Original Article: Integration of Renewable Energy Sources in Oil and Gas Operations a Sustainable Future

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Citation M Kiamansouri, ***Integration of Renewable Energy Sources in Oil and Gas Operations a Sustainable Future,*** *EJCMPR*. 2025; 4(1): 63-87.

https://doi.org/10.5281/zenodo.18792235

Article info:
Received: 21 September 2024
Accepted: 20 December 2024
Available Online:
ID: EJCMPR-2412-1266
Checked for Plagiarism: Yes
Peer Reviewers Approved by:
Dr. Frank Rebout
Editor who Approved Publication:
Dr. Frank Rebout

Keywords:
Resource Integration, Renewable Energy, Oil and Gas Operations, Sustainable Future.

ABSTRACT

The development of renewable energy in Iran is of great importance due to its favorable geographical conditions and the need for sustainable energy sources, and the integration of renewable energy sources in oil and gas operations will create a sustainable future for future generations. The world is at a critical juncture where the demand for energy intersects with the urgent need to combat climate change. Traditional energy sources, dependent on fossil fuels, significantly contribute to greenhouse gas emissions and environmental degradation. In response, there is a paradigm shift towards renewable energy sources such as solar, wind, hydro, and geothermal energy. Programming, in conjunction with technological innovations, plays a pivotal role in the use and optimization of these renewable energy solutions. The role of programming in renewable energy solutions is not just supportive but also transformative. From designing efficient systems and optimizing energy production to enabling smart grids and harnessing the power of artificial intelligence, programming is the main axis that drives the renewable energy revolution forward. As the world increasingly embraces sustainable energy sources, the challenges and opportunities for programming in this area continue to expand. By leveraging the capabilities of programming languages, frameworks, and emerging technologies, developers can help create a cleaner and more sustainable energy future. As we navigate the complexities of climate change, programming becomes an essential tool that enables us to harness the potential of renewable energy and lead the global transition to a more sustainable and resilient energy ecosystem.

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Introduction

In light of climate change and rising energy prices, effective energy management has become a strategic priority for organizations [1]. This note examines the importance, strategies, and challenges of energy management in organizations. Energy management not only helps reduce costs, but also improves an organization’s environmental performance and increases competitiveness. Some of the key benefits of energy management include:

- ✓**Reducing energy costs:** By identifying and implementing energy efficiency solutions, organizations can significantly reduce their operating costs [2].
- ✓**Reducing environmental impacts:** Optimizing energy consumption leads to a reduction in greenhouse gases and other pollutants, which helps improve the organization’s sustainability dimensions [3].
- ✓**Increased employee satisfaction:** Creating a higher quality and energy-efficient work environment can lead to improved employee health, comfort, and satisfaction [4].
- ✓**Creating a positive image:** Organizations that value energy management are recognized as sustainability leaders and can gain the trust of customers and stakeholders.

Energy management strategies

To achieve energy management goals, organizations can use various strategies:

Assessing and analyzing energy consumption: The first step in energy management is to accurately assess the organization's energy consumption [5]; This includes collecting data, analyzing it, and identifying weaknesses and opportunities for improvement. Using energy management software can be very helpful at this stage [6].

Improving technology and equipment: Replacing worn-out equipment with efficient and modern devices is one of the measures that can significantly reduce energy consumption. For example, the use of efficient LED and HVAC (Heating, Ventilation, and Air Conditioning) systems [7].

Training and culture: Creating an energy culture among employees through continuous training and increased awareness can lead to more efficient energy consumption behaviors in the organization [8].

Use of renewable resources: Integrating renewable energy sources, such as solar and wind energy, into the organization’s energy structure can help reduce dependence on non-renewable resources and reduce costs [9].

Implementation of standards and certifications: Obtaining international certifications such as ISO 50001 can help organizations implement an energy management system and continuously improve [10].

Energy management challenges

Despite its many benefits, energy management in organizations also faces challenges:

- ✓ **Initial implementation cost:** The initial costs of implementing energy optimizations can be high, which can prevent organizations from taking quick action [11].
- ✓ **Incomplete data and lack of transparency:** The lack of accurate and transparent data on energy consumption can prevent effective and strategic energy management analysis.
- ✓ **Resistance to change:** Employees may resist changes in working methods and new systems [12].

Integrating renewables with VRF systems

Rapid population growth and urban living have caused energy demand to increase at an alarming rate. According to the International Energy Agency (IEA), the building industry is responsible for more than a third of global final energy consumption. In developing countries, energy demand for HVAC (heating, cooling and ventilation) systems accounts for almost half of the total energy consumption in buildings. The new variable refrigerant flow air conditioning system, also known as the central split system or VRF, has used the world's most advanced technologies to improve energy consumption. Here are some of the benefits of this system [13].

1. Energy efficiency: Up to 30% energy savings compared to traditional systems;
2. Greater comfort: Individual temperature control for each zone and silent operation;
3. Design flexibility: Long refrigerant line, compact indoor units for easy installation;
4. Zoning and individual control: Customized temperature settings, increasing occupant comfort [14];
5. Scalability and future-proofing: Easy adaptation to building changes or upgrades.

Reasons for using photovoltaic energy generation systems

Solar cells are one of the most suitable and affordable technologies for generating electricity from renewable energy sources in urban areas. This technology also has other advantages, which we will discuss below.

- ✓ Photovoltaic systems are silent and visually unobtrusive;
- ✓ Clean technology for generating electricity [15];
- ✓ Small-scale solar power plants can use unused space on the roof of existing buildings.

