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Engineering management for Assessment of Solar Energy Development (case study of Jordan)

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ABSTRACT

The renewable energy sector in Jordan is rapidly growing as the government is committed to reducing the country's dependence on fossil fuels and increasing the contribution of renewable energy to its energy mix. However, the effective management of renewable energy projects requires a unique set of skills and expertise that is different from traditional engineering management. The agreement between solar energy yield and electricity demand is compared in terms of daily, monthly and yearly patterns. A special focus is oriented towards the current status of solar energy projects in Jordan area in terms of their sizes, reliability, feasibility and challenges. Finally, concerning the future plans of solar energy in Irbid area, a road map will be introduced to trigger the decision makers to convert Irbid to a green governorate in the next decade and examines the key skills and competencies required for engineering managers to succeed in the renewable energy sector in Jordan, including technical expertise, project management skills, financial and business acumen, and strong communication and leadership skills.

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Jordan is a small country with a population of around 10 million people. The country is heavily dependent on fossil fuels for its energy needs, and this dependence makes it vulnerable to fluctuations in oil prices. To reduce this dependence and promote sustainable development, the Jordanian government has initiated several policies and programs to Increase the share of renewable energy in the country's energy mix.

The Jordanian government has set a target to achieve 20% of its electricity generation from renewable energy sources by 2025. To achieve this target, the government has launched several initiatives to promote renewable energy investments. The government has introduced a feed-in tariff scheme to encourage private sector investments in renewable energy projects. The scheme offers guaranteed prices for the electricity generated from renewable energy sources for a period of 20 years [1,2,3].

Solar energy is the most promising renewable energy source in Jordan. The country has excellent solar resources, with an average of 300 days of sunshine per year. The government has launched several solar energy projects, including the Ma'an Development Company's 100 MW solar power plant, which is the largest solar power plant in the country. Wind energy is also gaining momentum in Jordan, with several wind energy projects in the pipeline [4].

RENEWABLE ENERGY EVELOPMENT IN JORDAN

Jordan was one of the first Middle East countries which have used PV solar as a promising source of renewable energy. The development of renewable energy in Jordan has gone through two routes; technical and legislative. Although Jordan is small country in terms of energy consumption and industrial level, it could attract a strong international interest for its renewable energy projects. There are several reasons for that interest. Firstly, it could develop an approach for using renewable energy in systematic form by setting a mature energy law, completing a renewable energy grid code, applying net metering and wheeling systems, exempting renewable energy equipment from all taxes and by applying other mechanisms. This has enabled all sectors in Jordan to significantly benefit from renewable energy use including commercial, industrial and residential customers. The second reason is the stability of political system in Jordan compared with all neighboring countries. This stability has encouraged several renewable energy companies to invest in this technology and to consider Jordan as a center for promoting and marketing their products to the surrounding countries. This role was facilitated by

the presence of a strong Jordanian engineering system able to transfer this technology to local community and neighboring countries. Moreover, the intensive cooperation between all governmental and private organizations, interested in energy industry, was significant in developing this new type of generation and its associated technology [5,6,7,8]

The third reason for successful application of renewable energy in Jordan is the prevailing moderate climate which is very suitable for optimum operation of renewable energy systems in general and Photovoltaic (PV) in particular. The annual moderate average temperature and the strong direct solar radiation in Jordan are important conditions for optimum operation of PV systems. These features have attracted all manufacturers to measure the performance of their PV products and to test them to take a true feedback of their new equipment and systems. The final reason for renewable energy development in Jordan is attributed to the harmony between PV generation and consumption modes. The daily load curve is in well-agreement with PV generation pattern as shown in Figs. 1 and 2 [9,10]. Although the daily average and peak load values are different from season to season, the pattern is the same and still in agreement with PV generation mode.

