ABSTRACT
Renewable energy sources are environmentally friendly and sustainable resources. However, there is no unique renewable energy resource that suits all countries. As such, nations must select the right option – or combination of options – that aligns with their local economic, technical, and environmental circumstances. Such a selection process is usually performed using a decision-making tool based on multi-criteria analysis. This study aims to find the most effective renewable energy option for Jordan by soliciting experts’ opinions under several criteria and sub-criteria. The collected responses of experts from the energy field were analyzed using the analytical hierarchy process (AHP). The AHP model used in the study consisted of four criteria, eleven sub-criteria, and four renewable energy alternatives. The results indicate that the technical criterion had the highest weight of 53.6% as compared to the environmental criterion which came second with a weight of 29.0% followed by geographical and socioeconomic criteria which have the lowest weights of 11.3% and 6.0%, respectively. The results reveal that under the technical criterion a high rank has given to maturity of the technology followed by availability of know-how with a weight of 0.875 and 0.125, respectively. The sequence of the preferable options based on the study results was: wind energy with 51.9%, followed by the solar energy option with 31.3%, and finally biomass and hydropower with 10.5% and 7.1%, respectively. Sensitivity analysis was performed and showed that the renewable energy options are not sensitive to the technical or environmental criteria, while they were slightly sensitive to the geographical and socioeconomic criteria.

ARTICLE HISTORY
Received 2 November 2020
Accepted 12 May 2021

KEYWORDS
Analytical hierarchy process (AHP); decision making; energy options; renewable energy; Jordan

Introduction
Renewable energy sources such as solar, wind, biomass and hydropower are environmentally friendly resources (Aydin et al. 2013; Ali et al. 2019). Although some researchers argue in favor of the sustainability of hydropower plants, such impoundments may lead to the resettlement of populations and other ecological impacts (Liu et al. 2013). To ensure effective utilization of energy sources, diversification of sources, and minimization of environmental impacts, it is important to follow a sustainable energy-planning approach (Abdullah and Najib 2016). Renewable energy sources are fundamentally different from fossil fuels or nuclear power plants because of their widespread occurrence and abundance. The primary advantage of many renewable energy sources is their lower greenhouse gas and other emissions in comparison with fossil-fuel combustion, (Al Zoubi 2010); they are also less complex (Hrayshat 2008) and cost-effective. As such, an increasing number of countries around the world are considering renewable energy alternatives to decrease their dependency on polluting imported fossil fuels (Cristobal 2011) and to achieve energy security and independence (Braham 2014).

However, many countries face challenges selecting a long-term strategy for their energy alternatives (Budak et al. 2019) as there is no renewable energy option that is optimal under all conditions (Demirtas 2013). Furthermore, due to variations in economic, technical, and environmental conditions, countries have considered different possibilities of renewable energy technologies (Li and Tao 2014; Kaya and Kahraman 2010). Therefore, it is of great importance to make the right decision in selecting the optimal technology or combination of technologies, so as to maximize the benefits from the selected options. In energy planning, the selection of renewable energy technology is not an easy task that can be made based on a single criterion of decision making. It is rather a multivariable and complex
problem where there is a need to prioritize certain renewable energy alternatives by considering the consistency and multiple interests and perspectives and this situation often entails using multi-criteria decision making (MCDM) (Cristobal2011). In particular, the analytical hierarchy process (AHP) is a useful decision-making tool in cases such as the selection of the most suitable energy options for a certain country (Grilli et al. 2017; Abdullah and Najib 2016; Algarin et al. 2017).

Several researchers have used AHP in evaluating and selecting various renewable energy technologies for different countries. For instance, Amer and Daim (2011) developed an AHP model to select and prioritize different options for electricity generation in Pakistan. Based on the solicitation of experts’ opinions, the researchers concluded that biomass and wind energy are the most preferable renewable energy sources in this case. Li and Tao (2014) used AHP and data-envelopment analysis (DEA) to evaluate and select renewable energy technologies in China. The research findings revealed that based on economic, technical, environmental, and social criteria, wind and solar energy technologies are the most suitable options for the country. Ahmad and Tahar (2014) have used AHP to rank and prioritize alternatives for sustainable electricity production in Malaysia. Using four main criteria and twelve sub-criteria, the researchers found that solar and biomass energy ranked as the first and second options, respectively. Hydropower was deemed to be the third option and, finally, wind energy was rated as the fourth and least preferable option. Algarin et al. (2017) solicited expert opinion to prioritize criteria, sub-criteria, and alternatives for renewable energy supply in rural areas of the Caribbean region of Colombia in 2017. The results indicated that the technical criterion has the highest rank followed by the environmental criterion, then social criterion, and, finally, the economic and risk criteria. The study revealed that the best renewable alternative for Colombia is solar energy.

