Renewable Energy, Environment, and Power Quality Journal (REE&PQJ)
ISSN:3020-531X
Volume No.2, July 2024

Sustainable Energy Transition in Jordan: Policies, Progress, and Promising Trends

Hiba Shakhashiro[1] and Maria Szalmane Csete[1]

[1] Department of Environmental Economics and Sustainability
Budapest University of Technology and Economics
Műegyetem rkp. 3., H-1111 Budapest, Hungary
Phone/Fax number: +0036 1 463 1941

Abstract. As global concerns regarding climate change escalate, the imperative to transition towards sustainable and renewable energy sources becomes crucial for ensuring the well-being of our planet. This paper examines Jordan's pursuit of a sustainable energy landscape amid challenges such as population growth, economic uncertainties, and geopolitical intricacies. Jordan faces challenges like a widening energy supply and demand gap and reliance on fossil fuels. The paper explores how Jordan, with its abundant renewable resources, can utilize it to enhance political and economic stability. Jordan, stands as a notable example in the Middle East, ranking high in the Arab Future Energy Index Report (AFEX) for sustainable energy practices. This study identifies key barriers to Jordan's energy independence, including insufficient electrical grid infrastructure growth, historical unfair contracts, and reliance on international funds. Jordan's achievements in renewable energy are acknowledged, with the government's initiatives and international collaborations propelling the sector forward. Despite challenges, Jordan's commitment to increasing renewable energy targets and exploring green hydrogen strategies positions it as a key player in the global transition towards sustainable energy. The overview concludes by emphasizing the importance of addressing challenges, implementing technical recommendations, and contributing to economic development and environmental sustainability in the region.

Keywords. sustainable energy transition, regional economic development, renewable energy, MENA region, Jordan, AFEX

1. Introduction

In the face of escalating global climate challenges, the pursuit of sustainable and renewable energy (RE) sources has become imperative for the well-being of our planet. The rapid depletion of fossil fuels, coupled with the undeniable impact of climate change, has spurred a global movement towards harnessing cleaner, more efficient energy alternatives. This paradigm shift is not only critical for mitigating the adverse effects of climate change but is also pivotal in securing a sustainable future for generations to come. Recent studies, such as Zhao et al. (2022), emphasize the positive impact of heightened renewable energy consumption on global energy conservation and emissions reduction [27]. Their findings suggest that RE usage can significantly alleviate energy poverty on a global scale, particularly in European countries, by enhancing energy efficiency. Moreover, other research establishes a solid unidirectional relationship between (RE) consumption and economic growth, underlining the integral role renewables play in sustainable development [22]. The commitment to RE is further underscored by the International Energy Agency's (IEA) projection that renewables are poised to become the largest source of electricity generation by 2040 [8]. The COVID-19 pandemic, despite causing a temporary reduction in global energy demand, had a positive impact on the development and utilization of renewable energy sources, as highlighted by the IEA in 2020 [8]. This momentum has been bolstered by international initiatives aimed at addressing climate change and various government policies promoting renewable energy industry growth.

As countries worldwide strive to enhance energy security and reduce reliance on fossil fuels, numerous success stories emerge. For example, analysts predict that biogas will play a pivotal role in Indonesia's energy mix in the coming years [25]. Additionally, the popularity of ground-source heat pumps has significantly increased, with countries like Thailand, Malaysia, Germany, and Singapore embracing geothermal energy [23] [16].