Advantages of integrating renewable energy systems and VRF systems

- ✓ **Sustainable energy source:** One of the most important points of integrating air conditioning systems with renewable energy sources is the sustainability of this and of course the need of people for air conditioning for greater comfort and well-being. Solar energy provides a stable and constant power source and ensures uninterrupted operation of HVAC comfort during power outages [16].
- ✓ **Greater efficiency:** Solar panels can significantly reduce the energy consumption of air conditioning systems by providing direct power, thereby reducing dependence on the power grid.
- ✓ **Incentive Grants:** Governments and organizations often offer tax incentives and rebates to promote the adoption of solar-powered HVAC systems, making it an attractive financial option [17].

What is renewable energy?

Renewable energy refers to energy that is produced from sources that can be replenished by nature when they run out, which is very important. This is because the world has been using fossil or non-renewable resources for a long time, and they are expected to run out in the near future. Therefore, it is necessary for the whole world to switch to renewable energy sources to save future generations [18].

9 renewable energy sources

- ✓ **Tidal energy:** This energy is similar to hydropower, by converting it into useful energy, you can easily provide the required electricity [19]. Of course, this energy is not yet very popular and its uses are few, but it is predicted to be very efficient in the future. The reason why this energy is not used much is that it is thought to be very expensive and it was difficult to find places to use it. In recent years, this energy has been used in technologies such as turbines, tidal lagoons and dynamic power plants. The first commercial example built to use tidal energy is in Ireland. The process of using this energy in history was that the incoming water was stored in large pools and when it was fashionable, water wheels were set in motion. With the help of the movement of the rotations, the necessary power can be obtained to grind grains. Their use has also been widespread in the past and their first use dates back to ancient Rome. Later, in the 19th century, America began using tidal energy to generate electricity [20].

- ✓**Solar energy from renewable sources:** Solar energy is one of the most unique methods of energy supply that is known as the main source of other energies. Two methods can be used to use solar energy and convert it into the required electricity, one directly with the help of a photovoltaic system and the second indirectly using concentrated solar power. In the second method, concentrated solar power, lenses, mirrors and tracking systems are used, and in the first method, the photovoltaic system converts light into electricity with the help of the photoelectric effect [21]. The first power plant that was built to use solar energy was in the 1980s. Also, the largest power plant ever built in the world with a capacity of 354 megawatts is located in the Mojave Desert. Iran is also one of the best countries in the field of solar energy production, given that it has at least 300 sunny days. Given the geographical location of Iran, many of its cities have the opportunity to benefit from this energy.
- ✓**CNG:** CNG is the compressed natural gas that is used as an alternative to other fuel sources. The reason why CNG is on this list is because it causes much less damage to the environment than other fuels such as gasoline and diesel and the amount of pollution caused by it is low [22]. CNG, which is compressed, takes up a very small volume and is one percent compared to other gases; The structure inside natural gases is methane and is obtained from gas, oil wells and waste. Iran is one of the countries that has the largest amount of CNG, followed by Pakistan, Argentina, China, Brazil and India on this list, respectively; in Iran, many cars use CNG and there are both special engines for it and this possibility is available in some gasoline cars.
- ✓**Geothermal electricity:** The first time this type of energy was used was during the time of Prince Piero Ginori in Italy, at that time, thermal energy was used for the first time in 1904 to generate electricity, then in 1958 a power plant was built to use this energy in Tusland [23]. These two made the use of this energy popular and in 1960 another power plant was built in an area where there is an active volcano in California, USA; it should be noted that this power plant is one of the largest power plants built for geothermal energy so far. The use of this energy became so popular that in 2008, one percent of the world's electricity was supplied by geothermal energy [24].
- ✓**Hydropower from renewable energy sources:** Most of the power plants that exist for this energy use water behind dams, in this case, if the amount of water behind the dams' decreases, the energy supply will also be affected. This difference in water level is called pressure height and is represented by the letter H [25]. There are some other hydropower plants that use the kinetic energy of water to supply their energy. In these power plants, dams are no longer needed and only turbines are used. The function of these turbines is such that they are like a water wheel and can obtain the necessary energy well.
- ✓**Atomic energy:** The structure of atoms is such that there are different components inside them that are connected to each other with the help of energy. Therefore, a lot of energy is hidden in the nucleus of atoms. If you release the nucleus of atoms such as uranium [26], it acts as if you have burned a

large volume of oil or gas. The first time this energy was used was in 1970 when the first nuclear power plant was built. In these power plants, like others, they produce energy by releasing energy within the nuclei of atoms [27]. The heat released from the atoms is removed using cooling systems, and with the help of the available heat, turbines connected to generators are driven to produce the required electricity.