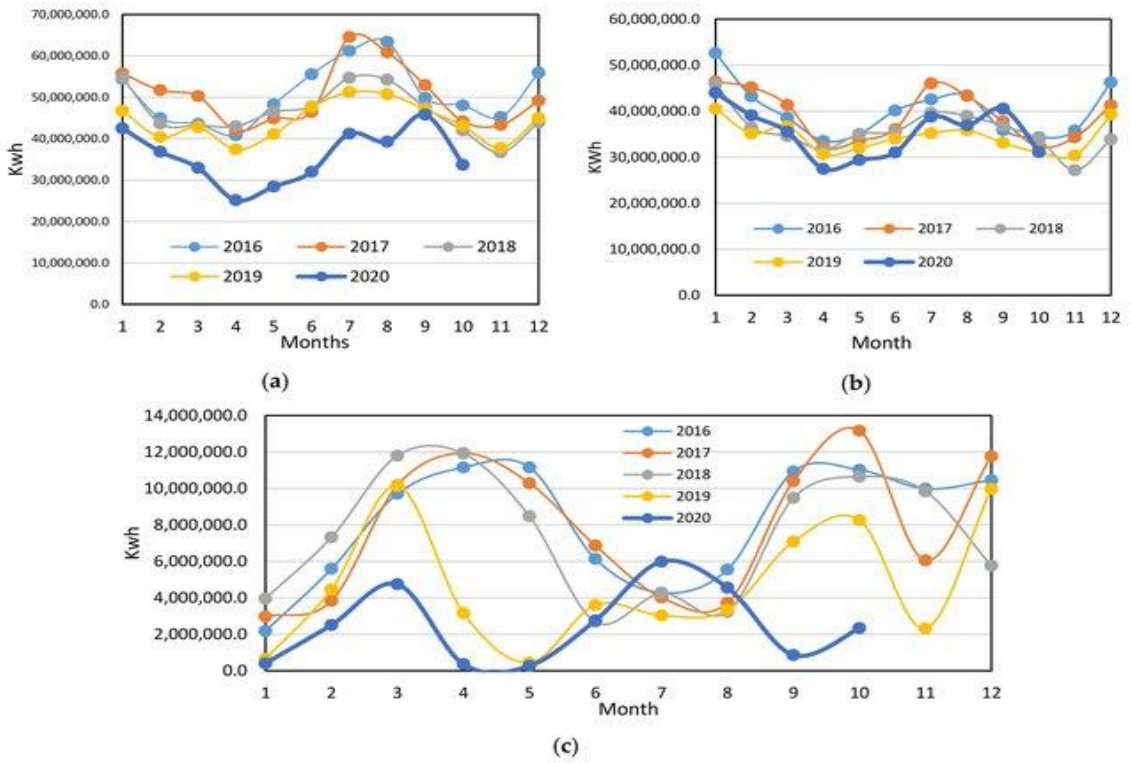

Figure 1. The monthly electricity demand (KWh) in Jordan over five years and during the ongoing pandemic: (a) city center; (b)

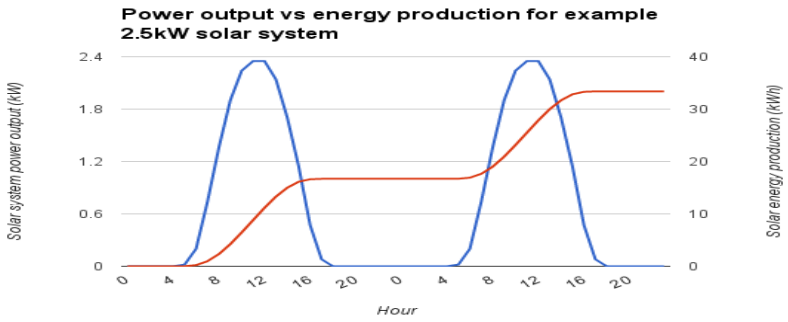

Figure 2. Daily energy generated by a 2.5kW PV system

Example using a ~2.5kW solar system

Instantaneous power output vs cumulative energy production over a two-day period. Peak power output is just under 2.3kW (due to standard inefficiencies), while the total amount of energy produced over the two days is just over 33k

Overview of Jordan Area

The Jordan Electricity Company (JEC) has been publishing annual reports on renewable energy in Jordan, including solar energy, since 2014. These reports provide valuable insights into the current status and future prospects of renewable energy in the country. According to the JEC's 2020 annual report on renewable energy, the installed capacity of renewable energy in Jordan reached 2,174 MW by the end of 2020, representing approximately 16% of the country's total installed capacity. Solar energy accounted for the largest share of renewable energy, with an installed capacity of 1,609 MW, followed by wind energy with 556 MW