Turkey, for instance, boasts renewable sources contributing to 45% of its energy-producing capacity, with hydropower being the largest contributor at 55.7% of the total renewable generation capacity [10]. The global energy landscape faces disruptions, such as the Russian-Ukrainian War of 2022, impacting energy markets and revealing strategic vulnerabilities in Europe. Despite challenges, renewable energy sources continue to grow, supported by the implementation of new policies and increased investments in sustainable energy and energy efficiency by governments worldwide, including the United States and the European [12] This resilient trajectory underscores the urgency for MENA (Middle East and North Africa) countries to intensify their efforts in embracing renewable energy. The MENA region, distinguished by its abundant

sunlight and vast untapped renewable energy potential, finds itself at a critical crossroads where its actions can wield a substantial impact on the global effort to combat climate change. As nations worldwide grapple with the consequences of carbon-intensive energy practices, MENA countries stand uniquely positioned to lead the charge in adopting and promoting RE solutions. Given the region's exceptional solar resources, MENA nations can transform their energy landscapes, not merely as a reaction to global crises but also as a strategic move towards cultivating a sustainable and resilient future. By capitalizing on their inherent advantages, MENA countries can set an influential example for the rest of the world, contributing significantly to the global transition towards cleaner and more sustainable energy practices. Middle East have long faced the challenge of achieving sustainable development. On one hand, they must satisfy the growing demand for energy due to increasing economic activity, as predicted by the International Energy Outlook [26], which states that global energy consumption will increase by 50% by 2050. On the other hand, the deteriorating environment is a major concern for political economists. The Middle East countries are grappling with the challenges of the widening energy supply and demand gap, reliance on fossil fuels, and rising global prices. To overcome these challenges, the Middle East can utilize its abundant potential in renewable energy.

In recent years, there have been notable advancements in the use of renewable energy in certain countries of the Middle East. However, the region is plagued by issues such as high population growth, conflict, and economic insecurity, which directly affect the RE sector. The Middle East boasts favourable conditions for solar, wind, and tidal energy production, making it a promising region for the development of renewable resources [7]. Despite being a major oil-producing region, continued extraction will eventually lead to the depletion of these resources, resulting in a severe crisis [13]. Therefore, there is a strong argument to be made that increased utilization of renewable energy can contribute to the political and economic stability of the Middle East [16].

The MENA region has a population of 578 million people and an average economic growth rate of 2.5%, which is driving electricity demand. In 2021, electricity consumption in the region rose by approximately 4%, and it is projected to grow by 2.6% in 2022. However, power generation is a significant contributor to pollution in the region. To address this issue, many intergovernmental organizations are promoting RE applications as a solution for eco-friendly power generation [24] [12] [22].

Jordan, like most developing countries, faces issues, constraints, and difficulties in increasing the utilization of renewable energy technologies. The most compelling argument in favor of adopting RE technologies in Jordan is the country's lack of conventional commercial energy sources but its abundance of solar and wind resources. Three key factors influence the future of RE technology: economic considerations, science and technology aspects, and the pursuit of a healthier environment, and taking these three factors into account, Jordan still has a long way to go before full implementation.

Our study case Jordan, as depicted in Figure (1), revealed its noteworthy standing as the third-ranked Arab nation in terms of renewable energy capacity dedicated to meeting domestic requirements.

Fig (1) MENA countries, own work based on [4]

Jordan, in 2021, demonstrated the highest proportion of renewable energy contribution among all Arab countries, excluding hydropower. In the subsequent year, the Arab Future Energy Index Report (AFEX) for 2022 affirmed Jordan's prominence, identifying it as one of the premier countries in the region for cultivating a conducive environment for investments in renewable energy and energy efficiency [9].

Pioneering the landscape of Arab indices, AFEX serves as the inaugural platform exclusively committed to scrutinizing and evaluating the competitiveness of sustainable energy within the Arab region. Offering an intricate blend of quantitative and qualitative analyses, AFEX dissects pivotal market drivers for both renewable energy and energy efficiency. This comprehensive assessment encompasses the meticulous ranking of countries based on over 40 indicators, elucidating critical facets of the energy market, spanning policies, institutional and technical capacities, strategies, socioeconomic data, and investments. The data collection process for AFEX is rigorous, drawing from an extensive array of local and international sources to uphold the highest standards of accuracy and transparency. Notably, AFEX is curated and disseminated by the esteemed Regional Centre for RE and Energy Efficiency (RCREEE), emphasizing its significance in monitoring and analysing sustainable energy competitiveness within the Arab region.

