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Renewable energy and climate change

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ABSTRACT

The current editorial summarized some of the scientific works presented in the Sustainable Energy and Environmental Protection (SEEP) conference-held at the University of the West of Scotland, UK, 2018. The selected work was directly related to the scope of the Renewable, Sustainable Energy Reviews (RSER) journal. During the conference activities, experts from all around the world in the subjects of: renewable energy, climate change, optimization, and economics presented and discussed the progress made in renewable energy sources, as well as the new strategies for protecting the environment from the hazards connected with fossil fuel utilization. The methods presented in the conference focused on several directions: the development of efficient energy conversion systems with low/no environmental impacts; the suggested policies to widespread renewable energies; the restriction in the emission of greenhouse gases, and the recent progresses in CO_2 capture. This editorial focused on the renewable energy developments and their positive effect on the climate change, and briefly summarized the accepted manuscripts in this issue.

1. Introduction

The rapid growth of the global population and advances in civilization have resulted in an exponential growth in energy demand. Although fossil fuels are not sustainable and have severe environmental and health problems [1,2], they are still the main contributor to the energy sector. Greenhouse gases, such as methane, carbon dioxide, and nitrous oxide are emitted in large quantities during the combustion process of fossil fuel. It is also expected that the emissions of these gases will increase with time, due to the rapid rate of civil and industrial growth. The present status of greenhouse gases and the expected one (if no change in the energy sources) will result in weather changes, severe health problems, sea-level rise, changes in the ecosystem, etc [4]. Such climate changes and health problems that arise from fossil fuels threaten human beings [5,6]. Based on these facts, all nations have started to implement several strategies to avoid these scenarios. Governments have started reviewing their energy strategies and policies to minimize these problems. Various methods have been proposed to reduce greenhouse gases and the related issues, either partially or entirely. Improving the efficiency of current technologies [7,8], developing new devices that are efficient and have lower environmental impacts [9,10], and/or transition into renewable energy resources partially or entirely [11,12] are different suggested methods. The latter, i.e., relying on renewable energy resources (RERs), is the most promising method to get rid of fossil fuels soon.

However, it is worth mentioning that the current realization of RERs has to overcome many challenges and barriers [13,14]. The different barriers to the diffusion of RERs as a reliable power supply have been the main topic of many research work and efforts, with huge attention being given to identifying, developing, and strengthening enablers to overcome these barriers [15,16]. The main obstacles to deploying RERs [17–19] have been categorized in Fig. 1.

The main purpose of the international Sustainable Energy & Environmental Protection "SEEP" conference is to unite all experts and scholars, with multidisciplinary backgrounds from all over the world. Experts then present and discuss the progress made in renewable energy resources, and address the challenges and barriers facing their commercialization. During the 11th SEEP conference, held at the University of the West of Scotland, UK (2018), experts discussed the progress made in saving the environment from the undesired gases associated with fossil fuels. These strategies are listed under the methods

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List of abbreviations:

SEEP	Sustainable Energy and Environmental Protection
RSER	Renewable, sustainable energy reviews
RERs	Renewable energy resources
FIT	Feed-in-tariffs
SCC	Social cost of carbon
LMDI	Logarithmic mean divisia index
SEC	Smart energy cities
SET	Smart energy towns
PV	Photovoltaic
VRE	Variable renewable energy
SESs	Storage energy systems
MPP	Maximum power point
MPPT	Maximum power point tracking
CSP	Concentrated solar power
PEMFCs	Proton exchange membrane fuel cells
SOFCs	Solid oxide fuel cells
AAS	Amino acid salt

mentioned above.

2. Overview

Professor Abdul Ghani Olabi established the SEEP conference in 2004. The conference was officially opened by his excellency Pat "the Cope" Gallagher, Minister of State at the Department of Environment and Local Government. The first edition of this series, held at Dublin City University, Ireland, took place between the 7th and July 11, 2004. After the great success of the first edition, the conference was held at different cities around the world, including: Dublin, Bari, Glasgow, Maribor, Dubai, Kayseri, and Bled.

During the activities of the SEEP 2018 conference, more than 350 papers were presented. The authors presented research and investigations on the development of renewable energy techniques and methods to tackle the problems mentioned above. Overall, the presented works and thus, the selected ones for Renewable & Sustainable Energy Reviews (RSER) journal were divided into several areas that are directly related to sustainable energy and environmental protection, as follows:

2.1. Policies and studies related to renewable energies and greenhouse gases

Due to the many barriers in RERs projects discussed earlier, regulatory and policy support has been viewed as a must to enable RERs deployment. The current regulations and policies have been mainly set up for an energy market that is dominated by fossil energy resources. Accordingly, modifications and changes to regulations and policies should be made to present the environmental and social advantages of RERs.

Fixed feed-in-tariffs (FIT), quotas, energy bids, and auctions are some of the enabling regulations to support the deployment of RERs projects. Energy incentives are another type of regulatory and policy that is beneficial for RERs projects [16,20]. Exemption from taxes, importation duties and customs, low-interest rate, and energy credit are other regulatory and policy products that can enable RERs projects [14,21]. Furthermore, given the broad and diverse entities and individuals that enable RERs, institutional and administrative barriers have gained huge attention. Institutions should help bring stakeholders such as policy- and decision-makers (governmental entities for regulatory and policy enabling), investors, industrialists, academics, the public, and any other needed entities to develop a unified framework for deploying RERs projects [13,22].