The report also highlights the growth in solar energy projects in Jordan, with a total of 2,211 solar projects installed by the end of 2020, with a total capacity of 1,609 MW. The majority of these projects were installed in the commercial and industrial sectors, with only a small portion installed in the residential sector. In terms of the number of subscribers to solar energy projects, the JEC's 2019 report indicated that there were a total of 6,670 subscribers to net metering programs [11,12,13]

Month / Station	Jan/Feb	Mar/Apr	May/Jun	Jul/Aug	Sep/Oct	Nov/Dec	Av/Yr
Dair Alla	2.9/3.5	4.9/6.1	7.0/7.5	7.3/6.6	5.6/4.4	3.1/4.9	5.3
Ghor Safi	3.0/3.7	5.1/6.2	7.0/7.5	7.3/6.7	5.7/4.4	2.9/2.3	5.1
Aqaba A.P	3.5/4.5	6.1/6.9	7.4/8.3	8.1/7.5	6.6/5.1	4.0/3.5	6.0
Irbid	3.1/3.7	5.1/6.4	6.9/7.7	7.6/7.5	6.0/4.6	3.3/2.9	5.4
Amman A.P	3.2/4.1	5.4/6.8	7.1/8.3	8.1/7.4	6.0/4.5	3.3/2.9	5.6
Wadi Dhlil	3.2/4.1	5.5/6.8	7.5/8.4	8.3/7.7	6.5/4.9	3.3/2.9	5.8
Rwished	3.3/3.9	5.0/5.9	6.3/6.8	6.6/6.3	5.5/4.4	3.5/2.9	5.0
Azraq	3.3/4.2	5.7/6.8	7.5/8.4	8.1/7.3	6.2/4.9	3.7/2.9	5.7

TABLE 1. Monthly solar radiation in different areas in Jordan in kWh/m2

Which allow customers to generate their own electricity using solar energy and feed any excess energy back into the grid. The report also noted that the number of subscribers had increased by 71% compared to the previous year, indicating a growing interest in solar energy among customers in Jordan. Overall, the JEC's annual reports on renewable energy in Jordan provide valuable information on the growth and development of renewable energy, particularly solar energy, in the country. These reports can serve as a useful resource for policymakers, investors, and other stakeholders interested in renewable energy development in Jordan.

On the light of the above facts, there was a strong interest in PV systems in Irbid area although the level of achievements was not high. In the following sections of this paper we will highlight the status of existing PV plants in Irbid area, the future plans for developing such type of energy and the technical and non-technical challenges facing PV project in such province.

Challenges facing the Renewable Energy Sector in Jordan

Engineering managers in the renewable energy sector in Jordan must have a solid understanding of renewable energy technologies, including solar, wind, and geothermal energy. They must be able to evaluate the technical feasibility of projects, design renewable energy systems, and manage the installation and operation of renewable energy systems. For

example [14].found that technical expertise was the most important factor in the successful implementation of renewable energy projects in Jordan. Technical expertise is a critical component of effective engineering management in the renewable energy sector. Engineering managers must have a deep understanding of the technical aspects of renewable energy projects to ensure their successful implementation. They must work closely with engineers to ensure that projects are designed, implemented, and maintained to the highest standards.

One area of technical expertise that is particularly important in the renewable energy sector is solar photovoltaic (PV) technology [15,16]. solar PV technology is one of the most widely used renewable energy technologies worldwide. Engineering managers must have a thorough understanding of the design and installation of solar PV systems to ensure their successful implementation.

In addition to solar PV technology, engineering managers must also be knowledgeable about wind turbine technology [17]. Wind power is the second-largest source of renewable energy worldwide, and its use is expected to grow significantly in the coming years. Engineering managers must have a deep understanding of the design and operation of wind turbines to ensure the successful implementation of wind energy projects. Other areas of technical expertise that are important in the renewable energy sector include energy storage technologies, grid integration, and energy efficiency measures. Engineering managers must be familiar with the latest developments in these areas to ensure the successful implementation of renewable energy projects.

In conclusion, technical expertise is a critical component of effective engineering management in the renewable energy sector. Engineering managers must have a deep understanding of the technical aspects of renewable energy projects to ensure their successful implementation. Areas of technical expertise that are particularly important in the renewable energy sector include solar PV technology, wind turbine technology, energy storage technologies, grid integration, and energy efficiency measures.

