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Review article

Incentives and strategies for financing the renewable energy transition: A review

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A R T I C L E I N F O

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A B S T R A C T

With the global population set to continue growing, the demand for energy will increase. Fossil fuel resources are in decline, and their use is associated with environmental destruction. This highlights the need for more investment in energy resources that can meet the global demand without harming the environment. Clean forms of energy, such as solar, wind, and hydropower, are both successful and readily available, yet investment in them has fluctuated. The affordability, ease of availability and technological maturity of oil in some regions has contributed to the slow uptake of investment in renewable energy projects. This paper discusses the main barriers hindering investment in clean energy production, highlights crucial incentives that could speed up investment processes, and examines several necessary strategies for the transition from fossil-fuel-based energy to renewable sources.

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Nomenclature

BP	British Petroleum
COP21	Conference of the Parties 21
COVID-19	Corona Virus Disease - 19
CPP	Clean Power Plan
CSP	Concentrated Solar Power
CVC	Corporate Venture Capital
EU	European Union
FiT	Feed-in-tariff
GCC	Gulf Cooperation Council
GEIDCO	Global Energy Interconnection Development and Cooperation Organization
GHG	Greenhouse Gas
GMP	Geomechanically Pumped Storage
IEA	International Energy Agency
IOC	International Oil Company
IRENA	International Renewable Energy Agency
MENA	Middle East and North Africa
MLP	Multi-Level Perspective
MW	Megawatts
NM	Net Metering
PHP	Pumped Hydro Storage
PV	Photovoltaics
R&D	Research and Development
RE	Renewable Energy
RET	Renewable Energy Transition
SDG	Sustainable Development Goals
SME	Small and Medium Enterprise
UAE	United Arab Emirates
UK	United Kingdom
UN	United Nations
US	United States
US EPA	US Environmental Protection Agency
VC	Venture Capitalists

1. Introduction

Energy usage is an integral part of daily life and is pivotal across different sectors, including commercial, transportation, and residential users, with the latter consuming 40% of the energy produced globally (Dawson, 2015). However, with the ongoing penetration of electric vehicles into the market (Hardman et al., 2017), the transportation sector's energy usage is expected to increase substantially (Fachrizal et al., 2020). According to the United Nations (UN), the world's population will reach 9.7 billion by 2050. To meet the growing demand for energy resources without the use of – depleting – fossil fuels that produce environmentally harmful carbon emissions, several actions have been implemented globally (Malik et al., 2019; Qadir et al., 2020; United Nations, 2015). The 1987 Montreal Protocol, aimed at reducing the consumption of ozone-depleting substances, led to a substantial recovery of the ozone layer (UN Environment Programme, 2009). Similarly, the 1997 Kyoto Protocol obliged countries to invest in green energy technologies (UNFCCC, 2012). This was later replaced in 2015 by the Paris Agreement/COP21 (Conference of the Parties), based on which subsequent energy policies and plans have been formulated (United Nations, 2015).

It is thus imperative to increase the production of green energy technologies, such as solar, wind, and biomass (Imteyaz and Tahir, 2019; Ou et al., 2018; Perlaviciute and Steg, 2014). Sustainable Renewable Energy (RE) comes with several other advantages, such as offering alternatives, thereby diversifying energy resources and helping to achieve energy security. Additionally, RE can provide easy access to energy, contribute to social and economic development and, most importantly, mitigate climate change and reduce its associated environmental and health impacts (Panwar et al., 2011).

The transition from fossil fuels to RE is indispensable to achieving a cleaner future (Imteyaz et al., 2021; Pilz et al., 2018), and intelligent solutions are needed to overcome the complex problems that emerge in this transition, such as the decoupling from inefficient and traditional methods while meeting energy needs (Alasseri et al., 2020; Pitelis et al., 2020; ul Abideen et al., 2019; Yoo et al., 2017).

The move from fossil fuel based energy sources towards RE sources is termed the Renewable Energy Transition (RET) (Li et al., 2020). To achieve an effective RET, an enormous amount of capital will be required (Hall et al., 2017). Although the overall costs relating to RE production have decreased significantly in recent years due to technological advancements (IRENA, 2019a), there has been no corresponding increase in investment. Investors are less willing to take investment risk due to changes in policies and the amount of capital involved, making financing the RET arguably one of the biggest problems of the 21st century.

The purpose of this study is to highlight the barriers critical to establishing RE projects and review the strategies used worldwide to overcome these obstacles. This work presents and discusses the existing practices of countries that are successfully undergoing the RET. A review of the existing literature is provided, and an outline is presented based on the gaps created, either by information not being addressed in previous studies, or by implications that were left unexplored. This paper identifies barriers to the RET that have not been previously considered in the literature surrounding the implementation of RE projects, such as biases against RE and the economic conditions of society. Although several research works exist on financing the RET, these either focus on one geographical region or discuss only a specific policy or strategy. Meanwhile, cross-regional studies of the RET are scarce in the literature. Therefore, to best represent the current landscape of financing RE projects, several research and review articles from various regions are considered, and an extensive state-of-the-art review of the existing literature on RET financing strategies is conducted. This paper also highlights rarely discussed strategies targeted at speeding up the implementation of the RET, such as initiatives relating to the roles of tech companies as large contributors of greenhouse gas emissions. To the best of our knowledge, no work looks at the installation, production, and usage of RE in a holistic sense. Indeed, it is essential that all the aspects of RET, such as policy formulation, financing mechanisms and storage technologies, should be examined for the effective decarbonization of the energy sector.

The rest of the paper is organized as follows: Section 2 explains the reasons for the RET, Section 3 presents an overview of the factors affecting the RET, Section 4 outlines the current RE markets and planned investments; Section 5 discusses the barriers that hinder the implementation of RE projects; and Section 6 discusses the perspectives of individuals, corporations, and government-linked institutions on strategies associated with incentives aimed at achieving the RET. Finally, Section 7 includes a discussion and future outlook, and the paper concludes in Section 8 by highlighting what is needed for the world to move away from fossil fuels by transitioning towards RE solutions.

2. Reasons for the RET

The global energy sector was significantly impacted following the political tensions and uncertainties that arose from the 1973 oil crisis (Xiangchengzhen and Yilmaz, 2020). Countries rich in fossil fuels are responsible for the global supply of oil and gas, meaning the entire world is dependent on them for their energy needs – a dependence that became clear during the crisis. Today, self-dependence in producing energy is essential for energy security. RE can play a vital role in achieving this, offering an important reason for investing in it (Hamed and Bressler, 2019). Furthermore, some regions have ample reserves of fossil fuels but have difficulties in extracting them due to harsh environmental conditions that require far more advanced technologies. This increases the cost of the fuel and the amount of greenhouse gases (GHG) produced during its extraction (Xiangchengzhen and Yilmaz, 2020).

Transitioning towards RE can also solve the issue of raising the living standards of rural populations (Sen and Ganguly, 2017). While some remote areas are hard to reach, establishing grid connectivity with neighboring countries is a viable option that can also bring regional harmony. This kind of initiative can offer several other benefits, such as reducing dependence on a particular country for energy needs, developing remote rural areas by providing electricity, and most importantly, creating an atmosphere of friendliness between nations (Xiangchengzhen and Yilmaz, 2020).

Some households choose to use renewable sources and go completely off-grid (i.e., are not connected to the country's main power grid and use only self-generated power), making them entirely energy independent. Approximately 75,000 to 100,000 people in the UK and 2 million in the US are thought to be not connected to a central power system (EC4U, 2020). Nevertheless, there is still a need to provide a more conducive environment to promote RE, and support should be provided to households or industries that take responsible actions to reduce their dependence on fossil fuels.

A recent report verified that some forms of RE can be cheaper in some instances when compared to conventional fuels (Heiligtag et al., 2019). Nevertheless, in the current scenario, society may continue to favor fossil fuel power generation because it is easier, mature, and more readily available.

3. Overview of the factors affecting the RET

The transition towards the usage of RE began towards the end of the 20th century. However, the commercial success of RE was only achieved after the 2000s, owing to the improvement in its efficiency and performance (Kammen, 2006). This section presents an overview of the factors affecting the RET, including RE policies in different markets, the public and private financing of RE investments, research and development in the field, and energy storage technologies.

Schiffer and Trüby (2018) reviewed the achievements of the *Energiewende* – the German policy framework for the RET – which had the goal of a 40% reduction in GHG emissions by 2020 and 80%–95% by 2050, compared with 1990 emissions. The authors argued that while the energy policy successfully reached its capacity target in Germany, the main goal (reducing GHG emissions) was not achieved since the energy usage pattern for other sectors, such as industry and transport, had not improved. Schiffer and Trüby (2018) also presented policy guidelines to achieve RET for the Middle East and North Africa (MENA) region by suggesting the utilization of all available RE technologies and using a market-based approach to provide cheap electricity to consumers through tax incentives, credit guarantees or emissions tax.

Geels et al. (2016) compared the RET policies of Germany and the United Kingdom (UK), and found that various institutions and actors are vital to achieving a policy shift towards renewable resources. Germany pursued a strategy in which new entrants, such as households and small power companies, were encouraged to invest in RE. Meanwhile, the UK relied on energy market players to achieve the RE transformation. Zhao et al. (2016) and Sheng et al. (2018) emphasized the role of policy development for RET and the latter also compared German and Chinese policies. While the Chinese policymaking approach is state-controlled, the German policies involve all stakeholders in the policymaking process, making Germany a good case study for other countries to follow.

Li et al. (2020) proposed a RET policy framework for Australia. The authors suggested that policy design should take into account three key parameters for the effective promotion of RE: (i) RE potential assessment, (ii) infrastructure development, and (iii) successful integration into the system. This policy framework for Australia can aid in achieving the target of reducing GHG by 26% by 2030 (Al Arrouqi et al., 2019). It should be noted that policies for transitioning towards RE resources vary across regions due to the variability in resource availability (Zhang et al., 2021). For example, in the case of southern European countries, Greece and Croatia need less assistance for their solar energy integration due to more annual solar radiation compared to, e.g., Slovenia (Punda et al., 2017). Crucially, along with policy design, financing mechanisms also need to be defined by policymakers to increase the pace of the global RET.

International oil companies (IOCs) account for 42% of the global GHG emissions (OECD/IEA, 2018) making their role pivotal in the RET. Zhong and Bazilian (2018) examined the issue from the perspective of the IOCs, discussing how major oil companies can aid the RET based on their expertise in the energy market. European oil companies such as Royal Dutch Shell and BP (British Petroleum) have invested heavily in the RE sector (for reasons, cf. Section 6). Indeed, Europe has been instrumental in reducing its oil usage and moving towards RE, specifically photovoltaics (PV) due to effective policy measures (Bersalli et al., 2020).

Public financing of research and development (R&D) for RE is needed to overcome the financing gap in the RET and to develop RE technologies. Indeed, a significant difference in technology development was observed when the R&D funding for RE was reduced in Europe (Bointner et al., 2016a). Technology improvement lowers the cost of RE, which ultimately helps to increase the level of investment in this sector due to anticipated higher returns. Bointner et al. (2016b) estimated that a colossal €55 billion is needed for R&D to help achieve the EU 2030 targets. One can infer from this that the success of the RET is directly related to the R&D support received from governments.

de Negri et al. (2020) studied the role of public funding in the R&D of photovoltaics in the context of the R&D policies of the European Union (EU) and their crucial role in meeting the 2020 decarbonization targets. The authors argued that additional efforts are required to increase investment in the RE sector by involving private investors to achieve the EU 2030 target of a 40% reduction in emissions relative to 1990.