In the middle East, the UAE is a leading country for innovation in RER projects and conversion from traditional energy sources into

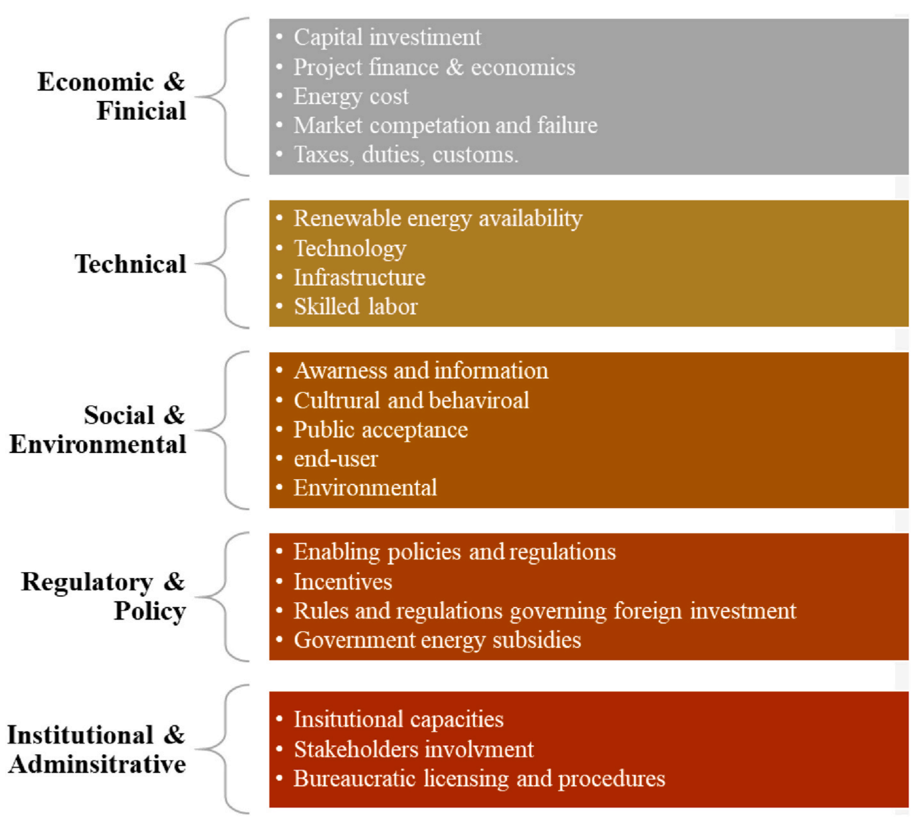

Fig. 1. Barriers to renewable energy resources deployment.

renewable energy ones. They built the first sustainable city in the Middle East (Masdar) [23] followed by other sustainable cities such as Dubai and Sharjah sustainable cities [24]. The UAE has one of the highest water and power consumption rates per capita; however, their greenhouse gas emissions are very high. For instance, the annual CO_2 emissions from fossil fuels (used for the energy and cement industry) reached 216.58 million tons in 2015 and then decreased to 150.27 million tons in 2020 [25]. Such a decrease in the CO_2 emissions would be related to the operation of several renewable energy projects such as Mohammed bin Rashid Al Maktoum Solar Park in Dubai [26] and Shams project in Abu Dhabi [27], as well as the effect of Covid 19 [28]. The social cost of carbon (SCC), based on the net present value of climate change over the next century of 1000 kg of CO_2 is an effective method to calculate the real cost of CO_2 [29]. Performing SCC calculations between 2010 and 2030 showed a total cost of 6.96 trillion dollars for power and 938.4 million dollars for water in the UAE, which corresponded to 139.252 billion tons of CO_2 from conventional power plants and 18.8 million tons of CO_2 from conventional water desalination units. This high cost encouraged governments to apply new policies to save the environment.

The UAE has aimed for 50% renewable energy sources by 2050, decreasing CO_2 emissions by 70%, and reducing current energy consumption by 40%. Saleh et al. [29] concluded that implementing taxes on CO_2 emissions would grow the investment in renewables and thus restrict CO_2 emissions. Al Naqbi et al. [30] created a market design that would be able to accommodate such changes. According to the study, the market design would need skilful human resources and infrastructures that are suitable for renewable energy. The study revealed that the target success requires cooperation between the different sectors, i.e., public, private, research institutes, and the end-user. The study also demonstrated that implementing renewable energy partially or fully would save a considerable part of costs.

Furthermore, China and Malaysia are good examples for studying the countries' technological advances on CO_2 release. Malaysia is a southeast Asian country, that has been developing during the last three decades. Due to this, it has shown a considerable contribution to global CO_2 emissions. While most of the studies related to CO_2 focused on the economic factors, Chong et al. [31] did a correlation between CO_2 emissions and the technical factors related to its release. The authors applied a logarithmic mean divisia index (LMDI) decomposition method to correlate the CO_2 release with these technical factors. This methodology was more effective than the traditional one, as it connected both the economic and technological factors on the CO_2 release. The study revealed that improving the end usage efficiency contributed positively to decreasing CO_2 emissions, while the coal-based power plants' usage adversely affected the environment. The study encouraged governments to consider both technical and economic factors to control CO_2 release.

