxide capture, transportation, and geological storage. These particular spheres are addressed by other ISO technical committees (ISO, 2023c).

In conjunction with the overarching focus of ISO/TC 67, there is a specialized sub-committee, ISO TC67/SC7. This committee primarily deals with standardization concerning offshore structures utilized in the oil & gas and lower carbon energy sectors. The purview of this sub-committee includes aspects related to the substructure for oil and gas, offshore structures promoting the use of lower carbon/renewable energy sources, offshore CO_2, H_2, NH_3 storage, platform re-purposing, its installation and removal, and the extension of its life (ISO, 2023d).

It is essential to underline that specific requirements tailored to different energy industries, such as offshore wind turbine support structures, draw from overarching industry standards. Despite its achievements, TC 67 faces challenges related to emerging technologies, environmental concerns, and the need to adapt to evolving industry landscapes (ISO, 2023c).

ISO TC 67 has emerged as a cornerstone of global standardization in the oil and gas industry, championing safety, environmental stewardship, and operational efficiency. Its significant contributions to the development and implementation of internationally recognized standards have fostered a culture of excellence and continuous improvement across the sector. As the industry evolves, TC 67's efforts to address emerging challenges and promote sustainable practices will remain instrumental in shaping the future of the oil and gas industry.

3.2.2 IPIECA

The International Petroleum Industry Environmental Conservation Association (IPIECA) stands at the forefront of promoting environmental stewardship and sustainable practices in the oil and gas industry. Since its establishment in 1974, IPIECA has evolved to become a paramount figure in guiding the oil and gas sector on environmental and social fronts. Originating as the International Petroleum Industry Environmental Conservation Association, its objectives and scope expanded, leading to a shift in its recognition simply as IPIECA in 2002, underscoring its broader commitment beyond environmental conservation (United Nations, 2023).

IPIECA's inception was in response to the formation of the United Nations Environment Programme (UNEP), marking the oil and gas industry's commitment to global environmental and social imperatives. One of its core programs is focused on greenhouse gas (GHG) emissions mitigation. IPIECA collaborates with member companies and partners to develop methodologies for measuring, reporting, and reducing emissions. Additionally, the association advocates for the adoption of energy-efficient technologies, carbon capture and storage (CCS) solutions, and renewable energy integration across operations

(IPIECA, 2023).

Governed by a General Committee of senior representatives from member entities, IPIECA's organizational structure allows it to tap into a diverse range of expertise. The General Committee is supplemented by an Executive Committee, responsible for determining the association's overarching strategy and direction. Further enriching its capabilities, the association relies on numerous specialists working groups, which focus on areas ranging from biodiversity and climate change to social responsibility and water (Climate Initiatives Platform, 2020).

At its core, IPIECA operates on the principles of collaboration, knowledge-sharing, and engagement. Recognizing the interconnected nature of the challenges faced by the industry, its strategy underscores a holistic and integrated approach to address these challenges. This is exemplified in their dedication to anticipate industry challenges, enable enhanced environmental and social performance, and credibly inform global policies and stakeholders on relevant issues (IPIECA, 2023).

IPIECA's role as a conduit for communication between the oil and gas industry and the UN cannot be understated. Acting as the industry's primary channel of dialogue with the UN, it facilitates an invaluable exchange of insights, challenges, and solutions (Climate Initiatives Platform, 2020). This dialogue has manifested in several ways, including virtual stakeholder meetings that convene members from civil society, academia, financial institutions, and more. Such initiatives serve to gather diverse perspectives, ultimately guiding IPIECA's strategies and actions (IPIECA, 2023).

In the present era, marked by the urgency of climate change and a paradigm shift towards sustainability, the O&G sector finds itself at a crossroads. IPIECA, through its robust framework and commitment to collaboration, offers the industry a roadmap. By championing sound practices, fostering understanding, and working in harmony with stakeholders, it envisions an oil and gas industry that aligns with society's environmental and social aspirations (Climate Initiatives Platform, 2020).

In summary, IPIECA stands as a beacon for the global oil and gas industry, illuminating the path to responsible environmental and social performance. As the world grapples with unprecedented challenges, the association's role becomes ever more crucial. IPIECA's endeavors to not only address these challenges but to also harness opportunities, ensuring that the oil and gas industry remains responsive, adaptive, and, most importantly, sustainable for future generations. Through collaboration with key stakeholders and a commitment to continuous improvement, IPIECA exemplifies the potential for industries to evolve in harmony with global environmental and social priorities (Climate Initiatives Platform, 2020; United Nations, 2023).

