REVIEW OF INTERNATIONAL GEOGRAPHICAL EDUCATION

ISSN: 2146-0353 ● © RIGEO ● 11(7), SPRING, 2021

www.rigeo.org

Research Article

The Role of Technological Innovation in The Sustainable Development of Alternative Energy in The Kingdom of Saudi Arabia

Khaled A. Z. Alyamani
Community College in Abqaiq, King Faisal University, P.O. Box 4000,
Al-Ahsa 31982, Saudi Arabia.
kalyamani@kfu.edu.sa

Abstract
The research paper sought to clarify global trends to curb the increasing pollution that was associated with the growth and economic development of countries by identifying technological developments in the field of alternative energy, and we will focus on solar energy technology and wind energy technology. The most important experiences in this field were also evident in Saudi Arabia, as it is one of the major exporting countries of fossil energy. The negative impacts of fossil energy on the environment in the world were also addressed, as was the mega investment projects in Saudi Arabia, which is considered one of the most important projects in the world in the field of alternative and sustainable energy and its role in reducing emissions, as well as the economic role of such projects at the level of creating new job opportunities and the role The projects planned in Vision 2030 in the future treatments of the environment and the economy have also been identified the most important factors helping the world to move towards alternative energy, such as lower costs compared to previous years

Keywords
Technology, Sustainability, Alternative Energy and Development

To cite this article: Alyamani, K, A, Z. (2021) The Role of Technological Innovation in The Sustainable Development of Alternative Energy in The Kingdom of Saudi Arabia. *Review of International Geographical Education (RIGEO), 11*(7), 2412-2424. Doi: 10.48047/rigeo.11.07.218

Submitted: 20-02-2021 ● **Revised:** 15-03-2021 ● **Accepted:** 25-04-2021

Introduction

The increasing demand for energy since ancient times, as countries have sought to control it because it can achieve growth and enhance energy security and the need to build a sustainable future. (Abbasi & Abbasi, 2010). The possession of energy also represents the possession of power and control of the situation. (Akinbami, 2001) The world is transforming due to the increasing demand for energy, states, peoples and consumers in general, (Amalia et al., 2021) on top of the reasons for the transformation that the energy world is witnessing.(Bagher, Vahid, Mohsen, & Parvin, 2015) During the past forty years, the world's population has increased from 4 to 7 billion as the poor have expanded as the poor are most likely the least likely to have access to energy. (Bozkurt, Foster, & Steinbuks, 2010) And they are most likely among those who would remain poor if their isolation continues without providing energy, as there are nearly one in seven, (Cheng, Blakers, Stocks, & Lu)[or 1.1 billion people, who do not have access to electricity, and nearly three billion still cook their food using polluting fuels such as kerosene and wood. Charcoal and animal dung. In Africa, the electricity challenge remains daunting. An example is Liberia, where only 2% of the total population has access to electricity on a continuous basis.(Development. Rural Development, Organisation de coopération et de développement, Staff, & Development, 1994) Even countries where electricity is available also suffer from erratic service. (Enete & Alabi, 2011) At least one in every three developing countries suffers from the lack of continuity of electricity, and the blackout may last more than 20 hours per month. Besides its high costs.: in many developing countries. (Hand et al., 2012) The consumer pays between 20 and 50 cents per kilowatt-hour versus the global average of 10 cents. Economic development in all aspects is considered one of the most important means to fight poverty, create new job opportunities and improve the standard of living. (Gencoğlu, 2008). However, most economic activities are impossible without reliable, affordable, modern energy. (Grigoriu, 2009) This is the reason why access to energy is important in fighting poverty during this period and electric power generation recorded a growth of more than 250%, with a strong trend towards continuing this growth in the future. (Guney & Onat, 2008) In 2030, the world population will exceed 8 billion, of whom 5 billion will live in urban societies.(Hand et al., 2012) It is also likely that electricity generation in the world will increase by 70%, to reach 37 thousand terawatts in 2030.(Javed, Ashraf, & Khan, 2020) But this energy does not come for free, as the risks of increasing the percentage of pollution to humans, animals, land and plants, which calls for concerted global efforts to reduce these harmful emissions. (John & Tony, 2006) If the percentage of carbon dioxide emissions continues to increase, these efforts will not be successful. Whereas, the average intensity of emissions from electricity generation has not changed.(Kartha, 2006; Kartha & Larson, 2000) Except in small percentages until before 2020, and despite the rapid transformation caused by the Corona pandemic and helped reduce emissions of harmful gases, (Kashian, Romme, Tinker, Turner, & Ryan, 2006)[the percentage emitted is still at the time of writing this research large for societies in general, where the work that causes emissions is still ongoing, including the extraction and use of fossil energy and it is noticeable (Kaur, Mukhija, Sharma, & Kaur, 2017)[There is a tendency for energy-exporting countries, especially Saudi Arabia, to move towards sustainable energy, and this is evident from the great trends in(Keith, 2004) the projects that it seeks , as billions of dollars have been invested in the field of alternative energy, which the study will talk about some of these projects. (Khan et al., 2021; Larson & Kartha, 2000) The elimination of emissions resulting from conventional and other energy generation will continue to be considered by increasing the share of alternative energy in future plans for all countries of the world. (Leible & Kälber, 2005) The impact of current global policies and plans that seek to reduce average carbon dioxide emissions will not exceed 498 grams / kilowatt hour by 2030, this rate is not Sufficient to keep carbon dioxide levels below 450 parts per million. (Lewandowski & Faaij, 2006)

