

Green Management and Energy Transition: Innovative Strategies based on Human Capital for Sustainable Organizational Performance

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Abstract:

This study investigates the influence of adaptation of green human capital (GHC) on firm future sustainability during energy transition, referring to SONATRACH, a reflected mirror of the Algerian energy sector. A qualitative approach was carried out through direct interviews conducted at the International Conference on Green Solutions in the Oil and Gas (O&G) Industrial Sector (May 14–15, 2025, Oran, Algeria). The interviewees consisted of industrial practitioners and academics from Algeria, the UAE, Canada, Saudi Arabia, and Turkey. Thus, for the purposes of this study, we focused on 15 professionals from SONATRACH, ranging from engineers and heads of services to department leaders and directors. The findings illustrate that green human capital (GHC) improves competitiveness, lowers carbon emissions, and increases resilience.

Keywords: Energy Transition, Green Human Capital, Green Management, Organizational Performance, Human Resources Strategies.

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I- Introduction:

Economics has long engaged with questions that extend beyond purely social concerns, notably the preservation and enhancement of natural assets. Since the Industrial Revolution of the late eighteenth century, both orthodox and heterodox economists have developed conceptual and methodological approaches to confront the ecological challenges generated by human activity. (Khelladi, 2021, p. 203). Among these ecological challenges is the so-called “*energy transition*” and the shift toward “*sustainability*” that has become inevitable, as reflected in the academic call to achieve net-zero carbon emissions by 2050 (INTERNATIONAL ENERGY & AGENCY, 2021). Energy transition is the process of abandoning dependence on fossil and fissile energies and shifting toward new, clean, transparent, and green energies that are friendly to the environment to meet the needs of the present generation without compromising the ability of future generations to meet their needs.

Energy transition necessitates significant organizational adjustments as well as technological innovation, especially in the areas of green governance and human resource management. Given this, green management becomes a crucial strategic approach that helps shape businesses toward ecologically conscious operations without sacrificing financial performance (Renwick et al., 2013). At the macroeconomic level, energy availability promotes economic growth and competitiveness across industrial, agricultural, and service sectors, while at the microeconomic level, household access to energy satisfies basic daily needs (Hamiti & Bouzadi-Daoud, 2021). Energy is therefore essential to the economic and social development of a country.

Petroleum institutions are under increasing pressure; given their role as major contributors to greenhouse gas emissions, the necessity to adopt sustainability strategies has been unavoidable. Strategies that are effective, steep reductions of greenhouse gas emissions and environmental footprint (Menéndez-Sánchez et al., 2023, p. 1) are the core of green solutions suggested by academics. This paper focuses on the GHC as a green and strategic method to transition the O&G companies toward sustainable and clean energy that maintains long-term organizational performance. GHC is a strategic involvement for the firm aiming for successful energy transition experience; it guarantees long-term firm performance, innovation and resilience (Jabbour & Santos, 2008). As G. Becker, a pioneer of labor market studies, stated, “*While all forms of capital are important, including machinery, factories, and financial capital, human capital is the most significant*” (Becker, 2002, p. 3). This shift in approaching sustainability using a strategic GHC approach is the most significant strategy for firms to maintain and sustain, leading to economic success and social & environmental respect.

Algeria’s ET is constrained by multiple structural and contextual factors. The economy’s heavy reliance on hydrocarbons, coupled with rising household demand, reinforces dependence on fossil fuels and slows diversification (Bouziani & Belghaoui, 2024, p. 187). Although the country has vast solar potential, high investment costs, limited technological capacity, fossil fuel subsidies, skill shortages related to green-oriented capabilities, and governance inefficiencies continue to hinder renewable deployment. Addressing these financial, technological, institutional, and labor behavioral barriers is essential for a successful transition.

The academic literature in ET within the Algerian context often focuses on shedding light on the delay of Algeria in adopting green energies and the necessity and importance of this shift to drive future resilience. However, the literature failed to provide useful strategies for a successful ET experience. To address this gap, this paper focuses on green human resources strategies as a methodology to adapt an ET and sustainability for long-term organizational performance. Therefore, it is crucial to reconsider HR strategies at the hierarchical level to match sustainability imperatives with both individual and group goals. The socioeconomic and cultural environment of the Algerian energy sector is usually coupled with SONATRACH practices, a leader and a mirror that reflects the Algerian hydrocarbon sector practices. Thus, SONATRACH has been chosen as a case study to investigate the adaptation of green human resources strategies in the ET of the O&G firm in Algeria with the aim of driving long-term firm organizational performance. The main research question posed for this matter is:

What strategic priorities guide the shift from a hydrocarbon-based model toward a sustainable energy future in the Algerian O&G sector's energy transition?

To answer this research inquiry, this study focus on human resource practices in Algerian energy companies incorporating green management concepts, paying special attention to strategic incentives, training regulations, and employee engagement. The following hypotheses are addressed to this research question:

H1: Developing green human capital is a strategic priority that significantly shapes the Algerian O&G sector's energy transition toward a sustainable future.

1. The theoretical framework of the study.

The theoretical framework clarifies the underlying concepts, their interrelations, and their relevance in addressing the central challenge of green management within the O&G sector. It establishes the conceptual foundation for analyzing the extent to which motivation policies, sustainability strategies, and human resource practices influence organizational performance.

1.1. Resource-Based View (RBV)

The Resource-Based View (RBV) provides a robust theoretical foundation for explaining how firms achieve and sustain competitive advantage through the strategic management of internal resources. Early contributions to RBV emphasise that performance differences among firms stem primarily from the heterogeneity of their resources rather than from external market conditions alone (Mahoney & Pandian, 1992). According to this perspective, resources generate sustained competitive advantage when they are valuable, rare, difficult to imitate, and non-substitutable.

Subsequent empirical extensions of RBV highlight the importance of strategic alignment and organisational integration. Rivard et al. (2006) (Przegalinska & Triantoro, 2025) demonstrate that internal resources contribute to firm performance only when they are embedded within firm-specific capabilities and aligned with competitive strategy. Although their study focuses on information technology, the underlying logic is directly applicable to sustainability-oriented resources, suggesting that environmental capabilities yield value only when effectively integrated into organisational practices and strategic objectives.