Reflecting the outcomes of these comprehensive assessments, Jordan's dedication to sustainable energy initiatives is evident. In the 2023 AFEX Renewable Energy, Jordan secured a commendable second position, boasting an impressive score of 83 percent, tying with Morocco. Egypt claimed the lead in the Arab region with an 87 percent score, while Tunisia followed in

third place. Furthermore, the UAE exhibited noteworthy progress, recording the highest score among Gulf countries at 80 percent, as illustrated in Figure (2).

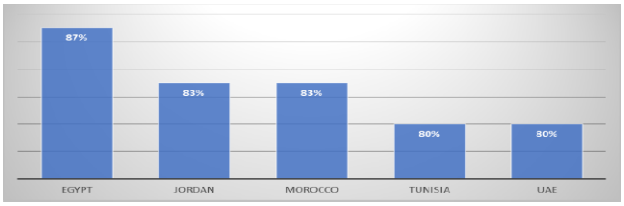

Fig (2) (AFEX) results for 2023

The examination of Jordan's energy landscape, as delineated in the AFEX and reinforced by data from the International Renewable Energy Agency (IRENA) in 2021, signifies a nuanced evaluation of the country's standing. Jordan's performance is notably indicated by its scores across key dimensions: 56 percent in market structure, 90 percent in policy framework, and 73 percent in institutional capacity.

Concurrent with the aforementioned advancements, Jordan is actively cultivating its domestic RE industry. Over the period spanning 2014 to 2020, the nation has garnered substantial investments through an array of financial incentives, tax reductions, and customs exemptions. Notably, foreign governments and international agencies have played a pivotal role, offering both technical expertise and financial support to facilitate critical projects. Bolstered by political stability and a well-established regulatory and legal framework, Jordan has successfully executed large-scale RE initiatives, positioning itself favourably to attract additional investments in this sector compared to its regional counterparts. Recent years have witnessed a surge in scholarly inquiries dedicated to the implementation and development of renewable energy in Jordan, encompassing activities crucial for a seamless transition to clean energy sources. Abu-Rumman et al. (2020) delved into the energy landscape, elucidating the success of clean energy programs propelled by government policies [1], financial incentives, and tax exemptions. Alrwashdeh (2018) contributed to the discourse with an energy source assessment, advocating for increased RE investment to fortify the country's energy resilience [4]. Hamed and Bressler (2019) scrutinized the intricate relationship between energy demand and renewable sources, emphasizing their role in ensuring supply-security dimensions. Alrwashdeh (2018) provided wind-distribution maps and identified wind farms across Jordanian governorates [4], while Azzuni et al. (2020) offered insights into the photovoltaic (PV) projects within the country [6]. However, despite the existing literature, a notable lacuna persists, with no recent comprehensive study summarizing (RE) projects and assessing the progress in Jordan over the last decade.

This overview seeks to address these gaps by conducting a thorough analysis of Jordan's current RE landscape. Our approach involves synthesizing qualitative data from various sources, including research studies, government statistics, and reports from international organizations and donors. It is crucial to emphasise that our research is delimited to offering comprehensive technical recommendations regarding various RE technologies in the country. Recognizing the inextricable link between renewables investment and the impact of greenhouse gas (GHG) emissions on the energy sector, this study facilitates informed decision-making for policymakers and investors, aligning future investments with the available opportunities.

2. Renewable energy landscape in Jordan

In the dynamic landscape of global energy transitions, Jordan emerges as a beacon of progress in the realm of renewable energy. Notably, the nation has attained a prestigious position by securing the highest percentage of renewable energy capacity, a feat excluding hydroelectric power. With an ongoing commitment to advancing its renewable energy mix, Jordan has achieved an impressive 27% share to date, underscoring its dedication to sustainable energy practices as indicated in Figure (3). Moreover, the horizon holds promise with the anticipation of preliminary agreements on green hydrogen expected to materialize by the close of 2023.