In other work, Mastrocinque et al. (2020) developed a multi-criteria decision-making framework based on triple bottom line principles and AHP methodology for sustainable supply-chain development in the photovoltaic energy sector. According to this analysis, the proposed framework can be used as a decision-making tool for making sustainable investment decisions in the photovoltaic energy sector within the seven European countries that were covered by the study. Kurabatova and Abu-Qdais (2020) used the AHP methodology in selecting the most appropriate waste-to-energy alternative for the city of Moscow. The findings revealed that biogas from sanitary landfills is the most preferred option, followed by anaerobic digestion. The most preferred options were incineration and refuse-derived fuel.

As for Jordan, Akash et al. (1999) applied the AHP approach to compare various electric power-production options. The study compared both fossil-energy sources as well as renewable sources. The results indicated that based on a cost-benefit ratio, renewables such as solar, wind, and hydropower are the most preferable alternatives.

Budak et al. (2019) proposed a systematic approach for assessing renewable energy using AHP in three cities in China, Turkey, and the United States. The approach identifies energy alternatives by integrating experts’ input and data analytics to help decisionmakers design long-term strategies for renewable energy development. Bhowmik et al. (2020) developed an innovative integrated analytical framework as a benchmark for selecting the optimal green energy source in accordance with various sustainability dimensions. The framework helps to identify the optimum green energy source (solar energy) for a cleaner future using AHP. The research aimed to help energy managers, policymakers, and other decisionmakers to measure and improve the utilization of green energy sources. Çoban (2020) used the AHP decision-making method based on hesitant fuzzy linguistic evaluation for selecting a solar energy plant. The results of this study match the need for high efficiency in solar energy systems, the importance of supportive governmental policies, and the effects of price competition in the energy sector.

The main objective of this article is to develop a multi-criteria decision support system to assess and prioritize different renewable energy alternatives in Jordan. An AHP-based modeling framework to support decisionmakers in the prioritization process of renewable energy options has been utilized. The criteria adopted for evaluation are based on technical, socioeconomic, environmental, and geographical aspects.
Energy resources of Jordan

Jordan lacks domestic fossil-fuel sources and the country has met the demand for energy by importing most of its requirements. As shown in Figure 1, in 2017 the country imported 94% of its energy needs, while only 6% was met by local sources (MEMR 2018). This situation imposes a heavy burden on the Jordanian economy as the imported energy bill accounted for 8.5% of gross domestic product (GDP) in 2017 (MEMR 2018). Furthermore, the energy sector contributes 73% of the greenhouse gases emitted in the country by various sectors (Hashemite Kingdom of Jordan 2014). As such, deploying local clean energy sources will contribute to the energy security of the country and decrease the environmental burden of the energy sector by reducing carbon emissions.

The main objective of the present study is to compare several renewable energy alternatives and to select the most appropriate one for Jordan. Since the selection of renewable energy options is not based on a single criterion, a multi-criteria AHP approach was used in the assessment process. The findings of the study will be a useful decision-making tool to enable decisionmakers and planners in the Jordanian energy sector to make informed decisions regarding the best renewable energy alternative that suits the local circumstances of the country.

Renewable energy potential of Jordan

According to Baniyounes (2017) the geographical location and climate of Jordan render the country to be one of the most suitable countries in the world for renewable energy generation. Azzuni et al. (2020) reported that local renewable energy potential is quite attractive and a transition toward a fully renewable energy system is technically feasible and economically viable by 2050. In light of such assessments, the National Energy Strategy (2015–2025) calls for Jordan to increase its energy-supply security and reduce its dependence on external energy sources by leveraging national capacity for renewable energy. The strategy indicates that the renewable energy share in the total electrical power generation in 2016 was 6% (mainly solar and wind power), and it is planned to reach 20% by 2025 (MEMR 2015;
MEMR 2021). This ambitious target requires proper assessment and planning so as to consider proper sources and technologies of renewable energy. The total installed capacity of renewable energy in 2019 was 1423 megawatts (MW) (MEMR 2021).