More recent studies further reinforce the relevance of RBV in contexts characterised by technological and environmental transformation. Przegalinska et al. (2025) show that collaborative artificial intelligence enhances organisational performance when combined with human capital and task-specific capabilities. Their findings confirm that value creation emerges from the complementarity between human resources and advanced organisational assets. From an RBV perspective, this supports the argument that green human capital (GHC), when combined with technological and organisational capabilities, constitutes a strategic resource capable of supporting complex transitions, such as the energy transition.

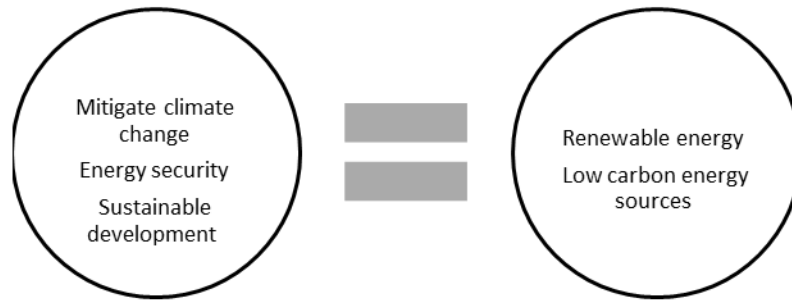
In the sustainability and energy domains, growing attention has been devoted to green human resource management as a mechanism for developing environmentally oriented capabilities. Sahan et al. (2025), through a systematic literature review, demonstrate that green HRM practices positively influence employees' energy-saving behaviours and environmental performance. These findings provide strong empirical support for RBV assumptions, highlighting that environmentally oriented human capital represents a valuable and difficult-to-imitate intangible resource, particularly in energy-intensive industries.

Taken together, these studies confirm the relevance of RBV for analysing green management strategies and energy transition processes. Green human capital satisfies the core RBV criteria of value, rarity, and inimitability, while its contribution to sustainable performance depends on managerial capabilities, leadership orientation, and effective organisational integration.

1.2. Definition of study variables.

- **Energy transition (ET)**

The energy transition in the oil and gas sector has been considered one of the most complex processes and the most significant challenges that O&G companies are dealing with. Oil and Gas global firms, such as BP and Shell, are facing a strategic decision between maintaining traditional fossil fuel operations and actively investing in clean energy technologies (Alsuwailem & Williams-Rioux, 2022). In Scotland, the narrative within the O&G industry supports the development of renewable and low-carbon energy projects, leveraging existing assets and expertise, with public policy playing a crucial role in steering corporate decision-making towards a just transition (Hughes & Zabala, 2023). Brazilian O&G companies continue to prioritise traditional activities rather than green energy investment, regardless of the government's effort in investment in green energies that shaped a mixed policy that is both facilitating and hindering the transition (Noguchi & Nobre, 2023). In Asia, Chinese O&G green transition toward renewable energy sources is aligned with environmental awareness, economic value estimation, and government actions, although resource endowment poses a significant barrier (Gao et al., 2024).



Source: authors own work

Figure 1

These studies collectively underscore the importance of tailored public policies, stakeholder pressures, and strategic corporate decisions in facilitating the ET of O&G companies across different regions. The transition is not only about technological shifts; it also involves retraining and capacity building to ensure a just transition that aligns private and social interests.

• **Green Human Capital (GHC)**

As stated in the Resource-Based View (RBV) theory of the firm, valuable, rare, inimitable, and non-substitutable firm resources can drive sustainable competitiveness (Barney, 1991). GHC is a concept that emerged in the human capital development theoretical framework. GHC refers to the sum of knowledge, skills, and abilities of individuals related to the environment. Firms GHC represents the collective environmental knowledge and innovative capacity of organizations and is increasingly recognized as a strategic tool for human resource managers and policymakers to design initiatives that advance environmental sustainability and green innovation (Qosim et al., 2023)

Empirical studies suggest that individuals with ecological education and awareness exhibit higher concern for the adverse impacts of climate change and greater willingness to participate in pro-environmental initiatives (Isiksal et al., 2022). Firms can develop their GHC through green training programs, environmental awareness campaigns, and sustainability-oriented leadership, which collectively improve both ecological and economic performance outcomes (Renwick et al., 2013). GHC is a strategic tool for developing a sustainable workforce and a catalyst for achieving the Sustainable Development Goals (SDGs) and for mitigating climate change (Ahakwa et al., 2024)

Environmental knowledge

Environmental knowledge, also known as "green knowledge," is a sum of knowledge related to environmental protection, ecological patterns, climate change, and sustainability that is often associated with waste management, energy conservation, and water use efficiency that has emerged as an important player for environmental protection (Brunswick & Chesbrough, 2018). Mobilizing green knowledge in high-impact industries such as oil and gas (O&G) firms represents both an understanding of environmental issues and the capacity to identify viable solutions (Angreani et al., 2022).

Environmental knowledge provides strong ecological awareness not only for stakeholders and policymakers but also for consumers regarding the environmental

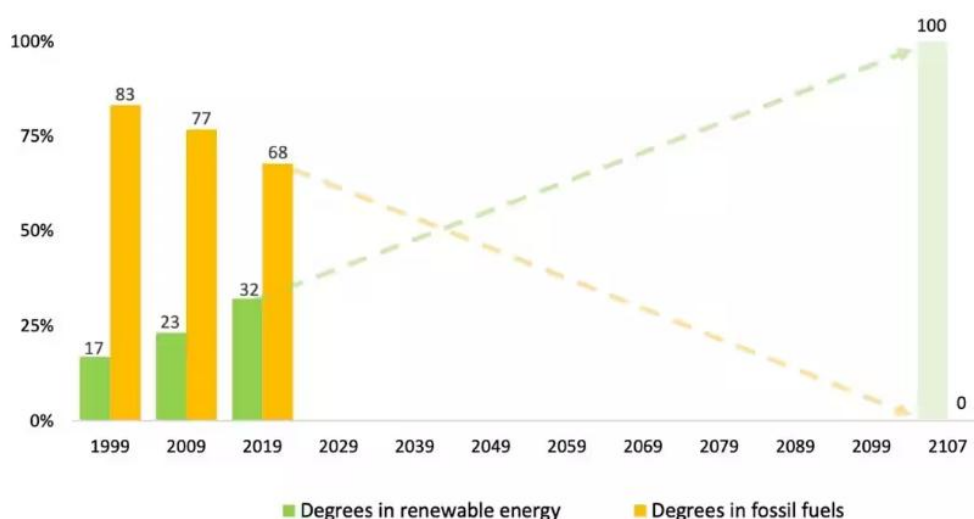
implications of products that influence sustainable consumption patterns (Mohd Suki, 2016). This green knowledge provides awareness for supporting carbon neutrality and enabling firms to integrate environmental responsibility into their core strategies and bridge ecological concerns with long-term performance.

