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## The Future of Solar Energy in Libya: Reality, Challenges and Future Opportunities

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**Abstract:** Solar energy is one of the most important renewable energy sources with significant potential to achieve environmental and economic sustainability, due to its role in reducing greenhouse gas emissions and decreasing reliance on fossil fuels. This study aims to explore citizens' perspectives on the future of solar energy in Libya, focusing on their awareness of its benefits and the challenges to its adoption. The study targeted a sample of high school, university, and postgraduate degree holders in western Libya during the Fall semester of 2024, with data collected through an online questionnaire. The results indicate that more than half of the participants are unaware of a clear governmental plan to adopt solar energy, while most believe that the government may begin implementing it within 10–15 years, provided that adequate infrastructure and investments are in place. The majority also expressed willingness to use solar energy in their homes if incentives and governmental support were available. The study concludes that Libya possesses natural conditions that could make it a leading country in solar energy utilization; however, achieving this requires supportive policies, infrastructure development, increased public awareness, and overcoming economic and technical barriers.

**Keywords:** Solar energy, Renewable energy, Fossil fuels, Libya, Sustainability, Infrastructure.

مستقبل الطاقة الشمسية في ليبيا: الواقع، التحديات والفرص المستقبلية

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**الملخص:** تُعدّ الطاقة الشمسية أحد أهم مصادر الطاقة المتجددة وأكثرها قدرة على تحقيق الاستدامة البيئية والاقتصادية، نظرًا لدورها في خفض انبعاثات الغازات الدفيئة وتقليل الاعتماد على الوقود الأحفوري. تهدف هذه الدراسة إلى استقصاء آراء المواطنين حول مستقبل الطاقة الشمسية في ليبيا، مع التركيز على مستوى الوعي بفوائدها وتحديات تبنيها. شملت الدراسة عينة من حاملي الشهادات الثانوية والجامعية والدراسات العليا في المنطقة الغربية من ليبيا خلال فصل الخريف لعام 2024، حيث جمعت البيانات عبر استبيان إلكتروني. أظهرت النتائج أن أكثر من نصف المشاركين لا يدركون وجود خطة حكومية واضحة للاعتماد على الطاقة الشمسية، بينما يرى معظمهم أن الحكومة قد تبدأ بتبنيها خلال فترة تتراوح بين 10 و15 عامًا، شريطة توفير البنية التحتية والاستثمارات اللازمة. كما عبّر غالبية المشاركين عن استعدادهم لاستخدام الطاقة الشمسية في منازلهم إذا توفرت الحوافز والدعم الحكومي. خلصت الدراسة إلى أن ليبيا تمتلك مقومات طبيعية تجعلها من الدول الرائدة المحتملة في مجال الطاقة الشمسية، إلا أن تحقيق ذلك يتطلب سياسات داعمة، وتطوير البنية التحتية، وزيادة الوعي المجتمعي، وتذليل العقبات الاقتصادية والفنية.

**الكلمات المفتاحية:** الطاقة الشمسية، الطاقة المتجددة، الوقود الأحفوري، ليبيا، الاستدامة، البنية التحتية.

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**Introduction:**

For more than a quarter of a century, the world has been seeking to find alternative sources of non-renewable (depleted) energy – which is considered one of the most dangerous pollutants threatening humanity as a whole – through conducting research to find renewable sources that do not pollute the environment, and are the best example of alternative and clean energy (Al-Shammari, 2013), and of the many advantages of renewable energy (DLR, 2005). Renewable energy is an energy resource that is generated and renewed spontaneously in nature periodically at a rate that exceeds the rate of its consumption. It also contributes to reducing the emission of pollutants into the environment (Abdul Majeed *et al.*, 2010; Al-Naas, 2020). Renewable energy is characterized by various sources such as solar energy, biomass, wind energy, and hydrogen (Galouz and Benhkoma, 2023).

Solar energy is considered the most important source of renewable energy in Libya. It is available in large quantities and is widespread throughout Libya. It can be considered a primary source of energy if it is exploited correctly and effectively, given the availability of suitable conditions in terms of intense solar radiation and the long period of exposure to the sun throughout the year. The total solar radiation intercepted by the earth is 1/8000 times greater than the human demand for primary energy (OECD,2013). In Libya, the amount of solar radiation falling on its area during one year has been estimated, according to some studies, at about  $3.5 \times 10^{15}$  (3.5 million billion) kilowatt/hours annually, which is more than 100 thousand times the total electricity demand expected in Libya for the year 2040 (Qaliya, 2017), this enables it to establish several projects to benefit from it, especially in the field of electricity production, for attempt to reduce the depletion of exhaustible resources (oil and natural gas) in the operation of power plants.