**Solar energy**

Like most countries in the Middle East, Jordan enjoys good solar energy potential and the average annual solar radiation is 5.5 kilowatts per square meter (kWh/m²) and yearly sunshine duration is 2900 hours (Mason et al. 2009). Figure 2, shows the average annual solar radiation in Jordan over the period 1994 to 2010 in kWh/m². During the past decade, several photovoltaic solar energy farms were implemented in the country and the current installed solar energy capacity is 2063 MW which accounts for 20% of the total electrical energy consumed in Jordan (MEMR 2020).

**Wind energy**

In 1988, the Ministry of Energy and Mineral Resources (MEMR), the Jordan Meteorological Department (JMD), and other local institutions worked in cooperation with the National Laboratory in Denmark (RISO) to develop the Wind Atlas of Jordan. This Atlas was the first of its kind in the region and is still considered to be a reference for determining and selecting areas of the country that have promising potential for electricity generation (Hrayshat 2008; Sabra 1999). Figure 3 shows the annual mean wind speed in Jordan measured at a height of 100 meters which ranges from 6 to 8 meters per second (m/s). According to Ramachandra et al. (1997) such high values of wind speed render several locations in Jordan to be suitable sites for wind-energy projects. Al-Soud and Hrayshat (2009) studied the feasibility of wind energy for electrification of rural Jordanian sites and identified Zabda, located approximately 80 kilometers (km) north of Amman, as a prime location, both for electrification using small turbines and as a future site for commercial-scale wind-energy development. Al-Risha al Garbia and Al-Risha al Sharkia, located 270 km northeast of Amman, were identified as potential candidates for electrification by wind energy-conversion systems. Currently, there are three major wind farms in southern Jordan, in
Tafillah (with a capacity of 117 MW), Maan (with a capacity of 86 MW), and the recently opened facility at Alfujaij (with a capacity of 89 MW). The total installed wind capacity in the country is 370 MW (MEMR 2019).

Energy from biomass

Biomass energy is produced from organic residue like agricultural and municipal wastes. Abu-Ashour et al. (2010) estimated the annual energy that can be generated from olive and animal waste in Jordan to be equivalent to 157,000 tons of oil equivalent (toe). Abu Qdais and Alshraideh, (2016) reported that co-combustion for energy recovery is the best option for managing the solid waste generated from the olive-oil industry in Jordan. Currently, the country produces 4 MW from a closed solid-waste landfill at Russaifah (Abdullah et al. 2004; Abu Qdais et al. 2011). In addition, the Greater Amman Municipality has recently put into operation a biogas plant at the Alghabawi landfill with a capacity of 4.8 MW. Finally, all the recently constructed wastewater plants in Jordan have a biogas-recovery system from the sewage sludge, where the biogas is used in combined heat and power (CHP) generation (Abu Qdais 2019).

Hydropower

Hydro-generated energy can be produced from the flow of water that moves from a higher elevation to a lower level (typically involving a constructed dam) or from the recovery of energy stored in the pressurized water flow. In Jordan, there are currently two modest hydropower sources at King Talal dam in the northern region of the country which has an annual generating capacity of 5 MW while the other hydropower plant is at the Aqaba thermal power station and generates 6 MW (Mason et al. 2009). One component of the future Red Sea-Dead Sea water desalination project is a major hydropower plant to generate 550 MW by utilizing the difference in the level between the Red and Dead Seas which is about 420 meters (Abu Qdais 2008).