Green skills & education

The adoption of green education alongside technological innovation represents a pivotal driver of organizational sustainability, through which organizations can reduce pollution and generate economic benefits, highlighting the dual ecological and financial value of GHC (Munawar et al., 2022, p. 143).

Renewable energy has created millions of jobs in O&G sector. However, the labour market supply is underqualified with green skills suitable to this energy transition. The O&G global shift toward clean energy requires industry-specific skills. According to the International Energy Agency (IEA), the energy transition is creating jobs faster than they can be filled.

Figure 1 the Future of Degrees Related to O&G Sector



Global share of degree programmes in renewable energy and fossil fuels.

Image: Vakulchuk, R. and Overland/Energy Research & Social Science

Source: World Economic Forum (2024), <https://www.weforum.org/stories/2024/04/green-skills-gap-educational-reform-renewable-energy/>

The LinkedIn Global Green Skills Report in 2023 indicated that only one in eight people possess climate-relevant skills. Another study have been done by the Norwegian Institute of International Affairs (NUPI) on 18,400 universities across 196 countries reveals that higher education remains skewed toward fossil fuels, with 68% of energy-related degrees focused on fossil fuels and only 32% on renewables. While Asia-Pacific, especially China and India, shows progress, many regions, particularly Latin America, Africa, the Middle East, and Eurasia, still offer few clean energy programs despite soaring demand for green skills. With this worldwide performance, clean energy degrees would not dominate until 2107.

• Firm Sustainability

Pressure is increasing among O&G firms to align their business models with sustainability trends and contribute to the global decarbonization agenda. Strategies like innovative technologies, multi-stakeholder collaboration and regional industrial clusters are

key elements of their sustainability strategies (Menéndez-Sánchez et al., 2023). The adoption of sustainable procurement practices is crucial for improving the environmental, social, and economic performance of O&G firms (Ekiugbo & Papanagnou, 2016).

The Basque O&G companies are undergoing a significant energy transformation by integrating clean technologies into their research and development activities, thereby contributing to the United Nations' Sustainable Development Goals (SDGs) and fostering a local innovation ecosystem that promotes low-carbon technologies (Menéndez-Sánchez et al., 2023). O&G companies in Russia are also contributing to reaching SDGs, particularly SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action), although challenges remain in aligning their corporate sustainability reports with United Nations indicators (Titova et al., 2023)

Furthermore, there is inconsistency in sustainability reporting practices across the industry, with a notable gap in supply chain management indicators, which hinders comprehensive sustainability assessments (Dai et al., 2024). Collectively, these efforts to reach SDGs highlight the complex yet critical role of O&G companies in advancing firm sustainability and supporting the global transition to a sustainable energy future.

Key Concepts and Strategic Insights for the Algerian Oil & Gas Sector

Concept	Key Authors	Main Insights	Value Added for Oil & Gas Sector (Algeria)
Green Management	Shrivastava (1995); Hart (1995); Daily & Huang (2001)	Firms must integrate ecological concerns into strategy; competitive advantage linked to sustainability.	Encourages transition from compliance-based practices to strategic environmental integration.
Human Capital	Becker (1993); Barney (1991); Wright & McMahan (2011); Renwick et al. (2013)	Employees as change agents; skills and competencies as sources of sustained competitive advantage.	Necessitates workforce training, empowerment, and green leadership for real transformation.
Sustainable Performance	Elkington (1997); Lozano (2008); Porter & Kramer (2006); Eccles et al. (2014)	Long-term resilience stems from balancing economic, environmental, and social goals.	Provides legitimacy and competitiveness through energy diversification and stakeholder trust.
Integrated Framework	Synthesized from above	Triangular model linking Green Management, Human Capital, and Sustainable Performance.	Offers actionable roadmap for Algerian oil & gas companies to reconcile growth with sustainability.

Source: authors own work

1.2 Green management practices (GMP) and future sustainability in the O&G companies

The literature defines *green management* as a set of managerial practices that integrate environmental considerations into overall business strategy, enabling firms to pursue both environmental and economic objectives. Prior studies indicate that green management contributes to cost reduction, revenue enhancement, improved eco-efficiency, lower carbon emissions, and the strengthening of human resources (Molina- Azorín et al., 2009). Achieving organizational sustainability, however, requires more than operational adjustments; it depends on active stakeholder engagement and the reconfiguration of internal processes (Shrivastava & Hart, 1995). Practices such as waste minimisation, energy

efficiency, and sustainable resource use are therefore essential for translating environmental strategies into operational outcomes, particularly through employee training and involvement in sustainability initiatives.

In the Algerian context, oil and gas companies have increasingly adopted strategies aimed at sustainable diversification in response to energy transition imperatives. This orientation is shaped by Algeria's dual position as a hydrocarbon-dependent economy and a country endowed with significant solar energy potential. Despite these strategic opportunities, the effective implementation of green management remains limited. Initiatives related to green skills development, environmentally oriented training, and green recruitment practices are still insufficient, indicating a limited recognition of the strategic role of green human capital (GHC) in ensuring long-term sectoral sustainability. The existing literature on Algeria confirms this gap, as empirical research on the integration of green management practices within the energy sector remains scarce.