The increase in renewable energy capacities in China has attracted policymakers to think of replacing traditional energy sources with renewable ones. However, the replacement cost of the existing power plants with renewable ones is expensive. The cost of electricity from renewable energy still needs a subsidy to be competitive with traditional sources. Also, coal power plants are scattered all over China, causing severe environmental impacts in broad areas. In spite of this, the increase in renewable energy capacity has been substantially increased in China. The prober replacement of the conventional coal-based power plants into renewable-based power plants could solve the climate change problem in China. Lingying et al. [32] studied renewable energy sources' potential to replace coal-based power plants in the Sichuan Province. The authors did an optimization model for the substitution scenarios of four different industries into renewable energy. The optimization model considered the subsidy policy required for the replacement "facility investment subsidy" and the electricity price "electricity price subsidy". The results of the study demonstrated that the success of substitution was dependent on the industry. And, as a general rule, the facility investment subsidy was more economical when the target was more than 25% substitution.

Several smart energy cities (SEC) have appeared/been proposed in different countries with renewable energy source growth. China is considered a good example of a developing country for the implementation of the SEC. Liang et al. [33] summarized the SEC's status in different countries, such as the USA, Japan, and Germany. The authors discussed the future of the SEC in China, and explored the challenges facing them. The authors then proposed and defined smart energy towns (SET) and their potential in China. Besides the economic barriers, the authors confirmed that planning, policy, and research were the other main challenges for the SET in China. The study results can be used as a guide for China and other developing countries wishing to implement the SEC and SET.

2.2. Technological advances

Producing efficient renewable energy harvesting devices is an essential requirement for improving efficiency and eventually, cutting down the cost of renewable energy sources. This is one of the challenges faceing the widespread implementation of RERs in comparison to traditional energy sources. Technical barriers are mainly concerned with the technology to harvest available and viable RERs. This starts from RERs availability, feasibility and viability, infrastructure, grid connectivity and capacity, the human factor of skilled labor, and technical expertise. In terms of technology, solar photovoltaic (PV) is a perfect example of technological advancement. The 3rd generation solar PV cells are currently employed, and they overcome many of the challenges associated with energy efficiency and cost [34]. The advancements in solar PV cells have led to lower costs, less energy-intensive manufacturing processes, and the use of available material resources (i.e., avoiding the use of precious metals). One of the main challenges of PV projects is their connectivity to the power grid, which is mainly due to their intermittent nature.

The term variable renewable energy (VRE) is usually used to refer to solar and wind RERs, due to their high intermittent nature, compared to other RERs [35–37]. In this regard, storage energy systems (SESs) have been widely viewed as an ultimate solution to smooth the RERs power generation scheme [38,39]. Skilled labor is another technical issue that is a challenge for the deployment of RERs projects. RERs usually require high-level skilled labor, with specific expertise to: install, commission, operate, and maintain RERs facilities. The recent deployment of RERs has made training facilities and accumulated experience in this area very limited, which hinders the wide deployment of RERs. Additionally, most of the current standards, codes, certification procedures, and requirements have been developed with fossil fuel resources in focus. This, in return, requires a critical technical review of such codes and standards to adapt and accommodate for the RERs projects [16,40–42].

Hydro energy is one of the cleanest renewable energies that can participate with a considerable renewable energy portion [43]. Bhattarai et al. [44] discussed the recent progress in the Pelton turbines' models for efficient harvesting of hydro energy. The authors investigated the effect of the optimization of the bucket profile on performance. The authors then compared the Lagrangian trajectory-based methods and Eulerian volume-based approaches to show water-bucket interaction. The study also gave insightful recommendations for future improvements in the turbine's performance-within the available resources [44]. Addressing environmental impacts is essential for decision-makers for long-term operation. In ocean energy, special care must be given to the effect of the ocean energy extracting devices on the physical and biotic marine systems. A detailed study of ocean energy harvesting systems' environmental impact was carried out by Mendoza et al. [45]. The authors demonstrated that such technology's environmental impacts depend mainly on the site and operation. Moreover, the authors suggested that early-stage technology and conventional fossil fuel's environmental impacts must be considered for a fair comparison with traditional fuel.

Biomass energy is one of the most attractive renewable energy sources, due to its role in waste management [46,47]. The technological progress for biofuel production from different biomass resources-focusing on lignocellulosic ones, was performed by Raud et al. [48]. The work represented vital points for improving efficiency, i.e., decreasing the production cost and increasing the overall yield. It is worth noting that in bioenergy production, the source of the biomass and the technology used both affect the overall efficiency [49]. The authors presented the technological developments achieved in biofuel production, focusing on the lignocellulosic biomass sources. They focused on bioethanol production from lignocellulosic biomass and gave recommendations for improving the productivity of bioethanol production [49]. Melts et al. [50] reported that the production rate of the bioenergy depended on the chemical characteristics of the biomass and the conversion method. For instance, bioenergy from floodplain meadows could reach 50% in methane conversion, while only 20% could be obtained in the case of ethanol conversion [50].