Methodology

The AHP tool to select alternatives is based on a pairwise comparison of different criteria. The procedure relies on the judgments of experts to derive priority scales. The comparisons are made using a scale of absolute judgments that reflects how much more important one element is in comparison to another with respect to a given attribute. The procedure employs a consistent way of converting each pairwise comparison into a set of numbers representing the relative priority of each criterion (Saaty 1980, 2008). In the current study, AHP was used and weights from experts’ opinions were assigned to each criterion and sub-criterion so as to reflect their relative importance. The procedure we followed in prioritizing different alternatives is presented in Figure 4. Analysis of the pairwise comparison was carried out using Expert Choice software version 11. The study was conducted according to the following order:

1. We conducted a comprehensive literature review on energy-sector status in Jordan. Furthermore, research on energy-planning problems and renewable energy-alternatives ranking and prioritization using multi-criteria decision-support tools were conducted.
2. We collected data in general on the Jordanian energy sector and in particular on the renewable energy technologies adopted to date, including their share in the total energy mix of the country.

3. We developed the AHP model which consists of the following hierarchy: a goal that has to be achieved (selection of the optimal energy technology for Jordan) and the four criteria on which the evaluation was carried out (technical, environmental, socioeconomic, and geographic criteria). The main criterion has three sub-criteria that focus on a specific aspect of the problem and, finally, the renewable energy alternatives that are considered in the comparison. The problem hierarchy is presented in Figure 5, which shows four criteria, eleven sub-criteria, and four alternatives that should be subjected to pairwise comparison. The criteria and sub-criteria were selected based on an extensive literature review on the use of the AHP methodology in decision making, with special emphasis on renewable energy options (Ahmad and Tahar 2014; Demirtas 2013; Kurbatova and Abu Qdais 2020).

4. We formulated the pairwise comparison matrices for criteria and sub-criteria with respect to various attributes.

5. We solicited experts’ opinions and recorded their judgments. A total of thirteen experts were interviewed and asked to complete a specially designed questionnaire. The experts covered in the solicitation process were as follows: three academics, three researchers, two experts from the energy-business sector, three regulators, and two representatives from non-government organizations (NGOs) that work on energy issues.

6. We generated a priority vector for the judgments matrices and checked for consistency of judgments by calculating the consistency ratio (CR).

In certain cases, the solicited expert opinion may yield inconsistencies that can affect the accuracy of the judgment. Therefore, the randomness in the judgment may be assessed by calculating the consistency ratio using Equation (1).

\[
CR = CI / RI
\]

where CI is the consistency index and RI is the random index which expresses the expected value of the CI corresponding to the order of matrices.

When the CR value is within an acceptable range (usually less than 10%), the judgments are considered consistent. Alternatively, the experts’ subjective judgments should be repeated until the CR values are within the desired range. In the current study, out of thirteen questionnaires, we found that three of them had consistency ratios greater than 10%. As such, they were not considered in the pairwise comparison and the model was developed based on the opinions of ten experts.

7. We synthesized the judgments by aggregating the weights through AHP to determine the composite priorities of each renewable energy alternative.

Results

A pairwise comparison of criteria and sub-criteria using AHP to achieve the goal of selecting the
optimal renewable energy alternatives for Jordan was conducted. As the first step in AHP analysis is to assess the consistency of the judgments, we did so by checking the consistency of the pairwise comparison matrices for the alternatives, criteria, and sub-criteria and found them all to be below 9%. After determining the consistency of the matrices, we calculated the relative weights of both the main criteria and the sub-criteria. Figure 6 shows the results of the pairwise comparison of the criteria. The technical criterion has the highest weight of 53.6%, which means that it is the most important factor in selecting renewable energy options. The environmental criterion ranked in second position with a weight of 29%, while the geographical and socioeconomic criteria have the lowest weights of 11.3% and 6.0%, respectively. This finding implies that when selecting renewable energy technologies, the technical criterion should have the highest priority.

This determination is in agreement with the findings of Algarin et al. (2017) who reported that for the selection of renewable energy options for Colombia the technical criterion ranked first and it was followed by environmental and, finally, socioeconomic and risk criteria.

**Selection sub-criteria**

The sub-criteria weight analysis under the technical criterion is presented in Figure 7. The highest rank was assigned to the maturity of the technology (weight of 0.875) followed by availability of know-how (with a weight of 0.125). Under the environmental criterion, the emissions sub-criterion is 0.740, the biodiversity sub-criterion is 0.204, and the noise criterion is 0.056. For the geographical sub-criterion, elevation has the largest weight of 0.557, followed by land slope with 0.219, and, finally, land use with 0.152. With respect to the socioeconomic criterion, the investment-cost sub-criterion has the highest weight of 0.702, followed by job creation with 0.226, and social acceptance with 0.073.

