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A brief assessment of renewable energy policies & initiatives in the Middle East, including Egypt

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Summary

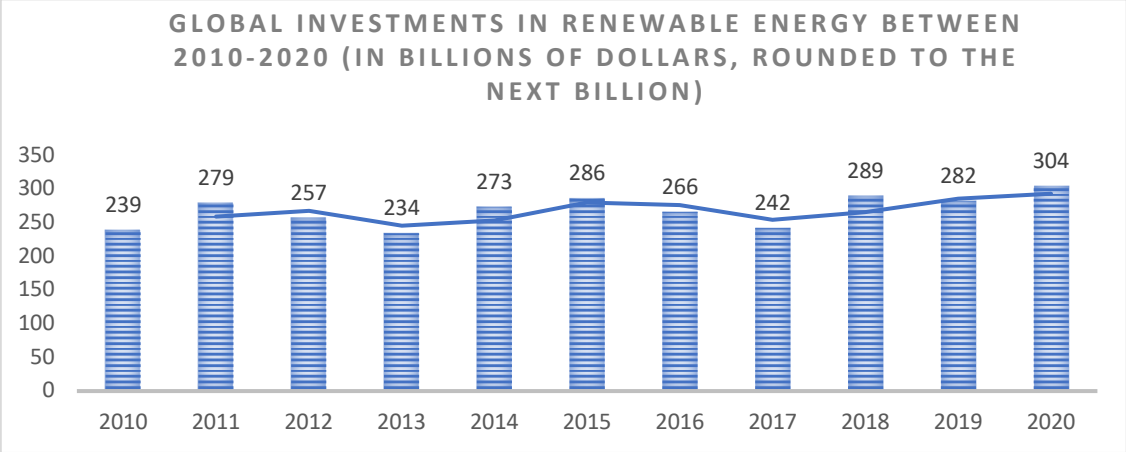
This paper assesses the strategies and policies associated with the development of the renewable energy sector globally as well as in the countries of the Middle East. It begins with looking at trends of the global investments in the sector between 2010-2050 as well as the development of renewable energy capacities in the world. It proceeds into considering the existing policy frameworks and strategies related to the renewable energy sector in the Middle East. The evidence provided in this paper confirms the long-term commitment of the states in the Middle East to develop the renewable energy sector. Furthermore, the paper concludes that the renewable energy sector is expected to undergo a substantial growth in the next 3 decades. By 2050, renewables could potentially dominate the generation of electricity replacing coal. The investments in renewables are set to increase in the future. Based on the evidence considered, the paper also concludes that solar energy and wind energy are going to dominate the energy mix by 2050 both globally and in the Middle East. The paper also considers potential challenges posed by a lack of large-scale battery capacity, intermittency, cybersecurity, that is likely to be mitigated in the future with the development of technology.

Global trends in the renewable energy sector

The International Energy Agency (IEA) defines renewable energy (hereafter also referred to as "RE" or "renewables") as *"energy derived from natural processes that are replenished at a faster rate than they are consumed"*. The importance of the RE sector was exacerbated by the Paris Agreement of 2015, which was signed by 190 states.[1] Under this Agreement, these governments solidified their commitment to introduce policies and practices which would mitigate the impact of climate change. RE became an integral part of these practices.

Since the Paris Agreement, renewables have experienced a steady growth. In 2019, the sector recorded its largest ever increase in installed capacity, with more than 200 GW added, outpacing installations in fossil fuels and nuclear power combined.[2] In one of the reports, the International Renewable Energy Agency (IRENA) stated that if the targets of the Paris Agreements were met, 85% of global power generation would come from renewable sources.[3] At present, both governments and international corporations around the world are engaged in a wide range of activities to develop the renewable energy capacity and its usage. Even ~~the~~ leading oil companies such as British Petroleum and Shell have launched initiatives to expand the global capacity of RE.

In the past 10 years, investments in the RE sector have remained relatively stable.[4] In 2020, despite the economic instability caused by the outbreak of the COVID-19 pandemic, renewables attracted $303.5bn which constituted a 2% increase in comparison to the value of investments raised in 2019.[5] In fact, this is the largest volume of investments raised by the sector so far.



[1] United Nations Framework Convention on Climate Change, "Paris Agreement – Status of Ratification"
[2] International Renewable Energy Agency, 2019, "Renewable Energy Statistics 2019"
[3] Ibid.
[4] World Bank Group, 2019, "Global Trends in Renewable Energy Investment 2019"
[5] Bloomberg NEF, 2020, "Energy Transition Investment Trends"

Some experts argue that the pandemic was a pivotal factor in strengthening the RE sector. With a decrease in demand for fossil fuels, there has been a surge in the usage of renewable sources. For instance, the USA increased its renewable energy consumption by 40% in 2020.[6] Furthermore, the oil price crisis in April 2020 was perceived by some as an indication that renewable energy sources are, in fact, more stable and resilient than oil and gas.