- ✓**Wave energy:** Wave energy is created on the surface of the water with the help of wind movement, the total amount of wave energy on the surface of the world is estimated to be about 2.5 * 106 MV, which is approximately equal to the energy from tides. It is interesting to know that wave energy, which is a renewable energy source, is more than wind energy [28]. The energy produced by waves is returned to the water surface by the regenerators; It should be noted that the energy produced by these waves is irregular and due to the variable frequencies they have, their frequency is converted to 60 Hz before they enter the network.
- ✓**Energy obtained from wind:** Usually on intercity roads and in farms, you have seen turbines placed to store wind energy, this device connects the energy obtained to the electrical grid. Wind is one of the characteristics that is abundant in the air and even a small part of the solar radiation that reaches the atmosphere from outside is converted into wind energy [29]. Wind energy is easily found and accessible to everyone. In addition, it is a renewable and clean energy source. Due to the many advantages that this method has, many countries use this energy. Apart from the above advantages, much less greenhouse gas is released when using wind energy compared to other energies, which is also an important reason for its popularity [30]. Regarding the history of using this energy, we should mention ancient Iran. Because Iran was the first country to be able to understand this energy [31]; At first, Iranians managed to move well wheels with the help of wind power and thus deliver water to all parts of their lands. Also, the first machine that was produced in ancient times and used by the Greeks to crush grains and sail boats was made by Iranians that used wind energy. But in the 13th century, this device was taken to Europe by soldiers and the Netherlands used it to make the desired changes and finally in the 19th century, almost nine thousand wind machines were produced [32].
- ✓**Biomass:** Biomass is a renewable energy source that is created from biological materials. For example, waste that has a biological origin and is created through the multiplication of cells is called biomass. Among these biomasses, a wide range is capable of producing energy, which is divided into several groups according to the different types they have.
- ✓Livestock and poultry waste.
- ✓Solid waste [33].
- ✓Urban and suburban sewage.
- ✓Industrial waste and residual waste.
- ✓Forests and forest waste.
- ✓Products in the agricultural, horticultural and food industries [34].

In addition to the above, biomass also includes waste that can be burned. However, note that fossil fuels, coal or oil are not biomass.

Discussion

Oil and gas price volatility, driven by geopolitical events and supply challenges, has highlighted the sector’s vulnerability. The slowdown in gas consumption and the shift towards renewable energy sources confirm the industry’s commitment to a global transition away from fossil fuels [35]. Taken together, these trends highlight the resilience and adaptability of the oil and gas sector in a period of change. The year 2023 brings a dynamic outlook for the oil and gas sector, marked by transformative trends in response to global pressures to reduce fossil fuel burning and a shift towards renewable energy sources. These trends not only reflect the industry's adaptability, but also its resilience in the face of a volatile market [36].

Artificial Intelligence; A Catalyst for Efficiency and Safety

A prominent trend in 2023 was the widespread adoption of AI, which emerged as a key player in the digitalization of the oil and gas industry. AI's ability to rapidly analyze data is instrumental in informed decision-making. Beyond analytics, AI has proven its prowess in automating physical labor, making operations safer, especially in risky offshore projects. Leading players in the oil industry such as Chevron, Shell, and BP have embraced AI and used it for predictive maintenance models and operational simplification [37]. The technology has brought stability to an inherently volatile market, leading to better decision-making, cost reduction, and increased efficiency. However, not all companies move at the same pace. While industry giants are embracing AI, others, including CNPC, MOL, ONGC, PKN Orlen and Qatar Energy, are still skeptical about its potential [38].

Developing new technologies in energy storage

AI technologies and increasing efficiency The use of solar and wind energy is being driven by emerging phenomena that can improve energy consumption and production patterns through real-time data processing and advanced algorithms [39]. In wind systems, especially large wind turbines, the type and materials used in them, as well as data on wind speed and direction, turbine status and technical condition of the equipment, are continuously processed by AI [40].

This technology can predict when energy production will increase or decrease depending on the wind and the degree of solar radiation, and adjust the systems for optimal performance. In solar systems, artificial intelligence also suggests the best times to produce and store energy by analyzing solar radiation data and weather conditions [41].

This technology can also increase the lifespan of equipment by accurately predicting technical problems and preventive maintenance, and minimize downtime and, as a result, production losses. Lithium-ion batteries, which are famous for their high energy density and long lifespan, are one of the main methods of energy storage. Thermal storage systems that store the energy produced in the form of heat are also used in solar power plants. In addition, the use of hydrogen gas as a means of energy storage has made great progress. In this method, excess energy is used to produce hydrogen through electrolysis, which can be stored as fuel and converted into electricity when needed [42].

Advanced research in solar photovoltaic technologies has led to the production of solar cells with higher efficiency and lower cost. One of the most serious challenges is the low efficiency of these panels. For example, new Percocet (PERC) solar cells use additional layers to increase efficiency and reduce light reflection [43]. The use of nanomaterials, such as carbon nanotubes and metal nanoparticles, to increase light absorption and reduce energy losses is also an important development in this field. These technologies increase the efficiency of solar cells and enable energy production even in poor environmental and light conditions [44].

Strategic maneuvers in a changing landscape

The oil and gas industry witnessed a total of 1,571 mergers and acquisitions (M&A) deals in 2023, indicating a strategic realignment of major players. The most significant financial transactions included the acquisition of Pioneer Natural Resources by ExxonMobil and the acquisition of Hess by Chevron. These transactions, valued at tens of billions of dollars, represent a response to evolving market dynamics. As the industry grapples with the imperative of sustainability, M&A activity is becoming a strategic maneuver to position companies for long-term survival [45].

Adapting the workforce for a sustainable future

Offshore oil and gas hiring trends in 2023 showed a clear emphasis on environmental issues. Environmentally-related roles saw a steady increase, with chemical engineers and electrical and electronics engineers in particular in demand. However, the overall job market in the sector declined, reflecting a broader shift in employment dynamics. The sector's move towards environmentally-focused roles reflects a proactive stance in addressing global environmental concerns. At the same time, the decline in job postings suggests a shift or diversification, likely driven by the oil industry's response to the changing energy landscape [46].

Oil and Gas Price Volatility

The International Energy Agency's (IEA) recent oil market report sheds light on the significant market volatility experienced in late 2023. The market experienced a noticeable downturn as high oil supply from non-OPEC+ countries coincided with a slowdown in global oil demand growth. This led to a significant drop in oil prices, reaching their lowest level in six months by December [47].