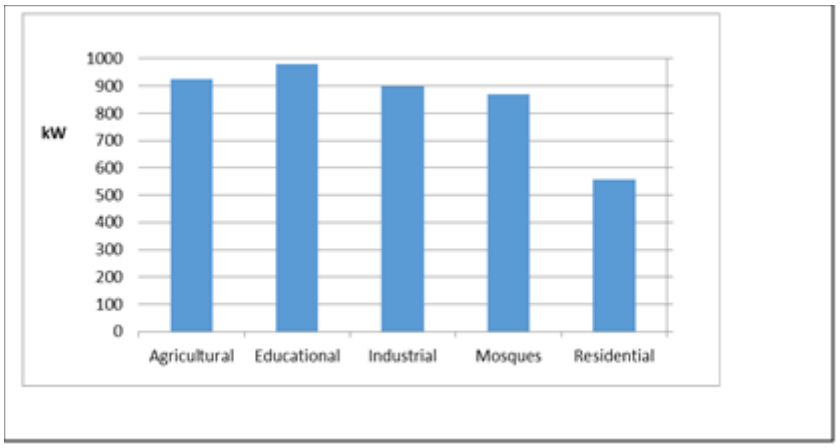

Figure 3. Main categories of customers installing PV systems

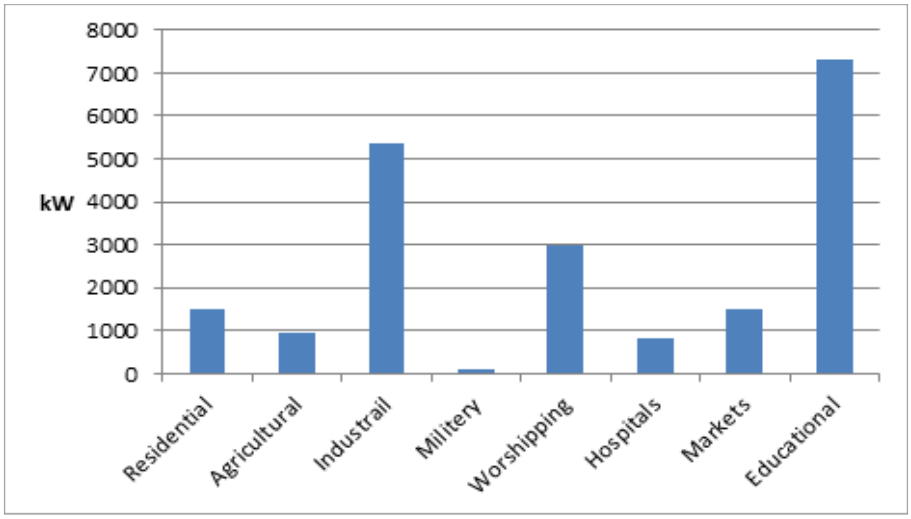

Figure 4. PV generation growth in Irbid area in term of capacity and customers.

The renewable energy sector in Jordan faces several challenges that hinder its growth and development. These challenges include:

Lack of a Clear Renewable Energy Strategy: Jordan lacks a clear renewable energy strategy, which makes it difficult to develop a sustainable and comprehensive plan for the sector. This can cause uncertainty for investors, which can make it difficult to attract the

Necessary investment to develop renewable energy projects.

High Initial Investment Costs: The initial investment costs for renewable energy projects in Jordan are high, which can make it difficult for developers to secure financing for their projects. This can limit the number of projects that are developed, which can slow the growth of the sector.

Limited Access to Financing: Access to financing is a major challenge facing the renewable energy sector in Jordan. Many banks are hesitant to finance renewable energy projects due to the high initial investment costs and the perceived risk associated with renewable energy technologies.

Limited Technical Expertise: The renewable energy sector in Jordan lacks the technical expertise necessary to develop and maintain renewable energy projects. This can lead to delays in project development and higher costs due to the need to hire experts from outside the country.

Regulatory and Policy Challenges: The regulatory framework and policy environment in Jordan can be challenging for the renewable energy sector. There is a lack of clarity and consistency in regulations related to renewable energy, which can make it difficult for developers to navigate the regulatory environment.