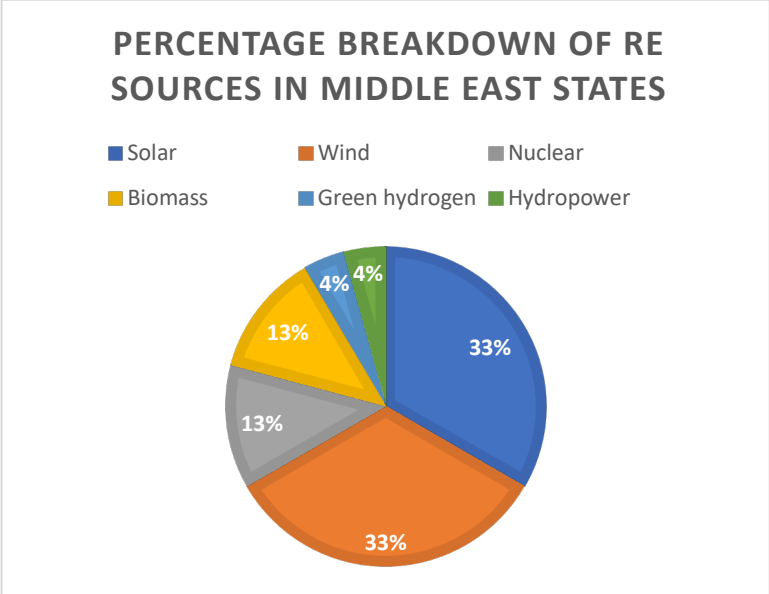
However, it would not be accurate to state that the pandemic has not damaged the renewable energy sector at all. Social distancing and self-isolation policies, coupled with economic pressure on governments caused delay or cancellation of some RE projects. Out of the existing renewables, biofuels have been impacted the most. Border closures and travel restrictions led to a decline in demand for fuel. Declining oil prices, coupled with the disruptions in supply and decline of the transportation sector put further pressure on biofuel producer margins.

The pandemic has also shifted the attention of governments and investors to other sectors such as public healthcare and pharmaceuticals. In one of his statements, the Secretary-General of the UN, António Guterres, highlighted the importance of supporting the development of the renewable energy sector through the introduction of stimulus packages and policies which would mitigate the damage caused by the pandemic.[7]

Despite the impact of the pandemic, the renewable energy sector is projected to expand further in the next 2-3 decades. For example, renewables are forecast to replace coal as the largest source of global electricity generation by 2050. Wind and solar energy are expected to dominate the energy mix. Renewable energy generation costs are forecast to decline in the next 2 decades.[8] This can potentially make solar and wind energy more attractive to the investors than fossil fuels. After wind and solar energy, hydrogen is expected to become the third most influential source of renewable energy. It is estimated that hydrogen will provide about 25% of global energy supply by 2050.[9] However, it is important to take into consideration the economic decline caused by the COVID-19 pandemic. While mass vaccinations are expected to foster economic recovery, new waves of the pandemic and further restrictions could potentially hinder the rate at which the global economy recovers. Consequently, a slower recovery would negatively impact the expansion of the renewable energy capacity. Furthermore, the aforementioned predictions cannot be considered as a blue print for all sectors of economy. Some sectors such as transport and aviation are heavily dependent on fossil fuels and their transition to the renewables could take longer hindering the implementation of the aforementioned targets for 2050.

[6] World Economic Forum, 2020, "COVID-19 is a game-changer for renewable energy. Here's why"
[7] Guterres, A., 2020, "Invest COVID-19 Stimulus Fund in Green Growth"
[8] BloombergNEF, 2020, "New Energy Outlook"
[9] Ibid.

Renewable Energy in the Middle East



Sammak et al. (2020) argue that the Middle East is one of the most interesting cases in terms of the development of RE given the region's climate conditions and dominant position in the oil market (around 56% of world's oil reserves are in the Middle East).[10] Despite the fact that the Middle Eastern states are considered to be "oil-dependent" nations, many of them are actively engaging in the development of renewable energy policies. This stems from their desire to diversify their economies.

There are five main types of renewable energy which can be found in the Middle East: solar, wind, biomass, hydropower and nuclear.

- Solar energy, generated from the sun's radiation through solar thermal systems, solar thermal power plants and photovoltaic (PV) systems.
- Wind energy, derived from the wind's kinetic energy and collected by wind turbines.
- Biomass energy, produced from unfossilised plant materials such as wood and biogas.
- Hydropower energy, electricity which is generated from flowing water.
- Green hydrogen, another source of RE is being considered by the countries of the Middle East uses electrolysis to split water and separate the hydrogen and oxygen atoms.

This paper will also consider states' policies dedicated to nuclear energy. In contrast to the aforementioned types of energy, nuclear energy is often defined as "sustainable" rather than "renewable". The difference lies in the characteristics of the sources of energy. While nuclear energy does not necessarily replenish itself, the global storage of uranium suggests that nuclear can meet the world's energy needs for a long period of time.[11] Generation of the nuclear energy does not produce CO2 emissions which places it at the centre of the states' energy strategies.

[10] Sammak, et al., 2020, "A Review of Renewable Energy in the Middle East"
[11] Conca, J., 2016, "Is Nuclear Power A Renewable Or A Sustainable Energy Source?"

It should be noted that this paper considers exclusively the abovementioned 6 types of energy. In geographical scope, 8 states will be considered for the analysis: Bahrain, Egypt, Israel, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates.

While there are multiple ways in which states' renewable energy capacity can be measured, this paper assesses governments' policies and ability of renewables to meet local energy demand in each state.