It is good during recent global developments that interest has increased in using innovative technology in the field of alternative energy in all its forms in the countries of the world In natural by the state of the energy and technology market. and the total installed capacity in the Arab region from alternative sub-hydro energy was about 5100 MW(Liqun & Zhixin, 2009)

Arab countries are not the only ones seeking to convert to this innovative technology for the sustainable development of alternative energy. (Lyons, Anthony, & Johnson, 2001)The world is facing an unprecedented turning point today(Maheshwari & Ramakumar, 2017), as the situation requires solidarity, as the issue is related to human survival and the continuation of life on the planet.(Møller, Pettitt, Reeves, & Berthelsen, 2006). In order to limit climate change, we must work

to spread the importance of using such technology and its positive impact to all countries of the world, and this study and other studies are considered one of the most important means to achieve this.(Naghiu, Vázquez, & Georgiev, 2005).

Previous studies: Assessing the Impact of Renewable Energy on Regional Sustainability A Comparative Study of SOGN OG FJORDANE (NORWAY) and OKINAWA (JAPAN). It is based on studying the motives and benefits of moving to alternative and sustainable energy and defining development goals with identifying the links between food, energy, water and land, and it seeks to identify the extent of self-sufficiency in energy, food and water. (Najam & Cleveland, 2005) Renewable Energy: Environmental Impacts and Economic Benefits for Sustainable Development The research paper emphasizes the necessity of energy in life and its importance increases with the increasing population in the world and the role of energy that is playing to address poverty and increase development (Oji et al., 2012) Smart Integrated Renewable Energy Systems (SIRES):A Novel Approach for Sustainable Integrated smart alternative energy systems are a new approach to sustainability that relies on smart systems that seek to find renewable energy with lower costs and seek to provide alternative energy to societies. The study relies on algorithms by using hypothetical examples and comparing smart systems SIRES with the costs of regular ACS systems(Otiman, 2008).

The methodology of the study: is based on the descriptive approach, which in turn relies on collecting data and information, analysing it and coming up with results, as is the case in all human studies that seek to produce results that serve different societies. The study focused on sustainable alternative energy technology, where the difference between the use of traditional energy and the different technologies in The field of alternative energy, whether through the sun or wind, and the focus of the study was on Saudi projects as the largest exporter for energy in the Middle East, the impact of conventional energy consumption on the environment, and the state's tendencies to find alternatives through mega projects in sustainable technology in alternative energy that will convert toxic emissions to a decrease in proportions big

• Energy produced from fossil fuels and the resulting damages

The depletion of the limited resources on the earth is the other side that is more dangerous for humans and the environment, as it results from the emissions that cause air pollution(Oyedepo, 2012), in addition to global warming(Özyurt & Dönmez, 2005), climate change and other serious environmental disasters. Where fossil fuels of all three types: coal, oil and gas are the most important sources on which people depend so far in energy production (Ren, 2017)[, as they constitute about 92% of the total sources of energy production, (Rosenqvist, Nilsson, & Ericsson) while other sources constitute approximately 8% only.(Sani, Ibrahim, Sahabi, & Lailaba) Fossil fuel sources are considered non-alternative or renewable sources and may end within a certain period of time. (Stojcetovic, Sarkocevic, Misic, & Jovanovic). The demand for them is constantly increasing and may be linked to further development and growth (Lewandowski & Faaij, 2006). in particular, rapid technological developments and growth in global economies.(Lewandowski & Faaij, 2006). The increase in the population is also playing its role in depleting from the energy resources. Not only that, but the future of the Earth's climate in the coming years has become alarming, (Maheshwari & Ramakumar, 2017) so that there are expectations that climate disasters, especially floods, are now threatening 2000 of the Indonesian islands with drowning, by the year 2030 AD. (Javed et al., 2020). This is due to global warming with the beginning of the formation of the El Nino phenomenon, which is a phenomenon that occurs in the Pacific Ocean every few years, ranging from three to seven years,(Kashian et al., 2006) and usually lasts from nine months to two years,(Guney & Onat, 2008) and the El Nino phenomenon causes global disturbances such as floods, droughts and other various disasters that Our planet is exposed to it due to the increase in the amount of greenhouse gases that increase the earth's temperature. (Leible & Kälber, 2005). We can learn about the size of the damage to the Earth's atmosphere due to carbon emissions due to the exhausts that our cars emit from fuel combustion, as a car that consumes a gallon of fuel for every 30 miles, the amount of carbon dioxide emitted is three times the amount of fuel used.(Lewandowski & Faaij, 2006). Let each of us imagine the number of cars in his country and then in the world, and how much carbon dioxide is expelled to the roof of the earth and concentrated in the atmosphere. Likewise, a 1,000-megawatt electric power plant releases carbon dioxide into the atmosphere, (Maheshwari & Ramakumar, 2017) equivalent to a million