The price volatility highlights the sector's vulnerability to geopolitical events, changes in global demand and supply challenges. The gas sector has also been affected by factors such as reduced Russian gas deliveries and supply-side challenges [48].

Future outlook for gas consumption

Looking ahead, the outlook for gas consumption is likely to be subdued, particularly in regions that are increasingly turning to renewable energy sources. Markets in Europe, the United States and Asia Pacific are expected to lead the shift, contributing to a slowdown in demand growth in Eurasia [49].

The International Energy Agency (IEA) predicts that market prices will be driven by demand growth in Asian markets, particularly China, Africa and the Middle East, where gas-intensive industries are expected to expand. In conclusion, the trends observed in 2023 portray the oil and gas sector as a dynamic industry undergoing a period of global change; From the widespread adoption of artificial intelligence and strategic M&A activity to changing hiring patterns and market price volatility, these trends highlight the industry's resilience and adaptability in response to the imperative for sustainability and the ongoing transition to cleaner energy sources [50].

The need to change the business model of oil and gas companies: Today, the increasing pressure from environmental regulators and green investors on oil and gas companies raises the expectation that the usual business performance of oil and gas companies will change in the long term [51]. In fact, the expansion of international agreements (especially the 2016 Paris Agreement) aimed at reducing reliance on fossil fuels and slowing the pace of climate change requires oil companies and oil-owning countries to review their energy mix and ultimately include the development of new sources of energy in their implementation plans [52].

In other words, the truth about oil and gas is that although the industry's activities account for approximately 3% of global economic output, it is responsible for more than 50% of global greenhouse gas emissions. Oil and gas companies are therefore faced with the challenge of meeting the increasing demand for energy in a more competitive future, while simultaneously striving to reduce greenhouse gas emissions both in their operations and by changing their value chains [53].

At the same time, renewable energy is expected to grow the fastest over the next two decades, with its development set to increase fivefold by 2040. This means that more of the world's energy needs will be met by renewable energy. Overall, the prospect of oil and gas's declining position in the global energy mix, coupled with the projected increase in energy demand in the coming years due to population growth, has made the transformation of oil and gas companies into "Energy companies" imminent [54].

Energy companies or oil and gas companies

The annual Energy Outlook report by the International Energy Agency (IEA) and consulting firm McKinsey shows that despite the fact that global energy consumption will increase by almost 50% by 2050. However, in late 2020, the number of private cars using petroleum-based products reached its highest number [55].

Therefore, oil demand growth is expected to peak in early 2030 and will subsequently be on a significantly declining trend. This means that while the share of renewable energies is set to double, oil and gas will remain the main components of the global energy mix. Therefore, the share of renewable energies in the global energy mix is expected to increase sharply (from 11% today to more than 20% by 2040). Based on the requirements mentioned in the energy market, oil and gas companies are forced to identify and outline a development strategy in the era of "Energy transition or energy transition" in order to develop sustainably [56].

By drawing new goals in accordance with the environmental needs of the whole world, the need for changes in traditional business models becomes inevitable. In other words, in the future, one of the important goals of these organizations will be to achieve sustainable development of nations, and in this direction, many programs, strategies, frameworks and projects will be created that will consciously and logically create two developments: First, these activities and compliance with the rules will help companies to have more trust in society, and second, this trust will lead to greater profits for these organizations in the long run [57].

The concept of "Energy transfer" in the business of oil and gas companies

A review of history over the past 200 years shows that, on average, every 50 to 60 years, there has been a major shift in the energy mix, driven by a specific identifiable driver. It has mainly been scientific innovations and discoveries that have led to significant changes in the use of energy resources. While the recent energy transition is driven by the driver of climate change and the prevention of air pollution [58].

This means that the "Energy transition" that is being considered today is not just a simple shift from high oil and gas consumption to greater use of renewable energies instead of oil and gas, but rather a change in the way energy is produced and consumed on a global scale. This means that this change can also include a shift in the activities of oil and gas companies from "High carbon" to "Low carbon" and, as a result, the production of fewer greenhouse gases [59].

History of the energy transition throughout history

Despite the inevitability of accompanying the "Energy transition", the speed of the transition to a state in which the global economy is less dependent on fossil fuels is still not fully understood by all players in this industry. However, what is certain is that the future for oil and gas companies without the "Energy transition" will be full of uncertainty and risk. What is certain is that taking a step in the "Energy transition" will enable them to participate in sustainable development and acquire the necessary expertise and technology in this field [60].

Therefore, becoming an energy supplier or at least a company that produces less environmental pollution is what leading companies in their sustainable development are pursuing. This will help them to evolve in terms of technology and have a competitive advantage and ultimately build trust in the company's commercial image among the public [61].

Business Adaptation of Oil and Gas Companies to the "Energy Transition"

A review of the official plans of well-known companies shows that "Energy transition" is being pursued in practice in different forms for different oil and gas companies. The companies' attitudes towards risk, different relationships with their customers and investors, the different geographical areas in which they operate and the type of expertise they have, require many differences in the choice of implementation plan in "Energy transition" [62]. In general, four transformation strategies can be considered in response to "Energy transition":

A- Strategy of reducing greenhouse gas emissions through improving operational efficiency: Many large oil and gas companies have set greenhouse gas reduction targets for themselves in relation to their activities and have also tied some operational costs to these targets. In this direction, some internal operational changes are required, such as regular audits, equipment upgrades, implementation of energy management systems, etc [63]. The trend towards reducing greenhouse gas emissions can also be by reducing energy consumption by the companies themselves through increasing efficiency in oil and gas operations. This also applies to national oil companies, for example, Malaysia's Petronas has actively reduced the burning of associated gases in gas flares [64].