International evidence increasingly highlights GHC as a critical driver of energy transition and long-term organisational performance. Based on a bibliometric analysis of 1,933 publications, Strielkowski et al. (2024) demonstrate that investment in human capital is essential for sustainable growth in energy companies, with skilled employees playing a central role in advancing renewable energy pathways. The persistent gap between environmental strategic intent and effective implementation is often attributed to leadership-related human capital constraints. Recent studies show that executives' environmental education and professional experience significantly influence whether green initiatives lead to substantive innovation or remain symbolic (Luo, Yang, et al., 2026). Limited environmental expertise among top managers increases the likelihood of symbolic practices aimed at legitimacy rather than meaningful sustainability outcomes.

Leadership styles further shape the development of green competencies and environmental innovation. In particular, green inclusive leadership has been shown to enhance employees' green creativity, with GHC and employee voice acting as key mediating mechanisms (Asghar, Bangash, et al., 2025). These findings suggest that beyond formal GHC policies, participatory managerial approaches are essential to the effective implementation of sustainability strategies.

Finally, cross-country studies confirm the broader impact of human capital on energy transition processes. Achuo et al. (2024), analysing 134 countries, find that human capital development positively influences energy transition outcomes, although effects vary across regions. Jirakraisiri et al. (2021) demonstrate that GHC, as a component of green intellectual capital, mediates the relationship between green strategic intent and green process innovation performance, often exceeding the influence of organisational and relational capital. Similarly, Zhang and Kong (2022) identify human capital, alongside technological innovation and energy pricing, as a key lever for reducing fossil fuel dependence and promoting clean energy adoption in OECD countries. Collectively, these studies suggest that green management practices constitute a strategic source of competitive advantage for oil and gas companies by supporting economic resilience, social responsibility, and environmental performance (Zhang & Kong, 2022).

2. Methodology

2.1 Research Design

This study adopts a qualitative research design grounded in a post-positivist epistemological perspective, which is appropriate for examining complex organisational

phenomena such as green management, energy transition, and human capital development in the oil and gas sector. A hypothetico-deductive approach guides the research, allowing theoretically informed assumptions regarding the strategic role of Green Human Capital (GHC) to be examined through empirical evidence. Given the exploratory nature of the research and the institutional specificity of the Algerian energy sector, a single-case study approach was employed. The study focuses on SONATRACH, Algeria's national oil and Gas Company, enabling an in-depth analysis of organisational practices and managerial perceptions related to sustainability and energy transition within a real-life context.

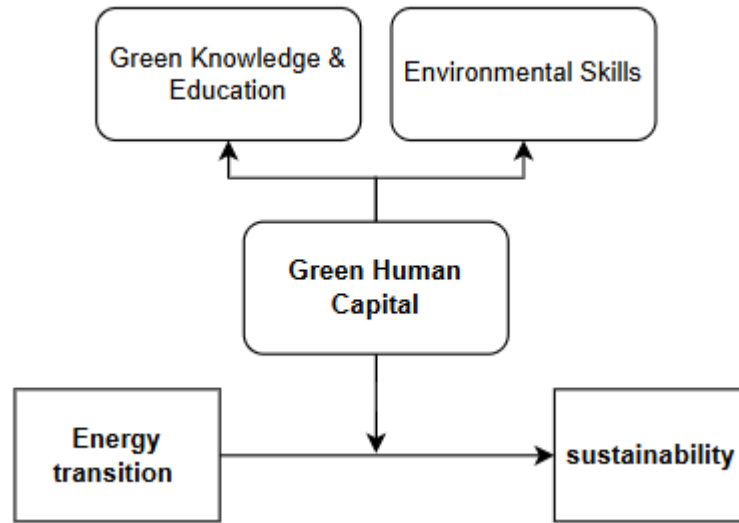
2.2 Data Collection

Primary data were collected through semi-structured interviews conducted during the International Conference on Green Solutions in the Oil and Gas Industrial Sector held in Oran, Algeria (14–15 May 2025). This setting provided access to professionals actively involved in sustainability initiatives and energy transition strategies. A total of 15 interviews were conducted with SONATRACH employees representing multiple hierarchical levels, including engineers, heads of services, department managers, and senior executives. Participants were drawn from operational sites in Hassi Messaoud, Skikda, Algiers, and Oran, ensuring functional and regional diversity. Additional interviews were conducted with international energy experts from the UAE, Saudi Arabia, Canada, and Turkey to provide broader strategic perspectives on SONATRACH's role in the global energy transition. All interviews were conducted with participants' consent, audio-recorded, and transcribed verbatim for analysis.

2.3 Data Analysis

This study employed thematic analysis as the sole qualitative data analysis method. Thematic analysis was selected due to its suitability for identifying, analysing, and interpreting recurring patterns within qualitative interview data, particularly in studies examining organisational strategies and human capital practices. The analysis followed a systematic and iterative process. First, the interview transcripts were carefully read to achieve familiarisation with the data. Initial codes were then generated by identifying meaningful segments of text related to green skills, sustainability-oriented human resource practices, energy transition challenges, emission reduction, and competitiveness. In the next phase, related codes were examined and organised into broader categories by identifying conceptual relationships among them. Finally, these categories were refined into overarching themes that captured how Green Human Capital contributes to sustainability performance and competitive advantage during the energy transition. The resulting themes provided the analytical basis for interpreting participants' statements and linking empirical findings to the study's theoretical framework. All participants were informed of the purpose of the study and participated voluntarily. Confidentiality and anonymity were assured, and interview data were used exclusively for academic research purposes.