Solar energy is available everywhere and is already commercially applied in several sectors, either solar thermal or electrical energy [51,52]. The widespread of solar PV systems requires efficient energy storage systems [53–55]. Batteries are the most affordable energy storage that are available in different sizes [56,57]. To decrease the capital cost of distributed photovoltaics in China, Bai et al. [58] studied the economics of reusing vehicle batteries as energy storage for solar PV systems. The proposed strategy was found to be economically feasible in the case of industrial and commercialization applications. However, it varied from one place to another in the residential sector. The authors suggested the following policies for the effectiveness of PV and recycled batteries as energy storage in PV: 1) a decrease in the subsidy for commercial and industrial sectors could be done, if the profit is achievable in the distributed solar PV projects without subsidy; 2) in the residential sector, the subsidy is required; 3) the government should implement policies that encourage PV and reuse batteries energy storage system; 4) provinces facing low economics of the PV are encouraged to do its local subsidy system. One of the main challenges facing solar PV is the shading that negatively affects power output. To maximize the solar PV system's power output, it is crucial to maximize the PV system's efficiency by tracking the maximum power point at which the solar PV panel can work. Several techniques have been proposed for this purpose [59]. Traditional optimization techniques are used under normal conditions of the PV. However, under nonuniform solar radiations, such as partial shading conditions, the solar PV panels have more than one Maximum Power Point (MPP) and the operation of the PV system is much more complicated than a normal one. Rezk et al. [60] summarized the modern optimization techniques for tracking the maximum power point under partial shading conditions. The study clearly showed the strong and weak points of the different optimization algorithms used for Maximum Power Point Tracking (MPPT).

Besides environmental concerns, economic ones are critical factors that must be considered in any decision related to renewable energy sources. From this perspective, Ji et al. [61] developed a model for calculating the levelized cost of energy for concentrated solar power in 31 provinces in China. The study revealed that a central receiver system, accompanied by thermal storage was better than a parabolic trough collector. However, the concentrated solar power (CSP) plant's high capital cost was one of the main challenges facing the widespread implementation of the CSP technology. The authors suggested that the large scale of the CSP and the governmental subsidies-in terms of decreasing the taxes on the renewable energy sector-would help the commercialization of the CSP power plants. In another study, Li et al. [62] performed a techno-economic study on a solar heat pump for water heating under three business models. Results demonstrated that the commercialization of the system needed a subsidy from the governmental side to reduce the gap between the prices of the traditional fuel systems "cheap one" and the renewable-based ones "expensive one".

The efficient utilization of renewable energy sources requires developing efficient and cost-effective devices that can effectively convert renewable energy sources into electricity, "the highest quality form of energy". Fuel cells are considered the ideal solution for this purpose [63]. In fuel cells, the chemical energy of the organic load of the biomass resources is converted directly into electricity [64–66]. Hydrogen obtained from the electrolysis of water, using different renewable energy sources, can be converted into electricity with the lowest environmental impacts and high efficiency in fuel cells [67–69]. According to the fuel, electrolyte membrane, or operating temperature, there are different fuel cell classifications. Low-temperature cells are conducted at room temperature and rise up to 120 °C, medium-temperature and high-temperature fuel cells can reach up to 500 °C. Each FC has its advantages and disadvantages.

The transportation sector is responsible for a large portion of pollution [70,71]. With minimal environmental impact, proton exchange membrane fuel cells can be applied in the transportation sector [72]. At low temperatures, securing cost-effective high purity hydrogen is one of the main challenges facing the widespread use of proton exchange membrane fuel cells (PEMFCs). Water electrolysis is considered the perfect method for hydrogen to be used in PEMFCs. The high cost of water electrolysis could be eliminated using electricity obtained from renewable energy sources. Khatib et al. [73] discussed different hydrogen production methods, especially those based on water electrolysis through polymer electrolyte membrane electrolytic cells. The authors also discussed the various factors affecting the cell components' durability and the best strategies to improve their lifetime performance and effectiveness.

The energy density of a fuel cell is inversely proportional its mass. As such, a smaller mass of fuel cell components will result in increased energy density. Bipolar plates of the PEMFC represent 70% of the fuel cell's mass and 30% of the cost [74]. They play an essential role in the mass, thermal, and charge transfer in PEMFCs. Wilberforce et al. [74] discussed the parameters used to guide a better selection of the different bipolar plates in order to achieve the highest performance and highest energy density of the PEMFC under the different operating conditions. The authors reported that the efficiency of the fuel cell directly depended on the flow channel used. Proper design of the bipolar plate's geometry would result in the uniform mass transfer of the reactants, even cell temperature distribution, even current distribution, and ease of water management. The potential of applying the PEMFC in the aviation sector was discussed by Baroutaji et al. [75]. The authors showed that the hydrogen from different renewable energy sources could be used in fuel cells for aviation sectors, thereby decreasing the amount of the released greenhouses from the conventional fuel. However, the aviation sector's fuel cell application is limited by hydrogen production, purity, transportation, and storage [76,77]. Such challenges need to be addressed before the commercialization of hydrogen fuel cells in the aviation sector becomes possible.

High-temperature fuel cells, such as solid oxide fuel cells (SOFCs) have the advantage of using various fuels, including those produced from different renewable energy sources, such as: biogas [78] and syngas [79]. Hydrogen could be obtained from syngas produced from the various lignocellulosic wastes [80,81]. In SOFC, the proper preparation of electrodes/electrolytes plays a critical role in their performance, price, and durability. Pikalova and Kalinina [82] discussed the fundamentals of electrophoretic deposition as a cheap, easy, and attractive method used to prepare the different components of SOFCs. The authors confirmed their success in preparing excellent functional layers of the planer and micro-tubular SOFCs that are dense, porous, and have a multilayered structure, by using electrophoretic deposition [82].