Private financing can play an important role in the RET, as emphasized by Curtin et al. (2017), who proposed feed-in-tariffs (FiTs), energy usage quotas, grants, and tax incentives to successfully involve citizens in RET. While these address the hurdles of

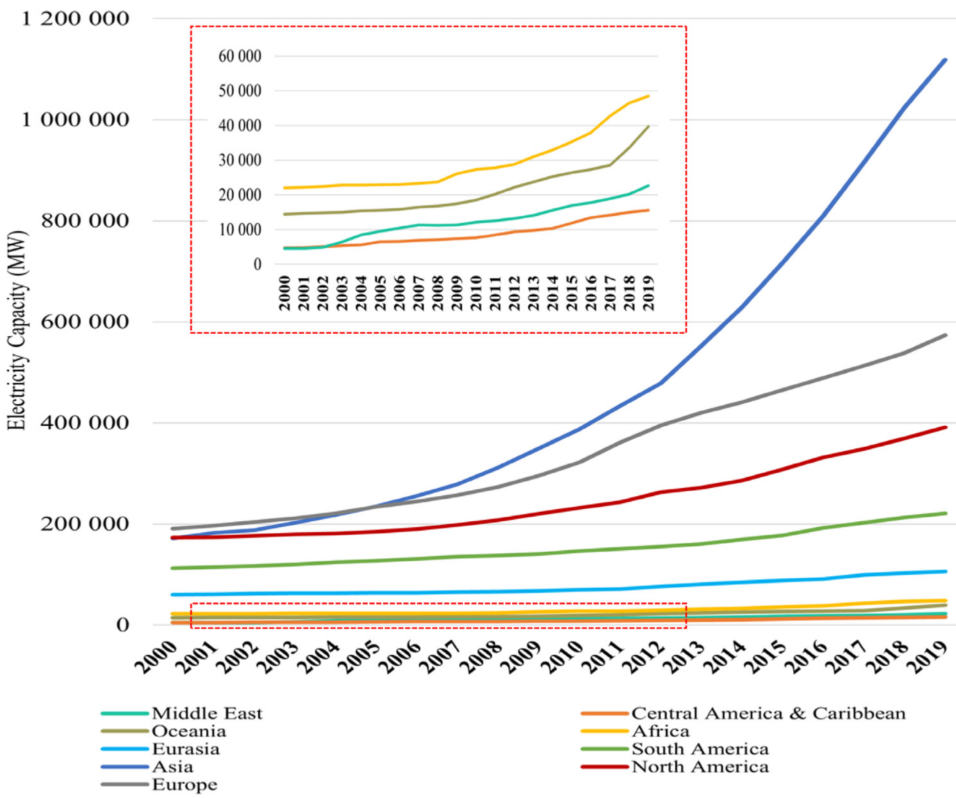

Fig. 1. Renewable energy production capacity increment from 2000 to 2019. The world is divided into nine geographical regions. *Source:* IRENA (2019b, 2020).

private financing from the citizens' perspective, the roles of other private financers, such as banks, venture capitals, and private equity, were not discussed. The role of these other private financers is crucial, but regulatory hurdles and low rates of return in RE projects have made investors reluctant to invest in RE projects (The Energy Council, 2020).

Energy storage technologies provide a feasible solution for the intermittent nature of RE (Yao et al., 2016). This makes investment in storage technologies necessary for the effective implementation of the RET. Gallo et al. (2016) argue that financial and regulatory barriers hinder the efficient use of energy storage technologies. Since energy storage technologies require investment and cooperation among different stakeholders, such as the investor, consumer and utility company, it is difficult to estimate the share of each stakeholder. Regulatory changes are needed to define how each stakeholder is charged/compensated. Parra et al. (2017) discussed the benefits of community RE storage and argued that the direct involvement of citizens through community storage increases the pace of the RET and encourages individuals to invest in clean energy technologies.

4. The current renewable energy market share

Various RE sources can be utilized for climate mitigation efforts based on regional and climatic differences and the resources available in a given country. Nonetheless, solar and wind represent the primary constituents of any RE policy. As a result of their technological maturity, solar and wind energy projects are currently seeing a rise in deployment and are expected to become the main contributors to the global energy supply by 2030 (Sayigh, 2020).

The growth of installed renewable power generation in different regions is presented in Fig. 1. With 758,626 megawatts (MW), China is leading in Asia – and the world – in terms of installed capacity. Second in the region is India, with an installed capacity of 128,323 MW (IRENA, 2019b, 2020). The United States (US) has the largest installed capacity in the North American region, at 264,504 MW, while in Europe (member states funding), Germany has taken the lead with an installed capacity of 125,386 MW.

Meanwhile, in the last 19 years, the installed capacity in the Middle East, Central America and the Caribbean, Africa, and Oceania has not increased as significantly as in other regions (IRENA, 2019b, 2020). Nevertheless, the Africa region is progressing towards more RE usage, especially in North Africa. The world's largest concentrated solar power (CSP) plant, the Ouarzazate Solar or Noor Power Station with a 580 MW capacity, has been installed in Morocco, and the country aims to produce 52% of its electricity from RE sources by 2030 (Climate Investment Funds, 2018). Morocco's current total installed solar and wind capacity is 711 MW and 1220 MW, respectively (MEM, 2018). Likewise, Tunisia also plans to increase its RE capacity from 3% to 30% by 2030 under the Tunisian Renewable Energy Action Plan 2030 (Zelt et al., 2019). Several renewable energy projects have been announced in the country since 2017, including 17 solar projects with a capacity of 620 MW and four wind projects with a total capacity of 120 MW (ITM, 2020).

Global investment in the RE sector from 2015 to 2019 is presented in Fig. 2. The US has increased its investment in RE by 25% since 2018, while Brazil has emerged as the leader in terms of percentage increase, with total investment in the RE sector rising by 78% since 2018. Other regions in the Americas have also seen a considerable increase in RE investment, with an average 20% rise compared to 2018 figures (Ajadi et al., 2019).

It is essential to recognize the difference between RE production and installation. RE plant installation by itself cannot be the solution to reducing global emissions; these installations will only be beneficial if the electricity is actually produced and used (Alarrouqi et al., 2020; Özdemir et al., 2019; Pilz et al., 2019).

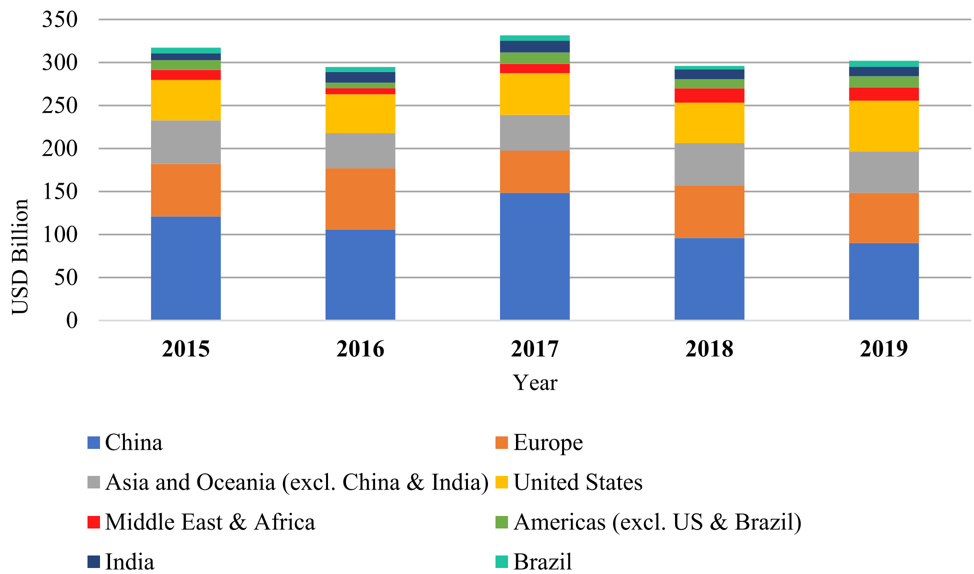

Fig. 2. Renewable energy investment, with on average 86% from private investors and 14% from the public sector. Values presented are nominal values. *Source:* Ajadi et al. (2019).

Moreover, if fallacies against RE are addressed, especially the conception that (i) RE is expensive, (ii) RE is difficult to access, and (iii) RE requires a significant amount of land, there will be a substantial increase in both installation and production (Inspire, 2017). Fig. 3 shows a downward trend in the installation costs for solar photovoltaics (PV) and onshore and offshore wind plants, while there has been no consistent trend in the cost of installing concentrated solar power (CSP), partly due to lower performance and more investment risks (IRENA, 2019a). The obstacles responsible for the slow development of RE are discussed in the next section.

5. Barriers to the achievement of the RET

This section discusses the major barriers that intervene in the deployment of RE projects and hinder the RET, including the economic, institutional, technological, and social barriers. Economic barriers include the lack of financing for RE projects, the high capital costs and the availability of lower-priced fossil fuels. A lack of awareness – a social barrier – is also hampering the RET as public resistance and opposition add further complications. Technological barriers also exist in the widespread utilization of RE, with a lack of infrastructure and grid connectivity in several countries being identified as a potential cause of delay. Hence, to meet the energy needs of the future, there is an urgent need for the formulation of effective policies that can overcome these barriers.

5.1. Government subsidies for fossil fuel

Fossil fuel subsidies are government measures put in place to lower the price paid for fuel by consumers or to increase the price received by energy producers (Hayer, 2017). The types of subsidy instruments vary between countries and can be classified into the following four categories: (i) direct financial transfers, (ii) preferential tax treatments, (iii) trade restrictions, i.e., import duties and tariffs; and (iv) regulations, i.e., price controls and rate caps. There are three approaches to the calculation of these subsidies, namely the price-gap approach, i.e., the comparison between the domestic price and the world reference price, the inventory approach, i.e., a bottom-up approach in which the inventory subsidy is formed by checking all policies providing support to a particular industry, and the total support estimate approach, i.e., a method in which the transfer and market support are combined (Taylor, 2020). The International Energy Agency (IEA) lists subsidies for 42 countries that use a price-based approach; however, this dataset excludes the US and European countries since they provide subsidies in the form of tax credits and loan guarantees for production rather than consumption (IEA, 2020; IER, 2018). Coady et al. (2019) state that the US and EU provided subsidies worth an estimated $649 billion and $289 billion, respectively, as per 2015 figures. The top 20 subsidy-providing countries in the IEA database and their respective subsidies in 2019 are presented in Fig. 4(a).

Since 2015, there has been a downward trend in subsidies (see Fig. 4(b)) as it has become clear that subsidized fossil fuels are environmentally damaging and thus contradict the COP21 aims (United Nations, 2015). Furthermore, the lower oil prices have led to lower subsidies, although the 2018 rise in oil prices briefly caused some upward movement in the amount of subsidies (Matsumura and Adam, 2019; Qadir et al., 2020).

Governments across the world are providing subsidized fossil fuels for the establishment of new industrial zones to accelerate economic growth and reduce income inequality (Al-Badi and AlMubarak, 2019; Alshehry and Belloumi, 2015; Howarth et al., 2017). However, non-sustainable energy subsidies are one of the main barriers to implementing clean energy projects (Erickson et al., 2017) as they not only limit the production of RE but also increase the demand for fossil fuels. As such, these subsidies need to be removed, albeit gradually and through reallocation to the promotion of RE (Geels et al., 2017).

5.2. Biases against renewable energy

The deployment of clean energy technologies is critical to transforming the energy sector to reduce fossil fuel usage (IEA, 2017). Major conventional energy producers have criticized the use of RE and portrayed it as costly and unpredictable (Geels et al., 2017). Several studies in different capacities thwart the deployment of RE by arguing that it is not feasible that RE will meet the world's energy demand (Brook and Bradshaw, 2015; Harjanne and Korhonen, 2019; Heard et al., 2017). These biases have impacted and indeed influenced public perception of RE sources in terms of reliability, security, and affordability (Diesendorf and Elliston, 2018). The authors in "State of Green" (2017) argue that renewables can be as reliable as conventional energy, with a