United Arab Emirates (UAE)

In the past 10 years, the UAE has expanded its energy portfolio by more than 400%. The UAE introduced Energy Strategy 2050 in January 2017 to increase the state's engagement in the RE sector.[12] The Strategy aims to increase the contribution of clean energy in the country's energy profile from 25% to 50%.[13] Hence, by 2050, energy demands of the population will be met by a hybrid system of fossil fuels and renewables. The policies are also designed to reduce the carbon footprint of power generation by 70% by 2050.[14] By this date, the Emirates plan to achieve the following energy profile: 44% clean energy; 38% gas; 12% clean coal; 6 % nuclear energy.[15], the Government has allocated $163 billion to the Energy Strategy 2050.[16]

Nuclear energy generation is not common in the Middle East in proportion to other sources, such as solar energy. However, in 2020, the UAE became the first Arab country to launch its own nuclear energy programme "Barakah unit 1", which has recently reached its full power capacity.[17] It is calculated that the plant will provide 25% of the UAE's Electricity.[18] While the Emirates has given assurance that the power plant will be used strictly for civil purposes, experts are concerned that it is causing rising tensions in the region. One of the concerns is that the reactors are vulnerable to cyberattacks. Cybersecurity of the government's energy infrastructures is particularly important after the Shamoon attack on Saudi Arabia and Qatar. The Stuxnet attack, which was conducted against the Iranian uranium facilities also evidences the vulnerability of the energy infrastructure against cyber threats.[19]

From the perspective of geopolitics, experts are concerned that the construction of the reactor will cause a nuclear race amongst the states in the region. Saudi Arabia has already begun the construction of its own nuclear plant and Qatar has put forward objections against the UAE's plant pointing to potential security threats.[20] This further solidifies the experts' view that the UAE's nuclear energy strategy can potentially destabilise the region.

[12] Thomson Reuters, 2020, "UAE to double renewable energy portfolio in next ten years: ADNOC",
[13] The United Arab Emirates Government Portal, "UAE Energy Strategy 2050"
[14] Ibid.
[15] Ibid.
[16] The United Arab Emirates Government Portal, "UAE Energy Strategy 2050"
[17] World Nuclear Association, 2020, "Nuclear Power in the United Arab Emirates"
[18] Emirates News Agency, 2020, "Barakah Unit 1 reaches 100% as it steps closer to commercial operations, due to begin in early 2021"
[19] Thomson Reuters, 2019, "Iran builds firewall against Stuxnet computer virus: minister"
[20] Thomson Reuters, 2019, "Exclusive: Qatar asks IAEA to intervene over 'threat' posed by UAE nuclear plant"

Israel

The Israeli Ministry of Energy plans to integrate renewable energy into the country's energy profile by developing solar, wind and biomass technologies. In autumn 2020, the Minister of Energy Yuval Steinitz announced that the government plans to meet 30% of the government's electricity consumption through solar energy by 2030.[21] According to the report by the Organisation for Economic Co-operation and Development (OECD), current electricity generation in Israel is heavily depended on fossil fuels and coal.

The government's plan originally dedicated $24bn of investments to the renewable energy sector.[22] In addition, the government initiated a partnership with the US Department of Energy under which $7.15 million have been allocated to renewable energy projects.[23] Given Israel's climate conditions, the prime focus of the government remains on the solar energy. To this end, the government plans to establish two thermo-solar power stations at Ashalim in the Negev.

In terms of the wind energy, Israel's Galilee Region and the Golan Heights present a significant potential. From 2016, the wind farms in Ma'ale Gilboa and Ramat Sirin became operable. Biomass is another source of RE which was integrated into the government's plans. As part of the government's strategy, the facility in Gush Dan was designed to generate biomass energy.

Consequently, through the development of solar, wind and biomass energy, the government plans to increase the share of renewables in the country's energy profile to meet local energy demands.

[21] Bloomberg, 2020, "Renewable Energy Push Boosts Bets on Wind, Solar In Israel"
[22] State of Israel Ministry of Energy, 2018, "Renewable Energies"
[23] State of Israel Ministry of Energy, 2018, "Energy Economy Objectives for the Year 2030"
[24] US Department of Energy, 2020, "Department of Energy Announces Eight New Projects Through BIRD Energy Partnership with Israel"

Saudi Arabia

The government of Saudi Arabia is planning to invest more than $30 billion in the Kingdom's renewable energy sector by 2025.[24] Saudi Arabia plans to generate 50% of its electricity from renewable sources by 2030.[25] According to the Saudi Arabia's Renewable Energy Programme, 70% of power will come from gas and 30% will be derived from the renewable sources of energy.[26] Given the climatic environment in the Kingdom, the government plans to focus principally on solar and wind energy.

Beyond this, the Saudi National Atomic Project (SNAEP) is designed to develop nuclear energy capacities energy.[27] There are 4 components of the Project:

(1) Large nuclear power plant
(2) Small Module Reactor
(3) Nuclear fuel cycle
(4) Regulator

The Saudi government is currently planning to construct 2 nuclear power reactors (the construction of one has been completed in 2019) to increase the nuclear power generation, which ultimately would make up 20% of the Kingdom's energy profile.[28] The development of nuclear energy capacities by both the UAE and Saudi Arabia can potentially cause instability in the region.

Green hydrogen is another important source of RE in Saudi Arabia. To generate green hydrogen, Saudi Arabia is planning to invest $5 billion into a plant which will be located near the Kingdom's borders with Egypt and Jordan.[29] Hence, Saudi Arabia plans to integrate solar, wind and nuclear energy to facilitate state's local energy supply.

