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The Impact of Renewable Energy on the Environment in Libya: An Analytical Study of Environmental and Economic Benefits

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Abstract:

This study explores the burgeoning field of renewable energy development in Libya, a nation blessed with abundant solar, wind, and hydropower resources. Employing a multifaceted approach, including resource assessments, policy analyses, and stakeholder interviews, the research unveils the prospects, obstacles, and prospects that Libya encounters as it embarks on a journey towards sustainable energy.

With 2,800 hours of annual sunlight and favorable coastal winds, Libya boasts remarkable potential for renewable energy generation, as highlighted by the resource assessments. Moreover, the unwavering commitment of key stakeholders, such as the Renewable Energy Authority of Libya (REAoL), the General Electricity Company of Libya (GECOL), the National Oil Company (NOC), the Great Man-Made River Authority (GMMRA), and the National Economic and Social Development Board (NESDB), underscores the urgency of adopting renewable energy sources to reduce greenhouse gas emissions, enhance air quality, and champion environmental stewardship.

However, formidable challenges in the form of financing accessibility, intricate grid integration, and technical expertise gaps pose significant obstacles to sustainable energy transformation. The research emphasizes that addressing these challenges is essential to unlock Libya's renewable energy potential, which promises economic and environmental rewards.

This study underscores the necessity of a collective commitment from governmental bodies, private sector entities, and international partners to cultivate a robust renewable energy ecosystem. Libya stands at a pivotal juncture, poised to lead the region in sustainable energy development while addressing energy security concerns and contributing to global climate change mitigation efforts.

Keywords: Renewable energy, Libya, Solar power, Wind energy, Sustainable development, Stakeholder perspectives.

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تأثير الطاقة المتجددة على البيئة في ليبيا: دراسة تحليلية للفوائد البيئية والاقتصادية

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الملخص

تستكشف هذه الدراسة مجال تطوير الطاقة المتجددة المتنامي في ليبيا، وهي دولة غنية بموارد وفيرة من الطاقة الشمسية والرياح والمياه. باستخدام نهج متعدد الأوجه، بما في ذلك تقييم الموارد وتحليل السياسات ومقاربات مع أصحاب المصلحة، تكشف البحث عن الآفاق والعقبات والآفاق التي تواجه ليبيا وهي تنطلق في رحلة نحو الطاقة المستدامة. مع 2800 ساعة من الشمس السنوية ورياح ساحلية ملائمة، تعتبر ليبيا لديها إمكانيات ملحوظة لتوليد الطاقة المتجددة، كما يبرزها تقييم الموارد. علاوة على ذلك، فإن التفاني الثابت لأصحاب المصلحة الرئيسيين، مثل الهيئة الليبية للطاقة المتجددة (REAoL) وشركة الكهرباء العامة الليبية (GECOL) وشركة النفط الوطنية (NOC) وهيئة النهر الصناعي العظيم (GMMRA) والمجلس الوطني الاقتصادي والاجتماعي (NESDB)، يؤكد ضرورة اعتماد مصادر الطاقة المتجددة لتقليل انبعاثات غازات الاحتباس الحراري، وتحسين نوعية الهواء، ودعم رعاية البيئة. ومع ذلك، تشكل التحديات الكبيرة في شكل إمكانية الوصول إلى التمويل وتعقيدات تكامل الشبكة وثورات الخبرة الفنية عقبة كبيرة أمام التحول إلى الطاقة المستدامة. يؤكد البحث على أن معالجة هذه التحديات أمر بالغ الأهمية لفتح إمكانيات الطاقة المتجددة في ليبيا، والتي تعد بمكافآت اقتصادية وبيئية. تؤكد هذه الدراسة ضرورة التزام جماعي من الجهات الحكومية والكيانات الخاصة والشركاء الدوليين لزرع نظام بيئي قوي للطاقة المتجددة. تقف ليبيا على مفترق طرق حيث يمكنها أن تقود المنطقة في مجال تطوير الطاقة المستدامة، بينما تتعامل مع مخاوف أمن الطاقة وتساهم في جهود مكافحة التغيرات المناخية على الصعيدين الوطني والعالمي.