2.3. CO_2 capturing

Vast amounts of CO_2 are released from power plants and the industrial sector [83,84]. As such, finding an effective CO_2 capturing method is essential for controlling the accumulation of CO_2 [85,86]. Due to this topic's importance and the promising features of the amino acid salt

(AAS), i.e., not easily vaporized or degraded, Zhang et al. [87] discussed the recent progress for using AAS for CO_2 capture. The authors summarized the recent progress made in CO_2 capturing using different types of AAS, including the kinetics and thermodynamics of the different AASs. The authors also introduced current directions in CO_2 absorption, using AAS and the guidelines for selecting new absorbents for CO_2 capture. Haze pollution has severe environmental impacts-namely on climate and air quality. This results in millions of deaths annually [88, 89]. Wang and Watanabe [90] studied the effects of the Chinese government's regulations "command-and-control regulation" on controlling haze through stopping construction works from October 2017 to March 2018. The results of the study demonstrated that laws have an apparent effect on controlling pollution. The authors suggested that applying the rules could eventually control pollution and could even result in the transition from fossil fuel to renewable and sustainable energy sources.

Energy and food are related to one another, and human beings cannot survive without them. Securing food is also essential for humans. Although the high energy consumption of the container-sized agriculture units, they require a minimal amount of water and limited areas. As such, they can solve the problems of water and land availability. Moreover, securing energy from renewable energy sources "from those available by 2050" will be a cost-effective and clean energy source. Farfan et al. [91] showed that using 5% of projected electricity from different renewable energy sources is enough for 55.4 million container-sized agriculture units, to secure around 25% of the global population's vegetables.

3. Conclusions and remarks

Renewable energy sources are the most affordable method for getting rid of fossil fuels, which are limited in resources and have severe environmental impacts. Several regulatory policies, technical barriers, and economic barriers hinder the widespread use of renewable energy sources. In this special issue of the international conference of sustainable energy and environmental protection (SEEP2018), several researchers and experts discussed the different methods to overcome such barriers. They concluded the following:

- New regulations and policies are needed to encourage the widespread use of renewable energy sources.
- Technological advancements are essential for improving efficiency and the economics of renewable energy processes and restricting CO_2 growth.
- Developing efficient carbon capture methods is also needed for controlling climate change.
- Producing efficient renewable energy harvesting devices is an essential requirement for improving efficiency and eventually, cutting down the cost of renewable energy sources.
- Widespread of the fuel cells in transportation sector will positively contribute in protecting the environment from harmful gases.

Declaration of competing interest

The authors declared that there is no conflict of interest in this work.

