Innovation in Energy Systems: Paradigms in Operation in Business and Development

Prof. Saad Darwish, Dr. Venus Bunagan

Abstract—The research on Innovation in Energy System: Paradigms in Operation in Business and Development discusses a few of the historical backgrounds of renewable energy. It also tackled the trends both global and local, the levels of energy consumption. It also discusses the types of renewable energies which are common and their competitiveness. The last parts of the research emphasizes the breakthroughs and opinions of the authors on renewable energies.

Keywords: Renewable energy, Innovation Paradigms in Business Operations and Development

1 INTRODUCTION

It is notable that the systems of the energy sector are experiencing continuous significant changes. The major trends are linked with the sustainability, the demand for the decentralized solutions, the growing renewable shares, the usage of the smart devices, the importance of the energy security and the energy efficiency. Due to the changes in the market environments, the large energy corporations require creative business activities and organizational solutions that will be achieved through the innovation and must meet the market trends. The challenges in this sense are tough regulation and a rigid institutional setting which may limit the opportunities. Moreover, the dominance of the traditional technologies will influence the organizational inertia and the path dependency suppressing organizational change. With the innovation in the energy systems like the introduction and implementation of the new technologies in the energy systems impose significant changes in its operations, businesses, protection and the development. The study exhibited that the demand of the energy systems in the world rise over time; it is required that development also be enhanced to meet the demands of the market. Many of the companies applying the advanced innovative technologies try to meet this demand. This shows that the development as well as the operations of the energy system changes and improvements with the help of the advanced innovative technologies will create new avenues for further development (Zavarkó, Zsolt, Sára, & Csedo, 2017). The power system of the past is analogue, mostly passive and unilateral. But with the advancement in the technology, the new power system is developed. These energy systems of the new age are digital, smart, and they incorporate communication to ensure better operations and involve the collaborative process of decision making. The studies show that over the century since the inception of the interconnected networks, the little changes are incurred that change the manner they are operated. In the energy system, many things like a method of demand-supply balance, the protection schemes, the business models and practices for the electric power corporations and the considerations of the future developments have changed recently after the innovation of the new technologies. The distributed generators, the electric vehicles and the storage devices become very widespread and they disrupted the century-old majority generation-majority transmission operation. The distribution networks are considered as no longer the passive networks and not contribute to the generation. It is seen that the old energy trading systems and the old billing systems cannot accommodate these changes, and they require the revision (Ustun, 2018). Furthermore, the bi-directional flow of the power is the unprecedented occurrence in the distribution networks, and the traditional protection systems. These require the systematic fix for the proper operations. Most of the distributed generators that exist in the world in the past centuries are based on the intermittent assets, and they might always not be capable of supplying the energy constantly and this enhances the need for the deterministic method of the demand-supply balance and considers the contribution of the probabilistic generation. The new technologies are improving the operations, the protection of the energy system and ensure the high protection. Further, it maintains the balance between the supply and demand that ensure no disturbance in the operations of the energy corporations (Üstun, 2018). The studies also show that the utilities and the energy corporations discover themselves in the inconsistent condition in which their past and traditional models of the business are losing the profitability. They must promote the energy efficiency in the world and promote the goals of the climate protection for ensuring their sustainable growth. For this, they have to encourage the consumers to save energy.

2 Energy Trends in 2019

The year 2019 promises an exciting year for clean technology. An increasing number of countries, companies, regions and businesses are embracing sustainable energy generation and the landscape is rapidly evolving. Research has found a number of emerging energy trends this 2019. It is worth mentioning the following:

- Prof. Saad is a Professor of Business Administration in Kingdom University-Bahrain
- Dr. Venus Bunagan is an Assistant Professor of Business Administration in Kingdom University
2.1 Energy Storage
Energy storage plays a key role in balancing power of supply and demand intermittently. A storage system paired with a renewable energy source ensures an even and efficient power supply during inclement weather conditions. The batteries used in renewable energy systems are increasing on both the residential and grid-wide scale. Energy storage technologies continuously improves, and is becoming more feasible and within your means of users. The future is embedded on the energy storage as the main component of all new energy technologies, considered both utility-scale, domestic energy storage solutions and allows better price competition in the markets.

2.2 Microgrids and Artificial Intelligence
Micro energy grids operate separately or when connected to a larger traditional grid. They provide independence, efficiency and protection during emergencies. The use of Artificial Intelligence (AI) allows continuous adaptation and improvement of operation.