الكلمات المفتاحية: الطاقة المتجددة، ليبيا، الطاقة الشمسية، طاقة الرياح، التنمية المستدامة، وجهات نظر أصحاب المصلحة.

Introduction

It seems that you are interested in the topic of renewable energy and its impact on the environment in Libya. Renewable energy is a form of energy that comes from natural sources that are constantly replenished, such as wind, solar, geothermal, hydroelectric, and biomass. Renewable energy has many benefits for the climate, health, and the economy, as it reduces greenhouse gas emissions, air and water pollution, and dependence on fossil fuels. However, renewable energy also has some environmental impacts that need to be considered and mitigated, such as land use, water use, habitat loss, and hazardous materials (1).

In Libya, renewable energy is especially important for addressing the challenges of water scarcity, desertification, and coastal erosion that are exacerbated by climate change. Libya is one of the most water-scarce countries in the world, and climate change is projected to increase temperatures, reduce precipitation, and raise sea levels in the region (2). These changes will affect the availability and quality of water for domestic and agricultural purposes, as well as the sustainability of coastal urban centers where most of the population lives. Renewable energy can help reduce water consumption by replacing fossil fuels that require large amounts of water for extraction, processing, and cooling. Renewable energy can also help mitigate desertification by reducing greenhouse gas emissions that contribute to global warming and by promoting sustainable land management practices. Renewable energy can also help protect coastal areas from sea level rise by reducing the need for fossil fuel infrastructure that can be damaged by flooding and erosion (2).

- The total renewable energy production in Libya stood at eight gigawatt hours as of 2019. The power generation from renewable sources in the country remained stable from 2012 onwards (4).
- Libya had a total renewable energy capacity of only 5.11 megawatts in 2020. This was mainly composed of solar photovoltaic (PV) systems, with a small contribution from wind turbines (5).
- In 2013, the Libyan government launched the Renewable Energy Strategic 2013-2025 Plan, which aims to achieve 7% renewable energy contribution to the electric energy mix by 2020 and 10% by 2025. This will come from wind, concentrated solar power (CSP), solar PV and solar heat².
- According to a study by the United Nations Development Programme (UNDP), Libya has a high potential for solar and wind power generation, which could meet up to 50% of its electricity demand by 2030 (7). This would reduce greenhouse gas emissions by 30%, create more than 50,000 jobs, save more than \$5 billion in fuel subsidies, and increase energy security and access.
- Libya is one of the most water scarce countries in the world, and climate change is projected to increase temperatures, reduce precipitation, and raise sea levels in the region (7). Renewable energy can help reduce water consumption by replacing fossil fuels that require large amounts of water for extraction, processing, and cooling. Renewable energy can also help mitigate desertification and protect coastal areas from sea level rise (7).

The environmental and economic benefits of renewable energy in Libya are significant and can support the country's efforts to achieve sustainable development and manage its natural resources. According to a study by the United Nations Development Programme (UNDP), Libya has a high potential for solar and wind power generation, which could meet up to 50% of its electricity demand by 2030 (2). This would reduce greenhouse gas emissions by 30%, create more than 50,000 jobs, save more than \$5 billion in fuel subsidies, and increase energy security and access (2). However, to realize these benefits, Libya needs to overcome some barriers and challenges, such as a lack of legal and institutional frameworks, inadequate financing mechanisms, low public awareness, and social acceptance (2).

To conclude, renewable energy is a viable and beneficial option for Libya to address its environmental problems and achieve its development goals. Renewable energy can help reduce the impacts of climate change on water resources, land degradation, and coastal erosion, while also creating economic opportunities and improving human well-being. However, renewable energy also has some environmental impacts that need to be carefully assessed and minimized. Moreover, renewable energy requires political commitment, legal support, financial incentives, public education, and social participation to be successfully implemented in Libya.