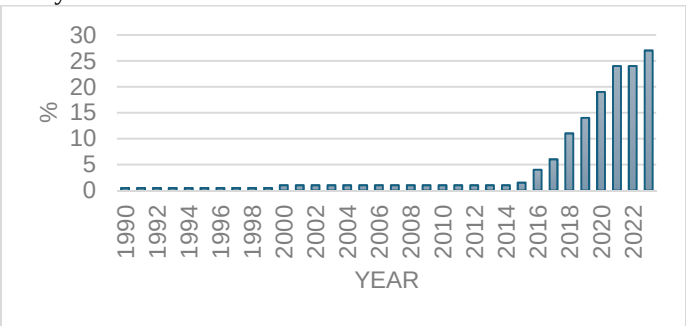

Fig (3) Jordan Share of Renewables in Electricity Production (including hydro) over the last 25 years, own work based on [21] [13]

As part of a comprehensive energy strategy, Jordan further asserts its ambitions by outlining plans to augment natural gas production at the Risha field, envisioning a substantial increase from the current 30 million cubic feet per day to an

ambitious 200 million cubic feet per day by 2030. In this context, Jordan positions itself as a dynamic force, navigating the complexities of energy diversification and renewable advancements.

1.1. Wind energy projects

Jordan boasts multiple locations conducive to wind power generation, exemplified by the initiation of its first commercial plant in Hofa in 1996, producing 1.125 megawatts of electricity. Subsequently, a second wind energy plant was established in Ibrahimyya in 1998, near Hofa, with a capacity of 320 kilowatts. By 2017, the combined electricity output from both plants had reached 3 gigawatt-hours. Regions in the northwestern and southern sectors of the country exhibit favourable wind speeds ranging from 7 to 11 meters per second, rendering them propitious for wind power generation. This transformative trajectory commenced in 2013 through an agreement between international corporations and a Jordanian consortium to erect a wind turbine (117 MW) in Tafila, located in the southern region. The project was operationalized in the latter half of 2015, marking a pivotal step in Jordan's RE endeavors [18] Furthermore, a collaborative effort with the Spanish firm Elecnor, under an Engineering, Procurement, and Construction (EPC) framework, culminated in the establishment of a wind farm in Ma'an, contributing 66 MW to the national grid in 2016 [18] In conjunction with the 117 MW Tafila wind farm operated by Masdar, these initiatives align with Jordan's objective of sourcing 15% of its domestic electrical needs from renewable sources. Collectively, the two projects are poised to contribute nearly 18% of the targeted 1.8 GW of (RE) or 20% of the envisaged energy mix by 2020. As of 2021, Jordan's cumulative installed wind energy capacity stands at 622 MW, projecting an estimated annual energy generation between 1,595 and 2,076 gigawatts (GWh), constituting approximately 11% of the country's electrical demand in 2021 [15]. Notably, wind-generating units contributed roughly 15.3% to the system-peak load in 2021, as delineated in the annual report of NEPCO (2021) [22]. This multifaceted expansion in wind energy infrastructure positions Jordan at the forefront of sustainable energy adoption, reflecting its commitment to meeting both environmental and energy security objectives.