[22] S&P Global, "Saudi Arabia expects more than $20bn investment in renewables over a decade"
[23] Ibid.
[24] Ibid.
[25] Ibid.
[26] Bloomberg, 2020, "Saudi Arabia news: Oils Giant Aims Next to Be Largest hydrogen exporter"
[27] Sustainable Energy Unit Kingdom of Bahrain, 2016, "National Renewable Energy Action Plan (NREAP)

Bahrain

In 2017, the Kingdom of Bahrain finalised the first National Renewable Energy Action Plan which highlighted the need to optimize the gas resources, reduce greenhouse emission and improve overall energy security of the country. In accordance with the Plan, Bahrain aims to increase the share of renewable energy in the country's energy profile to 5% by 2025 and 10% by 2035.[30] Consequently, the remaining 90% of energy is expected to be supplied to the population through fossil fuels.

Similarly, to other Middle Eastern countries, Bahrain places strong emphasis on solar energy. In fact, Bahrain has one of the highest levels of the sun radiation in the world, which greatly benefits the country's renewable strategies. In 2014, the Kingdom completed the construction of the first solar power plant that is estimated to deliver in excess of 8000 MWh of energy per year.

[28] REVE, 2018, "Bahrain to set up 5MW solar, wind energy plant"

Egypt

Alongside its neighbouring countries in the Middle East, Egypt focuses its effort on solar and wind energy. In 2012, the Government approved the Egyptian Solar Plan which aimed at adding 3.5 GW of solar energy by 2027.[31] To achieve this target, the government constructed the Benban Solar Park - the largest solar park in Africa, which will potentially reduce their carbon emissions by 900,000 tonnes a year.[32] The Park was constructed with the support of the European Bank for Reconstruction and Development (EBRD). The Bank approved a $500m framework to support the government in implementing this project.[33] Egypt is also constructing a wind power plant to be located in the Gulf of Suez. Overall, Egypt plans to increase its usage of wind and solar energy from 2% to 20% by 2022.[34] By 2035, wind and solar energy should provide 35% of the country's energy profile.[35]

Hydropower is Egypt's third-largest energy source, which accounts for around 7.2% of Egypt's total power generation. The central hydropower source in Egypt is the River Nile. However, the ongoing dispute between Egypt and Ethiopia over the $4.5 billion Grand Ethiopian Renaissance Dam can place certain obstacles upon Egypt's hydropower projects and strategy.[36] Egyptians justify its claim on the Dam based on the agreement with Sudan signed in 1959 and claim that filling of the Dam poses threat on Egypt.[37] Despite the ongoing tensions, Ethiopia plans to proceed with the phases of filling the Dam later this year in order to meet the country's energy demands.[38]

The Egyptian Nuclear Power Plants Authority (NAPPA) confirmed that a construction of its first nuclear power plant is expected to commence in the second half of 2021.[39] The plant will be constructed by the Russian Rosatom State Atomic Energy Corporation at a cost of more than $25bn loaned to Egypt by the Russian government.[40] Consequently, through the development of solar, wind and nuclear energy, the government plans to enhance the share of renewables in the country's energy profile to meet local demand.

[31] EBRD, 2019, "First EBRD funded Egyptian solar plant begins generation"
[32] International Renewable Energy Agency, 2018, "Renewable Energy Outlook. Egypt"
[33] Ibid.
[34] Wheeler, K., et al., 2020, "Understanding and managing new risks on the Nile with the Grand Ethiopian Renaissance Dam"
[35] Ibid.
[36] Aljazeera, 2020, "Sudan minister warns Ethiopia against filling dam without deal"
[37] Nuclear Power Plants Authority (NPPA), 2018, "Egyptian nuclear power plans discussed"; Thomson Reuters, 2016 "Russia to lend Egypt $25bn to build nuclear power plant"
[38] Ibid.
[39] Ibid.
[40] Ibid.

Oman

Oman plans to dedicate 10% of its overall energy profile to renewables by 2025, increasing it to 30% by 2030.[41] Oman mainly focuses on solar and onshore wind energy. In 2020, the Sultanate's first utility-scale solar power plant has become operable. The plant cost the government around $94m to build.[42]

The Government also completed construction of the Dhofar wind farm in 2019.[43] The project was implemented by the Abu Dhabi Future Energy Company. The farm is capable of generating electricity to supply around 16,000 households.[44]

Oman's Mazoon Dairy Company (MDC) opened a biogas plant on one of its farms in 2019. The World Biogas Association referred to the plant as "the first of its kind in the region" [45]. The plant will reduce dependency of farms on fossil fuels and switch to more sustainable sources of energy.

[41] International Trade Administration, "Oman-Country Commercial Guide"
[42] Ibid.
[43] Masdar, "Dhofar Wind Project"
[44] Ibid.
[45] Bioenergy Insight, 2019, "Oman launches first dairy waste-to-energy biogas project"

Kuwait

Kuwait has pledged to generate 15% of the country's energy profile from the renewable sources.[46] To reach this target, the government is planning to invest $100bn in renewable energy projects to facilitate local energy supply.[47]

Kuwait possesses wind and solar potential through its climate and natural resources. Hence, the Government has concentrated on construction of wind and solar plants. However, the outbreak of the COVID-19 pandemic disrupted the government's plan to build the Al-Dabdaba solar plant leading to suspension of construction.[48] This could potentially threaten the Government's targets for 2035.