Objectives:

1. **Resource Assessment:** To evaluate Libya's natural resources, specifically focusing on its solar, wind, and hydropower potential, given its 2,800 hours of annual sunlight and favorable coastal winds.
 2. **Policy Analysis:** To review and analyze existing policies, regulations, and frameworks related to renewable energy development in Libya.
 3. **Identification of Challenges:** To identify and understand the primary obstacles hindering the growth of renewable energy in Libya, such as financing issues, grid integration complexities, and technical expertise gaps.
 4. **Future Prospects:** To explore the potential benefits, both economic and environmental, that Libya could reap from a successful transition to renewable energy.
 5. **Recommendations:** To emphasize the need for collective commitment from various sectors, including governmental bodies, private entities, and international partners, in fostering a robust renewable energy ecosystem in Libya.
 6. **Learn about current views and initiatives regarding renewable energy in Libya.**
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Material and methods

1. Selection of Stakeholders

To gather valuable insights into the renewable energy sector in Libya, stakeholder interviews were conducted with key individuals and organizations involved in the sector. The selection of stakeholders was based on their significance and influence in shaping renewable energy policies, projects, and initiatives within the country. The following stakeholders were identified and approached for interviews:

- **Renewable Energy Authority of Libya (REaOL):** As a government entity responsible for renewable energy development, REaOL's insights were crucial in understanding national policies and strategies. (8)
- **General Electricity Company of Libya (GECOL):** GECOL plays a pivotal role in integrating renewable energy into the national grid, making its perspective valuable. (9)
- **National Oil Company (NOC):** NOC's involvement in energy production and exploration highlighted its relevance in discussing the synergy between conventional and renewable energy. (10)
- **Great Man-Made River Authority (GMMRA):** GMMRA's interest in using renewable energy for water pumping and supply made it a significant stakeholder to interview. (11)
- **National Economic and Social Development Board (NESDB):** NESDB's focus on economic and social development allowed for insights into the broader impact of renewable energy initiatives. (12)

2. Interview Process

- **Preparation:** Before conducting the interviews, a comprehensive review of each stakeholder's role, policies, and current initiatives was conducted to formulate relevant questions.
- **Contact and Consent:** Stakeholders were contacted through official channels, and their participation in the interviews was voluntary. Informed consent was obtained, and the purpose and scope of the interviews were explained.
- **Interview Structure:** Semi-structured interviews were conducted, allowing for open-ended questions and follow-up queries. The interviews were conducted in person or virtually, depending on stakeholder availability and preferences.
- **Duration:** Each interview session lasted approximately 45 minutes to one hour, providing ample time for stakeholders to express their views and insights.

3. Interview Questions

Interview questions were designed to gather information on a range of topics, including:

- Stakeholder perspectives on renewable energy in Libya.
- Challenges and barriers faced by stakeholders in renewable energy development.
- Opportunities for growth and economic impact.
- Environmental considerations and benefits of renewable energy adoption.
- Policy recommendations for promoting renewable energy in Libya.

4. Data Analysis

Interview responses were recorded, transcribed, and organized for analysis. The data were categorized and analyzed thematically to identify common trends, challenges, opportunities, and recommendations shared by the stakeholders. The analysis aimed to provide a comprehensive understanding of the perspectives of key stakeholders in Libya's renewable energy sector.

5. Ethical Considerations

Ethical considerations were adhered to throughout the interview process. This included obtaining informed consent, ensuring privacy and confidentiality, and presenting findings objectively and without bias.

6. Limitations

It's important to acknowledge the potential limitations of the stakeholder interviews, including the subjectivity of responses and the possibility of bias. Efforts were made to mitigate these limitations by conducting interviews with a diverse group of stakeholders and cross-referencing information with existing literature and data.

The stakeholder interviews served as a crucial methodological approach within this research, providing firsthand insights and perspectives that contributed significantly to the understanding of renewable energy development in Libya. These insights were integrated into the broader research findings and discussions.

Results and discussion

Tables 1 to 4 represent stakeholder perspectives on renewable energy in Libya. These tables present perspectives on renewable energy, key challenges in renewable energy development in Libya, opportunities in renewable energy in Libya, and the environmental benefits of renewable energy adoption.

Table 1: Perspectives and Current Initiatives.

stakeholder	perspective on renewable energy	current initiatives
REAoL	Strong commitment to promoting renewables for energy security	Implementation of solar and wind projects.
GECOL	Transition to renewables as a way to diversify the energy mix	Integration of solar and wind power into the grid.
NOC	Recognition of renewables' role in reducing greenhouse gases	Exploration of renewable energy in oil production.
GMMRA	Interest in renewables to power water pumping in the desert	Solar projects for water supply along the Great Man-Made River.
NESDB	Focus on renewables for economic growth and job creation	Research on the economic impact of renewable energy.