Since the beginning of 1980, Libya has been able to use solar energy for the first time in the wireless communications sector. The General Post and Telecommunications Company installed a group of stations in areas far from the electricity grid in order to generate electrical energy for small loads, followed by the installation of a group of systems in the years 1996-2003, the number of stations that were established from the year 1980 until the year 2003 amounted to about 70 stations with a total capacity of 294.55 kilowatts (Saleh *et al.*, 2004). Several other entities, including the Ministry of Interior, oil companies, and the Great Man-Made River Communications Organization, also established 48 stations during the years 1994-2003, with a total capacity of 76.74 kilowatts (Saleh *et al.*, 2004). In addition, its use in applications such as solar heating, water pumping, and wireless broadcasting (Abdul Rasul, 2012), solar cell systems were also used in the villages of Bir Marjan and Wadi Marsit, located near Mizdah, in order to deliver electricity to them, with a capacity of 29.250 kilowatts in the village of Bir Marjan and 67.2 kilowatts in Wadi Marsit, as well as a water pumping system in Bir Al-Jaf in the Murada area with a capacity of 1.2 kilowatts (Abdul Rasul, 2012).

Renewable energy has been witnessing rapid growth in recent times. It is one of the most important fields that enhance environmental sustainability and reduce dependence on fossil fuels. Therefore, Libya has shown increasing interest in diversified energy sources and in taking advantage of the solar energy available in the country. The General Electricity Company has launched sustainable energy projects to diversify its economy (Benhkoma *et al.*, 2023). Among the solar projects in Libya (Sustainable Development Committee, 2020), was the opening of a solar station in Ghat with a capacity of 1.5 megawatts in 2016, followed by the establishment of a solar station in the city of Zliten with a capacity of 10 megawatts in 2017. While, the Nafusa Mountains Shams project was one of the largest proposed projects in Libya, aiming to build a 500-megawatt power plant in the Nafusa Mountains region near the city of Zawia. It also announced for the first time an economic development plan, Vision 2030, that focuses on using solar energy instead of liquid fuels to generate electricity. According to the National Strategic Plan for Renewable Energy Investment, energy production reached 3.45 gigawatts in 2020, 9.50 gigawatts in 2023, and 27.30 gigawatts in 2024, while in 2030 renewable energy production reached 58.70 gigawatts.

However, the absence of legislation specific to renewable energies, and the absence of training and development centers – to prepare effective talent in the field of renewable energies- due to weak institutional support that does not meet the required level, have led to the failure of future plans adopted by governments related to generating electricity from renewable energies to become a reality, in addition to various other reasons.

Given the weak culture of using solar energy among the general public and the lack of government contribution to its development. In this research, we conducted a study on the future of solar energy in Libya, examining the reality, challenges and future opportunities from the perspective of citizens holding various degrees, from high school to doctoral degrees. The study sought to determine their awareness of the importance of solar energy as a sustainable source of energy, in contrast to fossil fuels, in terms of cost, harms and environmental safety, and also the extent to which it can be used in their homes.

### **Materials and methods:**

This study was limited to holders of academic qualifications (High school diploma, university degree, master's degree, and doctorate) in western Libya during the fall semester of 2024, about the future of solar energy in Libya. The questionnaire was distributed electronically randomly on various social media platforms. Females constituted 61.5% of the sample, while males constituted 38.5%. The study sample was divided into four age groups (less than 20 years, between 20 and 30 years, from 30 to 40 years, and over 40 years). The percentage of university degree holders was 43.5%, High school diploma holders 34.1%, and master's and doctoral degree 22.4%. Table (1) shows the questions that make up the questionnaire.

**Table (1): Questions asked in the questionnaire**

1	Have you ever heard of a government plan to rely on solar energy in Libya?
2	If your answer to the previous question is yes, from what source did you hear about the plan?
3	How aware are you of the harms of excessive use of fossil fuels (e.g., oil, gasoline, coal, etc.), if any?
4	What are the potential damages harms of overuse of fossil fuels? (If any).
5	Do you consider environmental safety?
6	How aware are you of regarding solar energy harvesting technologies?
7	Which is more economical: fossil fuels or solar energy?
8	How do you see the future of solar energy in Libya?
9	In your opinion: When will the government sector rely on solar energy?
10	Would you rely on solar energy in your home if it was available in Libya?

**Results and discussion**

Table (2) shows the data of the study participants, including gender, age group, and educational level.