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References

[1] Yang X, Pang J, Teng F, Gong R, Springer C. The environmental co-benefit and economic impact of China's low-carbon pathways: evidence from linking bottom-up and top-down models. Renew Sustain Energy Rev 2021;136:110438.
[2] Curtin J, McInerney C, Ó Gallachóir B, Hickey C, Deane P, Deeney P. Quantifying stranding risk for fossil fuel assets and implications for renewable energy investment: a review of the literature. Renew Sustain Energy Rev 2019;116:109402.
[4] Olabi AG, Obaideen K, Elsaid K, Wilberforce T, Sayed ET, Maghrabie HM, et al. Assessment of the pre-combustion carbon capture contribution into sustainable development goals SDGs using novel indicators. Renew Sustain Energy Rev 2022;153:111710.
[5] Gustavsson L, Nguyen T, Sathre R, Tettey UYA. Climate effects of forestry and substitution of concrete buildings and fossil energy. Renew Sustain Energy Rev 2021;136:110435.
[6] He X, Wang F, Wallington TJ, Shen W, Melaina MW, Kim HC, et al. Well-to-wheels emissions, costs, and feedstock potentials for light-duty hydrogen fuel cell vehicles in China in 2017 and 2030. Renewable and Sustainable Energy Reviews; 2020. p. 110477.
[7] Olabi AG, Elsaid K, Rabaia MKH, Askalany AA, Abdelkareem MA. Waste heat-driven desalination systems: Perspective. Energy 2020;209:118373.
[8] Pili R, García Martínez L, Wieland C, Spliethoff H. Techno-economic potential of waste heat recovery from German energy-intensive industry with Organic Rankine Cycle technology. Renew Sustain Energy Rev 2020;134:110324.
[9] Olabi AG, Abdelkareem MA, Wilberforce T, Sayed ET. Application of graphene in energy storage device – a review. Renew Sustain Energy Rev 2021;135:110026.
[10] Enas Taha Sayed MAA, Ahmed Bahaa, Eisa Tasnim, Hussain Alawadhi, A-Asheh Sameer, Chae Kyu-Jung. Synthesis and performance evaluation of various metal chalcogenides as active anodes for direct urea fuel cells. Renew Sustain Energy Rev 2021. in press.
[11] Hussain A, Arif SM, Aslam M. Emerging renewable and sustainable energy technologies: State of the art. Renew Sustain Energy Rev 2017;71:12–28.
[12] Madi E, Pope K, Huang W, Iqbal T. A review of integrating ice detection and mitigation for wind turbine blades. Renew Sustain Energy Rev 2019;103:269–81.
[13] Hu J, Harmsen R, Crijns-Graus W, Worrell E, van den Broek M. Identifying barriers to large-scale integration of variable renewable electricity into the electricity market: a literature review of market design. Renew Sustain Energy Rev 2018;81:2181–95.
[14] Karytsas S, Choropanitis I. Barriers against and actions towards renewable energy technologies diffusion: a Principal Component Analysis for residential ground source heat pump (GSHP) systems. Renew Sustain Energy Rev 2017;78:252–71.
[15] Shivakumar A, Dobbins A, Fahl U, Singh A. Drivers of renewable energy deployment in the EU: an analysis of past trends and projections. Energy Stategy Rev 2019;26:100402.
[16] Kim C. A review of the deployment programs, impact, and barriers of renewable energy policies in Korea. Renew Sustain Energy Rev 2021;144:110870.
[17] Reddy S, Painuly JP. Diffusion of renewable energy technologies—barriers and stakeholders' perspectives. Renew Energy 2004;29:1431–47.
[18] Sen S, Ganguly S. Opportunities, barriers and issues with renewable energy development–A discussion. Renew Sustain Energy Rev 2017;69:1170–81.
[19] Owen AD. Renewable energy: externality costs as market barriers. Energy Pol 2006;34:632–42.
[20] Eshchanov B, Abdurazzakova D, Yuldashev O, Salahodjaev R, Ahrorov F, Komilov A, et al. Is there a link between cognitive abilities and renewable energy adoption: evidence from Uzbekistan using micro data. Renew Sustain Energy Rev 2021;141:110819.
[21] Mutezo G, Mulopo J. A review of Africa's transition from fossil fuels to renewable energy using circular economy principles. Renew Sustain Energy Rev 2021;137:110609.
[22] Moorthy K, Patwa N, Gupta Y. Breaking barriers in deployment of renewable energy. Heliyon 2019;5:e01166.
[23] Mezher T, Tabbara S, Al-Hosany N. An overview of CSR in the renewable energy sector: examples from the Masdar initiative in Abu Dhabi. Manag Environ Qual Int J 2010;21. https://doi.org/10.1108/14777831011077619.
[24] Ibrahim IAS. Sustainable cities indices IN modern architecture: a comparative study IN UAE. Eco-architecture VIII: harmonisation between architecture and. Nature 2020;195:173.
[25] Ritchie H, Roser M. CO_2 and greenhouse gas emissions. Our world in data. 2020.
[26] Obaideen K, Nooman AlMallahi M, Alami AH, Ramadan M, Abdelkareem MA, Shehata N, et al. On the contribution of solar energy to sustainable developments goals: case study on Mohammed bin Rashid Al Maktoum Solar Park. Int J Thermofluids 2021;12:100123.
[27] Alobaidli A, Sanz B, Behnke K, Witt T, Viereck D, Schwarz MA. Shams 1-Design and operational experiences of the 100MW-540 C CSP plant in Abu Dhabi. In: AIP conference proceedings. AIP Publishing LLC; 2017. 020001.
[28] Elsaid K, Olabi V, Sayed ET, Wilberforce T, Abdelkareem MA. Effects of COVID-19 on the environment: an overview on air, water, wastewater, and solid waste. J Environ Manag 2021;292:112694.
[29] Saleh L, Ma Zaabi, Mezher T. Estimating the social carbon costs from power and desalination productions in UAE. Renew Sustain Energy Rev 2019;114:109284.
[30] Al Naqbi S, Tsai I, Mezher T. Market design for successful implementation of UAE 2050 energy strategy. Renew Sustain Energy Rev 2019;116:109429.
[31] Chong CH, Tan WX, Ting ZJ, Liu P, Ma L, Li Z, et al. The driving factors of energy-related CO2 emission growth in Malaysia: the LMDI decomposition method based on energy allocation analysis. Renew Sustain Energy Rev 2019;115:109356.