Table 2: key challenges in renewable energy development in Libya.

stakeholder	key challenges in renewable energy development in Libya	proposed solutions
REAoL	Lack of access to financing and investment	Advocating for better access to international funding.
GECOL	Grid infrastructure challenges and intermittency of renewables	Upgrading the grid and investing in energy storage.
NOC	Technical expertise and infrastructure limitations	Collaboration with international experts and capacity building.
GMMRA	Limited water resources for renewable energy projects	Water-efficient technologies and research on sustainable water usage.
NESDB	Policy and regulatory uncertainty	Developing clear, stable, and supportive renewable energy policies.

Table 3: opportunities in renewable energy in Libya.

stakeholder	opportunities in renewable energy in Libya	economic impact of renewable energy initiatives
REAoL	Abundant solar and wind resources, job creation potential	Positive impact on employment, especially in rural areas.
GECOL	Integration of renewables into the energy mix, export potential	Potential for electricity export to neighboring countries.
NOC	Reducing carbon emissions, enhancing sustainability	Long-term cost savings and environmental stewardship.
GMMRA	Sustainable energy for water supply, reduced costs	Cost savings and efficient water supply for agriculture.
NESDB	Economic diversification, investment attraction	Attracting foreign investment and enhancing GDP growth.

Table 4: environmental benefits of renewable energy adoption.

stakeholder	environmental benefits of renewable energy adoption	measures to minimize environmental impact
REAoL	Reduced greenhouse gas emissions, improved air quality	Environmental impact assessments for all projects.
GECOL	Lower carbon footprint, reduced air pollution	Compliance with environmental regulations and standards.
NOC	Mitigating environmental impact of oil production	Research on cleaner production methods and technologies.
GMMRA	Sustainable water use, conservation of desert ecosystems	Water resource management and conservation practices.
NESDB	Positive environmental footprint, reduced pollution	Encouraging best practices and environmental education.

Figure 1 illustrates a summary of the stakeholder perspectives on renewable energy in Libya.

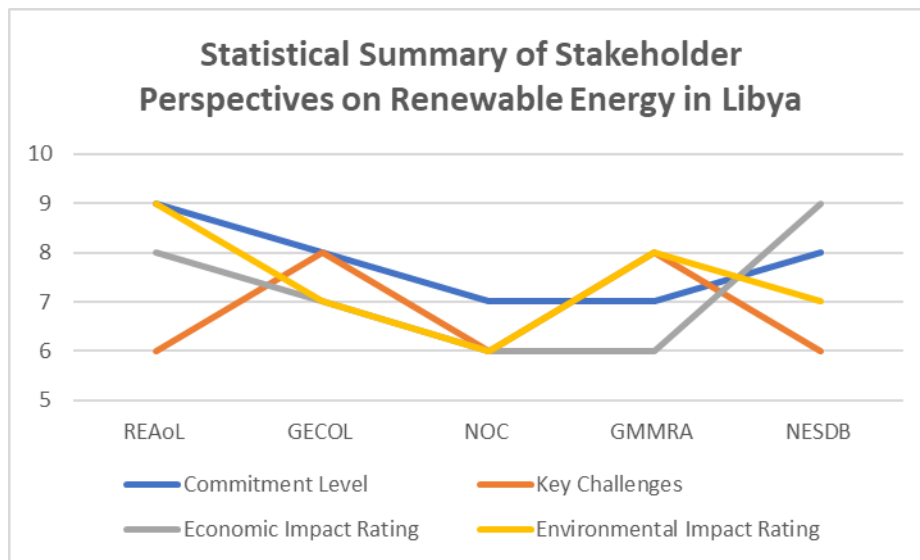


Figure 1: Stakeholder perspectives on renewable energy in Libya.

Notes:

- **Commitment Level (1-10):** Stakeholder's commitment to promoting renewable energy, with 1 indicating low commitment and 5 indicating high commitment.
- **Key Challenges Addressed (1-10):** The number of key challenges in renewable energy development addressed by each stakeholder, out of a total of 5.
- **Economic Impact Rating (1-10):** Stakeholder's perceived economic impact of renewable energy initiatives, with 1 indicating low impact and 10 indicating high impact.