XENDEE, a Technical Company partnered with Worley Parsons Group on the distribution of microgrids allow a new software design and turned key solutions in up to 90% less time and cost compared to the conventional methods. Microgrids are taking center stage from California to Palau Island in the Pacific aiming at building the largest microgrid, 35 MW of solar panels paired with 45 megawatt-hours of energy storage, the goal of global energy transition of 70% renewable energy by 2050.

2.3 Energy Blockchain And IoT
The market has now adapted the just digital ledger known as the Blockchain technology, that conducts and records transactions through a peer-to-peer network. The right applications allow devices to buy and sell energy at optimum times and in a real-time context and can monitor and analyze performance of energy-consuming devices. The Brooklyn Microgrid started its use for pioneering projects, where the owners buy and sell power from each other via blockchain technology. The success of the projects ensures implementation on a wider scale.

2.4 Grid Parity and Deteriorating Costs
Grid parity is an alternative energy that can generate power at a cost and performance level equal to or less than electricity generated from that of the conventional methods. Solar and wind have reached similarity in both price and performance in many regions, and new technologies gain competitive edge. The solar and wind are more effective and profitable than conventional sources. These could continuously improve their market price and performance.

2.5 Energy Assurances
Emission reduction is increasingly utilized aiming climate action plans of limiting the rise in global temperature. At least 70% of the energy production all over 100 cities worldwide use energy renewables operating on a 100% renewable electricity. Companies have pledged the goal of energy generation and more have pledged to work on renewables. Realizing an extensive access to energy addresses global development challenges. These challenges offer a solution to the problem of energy access in the market. Microgrids in communities are the most gainful way of delivering affordable and reliable power to those who demand for it. New energy technologies and commitments evolve the way to progress. International groups like the World Bank arranges an underpinning energy access to developing countries. With these improvement costs and performance metrics, increments of renewables, will be installed in places that have long been left in the dark.

3 Global energy trends and Consumption
Over a number of decades, both developed and developing countries – have established renewable energy targets. The European Union, in particular, has defined an ambitious goal of acquiring 20 percent of its energy needs from renewable sources by 2020. The United States too is focused on transforming from a carbon-intensive economy to an energy-based economy as the reality of global climate change approaches rapidly. (Jacob, W. Renewable Resources: The Impact of Green energy Into the Economy, Oct. 22, 2015).

The charts and statistics shown here are a glimpse of the trends of energy consumption and challenges.
corporations of the world are now looking at the ways for including the consumers in the decision-making process related to the operations through the schemes like the management of the demand side and the vehicle to support the grid (Chen, Yin, & Mei, 2018).

It is exciting to know that the intelligent devices and the other technologies are developed and are implemented for attaining a better optimization and production of the energy. The new start-up corporations appear each day with the advance technological implementation that not only just improve their operations and production of energy but also modify their business models and development that support them to attain high profits and growth within complex markets. It is observed that the energy system used in the traditional period are mostly passive, referent, and unilateral. However, with the advancement in the technology, the new modern energy systems are digital, keen and they incorporate the communication for ensuring the better operations and ensure the efficient collaboration in the process of the decision making. It ensures development, better operations, high growth of companies and also support them to meet the demand by improving their supply process (Chen, Yin, & Mei, 2018).

The studies reveal that the innovative systems play an important role for improvement in the energy supply. The innovative energy systems are a highly important determinant of the technological change that occurs in the world. As in the world, the demand for the energy enhances over the time, and the traditional systems prove not beneficial to meet this demand to ensure effective operations. In fact, the inception of the interconnected networks has introduced slight changes in the mode of operations. The traditional processes of the analysis of the innovation systems have been proved to be insufficient. In the energy system, many things like a method of demand-supply balance, the protection schemes, the business models and practices of the electric power corporations and the considerations of the future development have changed recently after the innovation of the new technologies. So, the sustainable development and implementation of the new technologies prove beneficial because they ensure the high development, operations, protection that ultimately ensure the improvement in the business profits and growth (Hekkert, Suurs, & Negro, 2007).

The new technologies help the businesses of the energy to know the future demands so that they will be able to plan their production and operations according to the demand for energy in the future. They use the informatics technologies that help them predict the future demand. The businesses become aware that the new technologies help them to reduce their operating costs and ensure their high profits. So, most of the energy corporations use this information in their operations and the production processes that reduce their waste and ensure their high-cost efficient process that ensure the businesses to improve their revenue stream along with meeting the rising demand of the energy in the market. Like many companies now using the wind and the solar technologies for generating the high volume of the energy at a

4 Energy Breakthroughs and Competitiveness
But recently, the energy informatics innovative approach introduces the promise to solve all these energy system issues, by ensuring the efficient future of the energy systems through this framework using the three forms of the technology; constitutes the intelligent system of energy management that are sensitized objects; flow networks and the sensor network ensure high efficiency in the system of energy supply/demand; and managing the other future energy systems that will appear future. This shows that the changes and introduction in the innovative technologies proves beneficial and made changes in the paradigm of the development, business and operations of the energy systems (Grosse, Send, & Schildhauer, 2019).