[32] Lingying P, Kui Z, Weiqi L, Fuyuan Y, Zheng L. Subsidy policy discussion on the hydroelectric power substitution for scattered coal consumption: a case study of Sichuan Province. Renew Sustain Energy Rev 2019;108:539–49.
[33] Liang X, Ma L, Chong C, Li Z, Ni W. Development of smart energy towns in China: concept and practices. Renew Sustain Energy Rev 2020;119:109507.
[34] Conibeer G. Third-generation photovoltaics. Mater Today 2007;10:42–50.
[35] Diesendorf M, Elliston B. The feasibility of 100% renewable electricity systems: a response to critics. Renew Sustain Energy Rev 2018;93:318–30.
[36] Alshawaf M, Poudineh R, Alhajeri NS. Solar PV in Kuwait: the effect of ambient temperature and sandstorms on output variability and uncertainty. Renew Sustain Energy Rev 2020;134:110346.
[37] Chen X, Foley A, Zhang Z, Wang K, O'Driscoll K. An assessment of wind energy potential in the Beibu Gulf considering the energy demands of the Beibu Gulf Economic Rim. Renew Sustain Energy Rev 2020;119:109605.
[38] Olabi AG, Abdelkareem MA. Energy storage systems towards 2050. Energy 2021;219:119634.
[39] Zhang Z, Ding T, Zhou Q, Sun Y, Qu M, Zeng Z, et al. A review of technologies and applications on versatile energy storage systems. Renew Sustain Energy Rev 2021;148:111263.
[40] Cieplinski A, D'Alessandro S, Marghella F. Assessing the renewable energy policy paradox: a scenario analysis for the Italian electricity market. Renew Sustain Energy Rev 2021;142:110838.
[41] Ghorashi AH, Maranlou H. Essential infrastructures and relevant policies for renewable energy developments in oil-rich developing countries: case of Iran. Renew Sustain Energy Rev 2021;141:110839.
[42] Arens M, Åhman M, Vogl V. Which countries are prepared to green their coal-based steel industry with electricity? - reviewing climate and energy policy as well as the implementation of renewable electricity. Renew Sustain Energy Rev 2021;143:110938.
[43] Xu B, Zhang J, Egusquiza M, Chen D, Li F, Behrens P, et al. A review of dynamic models and stability analysis for a hydro-turbine governing system. Renew Sustain Energy Rev 2021;144:110880.
[44] Bhattarai S, Vichare P, Dahal K, Al Makky A, Olabi AG. Novel trends in modelling techniques of Pelton Turbine bucket for increased renewable energy production. Renew Sustain Energy Rev 2019;112:87–101.
[45] Mendoza E, Lithgow D, Flores P, Felix A, Simas T, Silva R. A framework to evaluate the environmental impact of OCEAN energy devices. Renew Sustain Energy Rev 2019;112:440–9.
[46] Zailan R, Lim JS, Manan ZA, Alwi SRW, Mohammadi-ivatloo B, Jamaluddin K. Malaysia scenario of biomass supply chain-cogeneration system and optimization modeling development: a review. Renew Sustain Energy Rev 2021;148:111289.
[47] Tanveer WH, Abdelkareem MA, Kolosz BW, Rezk H, Andresen J, Cha SW, et al. The role of vacuum based technologies in solid oxide fuel cell development to utilize industrial waste carbon for power production. Renew Sustain Energy Rev 2021:110803.
[48] Raud M, Kikas T, Sippula O, Shurpali N. Potentials and challenges in lignocellulosic biofuel production technology. Renew Sustain Energy Rev 2019;111:44–56.
[49] Onumaegbu C, Mooney J, Alaswad A, Olabi AG. Pre-treatment methods for production of biofuel from microalgae biomass. Renew Sustain Energy Rev 2018;93:16–26.
[50] Melts I, Ivask M, Geetha M, Takeuchi K, Heinsoo K. Combining bioenergy and nature conservation: an example in wetlands. Renew Sustain Energy Rev 2019;111:293–302.
[51] Li J, Huang J. The expansion of China's solar energy: challenges and policy options. Renew Sustain Energy Rev 2020;132:110002.
[52] Mohammed RH, Rezk A, Askalany A, Ali ES, Zohir AE, Sultan M, et al. Metal-organic frameworks in cooling and water desalination: synthesis and application. Renew Sustain Energy Rev 2021;149:111362.
[53] Olabi AG, Onumaegbu C, Wilberforce T, Ramadan M, Abdelkareem MA, Al – Alami AH. Critical review of energy storage systems. Energy 2020:118987.
[54] Zhu Z, Xu Z. The rational design of biomass-derived carbon materials towards next-generation energy storage: a review. Renew Sustain Energy Rev 2020;134:110308.
[55] Diezmartínez CV. Clean energy transition in Mexico: policy recommendations for the deployment of energy storage technologies. Renew Sustain Energy Rev 2021;135:110407.
[56] Chowdhury JI, Balta-Ozkan N, Goglio P, Hu Y, Varga L, McCabe L. Techno-environmental analysis of battery storage for grid level energy services. Renew Sustain Energy Rev 2020;131:110018.
[57] Das UK, Shrivastava P, Tey KS, Myi Bin Idris, Mekhilef S, Jamei E, et al. Advancement of lithium-ion battery cells voltage equalization techniques: a review. Renew Sustain Energy Rev 2020;134:110227.
[58] Bai B, Xiong S, Song B, Xiaoming M. Economic analysis of distributed solar photovoltaics with reused electric vehicle batteries as energy storage systems in China. Renew Sustain Energy Rev 2019;109:213–29.
[59] Mohapatra A, Nayak B, Das P, Mohanty KB. A review on MPPT techniques of PV system under partial shading condition. Renew Sustain Energy Rev 2017;80:854–67.
[60] Rezk H, Al-Oran M, Gomaa MR, Tolba MA, Fathy A, Abdelkareem MA, et al. A novel statistical performance evaluation of most modern optimization-based global MPPT techniques for partially shaded PV system. Renew Sustain Energy Rev 2019;115:109372.
[61] Ji J, Tang H, Jin P. Economic potential to develop concentrating solar power in China: a provincial assessment. Renew Sustain Energy Rev 2019;114:109279.
[62] Li Z, Ma L, Li Z, Ni W. Multi-energy cooperative utilization business models: a case study of the solar-heat pump water heater. Renew Sustain Energy Rev 2019;108:392–7.
[63] Abdelkareem MA, Elsaid K, Wilberforce T, Kamil M, Sayed ET, Olabi A. Environmental aspects of fuel cells: a review. Sci Total Environ 2021;752:141803.