cars emit of carbon dioxide. (Najam & Cleveland, 2005). How many power plants are there on earth? How much of the emissions are going to our atmosphere?

Population growth and technological advancements have helped energy consumption significantly and increasing in recent decades. (Lewandowski & Faaij, 2006). The International Energy Agency has projected that global demand for oil will grow by 5.4 million barrels per day in the year 2021 to reach 96.4 million barrels per day,(Oji et al., 2012) recovering about 60 % Of the volume lost due to the epidemic in 2020.It seems that the oil market is beginning to recover in small rates that did not reach what preceded Corona, but the price is fluctuating and demand is still low. The closure imposed on the world due to the measures taken to contain the epidemic outbreak of the Coronavirus helped the environment recover, (Ren, 2017) as carbon dioxide emissions decreased by 17%.(Keith, 2004).

Toxic emissions in the Middle East

The increase in pollutants for the environment in the countries of the Middle East is the main reason for the rise in various dangerous diseases in the societies of Arab countries,(Kartha & Larson, 2000). including the high level of air pollution, as Arab countries are among the largest global contributors to emissions of carbon monoxide and nitrogen oxides.(Keith, 2004) Arab countries are among the largest exporters of energy, led by the Kingdom of Saudi Arabia. (Larson & Kartha, 2000) There are also other reasons for these emissions, especially in poor Arab countries, such as the continued work of dilapidated vehicles, inefficient use of fuel, and poor control of exhaust emissions.(Lyons et al., 2001) Regulations that control air quality on roads are absent in most Arab countries. In Lebanon, for example, there is only control over carbon dioxide, while Kuwait's regulations are the most complete in the region, and there are no regulatory legislations in most countries(John & Tony, 2006). Air quality indicators in Arab countries often exceed the WHO guidelines by 5-10 times in some regions. This low quality is attributed to both natural and anthropogenic factors. (Gencoğlu, 2008) On the one hand, the ambient air quality is negatively affected by sea salt and dust particles, and on the other hand it is related to human activity.(John & Tony, 2006). The Middle East and Gulf countries are among the top 10 countries in the world in terms of per capita carbon dioxide emissions. (Kashian et al., 2006) To be clear, an individual in Kuwait, the UAE, or Oman produces emissions equal to the emissions produced by 10 individuals in Egypt, Tunisia or Morocco. (Kaur et al., 2017). The most severe contradiction in the region in terms of emissions is that an individual in Qatar produces emissions equal to the emissions produced by 73 individuals in Djibouti or Palestine. (Lewandowski & Faaij, 2006) The Kingdom of Saudi Arabia recorded the highest levels of sulfur dioxide emissions in the Middle East and North Africa region during 2019. followed by Kuwait, the United Arab Emirates, Iraq and Morocco respectively, and the UAE and Iraq witnessed a decrease in the level of emissions between 2018 and 2019. [14] The change in its annual rates, (Stojcetovic et al.) while the levels of emissions of this gas in Saudi Arabia and Kuwait did not record a significant change in the same period. As for Morocco,(Kashian et al., 2006) it recorded an increase in the levels of emissions of sulfur dioxide, by an average of 15%. The ranking of Arab countries in terms of global annual contribution to carbon dioxide emissions measured in metric tons, according to the European Union report issued in 2018. The Kingdom of Saudi Arabia came in the forefront of Arab countries with 1.72 percent globally, with about 638 thousand tons of carbon dioxide In the year(Lewandowski & Faaij, 2006), followed by Egypt, with a production of 258 thousand tons, with a percentage of 0.70 percent of the global production. (Naghiu et al., 2005)

Table (1)
the amount of polluting emissions to the environment produced from the Middle East countries