3.2.3 OGCI

Founded as a CEO-led consortium, the OGCI brings together 12 of the world's largest oil and gas companies to spearhead the industry's climate response endeavors. As a collective, these companies, which include industry giants like Aramco, bp, ExxonMobil, Shell, and Petrobras, represent approximately 30% of global oil and gas production. United in their purpose, the OGCI members established the OGCI Climate Investments to set up a fund exceeding US$1 billion. This fund is earmarked for investments in businesses, technological innovations, and projects geared towards accelerating decarbonization across diverse sectors, such as energy, industry, infrastructure, and transportation (Climate Initiatives Platform, 2022).

OGCI is unwavering in its support for the Paris Agreement's objectives, particularly the commitment to restrict global warming to under 2°C and, if feasible, limit it to 1.5°C. The member companies of OGCI have set ambitious goals, aiming for net-zero emissions from operations they control. They also strive to extend their influence to achieve similar outcomes in non-operated assets, all within the timeline stipulated by the Paris Agreement. In their pursuit of these objectives, OGCI members have pledged to reduce upstream methane emission intensity to below 0.20% by 2025. They are also dedicated to diminishing the carbon intensity from upstream operations to 17.0 kg CO_2e per barrel of oil equivalent by 2025 and committing to eliminate routine flaring by 2030 (Climate Initiatives Platform, 2022).

The path to achieving OGCI's objectives lies in pioneering and scaling solutions such as efficiency measures, best practice dissemination, electrification, and advancements in hydrogen, carbon capture utilization and storage (CCUS), methane leak detection, bioenergy, and natural climate solutions (NCS). Since 2017, OGCI has reported a 40% reduction in upstream methane emissions and a 17% decrease in upstream carbon intensity, a testament to their unwavering commitment (OGCI, 2023a).

To extend their impact beyond the member companies, OGCI engages in capacity building, partnerships, and innovative ventures that focus on pivotal technologies and areas with the most potential for emission reductions, such as CCUS, and methane emissions reduction (OGCI, 2023b).

The organization's strategy rests on three pillars (OGCI, 2023b):

- Aiming for net-zero operations by providing a collaborative space for member companies.
- Leading the industry by actively reaching out and collaborating with global oil and gas companies on emission-reducing technologies and strategies.
- Helping in the broader societal decarbonization by focusing on solutions that supply energy while drastically cutting greenhouse gas emissions.

OGCI's operational governance is structured to foster collaboration and expedite the industry's response to climate change. This structure includes a CEO Steering Committee, an Executive Committee, and specific Workstreams and Taskforces, ensuring a comprehensive and organized approach to their mission (OGCI, 2023b).

In conclusion, the Oil and Gas Climate Initiative stands as a beacon of collaboration and action within the O&G sector. With its CEO-led direction, substantial investment in decarbonization projects, and unwavering commitment to the Paris Agreement goals, OGCI showcases the potential for industry giants to lead the charge against climate change. Through strategic partnerships, technological innovations, and robust governance structures, OGCI is not only reshaping the future of the O&G sector but also making significant strides in the global journey towards a sustainable and net-zero future.

3.2.4 IOGP

IOGP, as a pioneering voice for the oil and gas sector, has served as a forum for the upstream industry since 1974, focusing on a broad range of areas including safety, health, environment, engineering, and more recently, energy transitions. Representing a significant portion of global energy supply, their members span integrated energy companies, national oil companies, upstream operators, and service companies, effectively addressing over 40% of the world's oil and gas demands (IOGP, 2023b).

In the context of standardization, IOGP's commitment to excellence is evident in its extensive library of over 600 reports, many of which revolve around safety, environmental performance, and standardization. Notably, some of the association's most sought-after publications include the "Life Saving Rules", "Process Safety Fundamentals", and "Sustainability Reporting Guidance" (IOGP, 2023a).

Given the rapid changes in the energy landscape and heightened global concerns surrounding climate change, IOGP has strategically repositioned itself to lead the climate change and decarbonization agenda. This involves addressing themes like GHG measurement, energy efficiency, electrification, and CCS. Additionally, broader subjects, such as digitalization, industrial skills, and competency management are now part and parcel of their mandate (IOGP, 2023b).