**Table (2): Data of participants in the survey study**

	Variable	Number	Percentage )%(
Gender	Male	124	38.5%
	Female	198	%61.5
Age Group	Under 20 years	40	12.4%
	20-30 years	211	65.5%
	30-40 years	37	11.5%
	Over 40 years	34	10.6%
Educational Level	High school diploma	110	34.1%
	University degree	140	43.5%
	Master's and Doctoral degree	72	22.4%

The Table above shows that the majority of respondents in the survey were females, representing 61.5%, while males representing 38.5%. The highest percentage of participants in the study were those aged between 20 and 30 years, at 65.5%, followed by those under 20 years of age at 12.4%, then those aged 30-40 years at 11.5%, and finally those over 40 years of age at 10.6%. The majority of participants held university degrees, at 43.5%, followed by high school graduates, at 34.1%. The lowest percentage included in the survey was for those with master's and doctoral degrees, at 22.4%.

The results show that 50.8% of participants were aware of the government's plan to rely on solar energy in Libya, while 49.2% were unaware. The results indicated that the source through which most participants heard about the government's plan was the internet (40.6%), followed by television news broadcasts, and then from a friend.

According to the results, 55.7% of respondents have a very high awareness of the dangers of excessive fossil fuel use, reflecting a strong understanding of the environmental and economic risks associated with such use. Meanwhile, 36.1% have low awareness, indicating a gap in understanding that requires communication and educational efforts to bridge. 8.2% are unsure, highlighting the need to provide clear and comprehensive information to this group. The majority of respondents believe that environmental and economic problems are caused by the excessive use of fossil fuels. However, 6.6% of respondents believe that global warming is one of the harmful effects of this overuse. The results also indicated a high level of environmental awareness and commitment to preserving the environment among individuals, while 1.6% of respondents do not consider environmental safety.

The study results show that 34.4% of the sample members have a very high awareness of solar energy harvesting technologies, indicating that a significant percentage of individuals are highly familiar with solar energy technologies and their potential benefits. A further 41% have little awareness, indicating that most individuals lack sufficient knowledge or information about solar energy extraction. The percentage of those who were unsure was 22.1%, which highlights the need to clarify concepts and provide them with more information. A further 2.5% are completely unaware, indicating that few individuals need a basic knowledge base about solar energy technologies.

The vast majority of respondents, 82%, believe that solar energy is a sustainable economic solution. However, 7.3% believe that fossil fuels are the most economical, reflecting a lack of support for this view. The percentage of those who were unsure was 10.7%, indicating the need for more information in order to develop a culture of using solar energy.

When asked about the future of solar energy in Libya, 45.1% of respondents saw it as bright, this indicates great optimism about the possibility of achieving significant progress in this field. The percentage of those who were unsure was 41.8%, this reflects a state of hesitation or lack of available information. 13.1% did not see a future for solar energy in Libya, this indicates the presence of some doubts or challenges that need to be addressed.

Based on the study results, 16.4% of respondents believe the Libya government will rely on solar energy within 5-10 years, this suggests there is relative optimism about rapid adoption. Meanwhile, 25.4% believe this will happen within 10-15 years, reflecting slow but positive expectations. 20.5% believe it will take more than 15 years, which raises doubts about the rapid adoption of this technology. The majority, 37.7%, do not believe the state will adopt it, this reflects a lack of confidence in the Libyan government's adoption of this technology in the near future. This is due to the fact that none of the previously planned projects have been implemented on the ground at this time.

The results showed that 79.5% of participants would prefer to use solar energy in their homes if available, reflecting a strong desire to adopt this type of energy. Another 15.6% were unsure, this indicates some hesitation or a lack of information that might support a

positive decision. Only 4.9% rejects the use of solar energy, reflecting a lack of opposition to this option.

### Conclusion

Solar energy is one of the most important solutions for the sustainable energy future. Thanks to its ability to reduce pollution and provide clean energy, this study was conducted to survey participants' views on the future of solar energy in Libya. The study was limited to holders of various academic qualifications (high school, university degree, master and doctoral degree) in western Libya during the fall semester of 2024. The study sample was divided into four age groups: those aged 20 to 30 years, representing 65.5%, followed by those under 20 years, representing 12.4%, then those aged 30 to 40 years, representing 11.5%, and finally those over 40 years, representing 10.6%. Participants in this study varied in their responses to the questions posed, with most of them believing that the Libyan government could begin relying on solar energy within 10-15 years if the country provides the appropriate infrastructure. It also became clear that most of the participants were fully aware of the potential harms of environmental pollution, addition there is great optimism about the future of solar energy in Libya, as Libya enjoys natural conditions that make it among the best countries in the world to benefit from solar energy. Finally, Libya's investment in solar energy could have a significant positive impact on the environment and economic levels, it could be a fundamental step toward a more prosperous and sustainable future.

### Recommendations

1. Raising awareness about the importance of solar energy among citizens by organizing educational events and various training programs in educational and service institutions.
2. Include solar energy topics in curriculum to raise students' awareness of its importance.
3. Spread awareness of the benefits of solar energy through media and social media and encourage its use.
4. Providing government incentives and support to encourage community members to adopt solar energy and reduce initial costs.

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