Worldwide ratio	Quantity is metric tons	Country	Arrangement
%1.72	638.762	Saudi	1
%0.70	258.668	Egypt	2
%0.55	202.802	UAE	3
%0.54	199.296	Iraq	4
%0.43	159.929	Algeria	5
%0.26	97.787	Qatar	6
%0.26	97.151	Kuwait	7
%0.21	78.421	Amman	8
%0.17	61.584	Morocco, West, sunset	9
%0.16	57.584	Libya	10
%0.10	35.775	the two seas	11
%0.09	31.630	Tunisia	12
%0.08	28.377	Syria	13
%0.07	24.565	Jordan	14
%0.06	23.102	Lebanon	15
%0.03	21.768	To whom	16
%0.02	21.056	Sudan	17
%0.01	2.962	Mauritania	18
%0.00	1.014	Djibouti	19
%0.00	0.927	Somalia	20
%0.00	0.206	Comoros	21

Table (1) shows the amount of polluting emissions to the environment produced from the Middle East countries, and Saudi Arabia was the most emitting country, followed by Egypt. In addition, the volume of domestic consumption of fossil energy in the Kingdom of Saudi Arabia can be determined as it is at the top of the list in emissions for the Middle East region(Larson & Kartha, 2000), as the results of the quantities used to produce fossil energy until 2017 amounted to 288,656,845 M / H megawatts per hour of electrical energy in addition to that(Lewandowski & Faaij, 2006) The amount of energy consumed in Saudi Arabia is 1562.28 million barrels(Otiman, 2008), according to statistics until 2018, (Naghiu et al., 2005) when it consists: natural gas is 45%, as is crude oil 30%, while diesel is only 15%, and heavy fuel oil 10%

Table (2):
Domestic Consumption of Refined Products, Crude Oil and Natural Gas

(Million barrels)

Product	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Liquefied petroleum gas	12.19	11.86	12.46	13.01	13.21	13.15	15.84	13.74	12.27	11.48	12.60	13.40	12.87	13.23
Premium gasoline	108.79	115.3	126.71	136.70	145.12	151.35	162.46	175.92	184.14	190.71	203.98	203.37	208.00	194.49
Jet fuel and Kerosene	20.5	20.4	21.09	22.63	22.24	23.25	23.90	24.76	25.56	27.28	31.37	32.05	36.14	37.88
Diesel	164.51	178.97	191.85	208.12	214.80	220.38	234.01	253.06	259.40	261.22	276.07	248.54	207.91	182.75
Fuel oil	86.28	93.2	101.26	105.93	76.09	77.50	88.26	91.50	107.47	125.86	140.43	166.07	180.29	173.96
Crude oil	58.79	60.79	69.06	80.46	159.63	192.75	190.73	193.50	176.94	202.36	209.42	182.41	167.37	149.74
Asphalt	15.76	17.89	18.78	22.77	21.68	22.77	20.54	19.96	20.94	28.59	29.12	19.14	20.36	20.73
Lubricating oil	1.99	1.6	1.58	1.85	1.83	1.89	1.76	1.60	1.59	1.92	1.68	1.48	1.34	1.51
Natural gas	336.33	345.88	349.05	381.35	380.79	405.19	437.21	484.62	496.44	504.09	506.07	557.44	573.78	581.36
Naphtha	--	--	--	--	--	--	--	--	--	--	--	1.811	11.187	8.923
REFORMATE	--	--	--	--	--	--	--	--	--	--	--	---	10.48	10.16
Sub-total	805.14	845.89	891.82	972.81	**1035.38**	**1108.22**	**1174.72**	**1258.65**	**1284.72**	**1353.51**	**1410.72**	**1425.72**	**1429.73**	**1374.72**
Liquefied petroleum gas	1.04	1.27	2.45	2.57	2.64	0.28	2.45	2.62	2.99	3.71	3.52	4.58	4.39	3.91
Fuel oil	9.36	8.3	8.00	8.05	7.18	4.27	6.10	4.90	4.84	14.67	5.20	6.12	6.61	6.98
Diesel	4.11	4.97	2.45	3.35	6.01	5.51	3.62	7.10	6.92	13.72	8.04	8.03	7.68	7.71

Fuel gas	19.07	19.44	18.29	25.11	12.10	20.23	20.16	18.81	20.29	20.56	31.80	34.33	34.40	33.98
Crude oil	0.23	0.2	0.33	0.30	0.34	0.14	0.10	0.09	0.07	0.10	0.05	0.04	0.01	0.00
Natural gas	80.56	77.02	90.92	96.32	85.46	116.59	113.49	113.36	98.97	108.89	121.28	106.02	121.48	127.31
Others	4.42	-0.78	4.43	2.21	2.14	3.68	0.77	3.06	3.15	2.01	5.60	5.46	5.64	7.66
Sub-total	118.79	110.42	126.87	137.89	115.86	150.71	146.70	149.94	137.24	163.65	175.48	164.58	180.21	187.56
Grand Total	923.93	956.32	1018.68	**1110.70**	**1151.25**	**1258.93**	**1321.41**	**1408.59**	**1421.97**	**1517.16**	**1586.20**	**1590.30**	**1609.94**	**1562.28**