Figure 1: Research Model: Linking Green Knowledge, Skills, and Human Capital to Energy Transition and Organisational Sustainability

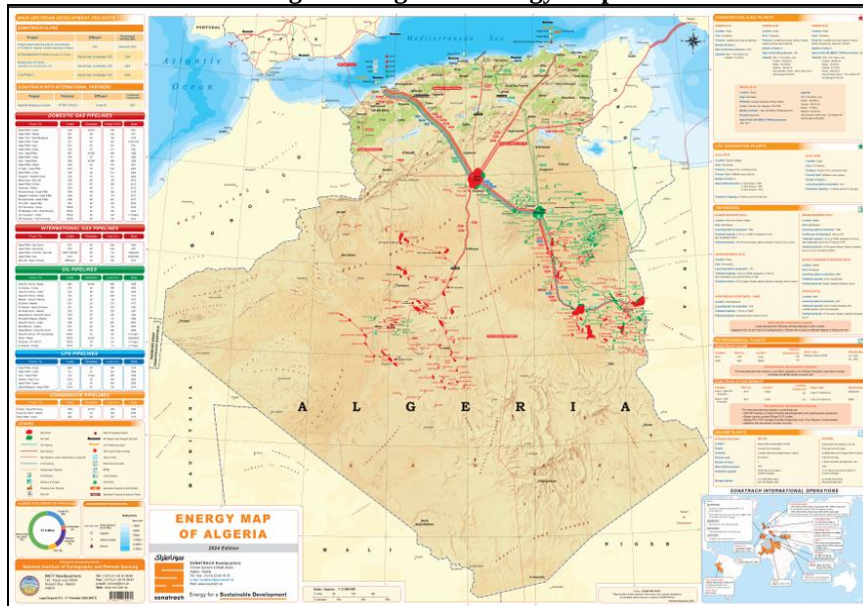


Source: Authors own work

3. Discussion and Analysis

- Overview of O&G Algerian sector led by SONATRACH

Figure 2 Algerian Energy Map

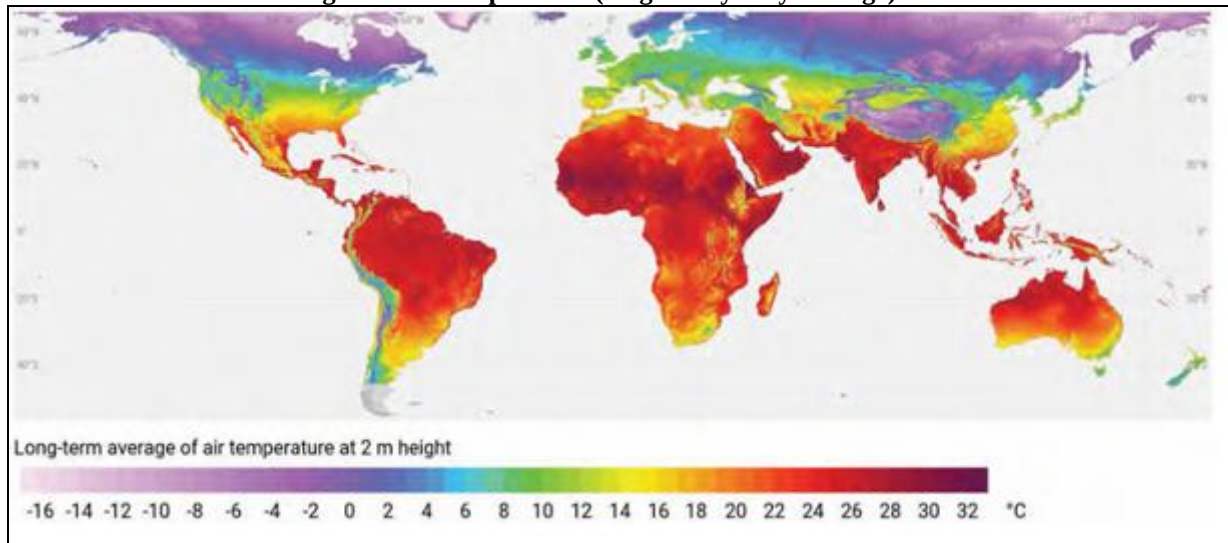


Source: <https://sonatrach.com/wp-content/uploads/2025/06/ENERGY-MAP-OF-ALGERIA-1-4.pdf>

The outcomes of the COP26 Glasgow conference underscored the urgency for all nations to adopt more ambitious targets for reducing emissions in order to limit global temperature increases to no more than 1.5°C above pre-industrial levels. Surpassing this threshold is expected to trigger severe and irreversible climatic consequences. For Algeria, a country heavily reliant on hydrocarbons, this call is particularly pressing. There is a growing necessity to accelerate investments in green initiatives to curb greenhouse gas

(GHG) emissions and advance sustainable development (Dey et al., 2022; Sarpong et al., 2023; Yolcan, 2023).

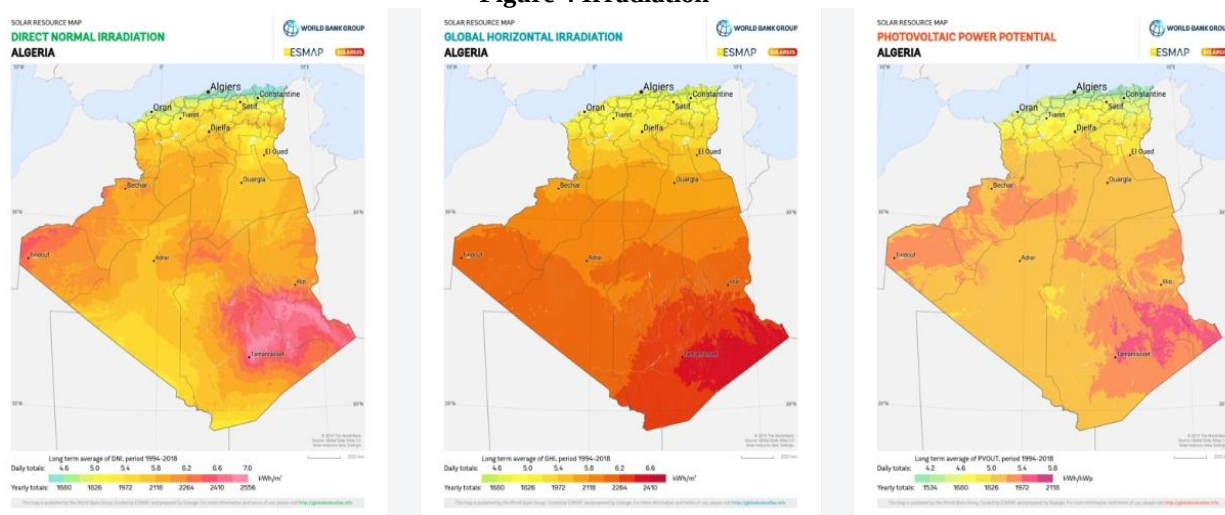
Figure 3 Air temperature (long term yearly average)



Source: ESMAP. 2020. *Global Photovoltaic Power Potential by Country*. Washington, DC: World Bank.