B- Portfolio diversification: This strategy refers to creating added value by incorporating renewable resources into a company's investment portfolio and assets. This diversification includes solar, wind and electricity technologies, which are among the most popular technologies for investment. Also, a number of major oil companies are forming partnerships with knowledge-based startups active in the field of renewable energy [65]. It is expected that with the expansion of these mergers and acquisitions, a wide range of low-carbon technologies in the oil and gas industry will develop rapidly. For example, in 2017, BP acquired 43% of the shares of Light source, Europe's largest solar developer, and total's recent investments now include solar, wind, energy storage, energy efficient distribution technology, hydrogen, biofuels and the development of advanced chemicals [66].

C- Integrating renewable technologies into oil and gas operations: Some major oil and gas companies are eliminating or reducing carbon emissions from their operations by powering their exploration, development, and production operations from renewable sources. In addition to renewable sources, some companies are using "Gas to power" to power their field development operations [67]. American companies are increasingly taking advantage of this strategy to implement "Energy transition." For example, in 2019, Chevron signed a 12-year agreement to power its West Texas fields from a wind farm [68].

D- Continued focus on oil and gas with a demarcation approach in the value chain: The reality is that currently, given the high cost of renewable energy production and the problems associated with their storage, most oil and gas companies still emphasize focusing on the oil and gas market. In fact, although the profitability of investing in renewable energy has been proven. However, the reality is that oil is still generally more profitable than renewable energy. This is especially true for Asian and US companies and smaller oil and gas players who want to benefit from the partial exit of large oil companies [69].

Four strategies in the face of the energy transition

Also, for companies that are less affected by the aforementioned drivers, the speed of their shift towards renewable energy is expected to be less evident. This means that if investor pressure is low and environmental oversight is not significant, or if the company has economic reserves (large and cheap reserves for production) of oil and gas, then there is not much determination to move towards the "Energy transition" [70]. This expectation is more true for developing countries that have large reserves of coal or oil and gas and have always had a cheap source available (such as Indonesia and Vietnam, and even Middle Eastern countries including Iran). In this regard, it can also be seen that so far the major European oil and gas companies have taken more steps towards the "Energy transition" compared to their American counterparts [71].
Regarding the strategy of continuing to focus on oil and gas, it should be noted that oil and gas companies will generally deploy their capital in various parts of the oil and gas value chain, in accordance with the risk conditions along with different sectors of the industry. The most important factor in diversification and elimination of boundaries in the activity chain in the oil and gas industry is also the general rule that the speed of technological change in this industry is high and companies must prepare themselves for flexibility in this industry [72].
Also, the lack of concentration of companies on a manufactured product will cause companies to focus less on a specific part of the oil and gas value chain and therefore to eliminate boundaries in the value chain. In fact, if the price of crude oil decreases, only those companies can be profitable over time that can produce value in more parts of the oil and gas chain. In general, the four strategies mentioned do not mean a complete separation of oil and gas companies' plans to implement the transformation in the "Energy transition" period. Rather, oil and gas companies use a combination of the above-mentioned strategies with different intensity and severity [73].

The business position of Iranian companies in the "Energy transition" period: In general, Iran is the only country out of the ten countries with the highest level of carbon dioxide production in the world that does not have an active presence in international summits of heads of state in 2016 and 2021 and has not yet developed systems to measure the amount of carbon dioxide emissions for the production of each barrel of oil [74].
Therefore, the lack of development of strict regulations to limit carbon production, along with the presence of significant economic reserves of hydrocarbons with cheap extraction conditions in the country, has resulted in the failure to adopt high-intensity strategies for "Energy transition" by the National Iranian Oil Company and Iranian oil and gas companies [75].

In this regard, a review of the activities of Iranian oil companies, which are known as companies active in the exploration, development, and production of hydrocarbon resources approved by the Ministry of Oil and are also known as exploration and production companies, shows that due to the availability of huge oil and gas reserves in the country, the strategy of continuing to focus on oil and gas is dominant in them, and only a limited number of Iranian companies have taken limited steps in line with the "Energy transition". In these initial steps, the most visible strategy is the diversification of the project portfolio and focusing on the development of oil and gas with the approach of eliminating boundaries in the value chain [76].

Strategies of Iranian oil and gas companies in keeping pace with the energy transition

In general, the strategies of Iranian companies in keeping pace with the "Energy transition" can be examined from two short-term and long-term perspectives:

A- Short-term strategies

- ✓ Formation of specialized committees to carefully review the strategies and strategies of the "Energy transition".
- ✓ Developing practical plans to implement the "Energy transition" as well as implementing the developed plan in the organization and monitoring its implementation [77].
- ✓ Trying to identify, select and develop technologies that will help digitize and optimize operations and management processes during the "Energy transition" period.
- ✓ Assisting in the establishment and development of centers to measure, monitor and standardize the amount of carbon produced in the country's current oil and gas industry activities [78].

B- Long-term solutions

- ✓ Efforts to integrate and eliminate the demarcation of the activity chain in the oil and gas industry (diversification of the project portfolio in the upstream and downstream sectors as well as the development of activities in the production of knowledge-based products) in order to develop added value.
- ✓ Identification and development of essential technologies in the development of technical and engineering knowledge related to renewable energies and technologies related to the reduction of greenhouse gas emissions by improving the efficiency of operations by establishing relevant engineering units [79].
- ✓ Focus on economic projects instead of focusing on a specific area in energy (a similar strategy is also followed by TOTAL, which focuses on the economic viability of the project and reducing costs in the company instead of focusing on a specific area in energy) [80].