1.2. Solar energy projects

In accordance with available data, Jordan stands as a region endowed with a noteworthy direct solar radiation intensity ranging from 5 to 7 kWh/m2, experiencing an average of 310 sunny days annually [17]. The annual average global solar irradiance on a horizontal surface approximates 5.6 kWh/m2 per day, with a total annual irradiance range spanning 1800-2700 kWh/m2. A strategic national objective aims to generate 800 MW from solar energy by the year 2020. Since the enactment of the Renewable Energy Law in 2012, the country has realized an estimated 236.4 MW of photovoltaic (PV) power generation [18]. The landscape of solar energy in Jordan is further enriched by the presence of over 300 registered installation companies, with approximately 20 actively participating in the market. In the year 2015, twelve direct power purchase agreements (PPAs) were inked for the construction and production of 200 MW of power, all concentrated within the Ma'an Development Area. Additionally, a project for a 75-100 MW PV plant is under assessment in the Quweirah region of Aqaba, with funding facilitated by the Gulf Corporation Council Fund (GCCF) [18]. The implementation of stand-alone PV systems has reached a zenith of 1000 kW for electricity generation, particularly in remote villages and rural/desert areas, where PV systems are employed for water pumping, residential power needs, and community activities. Approximately 20% of households in Jordan have embraced solar water heating systems, installed on their rooftops [17].
International collaborations also contribute to Jordan's solar energy landscape, exemplified by First Solar, a global company, entering a 20-year power purchase agreement (PPA) with Jordan's electrical company to oversee the 52.5 MW Shams Ma'an PV solar plant starting in 2016 (MEMR, 2014). Furthermore, ongoing assessments for two 200 MW tender rounds have the potential to add 400 MW of power plants to the grid [17]. In October 2016, Masdar, a company based in the United Arab Emirates, signed a power purchase agreement (PPA) for the construction of Baynouna, Jordan's largest solar power plant to date, with a capacity of 200 megawatts. This monumental plant is poised to cater to the annual electricity needs of approximately 110,000 households in the southern region by the conclusion of 2018. The solar energy landscape in Jordan is further characterized by the installation of approximately 1.4 square kilometers of solar water heating panels on building rooftops, alongside 150 kilowatts of photovoltaic (PV) panels. Locally manufactured by 25 small-scale solar water heating enterprises, these panels collectively produce around 4,500 solar water heaters annually. It is estimated that around 30% of residential buildings in the country are now equipped with solar water heating systems. Future trajectories for renewable energy development in Jordan encompass the construction of hybrid concentrated solar power (CSP) plants with a total capacity ranging from 100-250 megawatts, in addition to the installation of three wind turbines boasting a capacity of 125-150 megawatts. A noteworthy aspect of these endeavors is the commitment to local manufacturing, with an anticipated 60% of the wind turbine parts produced by local companies.

1.3. Bioenergy projects

Jordan's bioenergy initiatives center on municipal solid waste (MSW), starting with a 3.5 MW pilot plant near Amman in 2000 [21]. With over 50% organic content, the nation's daily per capita waste generation surpasses one kilogram, accumulating to an annual production of 2.7 million tons [20]. Despite this, biomass energy contributes only 0.1% to Jordan's total energy demand [20]. The Greater Amman Municipality's biogas unit aims to harness methane from the Ghabawi landfill, targeting a 7 MW capacity by 2023. Another biogas-pilot unit at Zaatari Refugee Camp is in progress since 2019 [19]. Studies suggest biogas could constitute 24% of Jordan's primary energy consumption in natural gas form

[2] [3]. To meet this potential, the government aimed for 40-50 MW of waste-to-energy projects by 2020. Beyond MSW, Jordan has untapped biomass resources like organic waste, animal excrement, olive mills, and Jift from olive-oil harvesting. Jift alone, estimated at 19,000 metric tonnes annually, holds potential as fuel or feed. Comprehensive studies are essential to optimize renewable energy (RE) harnessing from these diverse sources.

1.4. Geothermal projects

Jordan has recently turned its attention to geothermal energy as a promising renewable resource. The nation is endowed with geothermal sources, particularly hot mineral water found in springs and wells along the Rift Valley. Two distinct regions in Jordan exhibit high temperature gradients, reaching up to 50 °C per kilometer of depth (°C/km). These regions are situated in the northeastern part of the country and the Dead Sea escarpment. Despite the current temperature being below the requisite 100 °C for electricity generation, the hot water is actively harnessed for recreational purposes in numerous hotels and resorts.