Grid Integration Challenges: The integration of renewable energy into the grid can be challenging due to the intermittency of renewable energy sources. This can cause stability issues for the grid and can require significant investment in grid infrastructure to support the integration of renewable energy.

Project Management Skills:

Engineering managers must possess strong project management skills to ensure the successful implementation of renewable energy projects. They must be able to plan and coordinate activities, manage resources, and lead a team of professionals from diverse backgrounds. [18]. found that project management skills were critical for the successful implementation of renewable energy projects in Jordan.

Project management skills are essential for any engineering manager, as they play a critical role in ensuring the success of projects. Effective project management requires a combination of technical expertise, leadership skills, and organizational abilities. In this paper, we will discuss project management skills and their importance in engineering management, with references to relevant literature.

Financial and Business Acumen:

Engineering managers in the renewable energy sector must have a strong understanding of financial and

business concepts. They must be able to evaluate the financial viability of renewable energy projects, develop business plans, and manage budgets. For example, [19].found that financial and economic feasibility were critical factors in the success of renewable energy projects in Jordan.

Financial and business acumen are critical skills for engineering managers in the renewable energy sector in Jordan. Effective engineering management requires not only technical expertise but also an understanding of financial and business concepts. This is particularly important in the renewable energy sector, where projects often require significant initial investment and long-term planning.

One key aspect of financial acumen in the renewable energy sector is understanding the financial models used to evaluate renewable energy projects [20]. There are several financial models used to evaluate renewable energy projects, including the net present value (NPV), internal rate of return (IRR), and leveled cost of energy (LCOE) models. Engineering managers must be familiar with these models and understand how to use them to evaluate the feasibility of renewable energy projects.

In addition to financial models, engineering managers in the renewable energy sector must also be knowledgeable about financing options [21]. There are several financing options available for renewable energy projects in Jordan, including debt financing, equity financing, and public-private partnerships. Engineering managers must understand the advantages and disadvantages of each financing option and be able to select the option that best suits their project.

Business acumen is also important in the renewable energy sector, as engineering managers must understand the business environment in which they operate. This includes understanding the competitive landscape, market trends, and customer needs [22]. Understanding customer needs is particularly important in the renewable energy sector, as customers often have unique requirements and preferences when it comes to renewable energy.

Finally, engineering managers in the renewable energy sector must be able to develop and implement effective business strategies. This includes identifying opportunities for growth, developing partnerships and collaborations, and developing effective marketing strategies [23].effective marketing strategies are critical for the success of renewable energy projects, as they can help to raise awareness and generate demand for renewable energy.

In conclusion, financial and business acumen are critical skills for

engineering managers in the renewable energy sector in Jordan. Engineering managers must be familiar with financial models, financing options, and the business environment in which they operate. They must also be able to develop and implement effective business strategies to ensure the success of renewable energy projects.