The Shagaya Renewable Energy Project includes a Concentrated Solar Power Plant and two Wind Farms. The project is expected to develop a capacity of 2000 MW installed renewable energy.[49] The project was launched in 2012 by the Kuwait Institute for Scientific Research (KISR).[50] The Concentrated Solar Power plant has a capacity of 50 MW and it is expected reduce the CO2 emissions by 18,000 tons.[51]

[46] Oxford Business Group, "Kuwait turns to solar energy to further renewable goals and harness low-cost power"
[47] Ibid.
[48] Thomson Reuters, 2020, "Kuwait cancels Al-Dabdaba solar plant project due to coronavirus"
[49] Kuwait Authority for Partnership Projects, "Shagaya-Renewable Energy Park"
[50] Ibid.
[51] Ibid.

Qatar

Qatar's National Vision 2030 aims to diversify the country's energy profile by integrating renewable energy in it and ensuring that 20% of the overall profile consists of renewable sources.

Similarly, to other states in the region, Qatar concentrates its effort on the solar energy. In January 2020, Qatar signed an agreement with French *Total* and Japanese *Marubeni* to build solar power plants with a capacity of 800 megawatts.[52]

In contrast to other states in the region, Qatar's renewable energy strategies appear to be less extensive. This can be explained by the state's significant natural gas resources which can potentially meet the energy demands of the population in the event of a decline of fossil fuels.

[52] Total, 2020, "Total to develop Qatar's First large-scale (800 MWP) Solar Plant

Potential challenges

Geopolitics

Energy sources and policies can cause geopolitical tensions in the region. One of the most notable examples is the Grand Ethiopian Renaissance Dam (GERD) dispute between Egypt, Sudan (the downstream states of Nile) and Ethiopia (the upstream state). The dam is a $4bn initiative with a hydropower capacity of 6,450 MW. The project commenced in 2011 and it is a subject of high importance for energy strategies of each party involved. In 1959, Egypt and Sudan signed an agreement which allocated the waters of Nile mainly to the signatories of the agreement leaving out Ethiopia.[53] In 2019, Ethiopia announced that it is going to fill the reservoir behind the dam in 2020 which faced opposition from Egypt and Sudan. The latter parties refer to the Treaty of 1959 in their claims over Nile waters and potential economic damage which the filling of the dam can cause. The tensions have been further intensified after intervention of third parties, such as India, China and Gulf states. Despite the efforts made by the UN and African Union, the parties have not yet reached an agreement.

Growth of renewables can fundamentally shift the global balance of power reshaping the geopolitical landscape. Criekemans compares the development of the renewable energy sector to the industrial revolutions.[54] He argues that in the long run, countries with significant renewable energy capacities would have greater influence than those with substantial oil and gas resources creating a shift in the global geopolitical balance.[55] Countries with inferior technology and limited capacity to develop the RE will be dominated by the richer states with greater RE capacities. However, other scholars argue that global usage of renewable energy would actually introduce greater symmetry in the geopolitical balance. Countries will no longer rely on natural resources of oil and gas but rather gain greater independence in generating energy to meet the population's demands.[56]

Cyber attacks

Some experts and scholars warn about the cyber vulnerabilities of the renewable energy infrastructure. This challenge is not pertained exclusively to the Middle Eastern region or the renewable energy sector. The energy sector, in general, is vulnerable to cyber warfare and offensive operations which can cause a significant damage to the country's economy and security. One of the most notable attacks on the energy structures was a cyber attack on the Ukrainian power grid in 2015, which left more than 200 thousand people without electricity.[57] Between 2012 and 2016 the Shamoon cyber-attack targeted Saudi Arabia's and Qatar's

[53] Abdulrahman, S.A., "The River Nile and Ethiopia's Grand Renaissance Dam: challenges to Egypt's security approach", p.143
[54] Criekemans, D., "Geopolitics of the Renewable Energy Game and Its Potential Impact upon Global Power Relations", p.47 in Sholten, D., *The Geopolitics of Renewables*
[55] Ibid.
[56] Scholten, et al. "The geopolitics of renewables: New board, new game"
[57] BBC, "Ukraine power cut 'was cyber-attack'"

national oil companies.[58] The Shamoon attack forced the targeted companies to temporarily shut down their operations causing significant damage.

These attacks prove the need to strengthen the cyber resilience of the RE sector. Most of renewable energy facilities are geographically dispersed and not necessarily supervised by an operator. For instance, modern wind turbines are managed by industrial control systems, which can easily become a target of cyber attacks.[59] Usage of remote monitoring systems was further exacerbated by the COVID-19 pandemic, which highlights the need for robust cybersecurity mechanisms that would protect renewable energy infrastructures.

Intermittency

Intermittency is often defined as one of the main challenges which undermine the effectiveness of the RE sources. The production of both solar and wind energy is heavily depended on the climate and weather conditions resulting in fluctuating or 'cyclonic' generation of energy.[60] Consequently, its effectiveness in contrast to oil and gas can by undermined by the fluctuating generation of energy.