Empirical evidence highlights the vulnerability of Algeria to climate change: the country's average annual temperature rose from 23.77°C between 1999 and 2009 to 24.10°C in the period (2010-2022), an increase of 0.33°C within less than 23 years. Projections indicate a further rise of approximately 1°C by 2050 (Bouchenafa, 2025, p. 79). These dynamics reinforce the imperative for Algeria's O&G sector to undergo a structural transformation, aligning national energy policy with global decarbonisation pathways (Bouchenafa, 2025, p. 79).

Figure 4 Irradiation



Source: <https://globalsolaratlas.info/download/algeria>

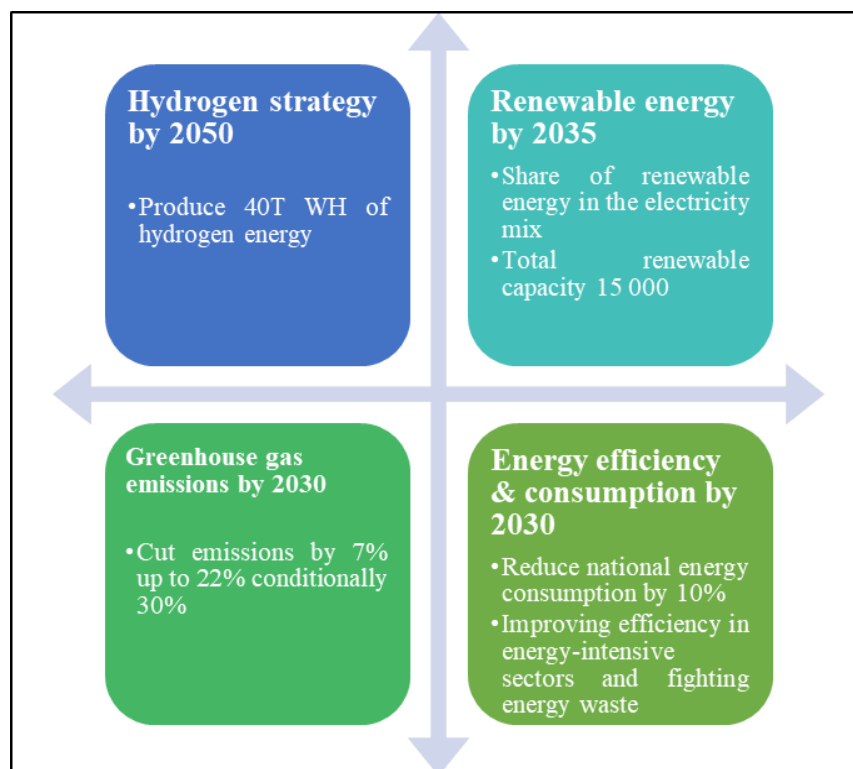
Algeria possesses one of the world's most significant solar energy potentials. Despite this, in 2015 the government revised its renewable energy strategy by postponing the deployment of Concentrated Solar Power (CSP) and reducing its capacity target from 7,200 MW to 2,000 MW. At the same time, the target for solar photovoltaic capacity was

raised to 13,575 MW, accounting for about 62% of the planned renewable energy mix (Bouziani & Belghaouti, 2024, p. 179). Estimates further underline the scale of this opportunity: Algeria's solar potential is equivalent to nearly 37,000 trillion cubic meters of natural gas, which is more than eight times the country's proven gas reserves. Unlike natural gas, however, solar energy is renewable and inexhaustible, positioning it as a cornerstone for the country's long-term ET (Hamaz & Ait Taleb, 2020)

Algerian O&G sector objectives

Data from the National Agency for Promotion and Rationalization of Energy Use, Algeria (APRUE) indicated that the objectives of the Algerian oil and gas sector are to implement a hydrogen strategy by 2050 aimed at producing 40 TWh of hydrogen, to achieve by 2035 a renewable energy capacity of 15,000 MW and increase its share in the electricity mix, to reduce greenhouse gas emissions by 2030 with a target cut of 7–22% and conditionally up to 30%, and to enhance energy efficiency and consumption by 2030 through a 10% reduction in national energy use, improving efficiency in energy-intensive sectors, and reducing waste.

Figure 5 Sontrach future objectives toward sustainability



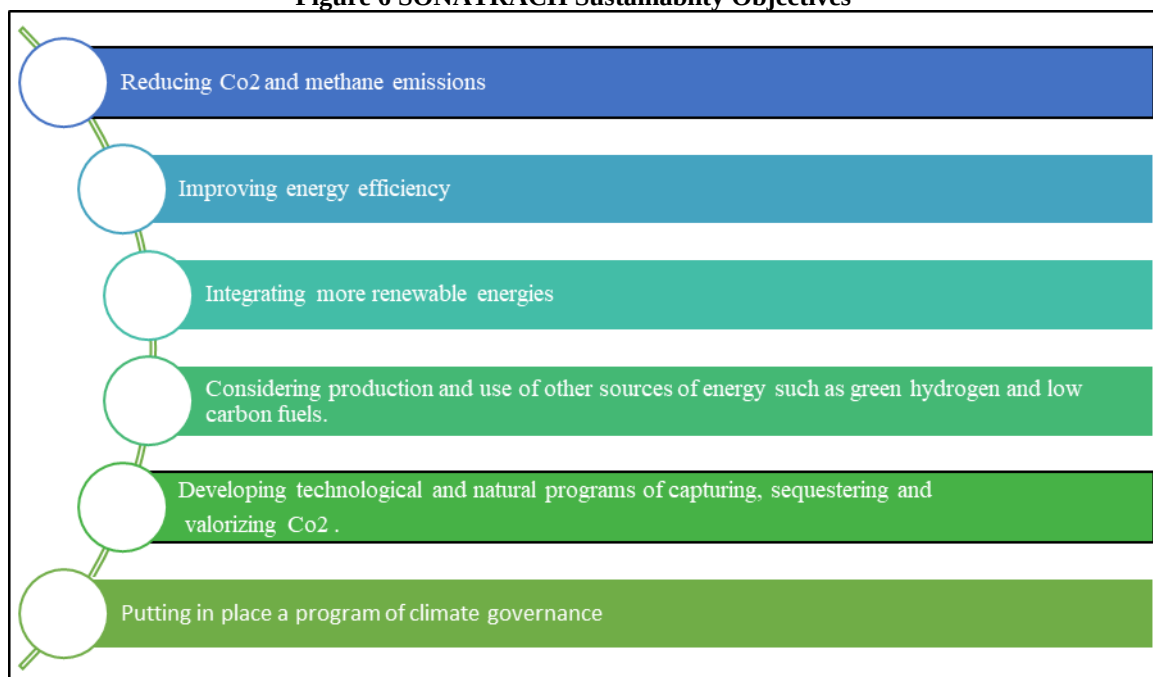
Source: adopted from National Agency for Promotion and Rationalization of Energy Use, Algeria (APRUE)