Statistics

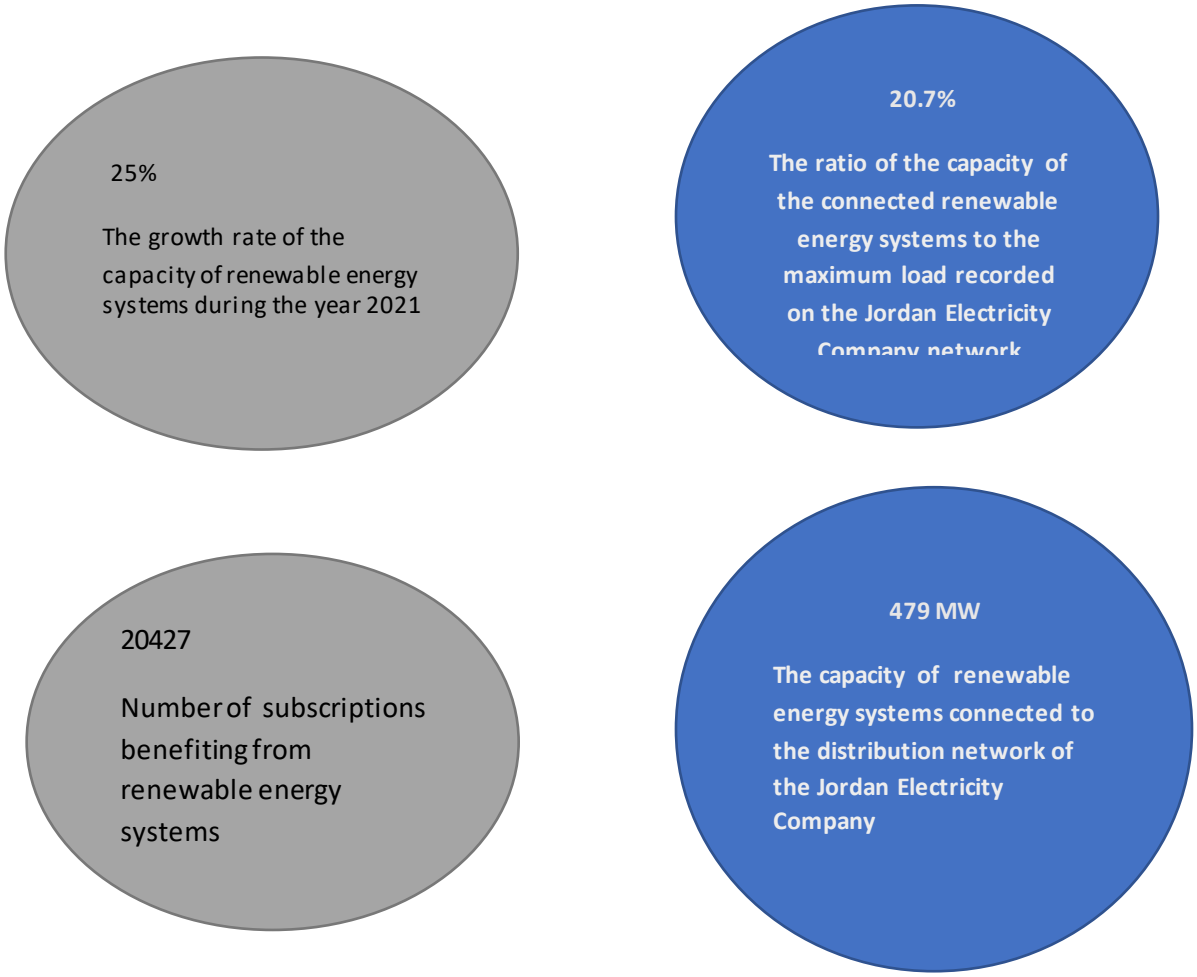

Fig 5 Statics the Strategic Objectives of diversifying energy sources

Scenario adopted by Jordan Energy Strategy for (2030-2020): High Dependency Scenario (Summary of Jordan Energy Strategy 2020-2030)

Building upon all results to the prioritized scenarios studied to select

the adopted Scenario, based upon the economic, social and environmental

Impacts; it has been Demonstrated that the high dependency scenario is the most appropriate scenario to Achieve

the Strategic Objectives of diversifying energy sources and forms, increasing The contribution of domestic energy sources to the overall energy mix, increasing Energy efficiency of all sectors alongside with the energy costs reduction in the national Economy and developing the energy sector system in Jordan to make it a regional center .Increase transport sector dependency on compressed

Table -1-Primary Energy Demand Forecast for (2020-2030)

	Primary Energy Demand
Year	(Overall domestic consumption)
	(toe)
2020	10,039
2021	10,267
2022	10,420
2023	10,595
2024	10,668
2025	10,967
2030	11,760