IOGP's future service is anchored on three pillars (IOGP, 2023b):

- Heritage of Excellence: Building on its legacy, the association continues to emphasize health, safety, security, and environment (HSSE), combined with a commitment to engineering standards, technical best practices, and innovative digital solutions.
- Global Advocacy: IOGP has elevated its advocacy efforts to a global scale, emphasizing agility and foresight in response to stakeholder queries and concerns.
- Energy Transition Directorate: Recognizing the urgency of the climate crisis, the IOGP has inaugurated a dedicated directorate focused on decarbonization. Prioritized initiatives include CCS, Electrification, Energy Efficiency, and reductions in Flares and venting.

The overarching goal is to promote the extensive adoption of technologies that mitigate greenhouse gas emissions both in existing and upcoming oil and gas facilities.

Standards are quintessential in bolstering technical integrity, augmenting safety, fostering cost-effectiveness, and mitigating the environmental repercussions of operations globally. IOGP's role in advocating for the development and application of international standards is crucial, especially in light of recent incidents in the sector (IOGP, 2023c).

Their involvement in the Standards Solution testifies to the significance of standards, not just for the industry but also for national regulators who actively participate in standardization processes. Such standards serve as vital tools for national regulators, aiding in the selection of topics for standardization, the crafting of new standards, and their implementation as a part of the broader regulatory landscape. The overarching objective is to harmonize these standards, thereby reducing disparities in the numerous national regulations faced by IOGP members in their operations across the globe (IOGP, 2023c).

A pivotal component in the development and endorsement of global standards is the involvement of international regulatory bodies. The International Regulators' Forum (IRF) stands as a principal international regulatory forum focused on offshore safety. Comprising seasoned offshore safety regulators from various countries such as Australia, Brazil, Canada, the UK, and the USA, IRF has shown increasing interest in the process of standards development and promotion. Post their Summit Conference in 2011, held in Stavanger, members expressed robust support for the International Organization for Standardization (ISO) standards system and the International Electrotechnical Commission (IEC) for electrical matters. By endorsing these bodies, IRF has emphasized the significance of achieving universally agreed upon offshore standards. Simultaneously, IRF recognizes the indispensable role of pertinent national and regional standards, especially when equivalent ISO or IEC standards are yet to be developed (IOGP, 2023c).

A great example is IOGP's Joint Industry Project (JIP) 35, also known as "Standardization of Offshore Structures Specifications," which was established to address the diverse array of specifications used in the design and construction of offshore structures. These variations often led to inefficiencies, increased costs, and safety challenges in the industry. JIP 35 sought to develop a unified set of standards and guidelines to foster consistency and promote best practices in offshore structures specifications (IOGP, 2023c).

The International Association of Oil & Gas Producers (IOGP) stands as a beacon of responsible practices and industrial collaboration within the oil and gas sector. Through its commitment to safety, environmental excellence, and social responsibility, IOGP plays a pivotal role in driving industry-wide improvements and fostering a sustainable energy future. By embracing collaboration, innovation, and continuous learning, IOGP exemplifies the industry's dedication to sustainable development and its responsiveness to the challenges of the modern world. As the energy landscape evolves, IOGP's contributions will continue to be instrumental in advancing sustainable practices and responsible operations within the global oil and gas industry.

4. Results and discussion

4.1 Standardization environment for energy management in O&G sector

ISO TC 301 is the forefront standardization environment for energy management and ISO 50001 anchors the best practices on establishing EnMS, having a significant importance in a global energy management discourse. However, as the subsequent developments of ISO TC 301 have shown, more detailed guidance is needed so that actors from different sectors can deal with their own specificities. For example, ISO 50005 was developed for the purpose of guiding SMEs and ISO 50009 to multiple organizations.

A sector-specific approach, however, was not adopted by ISO TC 301, being a strategy considered by associations and other organizations within each sector. In the case of the O&G sector, IPIECA and IOGP have worked on developing specific guidance for EnMS implementation according to ISO 50001, as well as a compendium of energy and GHG efficient technologies and practices.