In the pursuit of sustainable energy solutions, small-scale indirect geothermal systems have been successfully implemented for space heating and cooling in various public facilities, including the National Center for Research, the American University of Madaba, and the development building at the Higher Council of Science and Technology [5]. According to the International Geothermal Association (IGA 2021), Jordan's current geothermal energy capacity stands at 153.3 MW thermal (MWTH), representing a fraction of 0.42% of the total geothermal energy resources available in the country [14].

The versatility of geothermal energy extends beyond conventional applications, offering potential utilization in sectors such as fish farming, greenhouse heating, and the food industry. Despite these possibilities, a comprehensive evaluation of geothermal energy feasibility in Jordan remains an imperative, necessitating further research endeavors [5]. This underscores the need for strategic assessments to unlock the full potential of geothermal resources and integrate them into Jordan's diversified renewable energy portfolio.

2. Main Barriers

Jordan's pursuit of a sustainable and diversified energy landscape is met with formidable challenges that demand meticulous attention and strategic solutions. As the nation endeavors to broaden its energy portfolio for enhanced sustainability, critical barriers have surfaced, impeding a seamless transition towards a resilient and self-sufficient energy future. This narrative illuminates the intricate tapestry of challenges, ranging from the swift expansion of new energy sources outpacing electrical grid infrastructure growth to historical entanglements in unfair contracts. These complexities underscore the imperative for a comprehensive and nuanced approach to navigate the hurdles obstructing Jordan's path to energy independence.

1) Insufficient Electrical Grid Infrastructure Growth: The rapid integration of new energy sources in Jordan surpasses the expansion of electrical grid infrastructure, posing challenges in efficiently absorbing additional energy. A focused strategy is indispensable to bridge this infrastructure gap and ensure a harmonious transition.

2) Dependence on Unfair Contracts: Previous administrations in Jordan have engaged in unfair energy contracts, presenting obstacles to achieving energy independence. Addressing these historical agreements demands a careful re-evaluation and strategic renegotiation for a more equitable energy landscape.

3) Reliance on International Funds: The energy sector's dependence on private sector investments and foreign funds entails financial implications for the National Electric Power Company (NEPCO), limiting the nation's energy independence. A shift towards more self-sustaining financial models is essential for bolstering autonomy.

4) Excessive Reliance on Local and Imported Sources: Overreliance on local and imported energy sources, coupled with unaffordable prices, has inflated domestic energy costs and inflicted financial losses on the public energy sector. Efforts to diversify sources and optimize costs are pivotal for long-term sustainability.

5) Dependence on Israel for Gas: Jordan's dependence on Israel for gas, as evidenced in the water and electricity exchange agreement, introduces vulnerabilities to the country's energy security. Strategically reassessing and diversifying gas sources is imperative to mitigate potential risks and enhance resilience.

3. Recommendations

Embarking on a sustainable and resilient energy future, Jordan grapples with the imperative to overcome entrenched barriers hindering its progress. This exploration delves into a set of strategic interventions and policy recommendations essential for steering the nation towards energy independence. The challenges outlined in the previous section necessitate not only a thorough understanding but also a proactive and multifaceted approach to catalyze transformation. Here, we present a cohesive set of academic recommendations that, if implemented, could pave the way for a robust and sustainable energy landscape in Jordan.

1) Shift to Renewable Energy Sources: Gradual transition towards more renewable energy sources is essential, treating them as public goods rather than commodities.

2) Develop a National Strategy: Formulating a comprehensive national strategy for building Jordan's renewable energy capacity is crucial.