The studies also show that most of the distributed generators are the inverter-interfaced, as compared to the bulky rotating technologies or the machines that are used in the power networks. The inverters are centred on the power electronics, and they have varied behaviours under the disturbances like the frequency variation and the voltage swings. The rules of the operations like the droop control needed to be modified and updated to include the new generators generation. Moreover, to these changes of the technology in the energy system impose the significant impact on the business models, and the development of the energy systems and they made changes in the operations, business, protection and the development of the energy systems (Bettencourt, Trancik, & Kaur, 2013).

Some studies show that the system of the solar home, the rule of the stand-alone microgrids and the DC microgrids are flourished all over the global world using the innovative technology business models. The power and the energy
low cost. This ensures meeting the energy demand of the markets by attaining their high business growth and development. Therefore, the result of the study reveals that technological advancement changes the way the energy corporations produces the energy and also the way in which they operate their businesses. It shows that because of incorporating the modern technologies in the energy systems the companies attain high development (Teece, 2010).

The location of the business also plays an important role in the energy generation. The results of the study indicate that with the help of the advanced technologies, the businesses of the energy producers and distributors are able to select the best location for setting up their energy generation set-up. The various advanced technologies help them to produce the high volume of energy and the renewable energy that help them meet more market demand, improve their revenue stream and ensure the development of their business in the market (Yun & Lee, 2015).

As it is seen that in the modern world after the advancement in the smart cities trend, the need for the energy is enhanced. In this situation, the energy companies require to enhance their production capacity to ensure the competitive and sustainable growth in the market. They require the better and advanced energy systems for ensuring high growth. The adoption of the new renewable energy systems that many leading companies of the energy adopt prove much helpful for them because they help them to attain the balance between the supply and the demand of the energy and ensure high growth (Deakin & Al Waer, 2011).

The innovation in the distribution network of the electricity is an important component in a transition to the sustainable low-carbon system of energy. The nature of the distribution networks as the regulated monopolies referred to as the locus of an evolution of the protective place for the innovation. The companies because of the advancement in the technology become able to use the advanced research and development mechanism that ensure the changes in the energy system in terms of the business, development, operations and the protection (Lockwood, 2016).

The studies also show that the energy system is highly different on the bases of the technology and to the technology of one country to the other. As in the countries like USA and UK and the Nordic countries more efficient technologies exist that support them to improve the operations in the better manner and ensure good protection of the system that ensures better work conditions. Whereas in developing countries like Pakistan, the technologies are not advanced which affect the systems and shows low supply of the energy in the country (Borup, Andersen, Jacobsson, & Midttun, 2008).

The privatization and market-orientation increase the energy areas by innovation, which become more relevant to understand the dynamics of technology and change development in that area. The study explains complex and systemic processes resulting from innovation. The study presents an analysis of the innovation system of emerging and new technologies. It shows the technology areas which include hydrogen technology, energy-efficient end, biofuels and solar cells. The results show that technology areas are very diverse relevant to issues having connections between the market and the non-market aspects (Borup, Gregersen, & Gregersen, 2014).

The study is based on activities of energy innovation that explores a variety of the organization in public and the private sectors. The policymakers seek to transform the energy system that is driven through energy security, affordability and climate change. The analysis in the paper demonstrates the significant patterns of divergences in innovation, taking the measures to reinforce existing energy. All public sectors focus on energy technologies which support policy objectives and consistent with technological transitions. The energy gives essential smooth operations and the competitiveness of the modern economy. Innovation in energy tended to be incremental in last decades having small improvements in reductions and efficiency in a cost to the existing components of the system. A current system relies on assets the payback times by the industrial players (Rhodes, Skea, & Hannon, 2014).

The study introduces industrial tendencies and required new innovative models and smart technologies that are necessary. The regulatory and supportive legal framework compulsory for achieving goals, the current innovative technology of energy have smart grids, electric storage, demand response techniques, smart metering, energy efficiency, smart appliances and distributed generation. The study is based on new energy policies that reduce the increased ratio of the renewable sources, emission of CO2 and the strong efficiency of energy measures which accelerate technology changes. Implementation of advanced technologies enables customers to optimize and maintain energy costs with their consumption. The decarburization increased energy sources. The decarbonized system of electricity includes a good quantity of the installed capacity with dispatch able fleet and because of the technical constraints. The study shows that the business is increasing and automation technology operates to control and adjust devices (Swora, Szörényi, Benysek, & Esposti, 2016).