Intermittency raises the questions about the capacity of renewables to replace oil and gas. Intermittency negatively impacts the percentage of variable renewable energy (VRE) - RE which is available only at specific periods of time.[61] For instance, solar and wind energy can be generated under certain weather conditions, whether the extraction of oil and gas is not impacted by these factors. Some findings suggest that for some sectors, such as transport, the renewables will not replace fossil fuels at least till 2100.[62]

The lack of "constant" availability of RE increases both the price of RE itself as well as the costs associated with its generation.[63] However, a report by IRENA suggests that the costs for renewable energy has been steadily declining since 2010.[64] With the advancement of technology, the costs for renewables are expected to decline further making them a cost-effective investment.

There is a wide range of possible solutions to tackle these challenges. For instance, governments can design policies and projects which suggest a "mixture" of energy sources, including fossil fuels. This scenario can already be found in the policies of the Middle Eastern states which were considered in this brief. None of the aforementioned states are planning to eliminate fossil fuels completely in the next 20 years. There are also other solutions such as storage of energy, regulation of demand as well as other engineering solutions.

[58] European Union Agency for Cybersecurity, 2019, "Shamoon Campaigns with Disttrack"
[59] Accenture, "Building Greater Cyber Resilience in Renewables"
[60] Grams, M. et al., 2017, Balancing Europe's wind-power output through spatial deployment informed by weather regimes. *Nature Climate Change, 7*(8), 557-8
[61] Ritchie, E.J., "The Cost of Wind and Solar Intermittency", Forbes, 2017
[62] Shell, "Could Renewable Energy completely replace Fossil Fuels?"
[63] Ibid.
[64] IRENA, "How falling costs make renewables a cost-effective investment"

Storage

Currently lithium-ion batteries are most widely used for the storage of renewable energy. The battery technology can mitigate certain challenges such as intermittency. Storage of the generated energy and ability to utilise it when needed provides renewables with a strong advantage. Conversely, existing battery technology is not powerful enough to store energy for a long period of time and in large volumes which significantly undermines the potential of renewable energy.

According to a report by IRENA, technology to expand the storage capacity of lithium-ion batteries is improving continuously. The batteries' storage can potentially increase by 50% by 2030.[65] While there are other technologies such as pumped hydro, compressed air or stacked concrete blocks, global investments are still mainly centred within the lithium-ion batteries.[66] This suggests an increase in production of these batteries, particularly taking into account the falling costs of installation.

The role of technology

Technology plays a central role in the development of the renewables and energy sector in general. Artificial Intelligence (AI) can be considered as one of the central elements for the development of renewable energy capacity. A report by McKinsey & Company estimated that AI can potentially generate $3,5 to $5,8 trillion within the global energy industry.[67] In terms of the Middle Eastern economy, AI has a potential to generate $320 billion by 2030 across multiple sectors.[68] The countries in the region are already actively engaging with AI technology. For instance, the UAE has been actively developing its research facilities through the establishment of the academic institution dedicated primarily to AI.

One of the main benefits of AI is the ability of the algorithm to forecast the weather conditions through the analysis of past weather patterns. The algorithm can also be used to regulate the storage and distribution of the generated energy. Given that solar and wind energy hold the largest volumes of investments in the region, this report will look at the application of technology in the wind and solar grids. DeepMind, a Google-owned AI start-up, used AI technology in windfarms in the US to measure the impact of technology on the generation of wind energy.[69] The technology was used to deliver predictions and calculations of the weather patterns and consequent generation of the wind energy. The algorithm was used in the farms with a capacity of 700 megawatts in the central United States. The algorithm successfully predicted the wind power output 36 hours prior to the actual generation.[70] Based on these

[65] IRENA. "Electricity storage and renewables: Costs and markets to 2030"
[66] Ernst & Young, "Why battery storage must be at the heart of the low-carbon transition"
[67] Arab News "How artificial intelligence can revolutionize the Middle East energy sector"
[68] PwC, "The potential impact of Artificial Intelligence in the Middle East"
[69] DeepMind, "Machine learning can boost the value of wind energy"
[70] Ibid.

predictions, the technology advises on how to deliver the energy to the power grids (electricity grids, for example). The deliveries could, therefore be scheduled on hourly bases which increased the value of wind energy by 20%.[71]

Through calculation and forecasting, the algorithm can also help to regulate the functioning of the wind turbines. For example, based on the prediction of the weather conditions, the algorithm can rotate the turbines to maximize the volume of the energy generated. AI can also regulate the generation of energy from the demand side. For instance, the algorithm can distribute and store energy based on the meteorological and demand data.[72] Consequently, this can encourage smarter usage of energy. These features can also help the companies and governments to overcome the issue of intermittency.

AI can also be beneficial for the generation of solar energy. Raycatch, an Israeli-based start-up, uses AI algorithms to atomise and optimise the generation of solar energy.[73] The algorithms can provide an overview of the panels' performance which can improve the generation and storage of energy. According to research conducted by Raycatch, such diagnostics can increase the revenue by 2-7% as well as reduce maintenance costs by 10-20%.[74] Similar to the algorithms used for the wind turbines, AI technology can calculate the weather patterns based on past data. The US Department of Energy's SunShot Initiative employed AI technology on their solar panels which improved forecasting by 30%. This enhanced the generation and storage of solar energy.[75] The regulation of the function of wind turbines and solar panels as well as a more efficient storage of energy can resolve the challenge of intermittency making renewables more valuable investment.