Table (2) shows the domestic consumption of refined products, crude oils and natural gas in Saudi Arabia (Rosenqvist et al.)[49]Saudi Arabia's emissions are a source of concern in the event of failure to move to find alternative solutions, as it is expected to double in 2030 compared to 2014 levels, despite the increasing efforts to diversify energy sources away from dependence on oil. As the Saudi Vision 2030 contains alternative energy targets, (Oji et al., 2012) and is working to phase out fossil fuel subsidies. Saudi Arabia consumes a high amount of electricity and the demand for it is constantly increasing. Switching to alternative energy in household energy consumption will help to avoid huge amounts of harmful emissions, and this is the modern trend of Saudi Arabia, which we will explain later. (Kartha & Larson, 2000) We can explain the amount of electrical energy consumed through the following tables:

Table (3) :
ELECTRICITY CONSUMPTION OF THE KINGDOM BY TYPE OF CONSUMPTION.

(Megawatts/h)

Type of consumption	2010	2011	2012	2013	2014	2015	2016	2017	2018
Residential	**108627472**	**109261447**	**120466070**	**125678089**	**135907725**	**144040700**	**143212925**	**143054731**	**130041613**
Industrial	**38568706**	**42128709**	**41578629**	**51080064**	**51498586**	**45134213**	**46499379**	**47230778**	**51124592**
Governmental	**28525663**	**27527826**	**30348753**	**27383660**	**30010819**	**32795557**	**32719401**	**38420392**	**43050433**
Commercial	**28804641**	**32511031**	**39263946**	**39499621**	**42607597**	**47401581**	**48792853**	**48251809**	**47596447**
Agricultural	**3760936**	**3941851**	**4361931**	**4290278**	**4577353**	**5167533**	**5380610**	**5653346**	**4905383**
Others	**3975165**	**4290783**	**4268741**	**8755892**	**9900137**	**11497242**	**11087178**	**6045789**	**13103682**
The total for the region	**212262583**	**219661647**	**240288070**	**256687604**	**274502217**	**286036826**	**287692346**	**288656845**	**289822150**

Table (3) shows the amount of energy consumed in Saudi Arabia, divided by sector

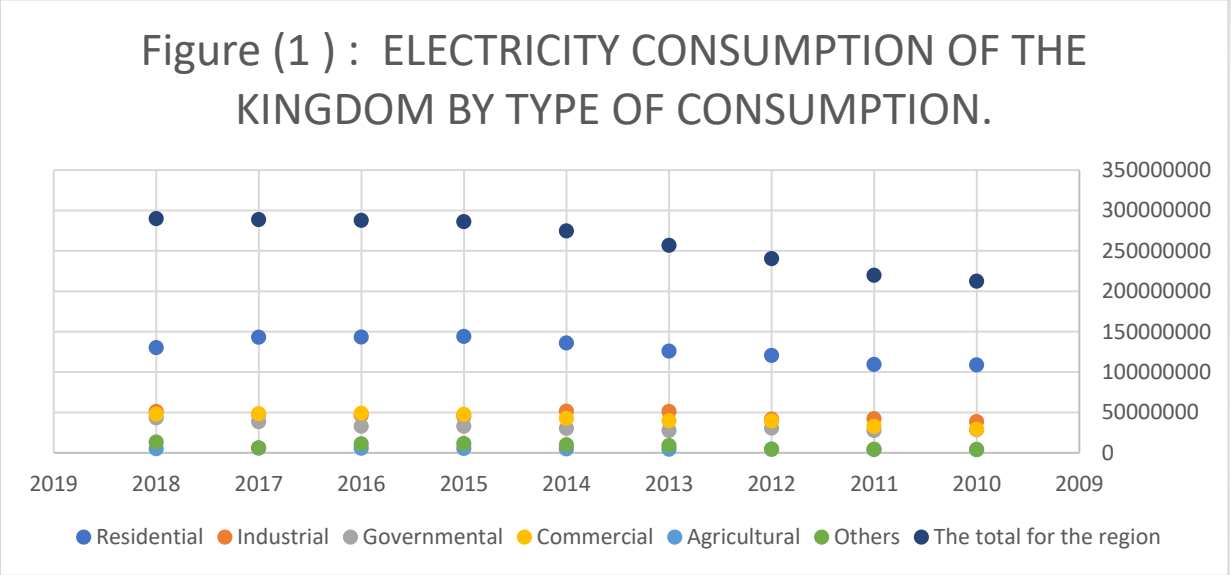

Figure (1) shows the amount of energy consumed in the Kingdom of Saudi Arabia divided by the sector for nine years