3) Promote Decentralized Small-Scale Generation: Development of decentralized small-scale self-generation systems can enhance energy equity and reduce the load on the national grid.
4) Stimulate Demand in Key Sectors: Stimulating demand for electricity in key sectors, such as electrifying government ministries and transportation, can optimize local resources and reduce energy costs.
5) Utilize Existing Generation Capacity for Desalination: Leveraging existing generation capacity for sea water desalination can address water scarcity issues in Jordan.
6) Cancel Dependence on Israel: Reassessing and potentially cancelling agreements with Israel for gas and water can promote domestic energy and water sector synergy through renewable energy technologies.
7) Establish a Unified Arab and Regional Energy Market: Creating a unified Arab and regional energy market would strengthen electrical interconnection projects with neighboring countries, increasing renewable energy network capacity and addressing energy shortages in the region.

4. Conclusion

In conclusion, Jordan's commendable strides in renewable energy underscore the nation's unwavering commitment to a diversified and sustainable energy future. Despite contending with population growth, economic uncertainties, and geopolitical intricacies, Jordan has emerged as a regional trailblazer, particularly in wind and solar energy. The government's proactive initiatives, supported by robust policy frameworks and international collaborations, have propelled the country's renewable energy sector forward. Evidenced by high rankings in the Arab Future Energy Index and a substantial share of renewables in the electricity mix, Jordan showcases a positive trajectory in its pursuit of clean energy. Nevertheless, challenges persist, notably in the form of an overstretched electrical grid and infrastructure limitations. Addressing these hurdles demands the formulation of a comprehensive national strategy, with a specific emphasis on decentralized, small-scale self-generation systems. These systems not only enhance energy sovereignty but also offer cost reductions and relieve pressure on the national grid. Furthermore, the integration of renewable energy technologies in desalination plants stands out as a promising solution to Jordan's water scarcity. The recent agreement with Israel accentuates the imperative of fostering domestic synergy in the energy and water sectors, utilizing modern renewables for desalination, and advancing towards a unified Arab and regional energy market. Looking ahead, Jordan's commitment to increasing renewable energy targets, exploring green hydrogen strategies, and engaging in international collaborations solidifies its pivotal role in the global shift towards sustainability. By systematically addressing existing challenges and implementing the outlined technical recommendations, Jordan is poised not only to fortify its energy security but also to catalyse economic development and promote environmental sustainability throughout the region. The trajectory of Jordan's renewable energy journey positions it as a beacon for other nations navigating the intricate path towards a cleaner, more sustainable energy landscape.

Acknowledgement

The research was funded by the Sustainable Development and Technologies National Programme of the Hungarian Academy of Sciences (FFT NP FTA).

References

[1] Abu-Rumman G, Khdair AI, Khdair SI. Current status and future investment potential in renewable energy in Jordan: An overview. Heliyon. 2020 Feb 1;6(2).
[2] Al-Hamamre Z, Saidan M, Hararah M, Rawajfeh K, Alkhasawneh HE, Al-Shannag M. Wastes and biomass materials as sustainable-renewable energy resources for Jordan. Renewable and Sustainable Energy Reviews. 2017 Jan 1;67:295-314.
[3] Alnhoud OT, Al-Harahsheh AM, Al-Harahsheh MS, Irshaid FI. Animal solid waste as a potential renewable biomass energy source: A case study of Jordan. Biomass Conversion and Biorefinery. 2021 Jul 10:1-0.
[4] Alrwashdeh SS. Map of Jordan governorates wind distribution and mean power density. Int J Eng Technol. 2018;7(3):1495-500.
[5] Al-Zyoud, Sanaa. "Shallow geothermal energy resources for future utilization in Jordan." Open Journal of Geology 9.11 (2019): 783.
[6] Azzuni, Abdelrahman, et al. "Energy security analysis for a 100% renewable energy transition in Jordan by 2050." Sustainability 12.12 (2020): 4921.
[7] Bahrampour, Hamid, et al. "Evaluation of renewable energies production potential in the Middle East: confronting the world's energy crisis." Frontiers in Energy 14 (2020): 42-56.
[8] Cozzi, L., et al. "Global Energy Review 2020: The impacts of the Covid-19 crisis on global energy demand and CO2 emissions." Paris, France: International Energy Agency (IEA Publication) (2020).
[9] Dadashi, Zahra, Ali Mahmoudi, and Saman Rashidi. "Capacity and strategies of energy production from renewable sources in Arab countries until 2030: a review from renewable energy potentials to environmental issues." Environmental Science and Pollution Research 29.32 (2022): 47837-47866.
[10] Erdin, Ceren, and Gokhan Ozkaya. "Turkey's 2023 energy strategies and investment opportunities for renewable energy sources: Site selection based on ELECTRE." Sustainability 11.7 (2019): 2136.
[11] Hamid, Bahrampour, et al. "Review of sustainable energy sources in Kerman." World Journal of Engineering 13.2 (2016): 109-119.