Currently, ISO TC 301 is develop-

ing a standard to specify requirements and guidance to enable organizations to reduce its energy related greenhouse gas (GHG) emissions. In other words, a standard that will work alongside ISO 50001 to help organizations to demonstrate how their improvement in energy performance can be translated as GHG emission reductions.

4.2 Qualitative research with specialists in the sector

The data presented herein stems from a qualitative research endeavor focused on energy management within FPSO platform ships, specifically utilized for oil production in ultra-deep waters. This study has recently been conducted, aiming to shed light on the intricate dynamics of standardization, energy management, and upstream operations in this context. In this article we highlight and generalize the insights gathered from four industrial experts, providing a comprehensive overview of their perspectives on these crucial topics.

Torres (2023) emphasized the crucial role of implementing energy management systems, such as ISO 50001, in offshore production units, highlighting their significance for both the O&G industry and the broader energy sector. He identified the primary challenges faced by companies in ISO 50001 implementation in offshore units, focusing on optimizing electric power generation systems and enhancing the energy efficiency of gas compression systems.

Medeiros (2024) underscored the fundamental importance of EnMS implementation in ensuring the adoption of new technologies for energy rationalization and sectoral decarbonization within the O&G industry. Medeiros stressed the need for early integration of ISO 50001 principles in offshore unit design and operation, emphasizing the utilization of standardized methodologies for validating energy efficiency measures, such as Key Performance Indicators (KPIs) and benchmarking.

Grillo (2024) provided insights into the benefits and risks associated with implementing EnMS in O&G operations. He highlighted potential areas within FPSOs that could benefit from energy efficiency standards, such as emissions impact assessment and infrastructure compatibility standards. Grillo anticipated future standardization efforts in performance measurement and safety standards for energy security, emphasizing stakeholder consensus and the consideration of taxes for addressing negative externalities, such as Pigouvian taxes.

Mc Laughlin (2024) shared expertise in implementing EnMS according to ISO 50001, stressing their significant benefits in enhancing energy performance, cost reduction, and emissions mitigation. He emphasized the importance of focusing on tangible results and securing senior management commitment for effective ISO 50001 implementation in O&G operations. Mc Laughlin cautioned against using ratio-type energy performance indicators and advocated for the development of normalized indicators tailored to FPSO operations. Additionally, outlined a methodology for establishing and monitoring energy baseline indicators using examples, such as regression analysis and Cumulative Sum Control (CUSUM) techniques.

4.3 Cases of energy management as a tool to achieve GHG emission reduction in the O&G industry

According to the Clean Energy Ministerial (2022), different O&G companies worldwide received the Energy Management Insight Awards in the last few years. These achievements underscore the pivotal role of proactive energy management strategies in not only reducing operational costs but also fostering environmental responsibility within the oil and gas industry.

The implementation of ISO 50001 standards has yielded remarkable results in the sector, particularly evident in the achievements of ADNOC in the United Arab Emirates. With 11 offshore sites located near Abu Dhabi, ADNOC has demonstrated a significant commitment to reducing its environmental footprint. Through the application of ISO 50001 principles, the company has achieved an average annual CO_2 reduction of 108,000 metric tons, showcasing the effectiveness of systematic energy management in mitigating greenhouse gas emissions. Similarly, in onshore operations, the Emirate company has made substantial strides in sustainability efforts. With an average annual CO_2 reduction of 97,000 metric tons, ADNOC exemplifies the tangible benefits of integrating energy efficiency measures into operational practices, not only enhancing environmental stewardship but also driving economic savings (CLEAN ENERGY MINISTERIAL, 2022).

In the same way, in Indonesia, the company PT Pertamina Hulu Energi has emerged as a notable success case in the adoption of the ISO 50001 standard within the project West Madura Offshore. Operating key facilities including the Poleng Processing Platform (PPP), Central Processing Platform (CPP), and Onshore Receiving Facility (ORF), the company has prioritized energy management practices to reduce its carbon footprint. With a commendable annual CO_2 reduction of 48,095 metric tons, the Indonesian company exemplifies the transformative potential of standards implementation in driving sustainable development (CLEAN ENERGY MINISTERIAL, 2022).