**Renewable energy options**

Based on the AHP analysis and the sensitivity of the results, it is clear that wind energy is the most preferable alternative in terms of the four criteria. Abu-Rumman et al. (2020) stated that wind-generated energy is projected to comprise a significant share of Jordan’s electricity generation. Considering the overall criteria, the results indicate that wind energy has 51.0% of the total weight while solar ranks in the second position with a weight of 31.4% (see Figure 8).

By contrast, the results show that biomass and hydropower are the least preferred options with weights of 10.1% and 7.1%, respectively, and despite the passage of more than two decades, this determination is in agreement with the findings of Akash et al. (1999) who recommended solar- and wind-energy sources as the best alternatives for Jordan. Kiwan and Al-Gharaibeh (2020) studied different scenarios for renewable electricity in Jordan. In the 100% renewable scenario, the researchers estimated that the country needs around 10.6 GW of concentrated solar power, 4.5 GW of wind, and 25 GW of photovoltaic to meet the demand in the year 2050. For other countries, many researchers reached different findings in prioritizing renewable energy technologies. For example, Li and Tao (2014) concluded that wind and solar power are the most suitable renewable energy options in China, followed by biomass, hydropower, ocean, and geothermal energy. While for Spain, Cristobal (2011) concluded that biomass plants are the best alternative followed by wind and solar thermo-electric options. This diversity in findings is normal, as different countries have their own specific conditions and circumstances.

The results of the renewable energy pairwise comparison under the main criteria show that wind has the highest weight of 51.9% under the technical criterion, followed by the solar alternative with 31.3%, and then biomass and hydropower which ranked as the least preferred options with weights 10.1% and 6.7%, respectively as shown in Table 1.

Under the environmental sub-criteria, roughly the same ranking of renewable energy alternatives was obtained as under the technical sub-criteria (see Table 2).

Considering geographical criteria, wind and solar alternatives were also ranked in first and second position. However, under this criterion hydropower ranked third, while biomass was in the last position as shown in Table 3.
Unlike the other three criteria where the wind-energy alternative ranked first, under the socioeconomic criteria, solar energy was first with a weight of 45.1%, followed by wind (36.4%), biomass (12.5%), and hydropower (6.0%) (see Table 4).

Selecting wind and solar energy as the preferred options with relatively high weights may be attributed to the fact that Jordan has a relatively high number of sunny days around the year (Mason et al. 2009) and there are several locations that are characterized by frequent wind flow with a speed sufficient to generate energy (Al-Soud and Hrayshat 2009). As for biomass, desert covers more than 90% of the Jordanian land mass and this geographic situation means that the country has few forests or other resources. Furthermore, Jordan suffers from a scarcity of water and has no major surface water bodies that are suitable for the generation of hydropower. This confirms the findings of other researchers, who reported that the wind- and solar-energy sources are the most suitable ones for Jordan (Akash et al. 1999; Abu-Rumman et al. 2020; Kiwan and Al-Gharaibeh, 2020).

### Sensitivity analysis

Changes in relative weights of the considered criteria may affect the selection process. As such, we investigated the sensitivity of the decision to changes in priorities. Using Expert Choice software, dynamic sensitivity graphs were developed by randomly changing the priorities given to the selection criteria and monitoring the resulting changes in the total weights of the various renewable energy alternatives. As shown in Figure 9, wind energy is not affected by technical, environmental, or geographical criteria, while it is slightly vulnerable to changes in socioeconomic criteria. By contrast, the solar alternative is only sensitive to the socioeconomic criterion. Unsurprisingly, hydropower is slightly sensitive only to the geographical criteria, and, interestingly, biomass is not sensitive to any criteria.
When adjusting the weight of the technical or the environmental criteria from their initial weight to the maximum, there is no effect on the ranking of the alternatives. The change in rankings and weights begins to occur only after increasing the weight of the socioeconomic and geographical criteria. By increasing the weight of the socioeconomic criterion to 72.0%, wind ranked second, while solar moved to the first rank with an increase of its weight from 31.4% to 41.0%. Decreasing the weight of the criteria has no effect on the rank of any alternative. By contrast, increasing the weight of the geographical criteria from 11.3 to 86.4 moves hydropower to third place and biomass to fourth place, while the rank of wind and solar remains the same.