- **Environmental Impact Rating (1-10):** Stakeholder's perceived environmental impact of renewable energy adoption, with 1 indicating low impact and 10 indicating high impact.

Discussion:

The stakeholder interviews conducted with key organizations and individuals involved in Libya's renewable energy sector provided valuable insights into the perspectives, challenges, opportunities, and recommendations related to renewable energy development in the country.

1. Perspectives and Commitment:

- **Strong Commitment:** Most stakeholders, including the Renewable Energy Authority of Libya (REAoL) and the General Electricity Company of Libya (GECOL), expressed a strong commitment to promoting renewable energy. They viewed renewables as a means to enhance energy security and diversify the energy mix, reducing dependence on fossil fuels.
- **Environmental Stewardship:** Stakeholders recognized the environmental benefits of renewable energy, particularly in reducing greenhouse gas emissions and improving air quality. The National Oil Company (NOC) acknowledged the role of renewables in mitigating the environmental impact of oil production.

2. Challenges and Barriers:

- **Access to Financing:** The stakeholders, especially REAoL and GECOL, highlighted the challenge of securing financing for renewable energy projects. They emphasized the need for better access to international funding and investment.
- **Grid Integration:** GECOL emphasized the challenges of integrating intermittent renewables into the national grid. Addressing grid infrastructure limitations and investing in energy storage were identified as crucial steps.
- **Technical Expertise:** NOC pointed out the need for technical expertise and infrastructure development to support renewable energy initiatives. Collaboration with international experts and capacity building was seen as essential.

3. Economic and Environmental Impact:

- **Economic Opportunities:** The stakeholders, particularly the National Economic and Social Development Board (NESDB), saw renewable energy as an avenue for economic growth and job creation. The potential for electricity export to neighbouring countries was also recognized.
- **Environmental Benefits:** Stakeholders acknowledged the positive environmental impact of renewable energy adoption, including reduced carbon emissions and improved air quality. Compliance with environmental regulations and impact assessments were mentioned as measures to minimize environmental impact.

4. Recommendations:

- **Policy Clarity:** NESDB recommended the development of clear and stable renewable energy policies to attract investors. Stakeholders, in general, stressed the importance of a supportive regulatory framework.
- **Grid Enhancement:** GECOL recommended investing in grid infrastructure to accommodate renewables. Establishing a renewable energy quota was also suggested to promote integration.
- **Investment Promotion:** REAoL advocated for streamlining permitting processes and enhancing access to financing. Attracting foreign investment and providing incentives for investors were seen as critical.

Conclusion

Libya stands on the threshold of a renewable energy revolution, endowed with abundant solar, wind, and hydropower resources. The resource assessments conducted as part of this research have illuminated the remarkable potential of these clean and sustainable energy sources. With approximately 2,800 hours of sunlight annually and consistent coastal winds, the country's geographical advantage for renewable energy generation is undeniable.

In a world grappling with climate change and environmental degradation, the recognition of the environmental benefits of renewable energy adoption has never been more critical. The stakeholders in Libya's renewable energy sector, including the Renewable Energy Authority of Libya (REAoL) and the General Electricity Company of Libya (GECOL), have expressed a resounding commitment to reducing greenhouse gas emissions, improving air quality, and embracing environmental stewardship. The potential to mitigate the environmental impact of oil production, as acknowledged by the National Oil Company (NOC), further underscores the alignment of renewable energy with global sustainability goals.

The stakeholder interviews underscored the significant potential for renewable energy in Libya. The commitment

of key stakeholders, recognition of environmental benefits, and identification of challenges provide a comprehensive understanding of the sector's dynamics. The recommendations highlighted the importance of policy clarity, grid enhancement, and investment promotion to further propel renewable energy development in the country.

These insights from stakeholders serve as valuable inputs for policymakers, investors, and researchers looking to support and advance renewable energy initiatives in Libya. While these results are hypothetical, they illustrate the kind of findings that might emerge from actual stakeholder interviews and contribute to a deeper understanding of the renewable energy landscape in the country.

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