[64] Li Y, Pei P, Ma Z, Ren P, Huang H. Analysis of air compression, progress of compressor and control for optimal energy efficiency in proton exchange membrane fuel cell. Renew Sustain Energy Rev 2020;133:110304.
[65] Bhosale AC, Ghosh PC, Assaud L. Preparation methods of membrane electrode assemblies for proton exchange membrane fuel cells and unitized regenerative fuel cells: a review. Renew Sustain Energy Rev 2020;133:110286.
[66] Yang W, Li J, Fu Q, Zhang L, Wei Z, Liao Q, et al. Minimizing mass transfer losses in microbial fuel cells: theories, progresses and prospectives. Renew Sustain Energy Rev 2021;136:110460.
[67] Niermann M, Timmerberg S, Drünert S, Kaltschmitt M. Liquid Organic Hydrogen Carriers and alternatives for international transport of renewable hydrogen. Renew Sustain Energy Rev 2021;135:110171.
[68] Burton NA, Padilla RV, Rose A, Habibullah H. Increasing the efficiency of hydrogen production from solar powered water electrolysis. Renew Sustain Energy Rev 2021;135:110255.
[69] Baeyens J, Zhang H, Nie J, Appels L, Dewil R, Ansart R, et al. Reviewing the potential of bio-hydrogen production by fermentation. Renew Sustain Energy Rev 2020;131:110023.
[70] Singh R, Kemausuor F, Wooldridge M. Locational analysis of cellulosic ethanol production and distribution infrastructure for the transportation sector in Ghana. Renew Sustain Energy Rev 2018;98:393–406.
[71] Duarte Souza Alvarenga Santos N, Rückert Roso V, Teixeira Malaquias AC, Coelho Baêta JG. Internal combustion engines and biofuels: examining why this robust combination should not be ignored for future sustainable transportation. Renew Sustain Energy Rev 2021;148:111292.
[72] Olabi AG, Wilberforce T, Abdelkareem MA. Fuel cell application in the automotive industry and future perspective. Energy 2021;214:118955.
[73] Khatib F, Wilberforce T, Ijaodola O, Ogungbemi E, El-Hassan Z, Durrant A, et al. Material degradation of components in polymer electrolyte membrane (PEM) electrolytic cell and mitigation mechanisms: a review. Renew Sustain Energy Rev 2019;111:1–14.
[74] Wilberforce T, El Hassan Z, Ogungbemi E, Ijaodola O, Khatib FN, Durrant A, et al. A comprehensive study of the effect of bipolar plate (BP) geometry design on the performance of proton exchange membrane (PEM) fuel cells. Renew Sustain Energy Rev 2019;111:236–60.
[75] Baroutaji A, Wilberforce T, Ramadan M, Olabi AG. Comprehensive investigation on hydrogen and fuel cell technology in the aviation and aerospace sectors. Renew Sustain Energy Rev 2019;106:31–40.
[76] Ishaq H, Dincer I. Comparative assessment of renewable energy-based hydrogen production methods. Renew Sustain Energy Rev 2021;135:110192.
[77] Gabrielli P, Poluzzi A, Kramer GJ, Spiers C, Mazzotti M, Gazzani M. Seasonal energy storage for zero-emissions multi-energy systems via underground hydrogen storage. Renew Sustain Energy Rev 2020;121:109629.
[78] Abdelkareem MA, Tanveer WH, Sayed ET, Assad MEH, Allagui A, Cha SW. On the technical challenges affecting the performance of direct internal reforming biogas solid oxide fuel cells. Renew Sustain Energy Rev 2019;101:361–75.
[79] Radenahmad N, Azad AT, Saghir M, Taweekun J, Bakar MSA, Reza MS, et al. A review on biomass derived syngas for SOFC based combined heat and power application. Renew Sustain Energy Rev 2020;119:109560.
[80] Ren J, Cao J-P, Zhao X-Y, Yang F-L, Wei X-Y. Recent advances in syngas production from biomass catalytic gasification: a critical review on reactors, catalysts, catalytic mechanisms and mathematical models. Renew Sustain Energy Rev 2019;116:109426.
[81] Inayat M, Sulaiman SA, Kurnia JC, Shahbaz M. Effect of various blended fuels on syngas quality and performance in catalytic co-gasification: a review. Renew Sustain Energy Rev 2019;105:252–67.
[82] Pikalova EY, Kalinina EG. Electrophoretic deposition in the solid oxide fuel cell technology: fundamentals and recent advances. Renew Sustain Energy Rev 2019;116:109440.
[83] Wang S, Li G, Fang C. Urbanization, economic growth, energy consumption, and CO2 emissions: empirical evidence from countries with different income levels. Renew Sustain Energy Rev 2018;81:2144–59.
[84] Oliveira T, Varum C, Botelho A. Econometric modeling of CO2 emissions abatement: comparing alternative approaches. Renew Sustain Energy Rev 2019;105:310–22.
[85] Bareschino P, Mancusi E, Urciuolo M, Paulillo A, Chirone R, Pepe F. Life cycle assessment and feasibility analysis of a combined chemical looping combustion and power-to-methane system for CO2 capture and utilization. Renew Sustain Energy Rev 2020;130:109962.
[86] Hidalgo D, Martín-Marroquín JM. Power-to-methane, coupling CO2 capture with fuel production: an overview. Renew Sustain Energy Rev 2020;132:110057.
[87] Zhang Z, Li Y, Zhang W, Wang J, Soltanian MR, Olabi AG. Effectiveness of amino acid salt solutions in capturing CO2: a review. Renew Sustain Energy Rev 2018;98:179–88.
[88] Lelieveld J, Evans JS, Fnais M, Giannadaki D, Pozzer A. The contribution of outdoor air pollution sources to premature mortality on a global scale. Nature 2015;525:367–71.

[89] Zhou X, Xu Y, Yuan S, Wu C, Zhang H. Performance and potential of solar updraft tower used as an effective measure to alleviate Chinese urban haze problem. Renew Sustain Energy Rev 2015;51:1499–508.

[90] Wang L, Watanabe T. Effects of environmental policy on public risk perceptions of haze in Tianjin City: a difference-in-differences analysis. Renew Sustain Energy Rev 2019;109:199–212.

[91] Farfan J, Lohrmann A, Breyer C. Integration of greenhouse agriculture to the energy infrastructure as an alimentary solution. Renew Sustain Energy Rev 2019; 110:368–77.