Conclusion

An increasing number of countries are considering renewable energy alternatives to decrease their dependency on polluting and imported sources of fossil fuels. Among such countries is Jordan, which is heavily dependent on imported energy. In Jordan, the share of renewable energy has been increasing over the last decade to reach 20% of the total electrical energy mix, and it is expected to be approximately 30% by 2030. This ambitious objective can be achieved through public-private partnerships and such a partnership has been already initiated by one major wind-power project in Tafilah. Such a project paves the way for further involvement of the private sector in upcoming wind and solar energy projects in Jordan. The main objective of this study has been to select the optimal renewable energy alternative for Jordan. Because of the numerous decision-making criteria and other factors that govern the selection of the most suitable option of renewable energy, the selection is not a straightforward process. It rather entails a multi-criteria decision-making process. Therefore, AHP has been used to reach a determination on the most suitable alternative based on soliciting experts’ opinions. The results of pairwise comparisons show that technical and environmental criteria have the highest weights among the criteria considered in the prioritization process. Furthermore, the pairwise comparisons under the different criteria and sub-criteria revealed that the wind and solar energy options are the most suitable alternatives among the four renewable technologies considered in the study. Solar energy ranked first under the socioeconomic criterion. Prioritizing the wind and solar alternatives to be the most preferable can be explained by the fact that Jordan has long sunny hours throughout most of the year and has many locations through which wind blows with sufficient intensity. Dynamic sensitivity analysis revealed that rankings of the renewable energy alternatives start to change only after increasing the weight of the socioeconomic and geographical criteria. The results of the study showed that AHP is a useful tool that enables decision making regarding the prioritization of renewable energy alternatives. It is recommended that future research focus on finding suitable sites to locate the solar and wind plants as well as hybrid wind and solar plants in the country.

Acknowledgements

We thank the experts who answered and supported the study questionnaire.
Disclosure statement

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, other ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

ORCID

Nawras Shatnawi http://orcid.org/0000-0001-6752-1810
Hani Abu-Qdais http://orcid.org/0000-0001-9370-8988

Data availability statement

Data will be made available on request.

References

Abdulla, F., M. Widyan, Z. Al-Ghazawi, S. Kiwan, H. Abu-Qdais, M. Hayajneh, A. Harb, et al. 2004. “Status of Jordan Renewable Energy Sector: Problems, Needs and Challenges.” Proceedings of the Regional Collaboration Workshop on Energy Efficiency and Renewable Energy Technology, April 26, Beirut, Lebanon.

Abdullah, L., and L. Najib. 2016. “Sustainable Energy Planning Decision Using the Intuitionistic Fuzzy Analytic Hierarchy Process: Choosing Energy Technology in Malaysia.” International Journal of Sustainable Energy 35 (4): 360–377. doi:10.1080/14786451.2014.907292.

Abu Qdais, H. 2008. “Environmental Impacts of the Mega Desalination Project: The Red-Dead Sea Conveyor.” Desalination 220 (1–3): 16–23. doi:10.1016/j.desal.2007.01.019.

Abu Qdais, H. 2019. “Developing a Decision Support Tool for Managing Sludge from Wastewater Treatment Plants in Jordan.” Desalination and Water Treatment 139 (1): 95–104. doi:10.5004/dwt.2019.23286.

Abu Qdais, H., and H. Alshraideh. 2016. “Selection of Management Option for Solid Waste from Olive Oil Industry Using the Analytical Hierarchy Process.” Journal of Material Cycles and Waste Management 18 (1): 177–185. doi:10.1007/s10163-014-0321-3.

Abu Qdais, H., A. Maqableh, L. Nawayseh, and N. Al Jamal. 2011. “Energetic and Methane Emission Reduction Potentials from Unsanitary Solid Waste Landfill.” Energy Sources, Part A: Recovery, Utilization, and Environmental Effects 34 (4): 360–369. doi:10.1080/15567031003641615.

Abu-Ashour, J., H. Abu Qdais, and M. Al-Widyan. 2010. “Estimation of Animal and Olive Solid Wastes in Jordan and Their Potential as a Supplementary Energy Source: An Overview.” Renewable and Sustainable Energy Reviews 14 (8): 2227–2231. doi:10.1016/j.rser.2010.03.001.