With more technical details and great results, the Safaniya Offshore Producing Department (SOfPD), a case within the Saudi Aramco Company, demonstrates a dedication to driving energy efficiency initiatives and addressing global emissions challenges. As the world's largest integrated oil company, the project SOfPD proportionate a safe, and eco-friendly O&G production across Sadaniya, Zuluf, and Marjan fields, in Saudi Arabia. Through strategic management applied to practices, SOfPD has achieved relevant outcomes, including a remarkable 38.9% improvement in energy performance over one year, resulting in substantial energy cost avoidance of US$ 7.4 million. Moreover, with a minimal implementation cost of $0.76 million for its EnMS, SOfPD has realized significant energy savings of 25.3 MWh and a notable reduction of 227,000 metric tons of CO_2 emissions over the improvement period, underscoring its steadfast commitment to sustainability and environmental stewardship within the oil and gas sector (CLEAN ENERGY MINISTERIAL, 2023).

The case of the Yumen Field, with operation by Chinese CNPC, was the first oil field in the company to achieve ISO 50001 certification, exemplifies the transformative impact of energy management systems (EnMS) as a crucial avenue for enhancing revenue, curbing expenditure, reducing costs, and amplifying efficiency. Situated in Jiuquan, China, this initiative has yielded satisfactory outcomes, including a 7.42% enhancement in energy performance over three years, resulting in

a total energy cost savings amounting to US$ 6.85 million. Moreover, with a conscientious approach towards sustainability, the company has successfully reduced total CO_2 emissions by 62,500 metric tons over the improvement period, marking a remarkable stride towards environmental stewardship within the energy sector (CLEAN ENERGY MINISTERIAL, 2019).

5. Conclusion and recommendations

The analysis of initiatives to reduce GHG emissions in the O&G sector demonstrates a constantly evolving scenario. With global recognition of the need for climate action, the O&G industry has strived to adopt and adapt to standards that encourage sustainable practices.

ISO TC 301, responsible for energy management and energy savings, has provided valuable tools for the sector. The adoption of these discussions demonstrates a tangible improvement in the energy efficiency of many companies, acting as a facilitator in the emissions reduction journey.

The ISO 50001 standard, which outlines EnMS, can become a cornerstone in the strategy of many companies in the O&G sector to address GHG emission reductions. This standard provides a detailed framework for establishing, implementing, maintaining, and continually improving EnMS, focusing on practices that lead to more efficient operation and a resulting reduction in emissions.

At the same time, ISO TC 67, aimed specifically at equipment and practices in the O&G sector, provides clear guidelines on cleaner and more efficient operations. These standards, when implemented, represent a significant potential for reducing the industry's carbon footprint, mainly collaboratively with other ISO standards.

The contribution of organizations such as IPIECA, OGCI, and IOGP is notable. They act as catalysts, promoting collaboration between leading O&G companies and encouraging the exchange of best practices. These alliances and collaborations have been instrumental in accelerating the transition to more sustainable operations. In the context of energy management and GHG emission reductions, one clear example of this collaboration is the development of guidance documents for the implementation of EnMS according to ISO 50001.

When applied correctly in the O&G sector, as shown by the presented cases of energy management as a tool for GHG emission reduction, ISO 50001 not only supports companies in their transition to a more sustainable operation but also has the potential to bring economic benefits, given the reduction in energy consumption and associated GHG emissions.

However, despite advances, challenges still exist. The heterogeneity of the sector, with companies of different sizes and capabilities, often results in disparities in the adoption of sustainable practices. While some leading companies are ahead in implementing green innovations, others may lag due to resource limitations or lack of knowledge. The dissemination of technical standards can be an important tool for the universalization of systems in favor of more sustainable O&G operations.

Acknowledgments

We would like to express our gratitude to the Fundação Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) (CAPES) and the Institute of Energy and Environment (IEE) at the University of São Paulo (USP).

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Appendix

Qualitative research: Interview forms questions

Milton Simas Gonçalves Torres – Constructibility Consultant Engineer, Petrobras (Brazil), Date: 12/29/2023

Question: How do you perceive the importance of implementing energy management systems, such as ISO 50001, in FPSO operations?

Answer: Extremely important for the Oil & Gas industry and the energy sector in general.

Question: In your experience, what are the biggest challenges faced by companies in implementing ISO 50001 in FPSOs?

Answer: Optimizing electric power generation systems (currently based on gas-consuming aero-derivative turbines) and enhancing the energy efficiency of gas compression systems.