Global economic reasons helped transform the sustainable technology in alternative energy

Solar PV

The cost of generating electricity from solar PV and concentrated solar power decreased by 82% between 2010 and 2019.(Bagher et al., 2015) This is primarily due to a 90% drop in panel prices. (Sani et al.)These factors have contributed to reducing the installed costs of solar PV by about four-fifths over the past decade. (Lyons et al., 2001)
Onshore and offshore wind energy
The cost of generating electricity from onshore and offshore wind power has decreased by 29% to 55%,(Hand et al., 2012) respectively, over the past decade, recording $ 0.053 / kWh and $ 0.115 / kWh respectively in 2019.(Lyons et al., 2001) The lower prices of onshore wind turbines - ranging from 60% to 55% since 2010 - have contributed to reducing the costs of installing them, while the increase in the heights of the turbines' axes and their range of rotation have enhanced the capacity factors in conjunction with lower operating and maintenance costs. The costs of installing offshore wind energy technologies decreased by 18% between 2010-2019 with an improvement in the power factor by about one-fifth over the past decade from 37% in 2010 to 44% in 2019. Capacity, (Maheshwari & Ramakumar, 2017) and record cost savings across the growing areas of offshore wind power plants. The results of the auctions, including non-subsidized bids, herald the increasing competitiveness of offshore wind energy significantly in the coming years,(Kashian et al., 2006)with prices ranging between $ 0.05 - $ 0.10 / kWh.

Concentrated solar power

Current technological developments and supply chain competitiveness have contributed to reducing the combined costs of CSP. (Kaur et al., 2017) Power factors have also increased from 30% to 45% over the decade, due to the construction of concentrated solar power plants in the most exposed areas around the world.

Technology and cutting-edge technologies

Bioenergy, hydroelectric and geothermal energy

The weighted global average cost of electricity for hydropower projects increased from $ 0.037 /

kWh in 2010 to $ 0.047 / kWh in 2019. Nevertheless, (Sani et al.) hydropower has remained highly competitive, (Ren, 2017) with nine-tenths of the total capacity commissioned in 2019 recording a lower cost of power generation than the cheapest new projects running on fossil fuels. In 2019, power generation costs were about $ 0.073 / kWh of geothermal energy and about $ 0.066 / kWh of bioenergy. (Guney & Onat, 2008) This technology provides a stable source of electric power at prices equivalent to the minimum costs of generating power from fossil fuels.(Özyurt & Dönmez, 2005)

The Role of Technological Innovation in The Sustainable Development of Alternative Energy in The Kingdom of Saudi Arabia

The 22nd International Exhibition on Electricity, (Najam & Cleveland, 2005)Alternative Energy, Water Technology and Lighting revealed technologies and innovations in the alternative and non-alternative energy sectors. This comes at a time when the alternative energy market in the Kingdom is witnessing great growth with the trend towards increasing the capacity of electricity generation approved, including 40 gigawatts of solar photovoltaic energy and 16 1 gigawatts of wind and 3 gigawatts of concentrated solar power until 2030 The Kingdom of Saudi Arabia has a high potential for producing alternative energy, with an emphasis on solar energy because it is located in the middle of the "solar belt", along with wind energy, as the annual average speed of coastal winds is relatively high and much higher than usual for most countries. (Lewandowski & Faaij, 2006)The government's commitment to open the alternative energy sector is in line with one of the goals of Saudi Arabia's Vision 2030: (Sani et al.) which aims to achieve environmental sustainability. The Kingdom of Saudi Arabia is currently ranked sixth in terms of solar energy potential in the world, and thirteenth in terms of wind energy potential. In the use of sustainable technology in Alternative Energy. (Ren, 2017)

Solar energy

• The importance of solar energy comes from the fact that it is a tremendous energy that can be exploited anywhere and constitutes a free and inexhaustible source of fuel. (Stojcetovic et al.)Solar energy is produced through what is called photovoltaic cells or photovoltaic technology, and it is based on absorbing the sun's heat and making it electrical energy. Thus, energy is collected until it begins to be used as electrical energy, whether for domestic use or commercial uses, and for manufacturing as well. (Kashian et al., 2006) It has become commonplace to store it in large batteries to operate buildings and institutions, and it can be used in many fields in agricultural activity, heating and cooling water, desalination, sewage treatment, and generating electricity as well. The current solar energy technology has witnessed a remarkable development in recent years and competition has played a role. In reducing the installed costs of a different solar technology and alternative energy as a whole. The capacity factors also increased from 30% to 45% during successive periods, as a result of the successive demand for the use of alternative energy through the construction of solar power plants in the areas most exposed to solar radiation around the world. (Oyedepo, 2012) The technological development in solar energy is not only limited to the type and shape of solar panels, but also includes the types of manufactured material, and energy storage mechanisms.