[12] International Energy Agency (IEA). 2022. World Energy, Outlook 2022 Edition. Paris: IEA. https://www.iea.org/reports/world-energy-outlook-2022.
[13] "International Energy Agency (IEA). 2023. Electricity, Market Report 2023. Paris: IEA. https://www.iea.org."
[14] "International Geothermal Association (IGA). 2021. Geothermal Power Database. Bonn: IGA. https://www. geothermal-energy.org/explore/our-databases/geothermal-power-database."
[15] Kiwan, Suhil, and Elyasa Al-Gharibeh. "Jordan toward a 100% renewable electricity system." Renewable Energy 147 (2020): 423-436.
[16] Luo, Jin, et al. "Heating and cooling performance analysis of a ground source heat pump system in Southern Germany." Geothermics 53 (2015): 57-66.
[17] Ministry of Energy and Mineral Resources (MEMR), Annual Reports, Amman, Jordan, 2014.
[18] Ministry of Energy and Mineral Resources (MEMR), Annual Reports, Amman, Jordan, Page30 [accessed Oct 2019], https://www.memr.gov.jo/echobusv3.0/Syst emAssets/56dcb683-2146-4dfd-8a15-b0ce6904f501.pdf, 2018.
[19] "Ministry of Environment (MoEnv). 2020. Energy Sector, Green Growth National Action Plan 2021–2025. Amman: MoEnv. http://www.moenv.gov.jo/ebv4.0/root_storage/ ar/eb_list_page/20022_jordan_energy _v03_rc_web.pdf."
[20] Nahar Myyas, Ra'ed, et al. "Review of Bioenergy Potential in Jordan." Energies 16.3 (2023): 1393.
[21] Nikolina, S. A. J. N. "International renewable energy agency (IRENA)." (2016).
[22] Radmehr, Riza, Shida Rastegari Henneberry, and Samira Shayanmehr. "Renewable energy consumption, CO2 emissions, and economic growth nexus: a simultaneity spatial modeling analysis of EU countries." Structural Change and Economic Dynamics 57 (2021): 13-27.
[23] Ratchawang S, Chotpantarat S, Chokchai S, Takashima I, Uchida Y, Charusiri P. A Review of Ground Source Heat Pump Application for Space Cooling in Southeast Asia. Energies. 2022 Jul 8;15(14):4992.
[24] "Renewable Energy Policy Network (REN21). 2022. Renewables 2022 Global Status Report. Paris: REN21.https://www.ren21.net/gsr-2022."
[25] Situmeang, Ricardo, Jana Mazancová, and Hynek Roubík. "Technological, economic, social and environmental barriers to adoption of small-scale biogas plants: case of Indonesia." Energies 15.14 (2022): 5105.
[26] United States Energy Information Administration (USEIA).2021. Annual Energy Outlook 2021. Washington, DC:USEIA. https://www.eia.gov/outlooks/aeo/tables_side.php
[27] Zhao, Jun, et al. "How renewable energy alleviate energy poverty? A global analysis." Renewable Energy 186 (2022): 299-311.