Objectives of SONATRACH

Rachid Hachichi, Chairman and CEO of SONATRACH, stated, "We want to achieve balance between our GHG emissions and their elimination through natural and technological sinks in the second half of the century (2025)." The country's prospects for

developing clean energy with zero carbon emissions are especially bright coupled with the action plan for SONATRACH is a part of a plan to diversify its energy mix, which includes renewable energy sources in addition to natural gas. Due to Algeria's abundant solar potential, extensive electrical grid, and national and international natural gas transportation infrastructure. The primary pillars of SONATRACH's transition strategy to renewable energy are the following objectives: first, enhancement of energy efficiency through audits conducted at the activity level. Second, building photovoltaic stations to meet the production sites' energy requirements. Third, initiation of pilot programs for green hydrogen production and transportation. Last, reducing the company's carbon footprint by lowering flared gas at its production facilities.

Figure 6 SONATRACH Sustainability Objectives



Source: Authors own work based on data from (<https://sonatrach.com/fr/>)

• ***GHC as a Strategic Tool for O&G Energy Transition***

SONATRACH human capital development strategic orientation toward energy transition focuses on matching workforce skills with skills related to sustainability, in which the HCD strategy is aligned with sustainability objectives. The company is known for the extensive investment in employee training and development. The company invested 5,672 million Algerian dinars in training activities in 2023. A total of 28,614 employees received training courses during 2023, representing 43% of the total workforce, with a rate of 301,029 hours of instruction per day. This massive expenditure shows the interest of SONATRACH in building a skilled-matched workforce for the green energy transition. The aim of the company is to design solid, skilled, ready laborers for the changing energy scenario. The company aims to develop green skills, technical knowledge, and innovation-oriented abilities to assist in transitioning away from a heavily hydrocarbon-reliant model and towards a more diverse and sustainable energy transition. SONATRACH is aware that skills development is necessary for successful strategy transition (SONATRACH, 2023).

The company's main objectives are reducing carbon emissions, optimizing the use of natural resources, and safeguarding the well-being of future generations, all of which are

closely related to international sustainable development directives. The mission of the company is to secure energy for Algeria under international regulations and SDGs. SONATRACH in collaboration with stakeholder impact, environmental stewardship and green management practices is committed to engaging in long-term sustainability projects, societal acceptability, and project legitimacy. The goal is to balance between massive energy demands and ecological responsibility .

Table 1 SONATRACH projects

Category	Actions in 2023 (Projects)	Strategic Implications
Solarisation of Industrial Sites	Launch of BRN Phase 2 Photovoltaic plant (10 MW) Feasibility study for MLE Photovoltaic plant (10 MW) Feasibility studies for solarisation of life-bases (Tin Fouyé Tabarkoukt & Gassi El Agreb)	Diversifies energy supply at production sites, reduces dependence on fossil fuels, and aligns with Algeria's 1.3 GW solar capacity target by 2030.
Green Hydrogen Projects	Pilot projects in maturation phase Planned reference plant with KfW (Germany) Pilot project with VNG AG (50 MW) for production, storage, and transport BRN Green Hydrogen project (FEED study ongoing)	Positions SONATRACH in the emerging hydrogen economy, supports decarbonisation of gas operations, and strengthens export potential to Europe.
International Partnerships	Collaboration with TotalEnergies (solarisation, low-carbon hydrogen, R&D) Strategic agreements with Eni (renewables, hydrogen, emissions reduction) Participation in global projects (H2 South Corridor, TaqatHy, World Bank & AfDB renewable programs)	Expands technological know-how, leverages international financing, and integrates Algeria into transnational renewable and hydrogen value chains.
Strategic Participation	Active role in ADIPEC 2023, promoting decarbonization, gas as a transition fuel, and flare reduction initiatives	Enhances SONATRACH's visibility as a regional energy transition actor and signals alignment with global decarbonisation narratives.

Source: adopted from sontrach report

Results

The study outcomes confirmed the importance of adopting green human capital strategies to promote a sustainable future during the energy transition. SONATRACH's qualitative findings show that embracing green technologies in the O&G sector's sustainable transition should be in parallel with training staff about renewable energy and environmental management to provide an ecological awareness that makes both the environment and the company more competitive.

Valid agreement evidence has been shown among SONATRACH practitioners and policymakers that cultivation of green human capital plays a crucial role in enhancing sustainable performance within the oil and gas industry. SONATRACH fosters the imitation of clean technologies to help the environment by lowering emissions and expenses, such as carbon capture and storage, energy-efficient systems, and solar-powered

facilities, by mobilizing its workforce to participate in national and international scientific events like seminars, expositions, and internships.

SONATRACH is doing immense work to collaborate with universities and laboratories to train its workforce to better align with the company objectives toward sustainability. This industry-university twinning is seeking one objective, which is human development with systematic training and upskilling programs aimed at improving skills in sustainability, energy efficiency, and digital innovation.

Research showed that SONATRACH is in compliance with ESG standards, and the inclusion of sustainability in its HR initiatives made it more appealing to global investors and strengthened its position as a regional leader in renewable energy. Lastly, the research indicated that green human capital makes organizations more resilient, which lets them diversify their energy portfolio, reduce their reliance on hydrocarbons, and adjust to changing market and regulatory conditions. These results show that putting money into people is just as important as putting money into technology to move the energy transition forward.