In light of the importance of preserving the right of future generations to oil wealth and making the period of benefiting from this wealth long enough, (Liqun & Zhixin, 2009) and in light of the large increase in electricity consumption in the Kingdom, (John & Tony, 2006)and consequently the increasing costs resulting from the use of fuel in generating electricity and in light of the importance of reducing gas emissions, (Kashian et al., 2006)attention must be paid to developing Alternative energy sources in the Kingdom, the most important of which is solar energy. (Javed et al., 2020) Interest in solar energy in the Kingdom of Saudi Arabia has witnessed a continuous increase, and this has been reflected in many government initiatives, including the National Initiative for the Production of Water and Electricity Using Solar Energy under the auspices of the King Abdulaziz City for Science and Technology, the Solar Electric Power Production Project for King Abdullah University of Science and Technology, the Solar Village Project, and others. (Kartha, 2006)

The most important experiments in Saudi Arabia that will change the energy system can be mentioned: the photovoltaic station in the Al-Jouf region, the city of Sakaka, about 1000 km north

of the capital, Riyadh.
The alternative energy generation plant was also implemented with a production capacity of 400 megawatts, (Sani et al.) clean energy dependent on the sun 100% through one million panels distributed over a distance of 6 square km, and the cost reached one billion and two hundred million Saudi riyals. This project helps eliminate half a million tons of fossil energy emissions annually The Kingdom is launching 12 projects in the alternative energy sector, (Lewandowski & Faaij, 2006) with a total value of about $ 4 billion. Among them is the establishment of the Al-Faisaliah Solar Power Plant in Makkah Al-Mukarramah, with a capacity of 2,600 megawatts, which is the result of cooperation between the Makkah Region Development Authority,(Lyons et al., 2001) the Ministry of Energy and the Public Investment Fund.(Keith, 2004)
Saudi Arabia's production of clean energy is expected to reach 27 gigawatts by 2024; Of which 20 gigawatts are solar power and 7 gigawatts are wind power.(John & Tony, 2006)
The Kingdom is currently establishing a center for alternative energy capabilities with a capacity of 200 gigawatts over the next ten years, which depends on local manufacturing and project development internally and externally(Kaur et al., 2017). The Saudi Ministry of Municipal and Rural Affairs(Kartha, 2006) has previously stated that it seeks to gradually shift from relying on the electric grid to relying on solar energy to illuminate streets, parks, parks and billboards.(Lewandowski & Faaij, 2006)
Advantages of solar energy: This type of alternative energy is considered one of the easiest technologies to use compared to its counterparts from other alternative energy technologies such as wind.(Kaur et al., 2017)Solar energy is one of the environmentally safe sources of energy production and is considered environmentally friendly and does not cause any kind of pollution, especially on the air. The general trend towards it is due to its great role in protecting the environment . It is considered a permanent source of energy. No fuel is required to produce this energy, making it an inexpensive resource.(Otiman, 2008) It often doesn't take many moving parts to produce it.
Downsides of solar energy: The efficiency of solar cells is estimated at about 20% only. Moreover research, studies, and experiments in the field of developing cell technology are continuing as companies and institutions compete to find new innovations that help raise the value and value of their products. (Ren, 2017) The exorbitant value of batteries still represents a barrier, as they are the only source of energy storage, in addition to the fact that it is difficult to store energy without losing quantities of it. (Leible & Kälber, 2005)Energy was considered a high cost, but with the rapid technological developments and the increase in competition to reduce the cost, the cost today is much less than it was, but it is still a great cost in some countries. Solar energy is an unstable source due to the appearance of the sun, its absence, and various climate influences. (Kaur et al., 2017)

Wind Energy

The recognition of the use of wind energy began 3700 years ago. As for the modern use of electricity generation, (Leible & Kälber, 2005) it did not begin until the end of the seventies of the last century in Denmark, when he perceived the strength of the air current at higher altitudes than before. (Keith, 2004; Khan et al., 2021)Wind energy is energy produced through the air and depends on the force of wind to move the fins of the fans and thus generate energy through wind turbines to generate electrical energy, and it is called electromechanical energy. The Kingdom of Saudi Arabia has long offshore shores capable of producing more than 200 gigawatts of wind energy when utilized with an average capacity of 35.2 percent, and this is a higher rate than most countries that develop plans to produce electric power depending on the wind, and this includes the United States (33.9), [4] The United Kingdom (27.8 percent), Denmark (28.4 percent) and Germany (19 percent).
The Kingdom includes several regions whose winds can be used to generate electric power, (Liqun & Zhixin, 2009)including the regions of Aqaba, Jahid, Taif, and Yadma. It has high wind speeds and promising energy capabilities that allow building high-efficiency projects to generate energy from wind.
Saudi experiences in sustainable technology to generate alternative energy:

Domat Al-Jandal is the name of the region, (Møller et al., 2006) and it is the same as the project for generating alternative energy by wind, as the project is considered the largest of its kind with a production capacity of 400 megawatts through 99 turbines and this project helps to get rid of

one million tons of emissions produced by fossil energy annually
• The advantages of wind energy: Preserves the environment, as it reduces carbon dioxide. Wind energy is free of all pollutants. (Otiman, 2008)It is also inexpensive as it is possible to establish an air farm containing large towers in a very short period of time. Not affected by rising fossil fuel prices. It does not need drilling to be extracted, not even for the generating stations.(Keith, 2004) Its low cost despite the high fuel prices. (Lewandowski & Faaij, 2006) It is considered renewable energy because it is infinite energy.
• Downsides of wind power: This energy cannot supply the transport sector, which leads to the transport sector's dependence only on oil products. Although it is a renewable energy, it is seasonal and sometimes the wind speed does not match the electric power.(Kartha, 2006)The visual effect of turbine rotation and the noise emitted by it may disturb the people living near wind fields, and to reduce these effects, it is preferable to establish wind fields in areas far from residential areas.(Larson & Kartha, 2000) Selecting the appropriate site to set up the turbine. The environmental impact of turbine construction and operation. The giant turbines sometimes kill some birds, especially during their migration period. (Naghiu et al., 2005).

The Returns To Technological Innovation In The Sustainable Development Of Alternative Energy To The Kingdom Of Saudi Arabia

The International Energy Agency(Stojcetovic et al.) recently released data showing a decline in levels of carbon dioxide emissions in the Kingdom of Saudi Arabia in 2018, at a rate of 2.7%. This is critical because it is the first major decline in carbon dioxide emissions levels resulting from public policy in the Kingdom of Saudi Arabia, (Otiman, 2008) and this decrease also highlights how Saudi Vision 2030 economic transformation plans help to decouple the link between economic growth and carbon dioxide emissions. The Kingdom of Saudi Arabia is now the fourth fastest country among the G20 countries to reduce greenhouse gas emissions.(Larson & Kartha, 2000).
Positive impacts can also be felt throughout the value chain; (Javed et al., 2020) Where alternative energy contributes to stimulating national economies as well as providing new job opportunities,] as five industrial clusters have been identified that focus on solar energy, medicines, biotechnology, auto industry, (Grigoriu, 2009) minerals, as well as plastic and packaging industries, the program has so far contributed to 48 industrial projects with an investment value of 76 billion Saudi riyals, creating 36,000 direct jobs, taking into account two potential industrial combinations. Alternative energy also helps provide electricity in many communities that are not connected to the official distribution networks. (Kashian et al., 2006)

Conclusion:

Although the Kingdom of Saudi Arabia is one of the world's largest countries in the export of oil and fossil energy products in all its forms, the various changes in the world that have affected the demand for oil in addition to the global trends of alternative energy. All this led to a reconsideration of the ideas and perceptions of the leadership in the Kingdom of Saudi Arabia in terms of the diversity of sources of income and the start of investment thinking in sustainable technology for the development of alternative energy, as mega projects appeared on the ground that are distinctive in the world that depend on modern technology to produce alternative energy through the sun And the wind and various other experiences. These giant projects in the field of alternative energy confirm the serious trends of the Kingdom of Saudi Arabia's pursuit of exporting clean energy, which reflects the achievement of the objectives of the Kingdom of Saudi Arabia in several aspects, whether as a strong economic return in line with market trends as well as protecting the general environment. Saudi Arabia may also need 400 projects similar to the capacity of the Sakaka and Domat Al-Jandal projects combined, in order to eliminate 600 million tons of annual emissions of fossil energy, and it also needs innovative projects to eliminate transport emissions. The Kingdom of Saudi Arabia is on the right path to achieving a zero-emissions future. The first project of its kind was revealed, which is the establishment of a city called Neom, which is considered 100% natural and has an estimated budget of $ 500 billion. This city will include knowledge societies enhanced by artificial intelligence over a length of 170 km within an environment free of noise or pollution, free of vehicles and congestion, and a direct response to the challenges of urbanization that impede the progress of humanity such as dilapidated infrastructure, environmental pollution, urban and population sprawl.

Acknowledgement

(The authors extend their appreciation to the Deanship of Scientific Research at King Faisal University for funding this research work through the project number No.206092)

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