While AI brings numerous benefits to the generation, storage and distribution of solar and wind energy, it also creates a number of challenges. One such challenge is development of an effective algorithm for weather and demand forecasting. The development requires substantial resources in terms of data, finances and expertise. The algorithm will require continuous improvements and adjustments which further raises the questions of skilled experts. Furthermore, the implementation of AI will require the growth of big data and cloud technology for storage of data.

While AI solves the question of intermittency, it raises cybersecurity concerns. Given that technology does not require a close supervision by the operator, it can make it vulnerable to cyber-attacks. Consequently, a company should consider investing in a robust cybersecurity defence structures to prevent breaches.

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[71] Ibid.
[72] Bakovic, T., Baloko, M. "Artificial Intelligence in the Power Sector", *International Finance Corporation World Bank Group,* p.4
[73] Raycatch, "Solar efficiency: ate defective panels hurting your bottom line?"
[74] Ibid.
[75] US Department of Energy, "SunShot Vision Study"

Opportunities and challenges: sector analysis

The pace at which renewables would be integrated into the State's economy depends not only on the government's policy but also on each sector individually. The transport and aviation sectors are potentially some of the most challenging industries in terms of energy transition. According to a study conducted by OECD, around 35.23% of global oil consumption was related to the transport sector in 2019.[76] By comparison, electricity generation accounted for 19.32% of the global oil consumption in the same year.[77] BloombergNEF estimated that the road transport alone accounted for more than 40% of the global oil demand in 2019.[78] While the demand for fossil fuels in these industries has dropped as a result of the COVID-19 pandemic, experts predict an increase in consumption once lockdown restrictions are lifted. It can be potentially challenging for renewables to be integrated in sectors which are so reliant on fossil fuels.

During the COVID-19 pandemic, jet fuel suffered the sharpest demand decline. The demand dropped from 10% in 2019 to 6% in 2020 in OECD countries.[79] However, as the restrictions are being lifted around the world, the experts predict a significant increase in number of flights operated and, consequently, in the demand for jet fuel. At present, jet fuel is considered as the only viable option given the significant amount of energy needed to power large aircrafts at long distances. In addition, aviation fuel is usually exempt from taxes, in contrast to road fuel. Lack of taxes makes fuel more attractive to airlines from the perspective of costs. Consequently, potential technical challenges, coupled with lower prices of jet fuel can potentially undermine the integration of renewables in the sector.

Despite the view that there is no viable alternative to oil, companies within both sectors began engaging in initiatives aiming at reducing their carbon footprint. For instance, an international aerospace corporation, Airbus considers hydrogen as the most suitable substitution for fossil fuels.[80] The company is looking into the application of hydrogen in synthetic fuels as well as fuel cells and gas turbine engines.[81] BloombergNEF defines green hydrogen fuel cells as one of the central forces behind the "de-carbonisation" of the transport sector.[82] While other renewables such as solar energy and biodiesels can also be considered as alternatives to fossil fuels, they might not have sufficient capacity to power an aircraft.

Hydrogen also poses a number of challenges for the sector. For example, generation and storage of hydrogen would require sufficient resources. It must be compressed in high-pressure tanks and extraction of hydrogen cells requires additional equipment. However, a

[76] OECD Library "IEA Oil Information Statistics"
[77] Ibid.
[78] BloombergNEF, "Oil Demand From Road Transport: COVID-19 and Beyond"
[79] Thomson Reuters, "Cloudy outlook for stalled jet fuel demand recovery"
[80] Airbus, "What is the next "clean" energy to power aviation?"
[81] Ibid.
[82] BloombergNEF, "Oil Demand From Road Transport: COVID-19 and Beyond"

report by EY suggests that the costs for generation of hydrogen could be as low as $3.40/kg, depending on the technology and climate condition in the individual state.[83] Another challenge lies in the availability of green hydrogen. Today, more than 90% of hydrogen is still made with the usage of fossil fuels and the generation of green hydrogen is still limited (less than 0.5% of hydrogen is produced through water electrolysis). Consequently, sectors like transport and aviation indicate a shift towards the renewables, however, the viability of the fossil-free alternative is questionable.[84]

Shipping industry is another potentially challenging sector for renewables. Annually maritime transport produces more than 1 billion tonnes of CO2 emissions.[85] To mitigate the level of emissions, International Maritime Organisation (IMO) issued IMO GHG Strategy in 2018, which is comprised of technical and operational changes. Some of these changes include reduction of speed at which vessels travel, energy management and voyage optimization.[86]

Other solutions include replacement of fossil fuels as the prime source of energy. Similarly, to the aviation industry, IMO defines biofuels and hydrogen as the main substitutions.[87] ExxonMobil conducted a trial using biofuel to measure its impact in respect to the greenhouse emissions. The results indicated up to 40% reduction of emissions when using biofuels instead of traditional marine fuel. Hydrogen is another potential substitution to fuel. A Global Maritime Forum research in March 2021 assessed 106 projects dedicated to zero emissions in maritime shipping.[88] The research concluded that nearly half of these projects employed hydrogen.[89] Hydrogen is considered to be more beneficial for transport and shipping industries as it is more efficient for the longer distances from both cost and capacity perspectives. The European Union launched a hydrogen strategy which aims to raise €470bn by 2050 in public and private sector investment to advance the implementation of hydrogen.[90]

Based on the GHG Strategy, IMO aims to reduce the emissions from shipping by 50% by 2050. However, this target might not be achieved. One of the reasons is lack of consensus amongst the governments on the set of international rules which would regulate the proportion of emissions produced.[91] The Organisation has already pointed out to the complex negotiation processes and lack of consensus in regards to the emission production in shipping. Another reason is increasing demand for shipping. While the pandemic has disrupted the sector due to global economic decline, the roll out of vaccines and recovery of the global economy suggests a rise in shipping operations.