How do artificial intelligence and automation help change the energy sector?

According to research, the global market for AI in renewable energy is projected to grow from US$0.6 billion in 2022 to US$4.6 billion by 2032, growing at a CAGR of 23.2% during the forecast period 2023-2032. Renewable energy sources are essential in the global effort to reduce carbon emissions and combat climate change [81].

These resources are abundant and sustainable. However, they also come with challenges such as variability in supply and demand for advanced grid management. AI and automation play a key role in addressing these challenges and optimizing the performance of renewable energy systems. Some of the key ways in which these technologies are impacting are discussed here:

Artificial Intelligence in Renewable Energy

Predictive Analysis and Maintenance One of the challenges of renewable energies is their unpredictable nature; the sun does not always shine and the wind does not always blow. Here, AI helps predict energy production by analyzing large amounts of data [82]. Predictive maintenance also reduces repair costs and extends the life of equipment, making energy production more sustainable. Smart Grid Management AI plays a key role in smart grid management. Integrating clean energy sources into power grids requires complex coordination [83].

By analyzing data in real time, AI optimizes energy supply and demand management and ensures grid stability. Energy Production Forecasting Using AI models, producers can predict energy production from clean sources based on weather and historical data. This forecasting helps in better planning and a sustainable energy supply [84].

Optimizing energy storage technologies such as batteries are essential for renewable energy. AI can optimize the charging and discharging cycle of energy and reduce waste. This ensures stable energy availability during peak times. Demand Response by analyzing energy consumption patterns, AI algorithms can automatically reduce consumption during peak times and match it with energy production. This reduces strain on the grid and lowers costs for consumers [85].

Challenges and Considerations of AI

While AI can help optimize clean energy, there are also challenges along the way:

1. Upfront costs: The initial investment in new technologies is very high.

2. Data security: Protecting information in smart systems is challenging [86].

3. Cyber threats: Grid-connected systems can be targets for cyberattacks.

4. Lack of regulation: The lack of clear regulatory frameworks makes it difficult to implement these technologies. To overcome these challenges, collaboration between industries, governments, and technology providers is essential [87].

Industrial Automation Improves Productivity

Increases Efficiency and Reduces Costs Industrial automation optimizes production processes and reduces dependence on human resources. This improves efficiency, reduces errors, and saves costs. Improves product quality Automated systems produce products with higher accuracy and quality and minimizes errors caused by manual processes. Greater safety in the workplace Automation reduces the rate of accidents and injuries by removing workers from hazardous environments and increases workplace safety. Flexibility and scalability Automated systems allow industries to quickly adapt to changes in market demand and expand or reduce production processes [88].

The role of artificial intelligence in optimizing energy efficiency

Artificial intelligence can help optimize industrial processes by analyzing real-time data and identifying energy consumption patterns. Machine learning algorithms can assess the energy consumption of various equipment and identify points where energy is wasted. This allows companies to use their energy resources optimally and reduce operating costs [89].

Developing Smart Energy Management Systems

AI, along with industrial automation technologies, can develop smart energy management systems (EMS). By automatically controlling equipment, such as lighting and heating systems, these systems can adjust energy consumption based on the actual needs of the environment. Using EMS not only reduces energy consumption, but also helps maintain grid stability and reduce environmental pollutants. Given these advantages, the combination of AI and modern technologies can lead industries towards higher productivity and more sustainable energy consumption [90].

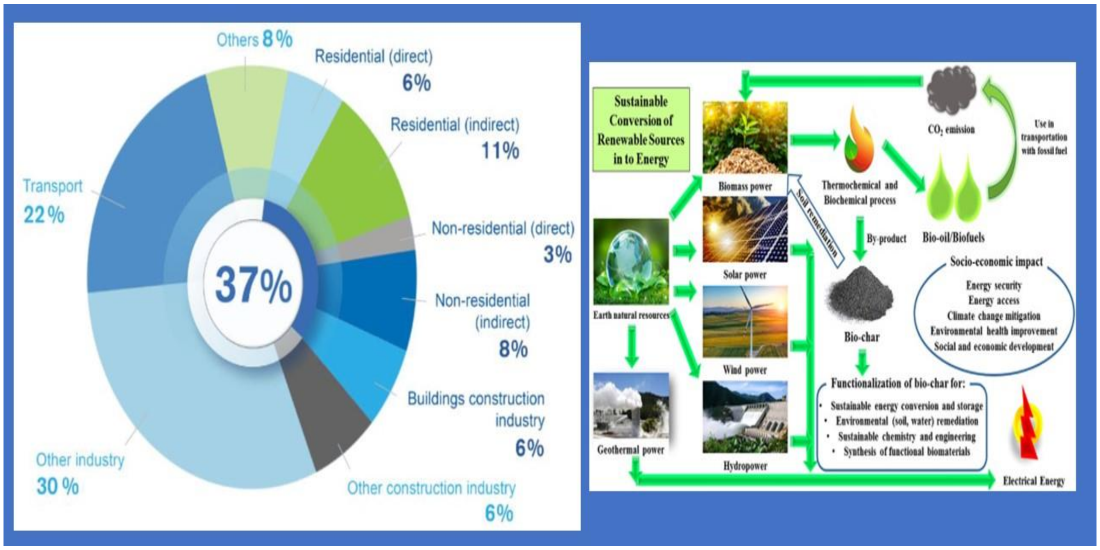

Figure 1. How do artificial intelligence and automation help change the energy sector?