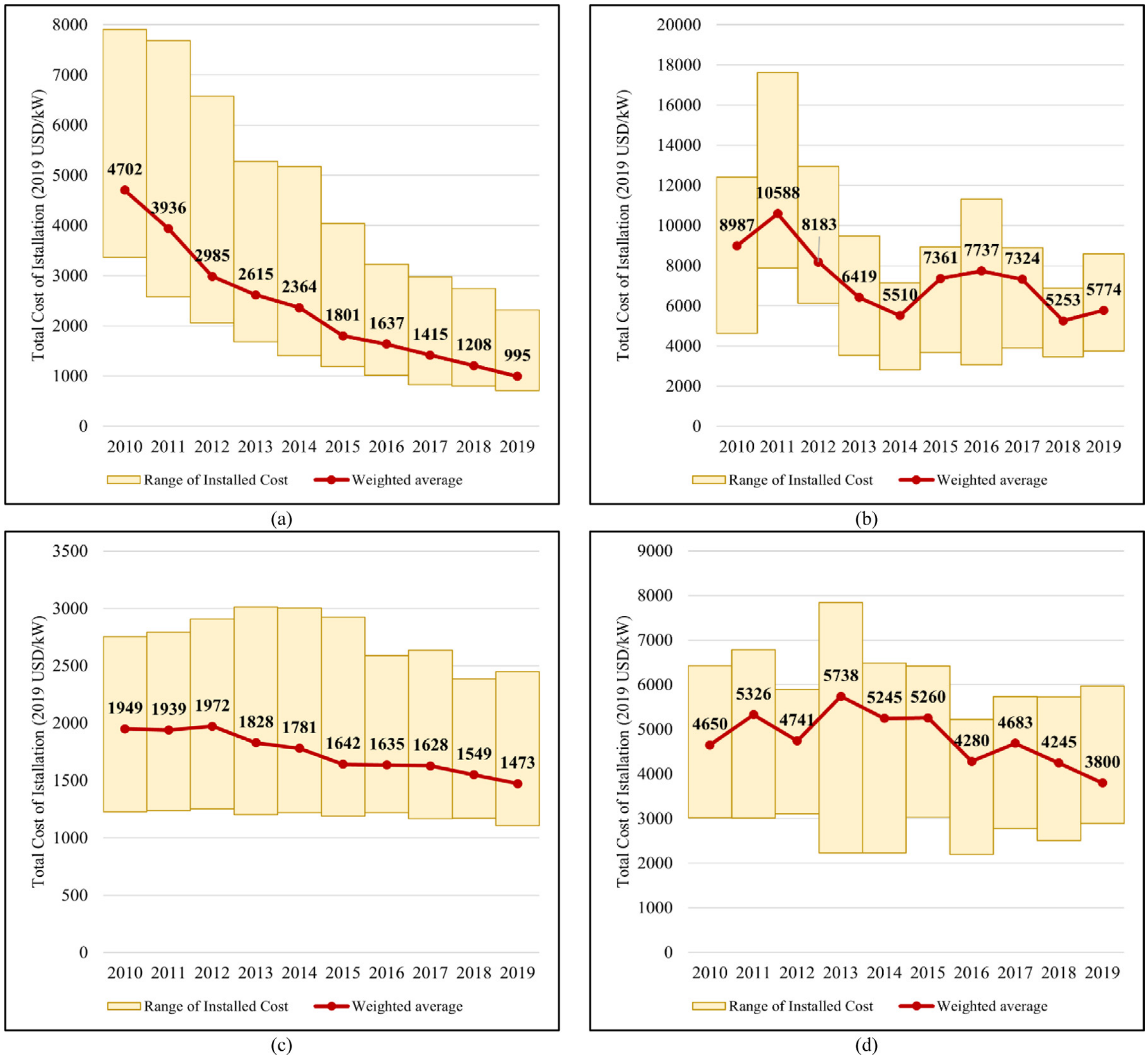

Fig. 3. Average installation cost of solar and wind technologies globally. (a) Installation cost - solar PV, (b) installation cost - CSP, (c) installation cost - onshore wind and (d) installation cost - offshore wind.
Source: IRENA (2019a).

minimal amount of conventional energy required as a buffer. As variabilities generally occur for a minimal amount of time, there is no need for 100% electricity backup.

Although some scholars argue that there is no guarantee that RE investment is secure (Johansson, 2013; Smil, 2016), RE generation can be more resilient and less prone to natural disasters since it is distributed across several regions, unlike centralized power generation from fossil fuels (Sen and Ganguly, 2017).

The non-affordability of RE is arguably the most significant bias mentioned in the literature, with some potential investors still basing their assumptions on the belief that renewables are expensive and cannot provide true financial benefit (Zakaria et al., 2019). Melović and Ćirović (2020), established that financial incentives are of little use when there is less public awareness.

Due to these biases against RE, more fossil fuel extraction is being carried out to meet the energy demand – a process that itself is a major consumer of fossil fuels, thus creating a cycle of consumption that will continue until it is interrupted by the inclusion of RE (Diesendorf and Elliston, 2018).

5.3. Psychological factors

Individuals tend to invest in something if they can envision the benefits they will receive. Perlaviciute and Steg (2014) suggest that people oppose RE integration due to the unfair distribution of the associated benefits. In a study on wind power plants in France, Enevoldsen and Sovacool (2016) found a lack of participation in wind projects from both individuals and the government due to a lack of public support. Indeed, setting up a wind farm is impossible without public support (Brinkerink et al., 2019). When RE plants are established, the local communities are more vulnerable to the negative effects of energy plants, such as noise pollution, landscape changes, and the potential for accidents. Meanwhile, other communities that consume the same electricity, yet are not situated near the plants, are less likely to experience such impacts. This unfair distribution of benefits and impacts leads people to neither support nor invest in the RE sector. Hence, additional benefits should be provided to those residents directly affected due to their proximity to an RE plant, particularly in the case of wind farms.

5.4. Cost unawareness

Key stakeholders, such as large investors or governments, are typically unaware of the market changes in the RE sector, and thus their decisions tend to be based on old perspectives (UNESCAP, 2021). This institutional barrier delays the provision of more space for RE to enter the market. Specifically, targets, which

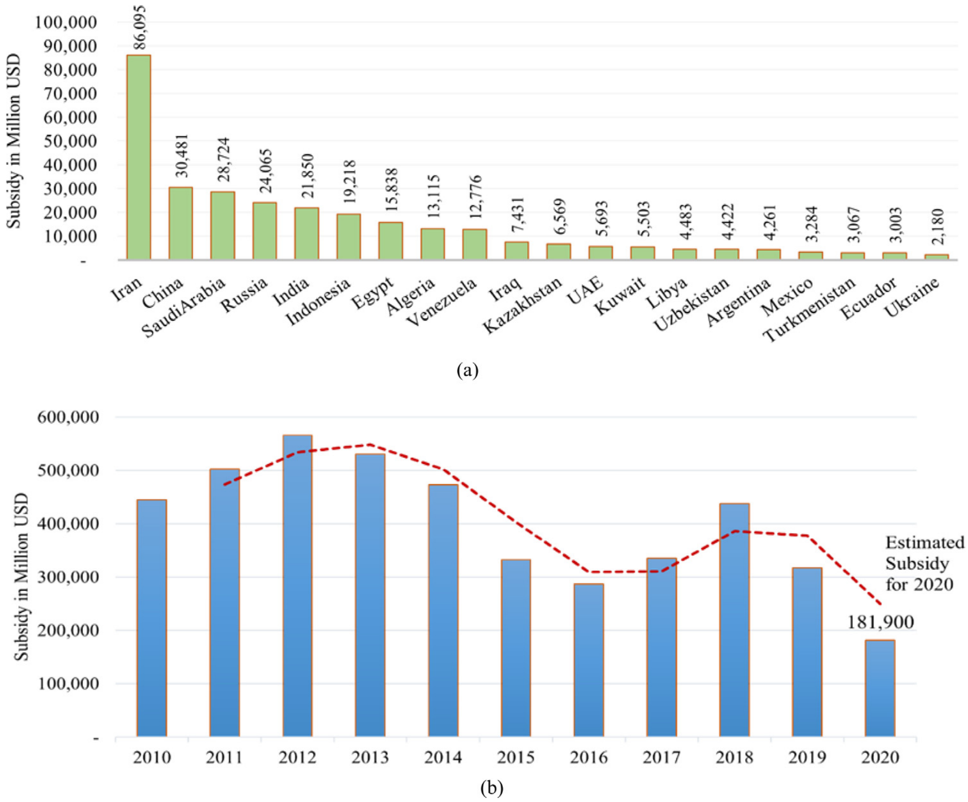

Fig. 4. Top 20 subsidy-providing countries 2019 (IEA); (b) the total sum of subsidies from 2010 to 2020.
Source: IEA (2020).

are often set in advance, need timely revisions. For example, PV prices have decreased significantly over time, yet policies are made based on past prices (Sgouridis et al., 2016). In such a case, priority may be given to conventional energy projects instead of solar energy projects due to this price unawareness.

5.5. Oil companies as a barrier

One of the difficulties in the transition to renewables is the unwillingness of some oil companies to diversify their portfolios. Hartmann et al. (2020) studied the differences in the investments made by several major oil companies, examining country regulations, public social pressure, and the oil companies' strategies. In general, European oil companies are keen to invest in RE partly due to the strict environmental regulations from the European Union (EU) and social pressure from consumers (Hartmann et al., 2020). In contrast, North and South American oil companies have less desire to diversify their portfolios (Murray, 2020). It has been observed that oil companies with more proven oil reserves are less keen on investing in the renewables sector (Pickl, 2019), while those with considerable investment in the core oil business are similarly reluctant (Pickl, 2021).

Another issue that discourages oil companies from investing in RE is the mixed opinions of their shareholders. Specifically, institutional investors generally want oil companies to move towards renewables, while non-institutional investors tend to be against it. This investors' dilemma has also harmed the transition process (Salzman, 2020).

5.6. Socio-economic conditions of society

It is an established fact that economic stability is achieved when societies use their natural and human resources efficiently. In addition, investment in physical infrastructure, such as roads, machinery and factories, also contributes to economic stability and growth (Boldeanu and Constantinescu, 2015). The socio-economic conditions of a society influence the energy usage habits of individual households (Khan et al., 2019). While a wealthy household can afford the extra capital needed to invest in clean energy, the same cannot be expected from an underprivileged family. Inaccessibility to capital to invest in clean energy is one of the main barriers for the RET (Kowalska-Pyzalska, 2018). Thus, inequality in socio-economic conditions form an additional barrier in the RET, and the promotion of RE in societies needs to be accomplished first by achieving economic stability, which will then lead to income equality. A good example of this is China, whose recent economic growth has been correlated with it being the world's leading country in utilizing RE potential (IRENA, 2019b). Therefore, RET research, investments and policymaking must incorporate the socio-economic attributes of society (Van Der Kroon et al., 2013).

5.7. Venture capitalists

As venture capitalists (VC) create breeding grounds for new technologies, their interest in funding green energy initiatives is vital. In particular, since private equity investors prefer to invest in more mature technologies, RE projects tend to receive less funding, and so VCs represent a suitable option (Bose et al., 2019). When the 2008 global financial crisis struck, RE investments were not immune to the impacts, and the subsequent lack of funding from VC investors has slowed the process of transitioning to RE, as can be seen in Fig. 6. Furthermore, drastic changes in oil and gas prices also affect the renewables market. For example, while investors believed that the 2008 rise in oil and gas prices would be beneficial for RE deployment, oil prices soon decreased in 2012. As RE could not compete with these lower prices, there was a stark decline in RE project funding despite the fact that

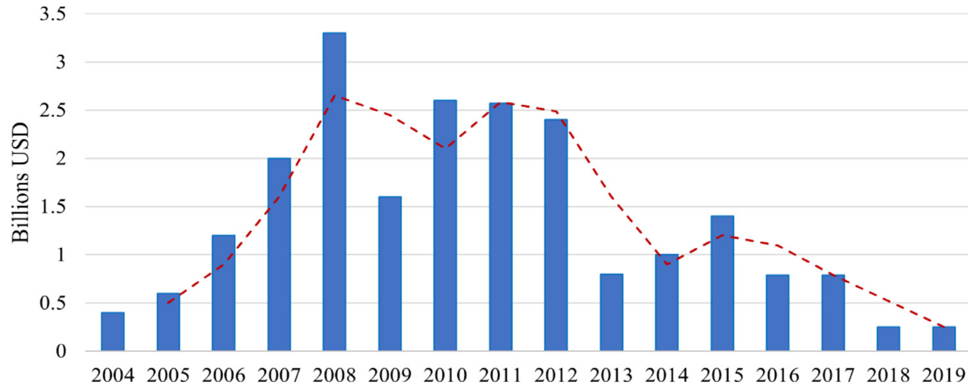

Fig. 5. The downward trend of RE projects since 2008.
Source: Ajadi et al. (2019).

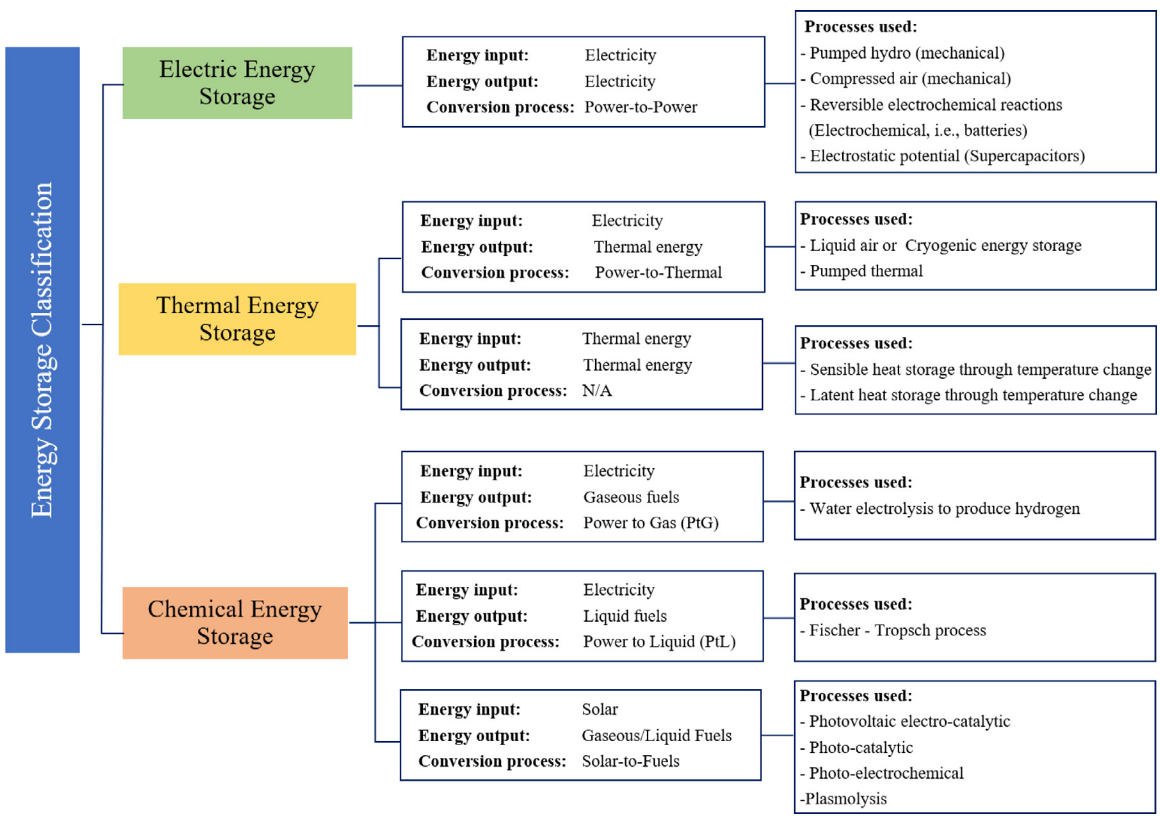

Fig. 6. Energy storage classification.
Source: AL Shaqsi et al. (2020), Gallo et al. (2016).

innovative ideas are usually supported by VCs (Bose et al., 2019). Fig. 5 depicts the investment trend for VCs. The reason for the sharp decline in investments from VCs is due to less return on investment. As the expected returns were not achieved, there has been less interest in investing in newer technologies (McCrone et al., 2020).