Hércules Medeiros – Deep Offshore Customer Line (Field Operations Support), TotalEnergies (France). Date: 03/02/2024

Question: How do you perceive the importance of implementing energy management systems, such as ISO 50001, in FPSO operations?

Answer: As a professional in the industry, I understand it not so much as relevant, but as fundamental to ensuring the implementation of new technologies that allow for energy rationalization and, consequently, the decarbonization of the Oil & Gas sector. In my view, FPSOs are just one type of offshore installation, but with their increasing use, they should already include the concepts of ISO 50001 in their design.

Question: Are there specific energy performance indicators (EnPIs) that your company or organization currently uses in FPSOs? If yes, can you provide examples?

Answer: Yes, one of them is the SEI, which measures the energy intensity of the plant, and the other, which measures emission intensity. Both are in relation to the BOE, which provides a good basis

for benchmarking. We also have one, not directly related, but which measures flaring intensity. However, in the end, it ends up being captured by the GHG index.

Question: In your opinion, what are the best practices or methods to validate the effectiveness of energy efficiency measures implemented in an FPSO?

Answer: Undoubtedly, associated KPIs and benchmarking. Choosing a methodology for baseline application in the same way across all assets is fundamental, and therefore, standardization through a norm like ISO can be a fundamental guiding milestone.

Filippo Grillo – Ph.D. Candidate, TU Delft (The Netherlands). Date: 02/14/2024

Question: How do you perceive the importance of implementing energy management systems, such as ISO 50001, in FPSO operations?

Answer: The implementation of standards and certificates for such standards in a growing sector, especially in the energy industry, is always risky. While it can share best practices, ensure transparency, and provide references for the organizations involved, it can also block innovation in a period where R&D investments are still heavy. As a result, standard-setting bodies like ISO should understand which technologies are mature enough to be standardized.

Question: Which specific areas within an FPSO do you believe could benefit most from the implementation of energy efficiency standards, such as power generation, processing, etc.?

Answer: This again depends on their level of maturity. My gut feeling from a non-expert standpoint is that enough mature areas are few, due to the ongoing battle between energy sources such as nuclear and hydrogen. Some mature areas can be the impact assessment of the emissions, and the compatibility/ reference standards for the infrastructure (the vessels) and the pipelines.

Question: In your opinion, what are the best practices or methods to validate the effectiveness of energy efficiency measures implemented in an FPSO?

Answer: I am unsure about the technicalities behind the measurement of emissions, but it is important to raise consensus among all stakeholders. The standard setting process in this sector have been barely inclusive in terms of stakeholder A potentially second area of standardization is the so-called Pigouvian taxes, aiming at compensating the negative externalities brought by emissions. It is hard to establish one standardized tax that accounts for all types of negative externalities, but standard setting organizations can suggest methods of calculation and common practices to establish them.

Liam Mc Laughlin – CEO, Gen0 (Ireland). Date: 02/20/2024

Question: How do you perceive the importance of implementing energy management systems, such as ISO 50001, in FPSO operations?

Answer: I have no experience of working with FPSOs but have extensive experience internationally of implementing EnMS and ISO 50001 in the petrochemical sector among many others. Experience shows that an effective EnMs has very significant benefits in terms of improving energy performance, reducing costs and GHG emissions. This happens when the focus is on these results as distinct from implementing an EnMS for the sole purpose of getting it certified.

Question: In your experience, what are the biggest challenges companies face when implementing ISO 50001 in FPSOs?

Answer: In general industry the biggest challenges are getting real commitment from senior management to implement the organisation changes necessary to implement an effective EnMS.

Question: Are there specific energy performance indicators (EnPIs) that your company or organization currently uses in FPSOs? If so, can you provide examples?

Answer: No FPSO experience. Avoid ratio type indicators as they are very misleading in almost all industries. These include specific energy consumption, energy intensity, energy efficiency, coefficient of performance, etc etc. Normalised EnPIs need to be developed.

Question: How are energy baseline indicators (EnBs) established and monitored in your operation?

Answer: For each available energy meters, establish the likely relevant variables for which data is available. Carry our regression analysis to establish he optimism baselines fore each meter and then compare actual energy consumption with expected energy consumption using CUSUM.

Received: 6 November 2023 - Accepted: 8 May 2024.