Tajikistan's Energy Storage System Integration

- ✓ Home;
- ✓ Tajikistan's Energy Storage System Integration.

Tajikistan's energy security is threatened by its aging infrastructure, as 80 percent of its hydroelectric power plants, including power generation and distribution facilities, are in urgent need of repair and reconstruction [91].

Energy Cabinet (50 kW/100 kWh)

Introducing the Energy Cabinet (50kWh/100kWh), an advanced distributed energy storage system designed for efficiency and reliability. This innovative cabinet features smart installation and operation features that significantly reduce on-site maintenance by up to 70%. Its non-isolated design increases system efficiency, while independent battery packs eliminate circulating currents and minimize power losses. It features a six-layer security protection design and supports multi-data integration, ensuring robust performance and data integrity [92].

Key Features: The all-inclusive design reduces transportation and installation costs. Enables local data collection, intelligent monitoring, and remote operation. Standard interfaces allow for parallel connection of multiple units. Facilitates seamless expansion and simple batch production. Provides peak-valley power regulation and emergency backup power supply. Optimizes the use of renewable energy and reduces investment costs in grid upgrades. Ideal for virtual power plants, grid-connected, off-grid operations, the Energy Cabinet maximizes efficiency and flexibility in various energy scenarios [93].

Energy Cabinet (50 kWh / 115 kWh)

Discover our Group Energy Cabinet (50kWh/115kWh) that integrates batteries, BMS, EMS, PCS and fire protection systems into one efficient unit. Designed for grid regulation, load tracking and peak shaving, it provides flexibility for various applications while reducing energy costs and promoting green energy [94].

Key Features: Integrated design reduces transportation and installation costs. Enables local data collection, intelligent monitoring and remote operation. Standard interfaces allow parallel connection of multiple units. Facilitates seamless development and simple batch production. Provides peak-valley power regulation and emergency backup power supply. Optimizes the use of renewable energy and reduces investment costs in power grid upgrades. Ideal for businesses looking to increase energy security and stability by significantly reducing workloads through smart installation and operation [95].

Energy Cabinet (100kWh - 215kWh)

The energy storage cabinet (100KWh/215KWh) is the core component of the distributed energy storage system. It has intelligent installation and operation, which reduces 70% of the on-site maintenance workload. It uses non-isolated design to improve efficiency, independent battery cluster to reduce energy loss, and six-layer safety protection design to ensure reliable performance and safety [96].

Key Features: The comprehensive design reduces transportation time and installation costs. Enables local data collection, intelligent monitoring, and remote operation. Standard interfaces allow parallel connection of multiple units. Facilitates seamless development and simple batch production. Provides peak-valley power regulation and emergency backup power supply. Optimizes the use of renewable energy and reduces the investment cost of power grid upgrades. Ideal for applications that require fast power response and adapt to virtual power plants, grid-connected and off-grid operations [97].

Energy Cabinet (150KWh-372KWh)

The energy cabinet (150kWh/372kWh) adopts an integrated design, integrating batteries, BMS, EMS, PCS and fire protection systems, and is very suitable for grid regulation, load tracking and peak shaving. It is designed for flexibility and scalability in various applications, providing green energy solutions for enterprises while reducing operating costs and ensuring system safety and stability [98].

Key features: The all-inclusive design reduces transportation time and installation costs. Local data collection enables intelligent monitoring and remote operation. Standard interfaces allow parallel connection of multiple units. Facilitates seamless development and simple batch production. Intelligent installation and commissioning reduces on-site maintenance workload by 70%. Non-isolated design increases system efficiency with independent battery clusters. Six-layer security protection design ensures comprehensive safety. Support local and remote upgrade, improve efficiency by more than 90%. Ideal for fast power response and compatible with virtual power plants, grid-connected and off-grid operations [99].

Commercial and industrial energy storage solutions (100kWh / 215kWh)

These solutions are designed for commercial and industrial energy storage needs, with grid voltage regulation, three-phase imbalance management, harmonic management, load tracking, backup power and peak correction functions. The integrated design includes batteries, BMS, EMS, PCS and fire protection systems to ensure flexibility and reliability in various operating modes [100].

Key Features: Flexible modular design for easy expansion. Fast response power and compatible with virtual power plants, grid-connected and off-grid applications. Local data collection, intelligent monitoring and standard interfaces for parallel expansion. Smart maintenance and efficient upgrades (local and remote).

Benefits: Reduces enterprise energy costs and increases green energy consumption. Improves power quality and system safety and stability. Reduces transportation and installation time and cost. Provides reliable backup power and economic benefits through peak-valley arbitrage. Improves the use of renewable energy and reduces investment in grid upgrades. Ideal for increasing the stability and efficiency of power systems in commercial and industrial environments [101].

Commercial and Industrial Energy Storage Solutions (150 kWh - 372 kWh)

Designed for commercial and industrial energy storage, this system features an integrated design that includes batteries, BMS, EMS, modular inverters and fire safety systems. It provides fast response power and can easily adapt to different modes such as virtual power plants, grid-connected and off-grid configurations. The system includes local data collection, intelligent monitoring, standardized interfaces for parallel expansion and intelligent maintenance support that can be effectively upgraded locally and remotely [102].

Key Features: Peak shaving and valley filling capability. Increases the stability of power consumption systems. Provides reliable backup power and peak-valley arbitrage for economic benefits. Improves renewable energy utilization rates and reduces investment in grid upgrades [103].