6. Incentives and strategies to encourage RE investment

6.1. Types of incentives

Targeted incentives and strategies have thus far proven to be constructive in encouraging the implementation of RE projects (Zhao et al., 2016). Based on the literature, several kinds of incentives can accelerate RE deployment. These can be categorized into four types of incentives, namely: (i) research and development (R&D), (ii) fiscal and tax, (iii) market development, and (iv) grid connection and tariff incentives.

R&D incentives

R&D incentives are provided to improve existing RE technologies by establishing R&D facilities or developing novel technologies (Zhang et al., 2021). R&D projects come with a high level of risk and uncertainty, making government support essential (Fernandes et al., 2016). Countries can become self-reliant in RE production by producing their own solar panels and wind turbines, as is the case with Chinese wind plant manufacturers, which have been dependent on the support of government R&D incentives (He, 2016). As importing RE infrastructure equipment from other countries makes the technology more expensive, especially for countries with no expertise or knowledge in component manufacture, investing in R&D should be the primary focus for any state aiming to shift towards RE (Zhao et al., 2016).

Fiscal and tax incentives

Fiscal and tax incentives are when taxes and duties on the imports of RE equipment are waived so that RE can progressively be integrated into the system. China implemented this policy to encourage the import of technologies that had not yet reached maturity in China (Zhao et al., 2016). When these taxes are waived, the per-unit electricity cost becomes cheaper, allowing the technology to compete with other power generation sources, such as gas and oil. Another way to promote RE is to tax fossil fuel generation, thereby increasing the per-unit cost of electricity generation and influencing the competition between the two power production technologies (Lipp, 2007). Another fiscal incentive is to provide loans at a minimal rate, specifically to construct RE plants for residential use (Zhi et al., 2014).

Market development incentives

Bureaucracy can be a major hurdle in the development of the RE market. Obtaining government approval for projects is often challenging, and projects are not always awarded based on merit (Zhao et al., 2016). Consequently, a loss of confidence may develop among potential investors. Establishing a policy with standard tariffs under a regulatory authority will encourage RE investors to participate in clean energy projects. Additionally, standard testing and certification for small power producers may also promote the RE market (Zhang and Ji, 2019).

Grid connection and tariff incentives

One reason for investors to not finance an RE project is grid non-availability , i.e. there is electricity production, but the grid infrastructure cannot accommodate the additional power. In such a case, the electricity generated from that power producer goes to waste or is only partially purchased (Pilz and Al-Fagih, 2019). Such situations prevent investment in RE. FiTs are the most common form of grid connection incentive. Hereby, the government sets the electricity price to benefit the producer; the high profitability paves the way for more investment (Zhao et al., 2016). However, legislation is required to bind the power grid companies to purchase the power generated by such RE producers.

Mihaylov et al. (2019) proposed a novel incentive in which energy is used as a digital currency to promote more RE usage and incentivize green energy consumption. The idea has traditional elements, based on FiTs, net metering (NM) and other market-based mechanisms in which reward is linked to usage. Such special incentives are necessary to promote the RE market. The authors also proposed real-time incentive distribution rewards, i.e., the payment to the RE producer varies based on the number of consumers and at what time the energy is fed into the grid. Payment for the produced energy is rewarded in terms of digital currency, which the authors called NRGcoin, that is traded on an open currency exchange market. They concluded that their incentive would reward "prosumers", i.e. producers and consumers, based on the amount of net energy supplied to the grid, unlike NM, in which there is a cap policy, where prosumers are only paid a certain amount regardless of how much they feed into the system. Using a real data set from Belgium to conduct the simulation, the authors compared their results with FiT and NM and found that prosumers' revenue was higher; however, cautioned that results may vary for different datasets.

An overview of the major incentive policies used under the five primary incentive types presented above can be found in Table 1.

6.2. Strategies for the RET

Several strategies are used in different countries and under different circumstances to promote the production and use of RE. This section discusses the strategies for three outlooks: The first refers to strategies in which governments or related agencies are involved in creating a new stream of literature by discussing the participation of stakeholders in policymaking, alternatives to carbon taxation, and global grid connectivity. The second outlook is related to corporate strategies, including the plans of international oil companies and the roles of tech companies in speeding up the RET. Lastly, the outlook on how ordinary people can help in the transition phase is discussed.

6.2.1. Government and linked institutions

Creating Energy Financing Literature

One of the main factors influencing the process of the RET is the availability of financing (Krupa et al., 2019). RE projects are typically financed through project financing, and investors generally consider two aspects before funding a project: investment returns and investment risks (Polzin et al., 2019). Several risks can be eliminated by selecting the right strategy, such as accurate project feasibility and the use of mature technology. Investors also look for management capability and whether, with advanced expertise, the project's execution is possible (Groobey et al., 2012).

Therefore, there is a need for specific energy financing literature that can educate all the stakeholders (Zhang and Ji, 2019). For a smooth RET, it is essential to understand the energy financial markets, particularly the relationship and interaction between energy markets and financial markets. Since the 2008 global financial crisis, words like volatility, uncertainty, complexity, and ambiguity (VUCA) have become associated with energy markets. As energy markets and business markets cannot be studied separately due to the influence of financial markets, they are incorporated to form an interdisciplinary research field. This field is relatively new, and thus comparing energy markets with financial markets is inadequate (Zhang and Ji, 2019). Much work remains to be done in the energy financial markets domain, with special attention paid to RE, to expand RE penetration worldwide.

Alternative to Carbon Taxation

Offering an alternative to carbon taxation is another policy measure that can be implemented by the government. Carbon taxation is one of the most efficient schemes for overcoming climate change issues by reducing GHG: Those who produce more carbon emissions must pay more, and thus energy producers try to avoid using resources that produce more emissions. An alternative to carbon taxation would be to bind energy producers to invest a certain amount in RE systems. To achieve this, policies need to be designed to encourage stakeholders to move away from hydrocarbons. For example, a portion of the revenue generated from hydrocarbons should be invested in RE technologies. This would help the energy businesses to gradually shift towards renewables (Taylor et al., 2017).

A study reported that carbon taxation is effective in countries where the trust in the government is high and the level of corruption is low, such as Sweden, Switzerland, and Norway (Funke and Mattauch, 2018). Climate policies are usually weak in countries that are characterized by a distrust of the government and a high level of corruption. In such countries, energy producers are unwilling to pay the carbon tax and continue to emit increasing amounts of GHG (Klenert et al., 2018).

Participation in Policy Making

RET is not a linear phenomenon. To transform the current energy usage from fossil fuel based technologies to RE, the government's role in policy formulation is crucial. However, government

Table 1
An overview of inventive policies.

Studies	Country of Study	Tax or Financial Incentive		R&D Incentive		Market Incentive				Grid Connection Incentive		Incentive via Regulations		
		Tax Support	Financial Subsidy/Loan	R&D Support	Establishment of R&D Institutions	Auctions	Quotas	Market Regulation	Development Plans	Feed-In-Tariffs (FIT)	Net Metering (NM)	Green Certificates	Power Purchase Legislations	Defined Targets
Zhao et al. (2016)	China	✔	✔	✔	✔			✔	✔	✔	✔			
Melović and Ćirović (2020)	Montenegro		✔											
Zhi et al. (2014)	China		✔	✔						✔				
Aquila et al. (2017)	Brazil					✔	✔			✔	✔			
Abdmouleh et al. (2015)	USA, India, Brazil, Australia, and the EU	✔	✔	✔						✔	✔	✔	✔	
Eichhammer et al. (2013)	Germany		✔					✔	✔	✔				
Štreimikiene et al. (2019)	Baltic States													✔
Malik et al. (2019)	GCC Region		✔	✔						✔				
Li et al. (2020)	Australia									✔				✔
Mihaylov et al. (2019)	Belgium									✔	✔			

intervention is not enough if the society is not actively participating in the transition phase. A socio-technological transition is composed of several stages, based on a multi-level perspective. This includes three key parameters, namely socio-technical systems, niche innovations, and the socio-technical landscape (Geels et al., 2017; Köhler et al., 2019). To diversify energy requirements, it is crucial to understand how the transition is derived from these key parameters. When the *Energiewende* happened in Germany, the most affected entities were the conventional energy producers due to the complete change of policy support for fossil fuel based power generation to RE in the socio-technical transition. RWE, E-ON, Vattenfall, and EnBW were the four big market players in the era before renewables, but following the introduction of RE and the changes in policy support from the government, these companies were forced to shift their portfolio to renewables (Geels et al., 2017). This German case is an example of what can happen to conventional power producers once the policy shift starts.

Another important argument is that with the RET, conventional energy plants need to be shut down gradually (Geels et al., 2017; Kivimaa and Kern, 2016). The US Environmental Protection Agency (US EPA) published its Clean Power Plan in 2015 (Davis et al., 2016), based on three key features: higher efficiency power plants, prioritizing low emission technologies, and expanding RE. They formulated this policy with input from all stakeholders to achieve a comprehensive approach that is acceptable for everyone. Hence, policymaking with stakeholder participation is vital for the RET.

Global Grid and RE

With the increasing environmental concerns due to the use of fossil fuels, the future belongs to RE sources. However, the world's environment is not uniform, and every region and country has varying conditions for RE production. Therefore, regional grids must be interconnected so that if one country cannot produce energy in a particular season, it can rely on a neighboring country to meet its needs (Xiangchengzhen and Yilmaz, 2020). There are already examples of regional cooperation regarding gas and oil pipelines for energy needs, such as the Nord Stream (Nord Stream, 2005) and South Stream projects (South Stream Transport B.V., 2007). A similar concept can be applied for the grid connectivity of renewables (Chatzivasileiadis et al., 2013).

China established an international organization to promote a global grid concept, known as the Global Energy Interconnection Development and Cooperation Organization (GEIDCO). Headquartered in Beijing and with regional offices worldwide, GEIDCO aligns with the UN Sustainable Development Goals (SDGs) #7 "Affordable and Clean Energy" and #13 "Climate Action" (GEIDCO, 2016). GEIDCO was formed to establish solar power plants in desert areas and dispatch electricity to where it is needed — which can only be achieved if grids are connected (Kraemer, 2019). In 2019, the State Grid Corporation of China (SGCC) published a plan to connect the world grid in three phases. In the first phase, which ran through 2020, the SGCC promoted the global grid concept by providing technical support to interested countries. From 2020 to 2030, a continental grid will be set up, and a transcontinental grid is proposed for the third phase, in 2030–2050 (Cornell, 2019).

Similarly, the MENA region has huge potential for RE generation and could lead the world in RE power export (Aghahosseini et al., 2016). DESERTEC Foundation (2020) first proposed this project, however, for it to be practical, €400 billion will be needed to install the necessary transmission lines (Muller-Steinhagen and Trieb, 2006). The project failed due to cost inefficiency. In 2020, work on this project restarted, however, to date not much information has been revealed.

The global integration of power grid systems facilitates the RET process for countries with fewer RE resources. While there are solutions for transforming the system, there are barriers to implementing them, such as a lack of investment for large projects and regional political instability (Brinkerink et al., 2019). Under such circumstances, cross-border cooperation on RE projects may be beneficial as it offers several advantages, including experience sharing, regional integration, and cost reduction, given that the investment opportunities are provided and political instability is addressed (Hamed and Bressler, 2019; Xiangchengzhen and Yilmaz, 2020). Hence, if implemented, a global grid connection proposal could become a game-changer on the RE market.