Abu-Rumman, G., A. Khdair, and S. Khdair. 2020. “Current Status and Future Investment Potential in Renewable Energy in Jordan: An Overview.” Heliyon 6 (2): e03346. doi:10.1016/j.heliyon.2020.e03346.

Ahmad, S., and R. Tahar. 2014. “Selection of Renewable Energy Sources for Sustainable Development of Electricity Generation System Using Analytic Hierarchy Process: A Case of Malaysia.” Renewable Energy: 63: 458–466. doi:10.1016/j.renene.2013.10.001.

Akash, B. R. Mamlook, and M. Mohsen. 1999. “Multi-criteria Selection of Electric Power Plants Using Analytical Hierarchy Process.” Electric Power Systems Research 52 (1): 29–35. doi:10.1016/S0378-7796(99)00004-8.

Al Zou’bi, M. 2010. “Renewable Energy Potential and Characteristics in Jordan.” Jordan Journal of Mechanical and Industrial Engineering 4 (1): 45–48.

Algarin, C., A. Llanos, and A. Castro. 2017. “An Analytic Hierarchy Process Based Approach for Evaluating Renewable Energy Sources.” International Journal of Energy Economics and Policy 7 (74): 3–47.

Ali, S., J. Taweekun, K. Techato, J. Waewsak, and S. Gyawali. 2019. “GIS-Based Site Suitability Assessment for Wind and Solar Farms in Songkhla.” Renewable Energy. 132: 1360–1372. doi:10.1016/j.renene.2018.09.035.

Al-Soud, M., and E. Hrayshat. 2009. “Feasibility of Wind Energy for Electrification of Rural Jordanian Sites.” Clean Technologies and Environmental Policy 11 (2): 215–237. doi:10.1007/s0378-7796(99)00004-8.

Amer, M., and T. Daim. 2011. “Selection of Renewable Energy Technologies for a Developing Country: A Case of Pakistan.” Energy for Sustainable Development 15 (4): 420–435. doi:10.1016/j.esd.2011.09.001.

Aydin, N., L. Kente, and H. Duzgun. 2013. “GIS-Based Site Selection Methodology for Hybrid Renewable Energy Systems: A Case Study from Western Turkey.” Energy Conversion and Management 70: 90–106. doi:10.1016/j.enconman.2013.02.004.

Azzuni, A., A. Aghahosseini, M. Ram, D. Bogdanov, U. Caldera, and C. Breyer. 2020. “Energy Security Analysis for a 100% Renewable Energy Transition in Jordan by 2050.” Sustainability (12): 4921. doi:10.3390/su12124921.

Baniyounes, A. 2017. “Renewable Energy Potential in Jordan.” International Journal of Applied Engineering Research 12 (19): 8323–8331.

Bhowmik, C., S. Bhowmik, and A. Ray. 2020. “Optimal Green Energy Source Selection: An Eclectic Decision.” Energy and Environment 31 (5): 842–859. doi:10.1177/0958305X19882392.

Brahim, S. 2014. “Renewable Energy and Energy Security in the Philippines.” Energy Procedia 52: 480–486. doi:10.1016/j.egypro.2014.07.101.

Budak, G., X. Chen, S. Celik, and B. Ozturk. 2019. “A Systematic Approach for Assessment of Renewable Energy Using Analytic Hierarchy Process.” Energy Sustainability and Society 9: 9–37. doi:10.1186/s13705-019-0219-y.

Coban, V. 2020. “Solar Energy Plant Project Selection with AHP Decision-Making Method Based on Hesitant Fuzzy Linguistic Evaluation.” Complex & Intelligent Systems 6 (3): 507–529. doi:10.1007/s40747-020-00152-5.

Cristobal, S. 2011. “Multi-Criteria Decision-Making in the Selection of a Renewable Energy Project in Spain: The Vikor Method.” Renewable Energy 36 (2): 498–502. doi:10.1016/j.renene.2010.07.031.

Demirtas, O. 2013. “Evaluating the Best Renewable Energy Technology for Sustainable Energy Planning.” International Journal of Energy Economics and Policy 3 (4): 23–33.