Commercial and Industrial Energy Storage (215 kWh to 1075 kWh)

These solutions are designed for commercial distributed energy storage, with maximum shaving, photovoltaic integration and off-grid backup power capabilities. Each cabinet offers independent control and management with a modular design that ensures 100% factory pre-assembly and simplifies installation. The EMS system enables integrated planning and cloud-based automated inspection, supports multiple operating modes and rapid response capabilities [104].

Key Features: Integrated design reduces transportation and installation costs. Local data collection, intelligent monitoring and standard interfaces for parallel expansion. Smart maintenance and efficient upgrades (local and remote) [105].

Commercial and industrial energy storage (372 kWh - 1860 kWh)

These systems are designed for commercial distributed energy storage, providing peak load shifting, photovoltaic integration and off-grid backup power capabilities. Each cabinet offers independent control and management with a modular design and 100% factory pre-assembly to simplify installation. The EMS system enables integrated scheduling and cloud-based automated inspection, supports multiple operation modes and rapid response capabilities [107].

Key Features: Integrated design reduces transportation and installation costs. Local data collection, intelligent monitoring, and standard interfaces for parallel expansion. Intelligent maintenance and efficient upgrades (local and remote).

Benefits: Increases the stability of power consumption systems. Provides reliable backup power and peak-valley arbitrage for economic benefits. Improves the utilization rate of renewable energy and reduces investment in grid upgrades. Ideal for optimizing energy efficiency and reliability in commercial and industrial applications [108].

4 MWh Hybrid Cooled Container Energy Storage

This system is designed as a containerized energy storage solution that integrates energy storage batteries, management, monitoring, temperature control, and fire protection systems. It is suitable for various voltage and capacity requirements and can be coordinated with solar, wind, and thermal power generation devices. Functions include energy absorption, smooth power transfer, peak load regulation, frequency regulation, and auxiliary grid support [109].

Key Features: Modular design with flexible battery pack capacity matching. Offers multiple PCS (Power Conversion System) options. Uses high-performance lithium iron phosphate batteries with long cycle life and high efficiency. Active and passive balancing functions for optimal performance. Supports flexible operation modes including grid-connected and off-grid settings. Integrated system management unit and intelligent monitoring and management platform.

Applications: Commerce and Industry - Mining and Industry - Border Guards - Field Construction - Emergency Rescue - Outdoor Repair [110].

Liquid Cooling Series Energy Storage System (372kWh - 1860kWh)

This solution is a containerized energy storage system that uses 10/20/40-foot prefabricated containers to meet the power output requirements at the megawatt level. It integrates energy storage battery systems, energy management systems, monitoring systems, temperature control systems, fire protection systems, etc. It uses battery packs as the core units and can adapt to a variety of voltage and capacity scenarios, and can be seamlessly connected to photovoltaic. Wind power, thermal power and other systems. The functions include energy absorption, smooth output power, peak shaving, frequency regulation and providing auxiliary services to the grid [111].

Key features: Modular design with flexible battery pack capacity matching. Multiple PCS (Power Conversion System) options. High-performance lithium iron phosphate batteries with long cycle life and high efficiency. Active and passive balancing functions for optimal performance. Flexible operation modes including grid-connected and off-grid settings. Integrated system management unit and intelligent monitoring and management platform [112].

Applications: Commerce and Industry - Mining and Industry - Border Guards - Field Construction - Emergency Rescue - Outdoor Repair.

Liquid-cooled energy storage container system (3440 kWh - 6880 kWh)

This liquid-cooled containerized energy storage solution is carefully manufactured by the group, using the most advanced design principles, integrated lithium iron phosphate battery cells and intelligent liquid cooling to improve efficiency, safety and reliability, ensuring integrated integrity and energy efficiency. The storage of this system is suitable for peak load regulation, large-scale grid expansion, reliable power backup and AC charging expansion [113].

Key features: Modular design with flexible matching of battery pack capacity. Multiple PCS (Power Conversion System) options. High-performance lithium iron phosphate batteries with long cycle life and high efficiency. Active and passive balancing functions for optimal performance. Flexible operation modes including grid-connected and off-grid settings. Integrated system management unit and intelligent monitoring and management platform. Functions include energy management, battery management, thermal management, fire protection, alarm, temperature and humidity detection [114].

Applications: Trade and Industry - Mining and Industry - Border Patrol - Field Construction - Emergency Rescue - Outdoor Repair.

Conclusion

Our energy system not only includes renewable, nuclear and fossil energy sources, but also creates electrical, thermal and fuel energy pathways and provides energy services at different physical scales. Interactions and interdependencies are increasing among pathways and across the physical scales of the energy system, as well as between the energy system and other systems, such as information and data networks. Energy Systems Integration (ESI) enables the effective analysis, design and control of these interactions and interdependencies in technical, economic, regulatory and social dimensions. By focusing on optimizing energy systems at different pathways and scales, we can better exploit the potential benefits that increase reliability and performance, reduce costs and minimize environmental impacts.

The integration of renewable energy sources into electricity grids is crucial to reducing carbon emissions and promoting a sustainable energy future. Adaptive load management systems play a key role in this process by dynamically responding to changes in energy supply and demand, optimizing the use of renewable energy sources and reducing dependence on traditional energy generation. These systems offer many benefits, including reducing energy consumption during peak times, optimizing the use of renewable energy, and improving the overall sustainability of the grid. They are crucial to reducing carbon emissions and promoting a sustainable energy future. Adaptive load management systems are an essential component in reducing greenhouse gas emissions and promoting the shift to renewable energy. They provide a practical solution to increase grid reliability and promote the shift to renewable energy. They are a practical solution to increase grid reliability and sustainability, ultimately leading to a greener and more sustainable energy system.

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