Microfinancing RE Infrastructure

While operating an RE plant, such as a solar or wind plant, is not necessarily expensive, building it can incur substantial costs, which is why RE has been slow to spread for both commercial and residential purposes (Union of Concerned Scientists, 2017). Introduced in the 1970s by the Grameen Bank of Bangladesh to develop rural communities, microfinancing provides easy installment loans to low-income households to improve their quality of life and economic wellbeing (Khan et al., 2019). Access to electricity remains a key element for economic progress, thus microfinancing clean energy can be conducive for the RET, not only in rural areas but also in urban areas with a heavy reliance on conventional energy sources. With approximately 1 billion people, or about 13% of the global population, without modern energy resources, there is a need to accelerate the microfinancing process at the global level to provide clean energy for all (IEA, 2018). As initiatives such as the establishment of microfinancing banks usually stem from the government, it has the opportunity to become a major contributor to creating a fast-paced track to the use of renewables.

6.2.2. Corporate strategies

IOCs and Their Strategies

IOCs are major stakeholders in the RET since they have been the most affected by it (Geels et al., 2017). While some IOCs are hesitant to diversify their business, others, such as Shell, Total, and Equinor, are actively involved in the RET (Zhong and Bazilian, 2018) and have incorporated several approaches to reduce GHG emissions. Similarly, other IOCs such as Chevron, BP, Eni, and Petrobras, have also invested in RE technologies to gradually participate in the energy transition, although their RET investment budgets are comparatively low (Pickl, 2019).

Since financing is a major issue in RE implementation, some IOCs have addressed the financing gap by funding new startups as corporate venture capital, prioritizing the funding of innovative startups working in the RE domain. Since these IOCs have both business and market knowledge, they can also provide mentoring services to new startups (Rai et al., 2015). In addition, IOCs have also been involved in acquiring well-established RE firms to ease their entry into the RE market (Zhong and Bazilian, 2018). The IOCs and their renewable business investments are summarized in Table 2.

Energy Storage Technologies

RE resources that are more abundant, such as solar and wind, have an intermittent nature. To meet peak demand given the variable production, storage technologies are required (Ali et al., 2018; Pilz and Al-Fagih, 2020), with batteries being the most common (Gallo et al., 2016). Storage technologies are classified based on energy input, energy output, conversion processes, and storage classification; Fig. 6 summarizes the most common storage technologies. It should be noted that some of these, such as pumped hydro storage (PHS), require an underground reservoir; this requires mining, which in turn, involves considerable costs. One of the advantages for oil-rich countries, such as the GCC countries, is the availability of inactive oil wells that could be used for energy storage purposes, e.g., to store hydrogen, water, or compressed air pumped using RE. This stored material can be later used to generate power when RE is not available (Imteyaz et al., 2020). For example, the US startup Quidnet Energy has developed a similar concept, using geomechanically pumped storage (GPS) technology to integrate large-scale renewables and reduce renewables' intermittency (Schmidt, 2020). As the share of RE is set to increase, more storage options will be required to deal with its variable nature (Gerdes, 2018).

Tech Companies in Transition

Technology companies such as Google, Facebook, Apple, and Microsoft can play a big role in the RET. Google, for example, is the sector leader in RE generation and has recently agreed to purchase 1600 MW of electricity to offset its GHG emissions. Power purchase agreements such as this enhance investors' confidence and ultimately push more investors to finance green technologies (Opiah, 2020). With the increasing number of digital technologies, there is a demand for large data centers, which need power. If more companies take similar initiatives, the speed of the RET will undoubtedly increase significantly as power purchase agreements reduce investors' risks.

6.2.3. Individuals

Renewable Energy Cooperatives and Financing

The objective of a RE cooperative is to set up a nonprofit entity to promote sustainable energy via local communities and the involvement of citizens in addressing the problem of capital unavailability for RE projects. When individuals invest in RE cooperatives, they become both producers and consumers, i.e. "prosumers". The distinctive feature of these cooperatives is the "one member one vote" policy, which gives equal ownership to all stakeholders. It reduces the overall risk of the investment, making this kind of investment attractive and helping to speed up the RET (Yildiz et al., 2015).

7. Discussion and outlook

Considerable work has been done on the RET in terms of policies and targeted feasibility studies. However, the RET process has not been fully embraced for political, societal, and cultural reasons. To promote the share of RE in the energy sector, governments offer various forms of financial assistance, incentives, and tax exemptions. To achieve a successful RET, these incentives must be provided for a definite period to allay investors' concerns.

While successful incentives have been discussed extensively in the literature (see, e.g., Abdmouleh et al., 2015; Lipp, 2007; Schiffer and Trüby, 2018), RE investment support measures are not analyzed according to the unique characteristics of different geographical regions (Pitelis et al., 2020). In addition, the failure of support measures has also not been discussed in the literature in further detail with the aim of analyzing the root cause(s) of these failures (Polzin, 2017; Sheikhhoseini et al., 2018).

Policy design plays a significant role in achieving a clean energy future. Policies designed to increase RE use by providing financial benefits, such as FiTs, NM, and subsidies, are termed "demand-pull policies". In contrast, policies intended to develop a business environment are called "supply-push policies"; these include R&D support, corporate tax reductions, and the availability of loans to establish the required infrastructure. There is a lack of studies investigating hybrid policies that incorporate both demand-pull and supply-push policies in the literature. Several risks and uncertainties are arising during the implementation of policies. Designing incentives to aid the RET needs to incorporate the uncertainties and risks associated with RE, which, if not measured, will lead to the failure of incentives. Only a few studies offer a comparison between successful incentives within a region, and even fewer studies do so in a cross-regional manner.

Table 2
IOCs and their renewable business investments (Pickl, 2019).

IOC Name	*Renewable Strategies/Company Acquired*	*Investment for Renewable Strategies/ Company Acquirement*	*Year*	*Overall RE Investment*
Royal Dutch Shell	First Utility, UK-based Consumer Electricity and Gas Supplier (Murray, 2020)	Acquired with 100% renewable electricity supply	2017	$1-2 billion/year (Wood Mackenzie, 2018)
	NewMotion, Europe's Largest Electric Vehicle Charging Company (Murray, 2020)	Acquired	2017	
	Silicon Ranch, US-based Solar Developer (Murray, 2020)	44% stake for $200 million	2018	
	British Solar Renewables, The Largest Solar Farm in England (Pickl, 2019)	Long-term power purchase agreement	2018	
	Husk Power Systems, India (Greentechmedia, 2018)	$20 million equity investment	2018	
ExxonMobil	Biofuels (ExxonMobil, 2020a)	Agreement with Global clean energy holding for renewable diesel starting 2022	2020	–
	Carbon Capture and Storage (ExxonMobil, 2020b)	ExxonMobil and Global Thermostat, development agreement for capturing carbon from industrial sources.	2020	
Chevron	Carbon Capture and Storage	The Quest CCS Project in the Canadian Oil Sands, which can store more than one million metric tons of carbon dioxide (CO_2) each year (Chevron, 2015).	2015	Small investments in solar and wind only in the US. Also announced a $100 million investment in technologies that reduce carbon emissions (Chevron, 2018).
		The Gorgon Project in Australia (Chevron, 2019)	2019	
Total	SunPower, US-based Solar Company (Total, 2019a)	60% stake for $1.4 billion	2011	$500 million/year (Murray, 2020)
	Saft, French Battery Manufacturer (Pickl, 2019)	Purchased for $1.1 billion	2016	
	Lampiris, Belgian Green Power Utility (Pickl, 2019)	Purchased for $224 million	2016	
	Eren, French Renewable Company (Total, 2017)	23% stake for $286 million	2017	
	GreenFlex, French Energy Efficiency Leader (Total, 2019a)	Purchased	2017	
	Converted La Mede Refinery in Biorefinery (Total, 2019b) Announced 2015 and operation started 2019	€275 million capital expenditure	2015	
	Direct Energies, French Electricity Retailer (Wood Mackenzie, 2018)	Acquired 74% stake for $1.7 billion	2018	
	Clean Energy Fuel Corps (Pickl, 2019)	Acquired 25% stake for $83.4 million	2018	
	As Venture Capital (Total, 2019c)	$400 million in innovative startups	2019	
BP	Lightsource, Europe's Largest Solar Power Project Developer (Murray, 2020)	43% stake for $200 million	2017	Committed $500 million in 2019 with a target to increase $5 billion/year by 2030
	StoreDot, Rapid Charging of Batteries (Murray, 2020)	Invested $20 million	2018	
	FreeWire, US Company for Developing Fast-charging Infrastructure for Electric Vehicles (Murray, 2020)	Invested $5 million	2018	
	Chargemaster, UK's Top Network of Charging Points for Electric Vehicles (Murray, 2020)	Bought for $160 million	2018	
	BP Ventures, As Venture Capital (Pickl, 2019)	Invested $300 million in 40 innovative startups since 2006	2006	
	Green Growth Equity Fund, India (BP, 2020)	$70 million investment	2020	
Eni	Conversion of Traditional Refinery into Biorefinery (Murray, 2020)	–	2014	Investing up to $1 billion through the Oil and Gas Climate Initiative (OGCI) (Eni, 2020)
	Working with X-Elio in Spain and Falck Renewables in the USA (Eni, 2021)	–	2021	
PetroBras	Agreement with Total for Assessment for Solar and Wind Potential in Brazil (Pickl, 2019)	–	2018	–

(*continued on next page*)

Table 2 (*continued*).

IOC Name	*Renewable Strategies/Company Acquired*	*Investment for Renewable Strategies/ Company Acquirement*	*Year*	*Overall RE Investment*
Equinor (previously Statoil)	World's First Floating Offshore Windmill Installed in Norway (Equinor, 2017)	–	2017	Planning to invest 15%–20% of Capital Expenditure (CAPEX) by 2030.
	Apodi Solar, 162 MW Solar Power Plant (Wood Mackenzie, 2018)	40% stake with partner Scatec	2018	
	Danske Commodities (Equinor, 2019)	Bought for €400 million	2019	
	Offshore Wind Projects Investment (Wood Mackenzie, 2018)	50% stake in Poland for wind projects	2019	
	As Venture Capital (Equinor, 2018)	$200 million committed for renewables	2018	

Moreover, there is a need to create a stream of literature focusing on private financing for clean energy projects. Mobilizing private financing refers to retail and commercial banks, investment and insurance companies, and other private lenders for investment in the RE sector via soft loans, i.e., interest-free loans or loans with low-interest rates and long repayment periods. Other ways to bridge the gap in financing and involve the community in the RET are energy cooperatives and crowdfunding for energy projects. Cooperative models for the RE are currently not as common as other cooperatives, such as housing, credit, and consumer cooperatives (Wierling et al., 2018). Crowdfunding is a similar option to involve citizens in the RET (Oji et al., 2016). Gradually increasing the participation of households can also help in stimulating the RET, although households typically avoid clean energy usage options due to the cost of the transition (Khan et al., 2019).

At present, academic research relating to the RET is mainly focused on technological development. A widening of the scope of research is needed to include areas such as exploring potential RET financing methodologies and effective management strategies for cleaner energy production (Elie et al., 2020).

In general, although it has been recognized that there will be a fall in overall investment in the energy sector after the COVID-19 pandemic, renewable investments have emerged as more resilient than conventional fuel investments. Investment in RE comes with risk-mitigating measures for the investors, such as power purchase agreements and guaranteed access to the grid; therefore, these investments are expected to grow at a substantial rate even after the pandemic.

8. Conclusion

This study reviewed the factors affecting the renewable energy transition (RET), outlined the current status of RE, and discussed the barriers to the take up of RE as faced by individuals, corporations, and government-linked institutions. This study also highlighted the importance of the participation of stakeholders in policymaking, offering alternatives to carbon taxation, and global grid connectivity to achieving the RET.

Financing has been a major hurdle in realizing the RET. While several policies and strategies have been developed, there remains a gap that needs to be addressed with swifter action. This financing gap can be reduced by involving financial institutions in providing support to the public willing to invest in RE in the form of e.g., soft loans or the creation, and facilitation of crowdfunding and crowdsourcing platforms. In this regard, the role played by international oil companies and tech companies such as Amazon will continue to influence the pace of the RET.

While targeted incentives and strategies have proven to be constructive in encouraging the implementation of RE projects, the optimal design of incentives aimed at individuals, companies and governments, in a way that accounts for all the externalities relating to RE, is key for a successful RET. The lack of public awareness about the benefits of RE and misconceptions relating to the associated installment and operating costs have contributed to the reluctance of individual and corporate investors and consumers of energy to make this shift. Hence, awareness of different aspects of RE technologies and their use should be at the forefront of all energy policies to encourage investment in RE for a cleaner future.