Fig 6 the ratio of fuel contribution to the total primary energy mix

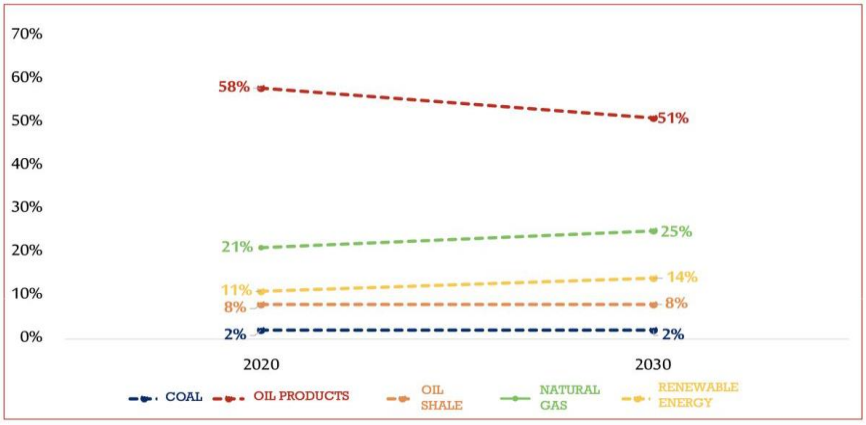

Table -2-Electricity Demand Forecast for (2020-2030)

Year	Electricity Demand
	Gigawatt hour (GWh)
2020	17,672
2021	17,831
2022	17,860
2023	17,950
2024	17,958
2025	18,686
2030	19,701

Communication and Engineering Leadership Skills

Engineering managers must possess excellent communication and leadership skills to effectively manage teams and stakeholders. They must be able to communicate technical information to non-technical stakeholders, negotiate with vendors and contractors, and build relationships with key stakeholders. A study by Al-Mohammad et al. (2020) found that effective communication and stakeholder engagement were

critical for the successful implementation of renewable energy projects in Jordan.

Communication and leadership skills are critical for engineering managers in the renewable energy sector. Effective communication is necessary to ensure that project goals are understood and achieved, while strong leadership skills enable managers to inspire and motivate their teams to achieve success. In this paper, we will discuss the importance of communication and leadership skills in engineering management of renewable energy, with references to relevant literature. Effective communication skills are critical for engineering managers in the renewable energy sector. Successful renewable energy projects require communication and collaboration among diverse stakeholders, including policymakers, engineers, and investors. Engineering managers must be skilled in both verbal and written communication, as well as in using communication technologies to facilitate remote collaboration. They must also be able to translate technical information into clear and concise language for non-technical stakeholders.

Leadership skills are also essential for effective engineering management of renewable energy projects. [24]. effective leadership involves setting clear goals, providing direction and support, and motivating team members to achieve success. Engineering managers must be able to lead teams of engineers, scientists, and other professionals, and facilitate teamwork and collaboration among team members. They must also be able to navigate complex political and regulatory environments to ensure project success.

In addition to communication and leadership skills, engineering managers in the renewable energy sector must be able to manage change effectively [25]. the renewable energy sector is constantly evolving, and engineering managers must be able to adapt to changing technological, economic, and regulatory environments. They must also be able to manage stakeholder expectations and facilitate communication among stakeholders during periods of change.

In conclusion, communication and leadership skills are critical for engineering managers in the renewable energy sector. Effective communication skills enable managers to facilitate collaboration among diverse stakeholders, while strong leadership skills enable managers to inspire and motivate their teams to achieve success. Additionally, effective change management skills are necessary for navigating the constantly evolving renewable energy sector.

Conclusion

This paper explores the role of engineering management in the renewable energy sector in Jordan. The paper reviews the current state of renewable energy in Jordan and identifies the key challenges facing the sector. The paper then discusses the role of engineering management in the renewable energy sector, including project management, risk management, and quality management. The paper also discusses the skills and competencies required of engineering managers in the renewable energy sector. Finally, the paper concludes with recommendations for improving engineering management practices in the renewable energy sector in Jordan.

Renewable energy is becoming increasingly important in many countries as a way to reduce their dependence on fossil fuels and decrease greenhouse gas emissions. Jordan is one of the leading countries in the Middle East in the adoption of renewable energy, with a goal to reach 20% of its energy consumption from renewables by 2025. The renewable energy sector in Jordan provides a great opportunity for engineering managers to contribute to the development and growth of the industry. This paper examines the key skills and competencies required for engineering managers to succeed in the renewable energy sector in Jordan, Including technical expertise, project management skills, financial and business acumen, and strong communication and leadership skills.

The renewable energy sector in Jordan provides a great opportunity for engineering managers to contribute to the development and growth of the industry. To succeed in this sector, engineering managers must possess a combination of technical expertise, project management skills, financial and business acumen, and strong communication and leadership skills. By possessing these skills, engineering managers can play a key role in the development and growth of the renewable energy sector in Jordan.

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