The shift to sustainable energy has technical, economic, and societal problems that need to be addressed. The main strategy recommended for a faster transition is a skilled workforce with green knowledge in renewable technologies, energy efficiency, and carbon management. In Algeria, where electricity makes up about 30% of energy use, a completely renewable system is not possible in the near future. GHC makes it possible to make a practical transition by using natural gas to provide low-carbon power, making the system more flexible, and protecting human development goals like energy security and food security.

SONATRACH is following the same practical approach used by international O&G firms to accelerate the energy transition, focusing on wise resource use and fostering R&D investment in green technologies to come up with new carbon-free or low-carbon options like hydrogen and investments in the workforce's green skills and knowledge. Together, these factors will speed up the energy transition and guarantee energy security.

Investment in GHC not only helps O&G firms to shift toward sustainability but also helps the country by creating new jobs (green jobs) and encouraging long-term sector performance. For Algeria, a country where the economy is fully based on hydrocarbons, this made the mission so sensitive and urgent. SONATRACH, a leader in this rentier economy, has committed all the resources available to reach these economic, social, and environmental objectives. A workforce with green skills is SONATRACH's strategy toward a resilient and sustainable future for Algeria.

In the end, a workforce with green skills is a strategic tool that helps Algeria move toward a resilient and sustainable energy transition (ET) by balancing the energy mix and encouraging the use of new technologies. Despite this awareness and calls to action, several problems emerged with modern green technology integrations, people's old mindsets that

hate change, the lack of specialist training programs, and high costs. These results confirmed the company's desire to change old hydrocarbon infrastructures while keeping energy security and economic stability. So, even while SONATRACH's work shows improvement, long-term success depends on regular investments in people, new ideas, and government support.

Recommendations

The evidence points to several important recommendations for strengthening the role of green human capital in the energy transition. At the policy level, governments should provide targeted financial incentives and establish clear regulatory frameworks to encourage large-scale investment in sustainability and skills development. This would reduce uncertainty and accelerate industry-wide adoption of green practices. At the organizational level, companies should systematically embed sustainability-related competencies into recruitment, training, and performance evaluation systems. Such integration would align employee capabilities with long-term energy transition objectives.

Further, organizations should invest more heavily in technological innovation through partnerships with universities and research institutions, particularly in renewable energy, carbon capture, and digital technologies such as AI and IoT. Finally, a cultural transformation is necessary, where sustainability is not viewed merely as compliance but as a strategic advantage. This requires leadership commitment, continuous employee engagement, and mechanisms to foster cross-functional collaboration that embeds sustainability across the organizational value chain.

This study has limitations even though it provides insightful information about how Green Management and creative HR practices can improve sustainable performance in the O&G industry. The availability of primary data limited the research's potential for interpretation and result generalizability outside of the context under study. A more thorough quantitative design might be used in future investigations, such as extensive surveys aimed at workers in the energy industry at different organizational levels. When evaluating the long-term impacts of green policies on employee engagement and organizational performance, longitudinal methods would also be very helpful.

Furthermore, a deeper comprehension of the transferability and contextual adaptation of Green Management practices would be possible by expanding the analysis to a comparative perspective, whether across various Maghreb nations or within other extractive industries dealing with comparable environmental and socioeconomic challenges. In addition to bolstering theoretical contributions, such research directions would produce useful information that practitioners and policymakers could use to navigate the challenges of sustainable transformation.

Research Limitation and Implications

This study's findings are constrained by the qualitative, single-case study design, focusing exclusively on SONATRACH, a large, state-owned national oil and gas company. While this in-depth approach provides rich insights into green human capital development and sustainability practices, the organisational and institutional specificity of SONATRACH limits statistical generalisability to other firms.

SONATRACH operates within a rentier economy and possesses structural characteristics: such as strong state involvement, long-term investment horizons, access to public financing, and a strategic mandate encompassing national energy security and socioeconomic stability that differ markedly from private or medium-sized energy companies. These characteristics influence the scope and pace of green human capital development and shape the feasibility of large-scale sustainability initiatives.

Accordingly, the findings are primarily applicable through analytical generalisation to organisations with similar attributes, such as other state-owned or large-scale energy firms in emerging or resource-dependent economies. Transferability to private or smaller firms requires careful consideration of differences in governance structures, financial capacity, workforce dynamics, and strategic priorities.

The managerial implications derived from this study are context-dependent and most relevant for organisations comparable to SONATRACH. For large, state-owned energy companies undergoing an energy transition, the study underscores the strategic importance of embedding sustainability-oriented competencies into core human resource functions, including recruitment, training, performance management, and leadership development. Specifically, such organisations may benefit from:

- Systematically integrating green competencies into workforce planning and training programmes;
- Aligning managerial evaluation systems with sustainability objectives;
- Fostering cross-functional collaboration to support innovation and organisational learning.

For smaller or privately-owned firms, these implications may require adaptation due to differences in organisational resources, governance, and strategic mandate. Context-specific adjustments are therefore essential to effectively develop green human capital and leverage it for organisational competitiveness and sustainability.

Conclusion

According to this study, the oil and gas (O&G) industry's sustainable performance is strategically enabled by green human capital. The example of SONATRACH shows how adopting green management practices and investing in employee skills can result in quantifiable gains in productivity, creativity, and resilience. In addition to lowering their environmental impact, businesses can maintain long-term competitiveness in the quickly

evolving global energy market by integrating sustainability goals with human resource strategies.

The ramifications are significant for emerging economies. Developing green human capital offers a way to improve integration into international markets while striking a balance between environmental commitments and national energy needs. In the end, the ability of people to initiate and maintain change will be just as important to the shift to a sustainable future as clean technologies.

To promote technological innovation, SONATRACH should deepen its collaborations with academic institutions, research centres, and eco-entrepreneurial start-ups. Algerian businesses will be able to compare themselves to international best practices by actively participating in global sustainability networks like ISO 26000 and the UN Global Compact. Bottom-up innovation can also be produced by promoting green intrapreneurship by praising staff members' eco-friendly projects.

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