In the past year, there has been less consumption of fossil fuels due to the COVID-19 pandemic, and lockdowns across the world have led to plummeting oil and gas prices. With countries starting to open, it is crucial that the necessary actions are taken to ensure that the paradigm shifts to RE are not reversed.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Abdmouleh, Z., Alammari, R.A.M., Gastli, A., 2015. Review of policies encouraging renewable energy integration & best practices. Renew. Sustain. Energy Rev. 45, 249–262. http://dx.doi.org/10.1016/j.rser.2015.01.035.

Aghahosseini, A., Bogdanov, D., Breyer, C., 2016. The MENA super grid towards 100% renewable energy power supply by 2030. In: 11th Int. Energy Conf.

Ajadi, T., Boyle, R., Strahan, D., Kimmel, M., Collins, B., Cheung, A., Becker, L., 2019. Global Trends in Renewable Energy. UN Environ. Program. Frankfurt Sch.

Al Arrouqi, R.A., Ellabban, O., Rasheed, M.B., Al-Fagih, L., 2019. An assessment of different electricity tariffs on residential photovoltaic system profitability: Australian case study. In: 2019 2nd International Conference on Smart Grid and Renewable Energy. SGRE, IEEE, pp. 1–6. http://dx.doi.org/10.1109/SGRE46976.2019.9021078.

Al-Badi, A., AlMubarak, I., 2019. Growing energy demand in the GCC countries. Arab J. Basic Appl. Sci. 26, 488–496. http://dx.doi.org/10.1080/25765299.2019.1687396.

AL Shaqsi, A.Z., Sopian, K., Al-Hinai, A., 2020. Review of energy storage services, applications, limitations, and benefits. Energy Rep. 6 (7), 288–306. http://dx.doi.org/10.1016/j.egyr.2020.07.028.

Alarrouqi, R.A., Ellabban, O., Al-Fagih, L., 2020. An assessment of different load demands on photovoltaic plus battery storage system profitability: A case study of Australia. In: 2020 IEEE 29th International Symposium on Industrial Electronics. ISIE, IEEE, pp. 1497–1502. http://dx.doi.org/10.1109/ISIE45063.2020.9152221.

Alasseri, R., Rao, T.J., Sreekanth, K.J., 2020. Institution of incentive-based demand response programs and prospective policy assessments for a subsidized electricity market. Renew. Sustain. Energy Rev. 117, 109490. http://dx.doi.org/10.1016/j.rser.2019.109490.

Ali, H., Tahir, F., Atif, M., AB Baloch, A., 2018. Analysis of steam reforming of methane integrated with solar central receiver system. In: Qatar Foundation Annual Research Conference Proceedings Volume 2018 Issue 1. Hamad bin Khalifa University Press (HBKU Press), http://dx.doi.org/10.5339/qfarc.2018.EEPD969.

Alshehry, A.S., Belloumi, M., 2015. Energy consumption, carbon dioxide emissions and economic growth: The case of Saudi Arabia. Renew. Sustain. Energy Rev. 41, 237–247. http://dx.doi.org/10.1016/j.rser.2014.08.004.

Aquila, G., de, O. Pamplona, E., de Queiroz, A.R., Rotela Junior, P., Fonseca, M.N., 2017. An overview of incentive policies for the expansion of renewable energy generation in electricity power systems and the Brazilian experience. Renew. Sustain. Energy Rev. 70, 1090–1098. http://dx.doi.org/10.1016/j.rser.2016.12.013.

Bersalli, G., Menanteau, P., El-Methni, J., 2020. Renewable energy policy effectiveness: A panel data analysis across Europe and Latin America. Renew. Sustain. Energy Rev. 133, http://dx.doi.org/10.1016/j.rser.2020.110351.

Bointner, R., Pezzutto, S., Grilli, G., Sparber, W., 2016a. Financing innovations for the renewable energy transition in Europe. Energies 9, http://dx.doi.org/10.3390/en9120990.

Bointner, R., Pezzutto, S., Sparber, W., 2016b. Scenarios of public energy research and development expenditures: financing energy innovation in Europe. Wiley Interdiscip. Rev. Energy Environ. 5, 470–488. http://dx.doi.org/10.1002/wene.200.

Boldeanu, F., Constantinescu, L., 2015. The main determinants affecting economic growth. Bull. Transilv. Univ. Brasov. Econ. Sci. Ser. V 8, 329.

Bose, S., Dong, G., Simpson, A., 2019. Financing clean technology innovation and the transition to renewable energy. pp. 339–368. http://dx.doi.org/10.1007/978-3-030-05624-7_14.

BP, 2020. BP to Invest $70 Million in India's Green Growth Equity Fund [WWW Document]. BP, URL https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-to-invest-70-million-dollars-in-indias-green-growth-equity-fund.html. (Accessed 1 March 2021).

Brinkerink, M., Gallachóir, B., Deane, P., 2019. A comprehensive review on the benefits and challenges of global power grids and intercontinental interconnectors. Renew. Sustain. Energy Rev. 107, 274–287. http://dx.doi.org/10.1016/j.rser.2019.03.003.

Brook, B.W., Bradshaw, C.J.A.A., 2015. Key role for nuclear energy in global biodiversity conservation. Conserv. Biol. 29, 702–712. http://dx.doi.org/10.1111/cobi.12433.

Chatzivasileiadis, S., Ernst, D., Andersson, G., 2013. The global grid. Renew. Energy 57, 372–383. http://dx.doi.org/10.1016/j.renene.2013.01.032.

Chevron, 2015. Oil Sands: Unlocking Untapped Energy [WWW Document]. Chevron, URL https://www.chevron.com/stories/oil-sands. (Accessed 22 March 2021).

Chevron, 2018. Chevron Technology Ventures Launches Future Energy Fund [WWW Document]. Chevron, URL https://www.chevron.com/stories/chevron-technology-ventures-launches-future-energy-fund. (Accessed 21 January 2020).

Chevron, 2019. Gorgon Project Business Overview [WWW Document]. Chevron, URL https://www.chevron.com/projects/gorgon. (Accessed 22 March 2021).

Climate Investment Funds, 2018. Ouarzazate Solar Power Station [WWW Document]. CIF, URL https://www.climateinvestmentfunds.org/CIF10/morocco/ouarzazate. (Accessed 1 March 2021).

Coady, D., Parry, I., Le, N.-P., Shang, B., 2019. Global fossil fuel subsidies remain large: an update based on country-level estimates IMF working paper fiscal affairs department, IMF working papers.

Cornell, P., 2019. Energy Governance and China's Bid for Global Grid Integration [WWW Document]. Atl. Counc., URL https://www.atlanticcouncil.org/blogs/energysource/energy-governance-and-china-s-bid-for-global-grid-integration/. (Accessed 27 June 2020).

Curtin, J., McInerney, C., Ó Gallachóir, B., 2017. Financial incentives to mobilise local citizens as investors in low-carbon technologies: A systematic literature review. Renew. Sustain. Energy Rev. 75, 534–547. http://dx.doi.org/10.1016/j.rser.2016.11.020.

Davis, C., Bollinger, L.A., Dijkema, G.P.J., 2016. The state of the states. Renew. Sustain. Energy Rev. 60, 631–652. http://dx.doi.org/10.1016/j.rser.2016.01.097.

Dawson, J., 2015. The Different Uses of Energy in Our Daily Lives [WWW Document]. Renew. Energy World, URL https://www.renewableenergyworld.com/energy-efficiency/the-different-uses-of-energy-in-our-daily-lives/#gref. (Accessed 24 February 2021).

de Negri, J.F., Pezzutto, S., Gantioler, S., Moser, D., Sparber, W., 2020. A comprehensive analysis of public and private funding for photovoltaics research and development in the European Union, Norway, and Turkey. Energies 13, http://dx.doi.org/10.3390/en13112743.

DESERTEC Foundation, 2020. Energy for the next billion [WWW Document]. URL https://www.desertec.org/. (Accessed 24 April 2021).

Diesendorf, M., Elliston, B., 2018. The feasibility of 100% renewable electricity systems: A response to critics. Renew. Sustain. Energy Rev. 93, 318–330. http://dx.doi.org/10.1016/j.rser.2018.05.042.

EC4U, 2020. Life with No Electricity and Living Off the Grid - Could You Survive? [WWW Document]. Electr. Courses 4 You, URL https://www.electriciancourses4u.co.uk/useful-resources/life-with-no-electricity/. (Accessed 25 July 2020).

Eichhammer, W., Ragwitz, M., Schlomann, B., 2013. Financing instruments to promote energy efficiency and renewables in times of tight public budgets. Energy Environ. 24, 1–26. http://dx.doi.org/10.1260/0958-305X.24.1-2.1.

Elie, L., Granier, C., Rigot, S., 2020. The different types of renewable energy finance: A Bibliometric analysis. Energy Econ. 93, 104997. http://dx.doi.org/10.1016/j.eneco.2020.104997.

Enevoldsen, P., Sovacool, B.K., 2016. Examining the social acceptance of wind energy: Practical guidelines for onshore wind project development in France. Renew. Sustain. Energy Rev. 53, 178–184. http://dx.doi.org/10.1016/j.rser.2015.08.041.

Eni, 2020. Eni's International Partnerships [WWW Document]. Eni, URL https://www.eni.com/en_IT/sustainability/decarbonization/climate-strategy/international-partnership.page. (Accessed 21 January 2020).

Eni, 2021. Renewable Energies [WWW Document]. Eni, URL https://www.eni.com/en-IT/operations/renewable-energy.html. (Accessed 1 March 2021).

Equinor, 2017. Floating Offshore Wind in Equinor [WWW Document]. Equinor, URL https://www.equinor.com/en/what-we-do/floating-wind.html. (Accessed 8 March 2021).

Equinor, 2018. Equinor Energy Ventures - Attractive Partner for Growth Companies [WWW Document]. Equinor, URL https://www.equinor.com/en/what-we-do/new-energy-solutions/equinor-energy-ventures.html. (Accessed 21 January 2020).

Equinor, 2019. Equinor Completes Acquisition of Danske Commodities [WWW Document]. URL https://www.equinor.com/en/news/2019-02-01-danske-commodities.html. (Accessed 22 March 2021).

Erickson, P., Down, A., Lazarus, M., Koplow, D., 2017. Effect of subsidies to fossil fuel companies on United States crude oil production. Nat. Energy 2, 891–898. http://dx.doi.org/10.1038/s41560-017-0009-8.

ExxonMobil, 2020a. ExxonMobil and Global Clean Energy Holdings Sign Agreement for Renewable Diesel [WWW Document]. ExxonMobil, URL https://corporate.exxonmobil.com/News/Newsroom/News-releases/2020/0811_ExxonMobil-and-Global-Clean-Energy-Holdings-sign-agreement-for-renewable-diesel. (Accessed 1 March 2021).

ExxonMobil, 2020b. ExxonMobil Expands Agreement with Global Themostat Sees Promise in Direct Air Technology [WWW Document]. ExxonMobil, URL https://corporate.exxonmobil.com/News/Newsroom/News-releases/2020/0921_ExxonMobil-expands-agreement-with-Global-Thermostat-re-direct-air-capture-technology. (Accessed 22 March 2021).

Fachrizal, R., Shepero, M., van der Meer, D., Munkhammar, J., Widén, J., 2020. Smart charging of electric vehicles considering photovoltaic power production and electricity consumption: A review. eTransportation 4, http://dx.doi.org/10.1016/j.etran.2020.100056.

Fernandes, G., Perobelli, F.F.C., Brandaõ, L.E.T., 2016. A model for valuing new technologies under a pull incentives environment. Renew. Sustain. Energy Rev. 59, 482–493. http://dx.doi.org/10.1016/j.rser.2016.01.007.

Funke, F., Mattauch, L., 2018. Why is carbon pricing in some countries more successful than in others? - Our World in Data [WWW Document]. URL https://ourworldindata.org/carbon-pricing-popular. (Accessed 21 October 19).

Gallo, A.B., Simões-Moreira, J.R., Costa, H.K.M.M., Santos, M.M., Moutinho dos Santos, E., 2016. Energy storage in the energy transition context: A technology review. Renew. Sustain. Energy Rev. 65, 800–822. http://dx.doi.org/10.1016/j.rser.2016.07.028.

Geels, F.W., Kern, F., Fuchs, G., Hinderer, N., Kungl, G., Mylan, J., Neukirch, M., Wassermann, S., 2016. The enactment of socio-technical transition pathways: A reformulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990–2014). Res. Policy 45, 896–913. http://dx.doi.org/10.1016/j.respol.2016.01.015.

Geels, F.W., Sovacool, B.K., Schwanen, T., Sorrell, S., 2017. The socio-technical dynamics of low-carbon transitions. Joule 1, 463–479. http://dx.doi.org/10.1016/j.joule.2017.09.018.