[83] Ernst&Young, "How green hydrogen could change the renewables landscape"
[84] CNBC, "Green hydrogen is gaining traction, but still has massive hurdles to overcome"
[85] World Economic Forum, "Here's how we can reduce emissions from the shipping industry"
[86] Ibid.
[87] International Maritime Organisation (IMO), "IMO action to reduce greenhouse gas emissions from international shipping"
[88] Global Maritime Forum, 2021, "Mapping of Zero Emission Pilots and Demonstration Projects"
[89] Ibid.
[90] European Commission, 2020, "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee of the Regions. A hydrogen strategy for a climate-neutral Europe"
[91] World Economic Forum, "Here's how we can reduce emissions from the shipping industry"

Electricity, in contrast to aviation and transport, offers a smoother transition to the renewable energy industry. For example, countries like Egypt and the UAE hope to generate more than 40% of their electricity from the renewable sources by 2040. This is particularly important given a predicted increase for the electricity demand in the region by 2030. As it was mentioned earlier in this report, the countries in the region possess unique conditions for successful generation of solar energy, making it one of the central energy resources for electricity and other sectors. Frost & Sullivan values the region's PV (photovoltaics) capacity at around $5-7.5 billion. Furthermore, with the implementation of the relevant technology (such as AI), the value of solar energy can be further increased.

Conclusion

The data in this paper conclusively evidences the long-term engagement of the Middle Eastern states in the RE policies and initiatives until at least 2030. It also assessed the potential development of renewables for the next 30 years.

Solar energy is the most developed source of RE in the Middle East. Out of the eight states considered in this paper, three states seem to possess advanced solar capacities: the UAE (based on the volume of investments and strategy), Egypt (based on the construction of the largest solar plant in Africa) and Bahrain (due to the country's climate conditions). The countries in the region also actively invest in the wind energy, which is the second most common source of renewable energy in the region. Nuclear energy strategies, on the other hand, can only be found in 3 countries: the UAE, Saudi Arabia and Egypt.

Based on the evidence provided in this paper, Egypt and the UAE invested the largest volumes in the RE sector with Egypt spending $500bn on the solar park alone. While these countries dedicate significant financial resources to the RE sector, their targets seem to appear less ambitions than those of the European states. For example, in Germany, the Europe's pioneer of renewable energy, renewables met 46.3% of country's power consumption in 2020.[92] Germany is planning to further increase the share of RE in its energy profile to 65% by 2030.[93] This is more than a double of the targets of other states in the Middle East, such as Saudi Arabia, for example. However, it should be taken into account, that in comparison to the European states, RE sector is at the relatively early stage in the Middle East and it would be too early to draw comparisons between two regions.

The pace at which renewables will be developing in the future is also subject to technological advancement and characteristics of the individual sector. For example, this paper looked at some of the challenging sectors, such as transport and aviation, which heavily rely on the fossil fuels. Shipping industry also poses challenges for renewables. Large volumes and long travel distances require complex operational and technical solutions as outlined by IMO.

[92] Thomson Reuters, "Renewables meet 46.3% of Germany's 2020 power consumption, up 3.8 pts"
[93] Ibid.

Aside from technical matters, implementation of renewables is delayed by the lack of consensus amongst states. Absence of a universal set of regulations could undermine the impact of existing renewable energy projects and strategies. Other sectors, such as electricity, indicate a quicker transition to the renewables. Development and implementation of technology such as AI can potentially accelerate the generation and implementation of RE, mitigating the problem of intermittency and increasing the revenue. However, successful employment and maintenance of such technology demands investment and resources.

It is expected that, in the near future, RE will continue to grow globally. According to the *World Economic Forum*, it is expected that wind, solar and hydro energy will account for 95% of the increase in global electricity generating capacity in the next 5 years.[94] It is also predicted that global capacities of wind and solar energy are expected to double between 2020 and 2025.[95] Solar and wind energy, are expected to dominate some sectors of the global economy by 2050. Renewables are particularly important in electricity generation and are predicted to replace coal by 2050. Solar and wind energy is set to dominate the global energy mix by 2050.

So, what about oil and gas? These forecasts do not necessarily imply that oil and gas will lose their place in the markets and economy. As stated earlier, at the moment renewables do not possess the capacity to fully replace oil and gas. This paper has discussed some of potential challenges associated with the RE, for example, intermittency. While oil prices experienced a sharp decline in 2020, the market recovered in the second half of 2020. In addition, sectors such as transport and aviation will depend on fossil fuels in the next 5-10 years. Fossil fuels will continue to play a central role in the economy of the Middle East for at least in the next 10 years. As discussed earlier, all policy frameworks considered in this paper preserve fossil fuels as a part of their energy portfolio. However, in the long term, renewables will further advance their position in the energy market and can potentially monopolise it in some sectors of the economy.

[94] World Economic Forum, 2020, "IEA: Wind and Solar capacity will overtake both gas and coal globally by 2024"
[95] Ibid.

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