GEIDCO, 2016. Global energy interconnection development and cooperation organization [WWW Document]. URL https://en.geidco.org.cn. (Accessed 26 June 2020).

Gerdes, J., 2018. Enlisting Abandoned Oil and Gas Wells As Electron Reserves | Greentech Media [WWW Document]. Green Tech Media, URL https://www.greentechmedia.com/articles/read/enlisting-abandoned-oil-and-gas-wells-as-electron-reserves. (Accessed 12 November 2019).

Greentechmedia, 2018. Shell Technology Ventures Leads $20 Million Investment in Minigrid Specialist Husk | Greentech Media [WWW Document]. Greentechmedia, URL https://www.greentechmedia.com/articles/read/shell-ventures-leads-20-million-investment-in-minigrid-specialist-husk. (Accessed 21 January 2020).

Groobey, C., Faber, M., Klaus, M., 2012. Project finance for renewable energy and clean technology projects.

Hall, S., Foxon, T.J., Bolton, R., 2017. Investing in low-carbon transitions: energy finance as an adaptive market. Clim. Policy 17, 280–298. http://dx.doi.org/10.1080/14693062.2015.1094731.

Hamed, T.A., Bressler, L., 2019. Energy security in Israel and Jordan: The role of renewable energy sources. Renew. Energy 135, 378–389. http://dx.doi.org/10.1016/j.renene.2018.12.036.

Hardman, S., Chandan, A., Tal, G., Turrentine, T., 2017. The effectiveness of financial purchase incentives for battery electric vehicles – A review of the evidence. Renew. Sustain. Energy Rev. 80, 1100–1111. http://dx.doi.org/10.1016/j.rser.2017.05.255.

Harjanne, A., Korhonen, J.M., 2019. Abandoning the concept of renewable energy. Energy Policy 127, 330–340. http://dx.doi.org/10.1016/j.enpol.2018.12.029.

Hartmann, J., Inkpen, A.C., Ramaswamy, K., 2020. Different shades of green: Global oil and gas companies and renewable energy. J. Int. Bus. Stud. http://dx.doi.org/10.1057/s41267-020-00326-w.

Hayer, S., 2017. Fossil fuel subsidies.

He, D.-X., 2016. Coping with climate change and China's wind energy sustainable development. Adv. Clim. Change Res. 7, 3–9. http://dx.doi.org/10.1016/j.accre.2016.06.003.

Heard, B.P., Brook, B.W., Wigley, T.M.L.L., Bradshaw, C.J.A.A., 2017. Burden of proof: A comprehensive review of the feasibility of 100% renewable-electricity systems. Renew. Sustain. Energy Rev. 76, 1122–1133. http://dx.doi.org/10.1016/j.rser.2017.03.114.

Heiligtag, S., Kleine, J.F., Schlosser, A., 2019. Fueling the Energy Transition: Opportunities for Financial Institutions. McKinsey & Company.

Howarth, N., Galeotti, M., Lanza, A., Dubey, K., 2017. Economic development and energy consumption in the GCC: an international sectoral analysis. Energy Trans. 1, 1–19. http://dx.doi.org/10.1007/s41825-017-0006-3.

IEA, 2017. Energy technology perspectives 2017.

IEA, 2018. Population Without Access to Electricity Falls below 1 Billion [WWW Document]. IEA, URL https://www.iea.org/commentaries/population-without-access-to-electricity-falls-below-1-billion. (Accessed 28 June 2020).

IEA, 2020. Energy Subsidies Tracking the Impact of Fossil-Fuel Subsidies [WWW Document]. Int. Energy Agency, Paris, URL https://www.iea.org/topics/energy-subsidies. (Accessed 5 June 2020).

IER, 2018. Global Fossil Fuel Consumption Subsidies [WWW Document]. Inst. Energy Res, URL https://www.instituteforenergyresearch.org/fossil-fuels/global-fossil-fuel-consumption-subsidies-abound-not-united-states/. (Accessed 6 June 2020).

Imteyaz, B., Lawal, D.U., Tahir, F., Rehman, S., 2021. Prospects of large-scale photovoltaic based power plants in the Kingdom of Saudi Arabia. Eng. Rep. http://dx.doi.org/10.1002/eng2.12398.

Imteyaz, B., Qadir, S.A., Tahir, F., 2020. Prospects of CO_2 utilization after carbon capture process. In: 12th International Exergy, Energy and Environment Symposium. IEEES-12. Doha, Qatar.

Imteyaz, B., Tahir, F., 2019. Thermodynamic analysis of premixed and non-premixed oxy-methane combustion cycle with membrane assisted oxygen separation. In: 8th Global Conference on Global Warming. GCGW. Doha, Qatar. p. 33.

Inspire, 2017. Top 10 clean energy myths & facts: The truth about alternative energy [WWW Document]. URL https://www.inspirecleanenergy.com/blog/clean-power/3-clean-energy-myths. (Accessed 5 October 2020).

IRENA, 2019a. Renewable Power Generation Costs in 2019 [WWW Document]. Int. Renew. Energy Agency, URL https://www.irena.org/publications/2020/Jun/Renewable-Power-Costs-in-2019. (Accessed 13 September 2020).

IRENA, 2019b. Renewable capacity statistics 2019. In: Int. Renew. Energy Agency. IRENA. Abu Dhabi.

IRENA, 2020. Renewable energy installed capacity 2019 [WWW Document]. URL https://www.irena.org/. (Accessed 5 June 2020).

ITM, 2020. Tunisia - Power Systems and Renewable Energy [WWW Document]. Int. Trade Adm., URL https://www.trade.gov/country-commercial-guides/tunisia. (Accessed 1 March 2021).

Johansson, B., 2013. Security aspects of future renewable energy systems-A short overview. Energy 61, 598–605. http://dx.doi.org/10.1016/j.energy.2013.09.023.

Kammen, D.M., 2006. The rise of renewable energy. Sci. Am. 295, 84–93. http://dx.doi.org/10.2307/26068966.

Khan, T., Khanam, S.N., Rahman, M.H., Rahman, S.M., 2019. Determinants of microfinance facility for installing solar home system (SHS)in rural Bangladesh. Energy Policy 132, 299–308. http://dx.doi.org/10.1016/j.enpol.2019.05.047.

Kivimaa, P., Kern, F., 2016. Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions. Res. Policy 45, 205–217. http://dx.doi.org/10.1016/j.respol.2015.09.008.

Klenert, D., Mattauch, L., Combet, E., Edenhofer, O., Hepburn, C., Rafaty, R., Stern, N., 2018. Making carbon pricing work for citizens. Nat. Clim. Change 8, 669–677. http://dx.doi.org/10.1038/s41558-018-0201-2.

Köhler, J., Geels, F.W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., Alkemade, F., Avelino, F., Bergek, A., Boons, F., Fünfschilling, L., Hess, D., Holtz, G., Hyysalo, S., Jenkins, K., Kivimaa, P., Martiskainen, M., McMeekin, A., Mühlemeier, M.S., Nykvist, B., Pel, B., Raven, R., Rohracher, H., Sandén, B., Schot, J., Sovacool, B., Turnheim, B., Welch, D., Wells, P., 2019. An agenda for sustainability transitions research: State of the art and future directions. Environ. Innov. Soc. Transit. 31, 1–32. http://dx.doi.org/10.1016/j.eist.2019.01.004.

Kowalska-Pyzalska, A., 2018. What makes consumers adopt to innovative energy services in the energy market? A review of incentives and barriers. Renew. Sustain. Energy Rev. 82, 3570–3581. http://dx.doi.org/10.1016/j.rser.2017.10.103.

Kraemer, S., 2019. Could China's Global Grid Idea Help Grow CSP? [WWW Document]. SolarPACES, URL https://www.solarpaces.org/could-chinas-global-grid-idea-help-grow-csp/. (Accessed 26 June 2020).

Krupa, J., Poudineh, R., Harvey, L.D.D., 2019. Renewable electricity finance in the resource-rich countries of the Middle East and North Africa: A case study on the Gulf Cooperation Council. Energy 166, 1047–1062. http://dx.doi.org/10.1016/j.energy.2018.10.106.

Li, H.X., Edwards, D.J., Hosseini, M.R., Costin, G.P., 2020. A review on renewable energy transition in Australia: An updated depiction. J. Clean. Prod. 242, 118475. http://dx.doi.org/10.1016/j.jclepro.2019.118475.

Lipp, J., 2007. Lessons for effective renewable electricity policy from Denmark, Germany and the United Kingdom. Energy Policy 35, 5481–5495. http://dx.doi.org/10.1016/j.enpol.2007.05.015.

Malik, K., Rahman, S.M., Khondaker, A.N., Abubakar, I.R., Aina, Y.A., Hasan, M.A., 2019. Renewable energy utilization to promote sustainability in GCC countries: policies, drivers, and barriers. Environ. Sci. Pollut. Res. 26, 20798–20814. http://dx.doi.org/10.1007/s11356-019-05337-1.

Matsumura, W., Adam, Z., 2019. Fossil Fuel Consumption Subsidies Bounced Back Strongly in 2018 – Analysis - IEA [WWW Document]. IEA, URL https://www.iea.org/commentaries/fossil-fuel-consumption-subsidies-bounced-back-strongly-in-2018. (Accessed 21 July 2020).

McCrone, A., Moslener, U., D'Estais, F., Grüning, C., Emmerich, M., 2020. Global Trends in Renewable Energy Investment 2020 – [WWW Document]. UN Environ. Program. Frankfurt Sch., URL https://www.fs-unep-centre.org/global-trends-in-renewable-energy-investment-2020/#main. (Accessed 24 July 2020).

Melović, B., Ćirović, D., 2020. Analysis of financial incentives as an instrument of renewable energy sources management in Montenegro. In: E3S Web Conf. p. 157. http://dx.doi.org/10.1051/e3sconf/202015704001.

MEM, 2018. Renewable Energies [WWW Document]. Minist. Energy, Mines Environmnet, Kingdom Morroco, URL https://www.mem.gov.ma/en/Pages/secteur.aspx?e=2. (Accessed 1 March 2021).

Mihaylov, M., Rădulescu, R., Razo-Zapata, I., Jurado, S., Arco, L., Avellana, N., Nowé, A., 2019. Comparing stakeholder incentives across state-of-the-art renewable support mechanisms. Renew. Energy 131, 689–699. http://dx.doi.org/10.1016/j.renene.2018.07.069.

Muller-Steinhagen, H., Trieb, F., 2006. Sustainable electricity and water for europe, middle east and north africa. http://dx.doi.org/10.1615/ichmt.2009.conv.100.

Murray, J., 2020. How the 6 Major Oil Companies Have Invested in Renewable Energy Projects [WWW Document]. NS Energy, URL https://www.nsenergybusiness.com/features/oil-companies-renewable-energy/. (Accessed 1 March 2021).

Nord Stream, 2005. The pipeline - nord stream AG [www document]. URL https://www.nord-stream.com/the-project/pipeline/. (Accessed 26 June 2020).

OECD/IEA, 2018. World Energy Outlook 2018: Electricity. IEA Publications.

Oji, C., Soumonni, O., Ojah, K., 2016. Financing renewable energy projects for sustainable economic development in africa. Energy Procedia 93, 113–119. http://dx.doi.org/10.1016/j.egypro.2016.07.158.

Opiah, A., 2020. Google Vs Microsoft Vs Apple Vs Facebook. The Race to Be 100% Green [WWW Document]. BroadGroup, URL https://www.broad-group.com/data/news/documents/b1m08w5r19jtlg. (Accessed 24 July 2020).

Ou, Y., Shi, W., Smith, S.J., Ledna, C.M., West, J.J., Nolte, C.G., Loughlin, D.H., 2018. Estimating environmental co-benefits of U.S. low-carbon pathways using an integrated assessment model with state-level resolution. Appl. Energy 216, 482–493. http://dx.doi.org/10.1016/j.apenergy.2018.02.122.

Özdemir, Ö., Hobbs, B.F., Van Hout, M., Koutstaal, P., 2019. Capacity vs energy subsidies for renewables: Benefits and costs for the 2030 EU power market.

Panwar, N.L., Kaushik, S.C., Kothari, S., 2011. Role of renewable energy sources in environmental protection: A review. Renew. Sustain. Energy Rev. 15, 1513–1524. http://dx.doi.org/10.1016/j.rser.2010.11.037.

Parra, D., Swierczynski, M., Stroe, D.I., Norman, S.A., Abdon, A., Worlitschek, J., O'Doherty, T., Rodrigues, L., Gillott, M., Zhang, X., Bauer, C., Patel, M.K., 2017. An interdisciplinary review of energy storage for communities: Challenges and perspectives. Renew. Sustain. Energy Rev. 79, 730–749. http://dx.doi.org/10.1016/j.rser.2017.05.003.

Perlaviciute, G., Steg, L., 2014. Contextual and psychological factors shaping evaluations and acceptability of energy alternatives: Integrated review and research agenda. Renew. Sustain. Energy Rev. 35, 361–381. http://dx.doi.org/10.1016/j.rser.2014.04.003.

Pickl, M.J., 2019. The renewable energy strategies of oil majors – From oil to energy? Energy Strateg. Rev. 26, 100370. http://dx.doi.org/10.1016/j.esr.2019.100370.

Pickl, M.J., 2021. The trilemma of oil companies. Extr. Ind. Soc. http://dx.doi.org/10.1016/j.exis.2021.01.003.

Pilz, M., Al-Fagih, L., 2019. Selfish energy sharing in prosumer communities: A demand-side management concept. In: 2019 IEEE International Conference on Communications, Control, and Computing Technologies for Smart Grids. SmartGridComm, pp. 1–6. http://dx.doi.org/10.1109/SmartGridComm.2019.8909791.

Pilz, M., Al-Fagih, L., 2020. A dynamic game approach for demand-side management: Scheduling energy storage with forecasting errors. Dyn. Games Appl. 10, 897–929. http://dx.doi.org/10.1007/s13235-019-00309-z.

Pilz, M., Ellabban, O., Al-Fagih, L., 2019. On optimal battery sizing for households participating in demand-side management schemes. Energies 12, 3419. http://dx.doi.org/10.3390/en12183419.

Pilz, M., Nebel, J.-C., Ai-Fagih, L., 2018. A practical approach to energy scheduling: A game worth playing? In: 2018 IEEE PES Innovative Smart Grid Technologies Conference Europe. ISGT-Europe, IEEE, pp. 1–6. http://dx.doi.org/10.1109/ISGTEurope.2018.8571522.

Pitelis, A., Vasilakos, N., Chalvatzis, K., 2020. Fostering innovation in renewable energy technologies: Choice of policy instruments and effectiveness. Renew. Energy 151, 1163–1172. http://dx.doi.org/10.1016/j.renene.2019.11.100.

Polzin, F., 2017. Mobilizing private finance for low-carbon innovation – A systematic review of barriers and solutions. Renew. Sustain. Energy Rev. 77, 525–535. http://dx.doi.org/10.1016/j.rser.2017.04.007.

Polzin, F., Egli, F., Steffen, B., Schmidt, T.S., 2019. How do policies mobilize private finance for renewable energy?—A systematic review with an investor perspective. Appl. Energy 236, 1249–1268. http://dx.doi.org/10.1016/j.apenergy.2018.11.098.

Punda, L., Capuder, T., Pandžić, H., Delimar, M., 2017. Integration of renewable energy sources in southeast Europe: A review of incentive mechanisms and feasibility of investments. Renew. Sustain. Energy Rev. 71, 77–88. http://dx.doi.org/10.1016/j.rser.2017.01.008.

Qadir, S.A., Tahir, F., Al-Fagih, L., 2020. Impact of fossil fuel subsidies on renewable energy sector. In: 12th International Exergy, Energy and Environment Symposium. IEEES-12. Doha, Qatar.

Rai, V., Funkhouser, E., Udwin, T., Livingston, D., 2015. Venture capital in clean energy innovation finance: Insights from the U.S. market during 2005–2014. SSRN Electron. J. http://dx.doi.org/10.2139/ssrn.2676216.

Salzman, A., 2020. How Renewable Energy Can Pay Off for Big Oil [WWW Document]. Barrons, URL https://www.barrons.com/articles/how-renewable-energy-can-pay-off-for-big-oil-51605632723. (Accessed 8 March 2021).

Sayigh, A., 2020. Solar and wind energy will supply more than 50% of world electricity by 2030. In: Green Buildings and Renewable Energy. Innovative. Springer, Cham, pp. 385–399. http://dx.doi.org/10.1007/978-3-030-30841-4_27.

Schiffer, H.-W., Trüby, J., 2018. A review of the german energy transition: taking stock, looking ahead, and drawing conclusions for the Middle East and North Africa. Energy Trans. 2, 1–14. http://dx.doi.org/10.1007/s41825-018-0010-2.

Schmidt, H., 2020. Quidnet Energy [WWW Document]. Quidnet Energy, URL https://www.quidnetenergy.com/. (Accessed 29 November 2020).

Sen, S., Ganguly, S., 2017. Opportunities, barriers and issues with renewable energy development – A discussion. Renew. Sustain. Energy Rev. 69, 1170–1181. http://dx.doi.org/10.1016/j.rser.2016.09.137.

Sgouridis, S., Abdullah, A., Griffiths, S., Saygin, D., Wagner, N., Gielen, D., Reinisch, H., McQueen, D., 2016. RE-mapping the UAE's energy transition: An economy-wide assessment of renewable energy options and their policy implications. Renew. Sustain. Energy Rev. 55, 1166–1180. http://dx.doi.org/10.1016/j.rser.2015.05.039.

Sheikhhoseini, M., Rashidinejad, M., Ameri, M., Abdollahi, A., 2018. Economic analysis of support policies for residential photovoltaic systems in Iran. Energy 165, 853–866. http://dx.doi.org/10.1016/j.energy.2018.08.217.

Sheng, C., Cao, Y., Xue, B., 2018. Residential energy sustainability in China and Germany: The impact of national energy policy system. Sustainability 10, http://dx.doi.org/10.3390/su10124535.

Smil, V., 2016. Energy transitions: Global and national perspectives [WWW Document]. URL https://publisher.abc-clio.com/9781440853258/. (Accessed 20 October 2019).

South Stream Transport B.V. [WWW Document], 2007. URL https://www.south-stream-transport.com/. (Accessed 26 June 2020).

State of Green, 2017. Wind Energy Moving Ahead - How wind energy has changed the Danish energy system.

Štreimikiene, D., Mikalauskiene, A., Atkočiūniene, Z., Mikalauskas, I., 2019. Renewable energy strategies of the Baltic states. Energy Environ. 30, 363–381. http://dx.doi.org/10.1177/0958305X18790961.

Taylor, B.Y.M., 2020. Energy Subsidies: Evolution in the Global Energy Transformation to 2050. International Renewable Energy Agency.

Taylor, D.D.J., Paiva, S., Slocum, A.H., 2017. An alternative to carbon taxes to finance renewable energy systems and offset hydrocarbon based greenhouse gas emissions. Sustain. Energy Technol. Assess. 19, 136–145. http://dx.doi.org/10.1016/j.seta.2017.01.003.

The Energy Council, 2020. Five Things Stopping Institutional Investors Putting more Capital Into Renewables [WWW Document]. Power Eng., URL https://www.power-eng.com/emissions/the-secret-sauce-five-things-stopping-institutional-investors-putting-more-capital-into-renewables/#gref. (Accessed 20 April 2021).

Total, 2017. Total Partners with EREN Renewable Energy to Expand its Renewable Business [WWW Document]. Total, URL https://www.total.com/en/media/news/press-releases/total-partners-eren-renewable-energy-expand-its-renewable-business. (Accessed 21 January 2020).

Total, 2019a. Total Expands its Energy Efficiency Business with the Acquisition of GreenFlex [WWW Document]. Total, URL https://www.total.com/en/media/news/press-releases/total-expands-its-energy-efficiency-business-with-the-acquisition-of-greenflex. (Accessed 21 January 2020).

Total, 2019b. Total Starts Up the la Mède Biorefinery [WWW Document]. Total, URL https://www.total.com/media/news/press-releases/total-starts-la-mede-biorefinery. (Accessed 1 March 2021).

Total, 2019c. Total Dedicates its $400 Million Global Venture Fund to Carbon Neutrality [WWW Document]. Total, URL https://www.total.com/media/news/press-releases/total-dedicates-its-400-million-global-venture-fund-carbon-neutrality. (Accessed 8 March 2021).

ul Abideen, M.Z., Ellabban, O., Refaat, S.S., Abu-Rub, H., Al-Fagih, L., 2019. A novel methodology to determine the maximum PV penetration in distribution networks. In: 2019 2nd International Conference on Smart Grid and Renewable Energy. SGRE, IEEE, pp. 1–6. http://dx.doi.org/10.1109/SGRE46976.2019.9020948.

UN Environment Programme, 2009. Montreal Protocol [WWW Document]. United Nations, URL https://www.unenvironment.org/ozonaction/who-we-are/about-montreal-protocol. (Accessed 2 June 2020).

UNESCAP, 2021. Shaping a sustainable energy future in Asia and the Pacific.

UNFCCC, 2012. Kyoto Protocol - Targets for the First Commitment Period [WWW Document]. United Nations, URL https://unfccc.int/process-and-meetings/the-kyoto-protocol/what-is-the-kyoto-protocol/kyoto-protocol-targets-for-the-first-commitment-period. (Accessed 4 June 2020).

Union of Concerned Scientists, 2017. Barriers to renewable energy technologies [WWW Document]. URL https://www.ucsusa.org/resources/barriers-renewable-energy-technologies. (Accessed 28 June 2020).

United Nations, 2015. COP 21 [WWW Document]. UNFCCC, URL https://unfccc.int/process-and-meetings/conferences/past-conferences/paris-climate-change-conference-november-2015/cop-21. (Accessed 5 October 2020).

Van Der Kroon, B., Brouwer, R., Van Beukering, P.J.H., 2013. The energy ladder: Theoretical myth or empirical truth? Results from a meta-analysis. Renew. Sustain. Energy Rev. 20, 504–513. http://dx.doi.org/10.1016/j.rser.2012.11.045.

Wierling, A., Schwanitz, V.J., Zeiß, J.P., Bout, C., Candelise, C., Gilcrease, W., Gregg, J.S., 2018. Statistical evidence on the role of energy cooperatives for the energy transition in European countries. Sustainability 10, 3339.

Wood Mackenzie, 2018. Majors' renewables project tracker.

Xiangchengzhen, M., Yilmaz, S., 2020. Renewable energy cooperation in Northeast Asia: Incentives, mechanisms and challenges. Energy Strateg. Rev. 29, http://dx.doi.org/10.1016/j.esr.2020.100468.

Yao, L., Yang, B., Cui, H., Zhuang, J., Ye, J., Xue, J., 2016. Challenges and progresses of energy storage technology and its application in power systems. J. Mod. Power Syst. Clean Energy 4, 519–528. http://dx.doi.org/10.1007/s40565-016-0248-x.

Yildiz, Ö., Rommel, J., Debor, S., Holstenkamp, L., Mey, F., Müller, J.R., Radtke, J., Rognli, J., 2015. Renewable energy cooperatives as gatekeepers or facilitators? Recent developments in Germany and a multidisciplinary research agenda. Energy Res. Soc. Sci. 6, 59–73. http://dx.doi.org/10.1016/j.erss.2014.12.001.

Yoo, T.H., Ko, W., Rhee, C.H., Park, J.K., 2017. The incentive announcement effect of demand response on market power mitigation in the electricity market. Renewable Sustainable Energy Rev. 76, 545–554. http://dx.doi.org/10.1016/j.rser.2017.03.035.

Zakaria, S.U., Basri, S., Kamarudin, S.K., Majid, N.A.A.A., 2019. Public awareness analysis on renewable energy in Malaysia. IOP Conf. Ser. Earth Environ. Sci. 268, http://dx.doi.org/10.1088/1755-1315/268/1/012105.

Zelt, O., Krüger, C., Blohm, M., Bohm, S., Far, S., 2019. Long-term electricity scenarios for the MENA region: Assessing the preferences of local stakeholders using multi-criteria analyses. Energies 12, http://dx.doi.org/10.3390/en12163046.

Zhang, D., Ji, Q., 2019. Energy finance: Frontiers and future development. Energy Econ. 83, 290–292. http://dx.doi.org/10.1016/j.eneco.2019.07.003.

Zhang, D., Mohsin, M., Khaliq, A., Chang, Y., Taghizadeh-hesary, F., 2021. Public spending and green economic growth in BRI region: Mediating role of green finance. Energy Policy 153, 112256. http://dx.doi.org/10.1016/j.enpol.2021.112256.

Zhao, Z.Y., Chen, Y.L., Chang, R.D., 2016. How to stimulate renewable energy power generation effectively? - China's incentive approaches and lessons. Renew. Energy 92, 147–156. http://dx.doi.org/10.1016/j.renene.2016.02.001.

Zhi, Q., Sun, H., Li, Y., Xu, Y., Su, J., 2014. China's solar photovoltaic policy: An analysis based on policy instruments. Appl. Energy 129, 308–319. http://dx.doi.org/10.1016/j.apenergy.2014.05.014.

Zhong, M., Bazilian, M.D., 2018. Contours of the energy transition: Investment by international oil and gas companies in renewable energy. Electr. J. 31, 82–91. http://dx.doi.org/10.1016/j.tej.2018.01.001.