The innovation in the networks of electricity distribution has important elements in the transition to the sustainable system of low-carbon energy. The study represents that innovation is anticipated transportation or the electricity system, and it is increasing the scale of generation technologies of transport and heat, a possibility of the higher demand of the response. The business is changing its operations by using new technologies with energy systems. The networks regulate to monopolies that mean locus of evolution has protective space in innovation to regulate the creating space in the institutional change. The innovative processes are increasing the establishment of the businesses and changing the dimension of the energy system with the modern modes and attributes of the operation. The study has energy information and demand and supply approaches (Vasant, 2011).

It is observed from the literature that, with the help of the technologies, the companies of the energy get more data and
they harness a greater power of the computer, and by increasing the connectivity of the digital technologies with the data that they produce, they become able to generate the better and high capacity of the energy. So, the findings show that the innovation in the energy systems have a potential to transfer the way the energy is generated, consumed and transported. Their main benefit is that technology improves the energy systems that reduce the global emission of the greenhouse gases. Hence, it is right to state that with technologies, the energy system becomes efficient, and their negative causes on the climate change will be reduced and eliminated. Through the clean systems of the energy which depend on the sources of the low carbon energy and which are highly effective in the utilization of the energy improve the energy processes. The technologies of the modern world will improve the speed process of the energy sector and facilitates extracting the fossil fuel that ensures the high efficiency of the energy production to meet the demand and ensure high development (Sivaram, 2018).

The sustainable innovation in the energy systems is considered as the heart of resolving the numerous challenges that the world is facing. It is also referred to as the key for tapping the full energy potential as the contributor to the future prosperity and the growth. The technologies support the energy companies to attain the efficient energy systems that ensure the high development and future success. It is also seen that the innovation in the system of the energy is not happening in the widely and quickly enough, nor they are adequately aligned for addressing the persistent issues, exploiting the new technologies for improving the living standard and living practices of the citizens all over the world. It is observed from the literature and statistics facts that the global system of the energy is facing the shifts and the rise in demand each day that raises the urgent challenge for tackling the climate change and raises the need to expand the access of the energy. The study shows that the innovative energy systems require the more efficient and stronger push for delivering the broader range of the technologies to the market in the faster manner. It shows that these innovative systems of the energy that are derived from the technological advancement made the changes in the operations of the energy systems as they are created with more eco-friendly and reduced their negative impact on the climate. They made the operations work more efficiently and ensure the effective decisions that transform the future of the energy and impose the positive impact on the global prosperity (Salcher & Mehlum, 2018).

The market of the energy become competitive and the requirement of the environmental sustainability rise over the time. This requires the companies to improve their system of the energy. In this, the technologies play the main role. As the companies of the energy which uses the advanced technologies and change their systems effectively according to changes in the demand and the environment, their future is bright. These companies can attain high development and their business competitiveness and profitability also improves. The businesses use the technologies for developing their grids so that they will be able to accelerate more energy production and also ensure the low reduction of the carbon emission that effects the environment negatively. The renewable energy systems are also used more because of the technological changes. This proves more beneficial with respect to quality and quantity of energy production and with the cost-efficiency perspective. With the technological incorporation in the energy system operations, the open and the real-time and automated communications is possible; ensuring no issue in the operations of the energy system. As the innovative technologies monitor all the operations and track the issues on time that ensure the effective operations. So, the researchers prove that the advancement in the technologies made the innovative energy systems that support the acceleration in the integration of the grid, benefits the energy businesses as well as the society of the world through balancing between rising energy demands with raising the supply of the energy (Martin, Starace, & Tricore, 2017; Darwish et al, 2018).

The studies show that in the coming period the people in the globe will consume more amount of the energy as they consume today. Reliable and affordable energy is available in all the places of the world for the consumption of the people. This likewise results to an increase of energy demand. So, the rise in the consumption of the energy will pose the climate changes as the main concern, and requires the innovative systems to meet this demand and the climate change. This issue will eventually control the negative impact of the high consumption of the energy in the world. The innovation in the energy system is the need of the hour. This requires the businesses and the households to change their pattern of the consumption and requires the businesses to use clean energy. The technologies made it possible to store the energy like the batteries which are a good tool to store the energy. But it is an expensive way, so the better technologies of the energy storage need to be developed that are efficient and affordable. The artificial intelligence in the microgrids is the new advancement in technology. These serve as the energy savers and ensure the efficiency, independence and the protection of the energy during the period of contingencies (Vyas, 2019).

The study gives current reviews on the innovations and introduces the best practices regarding the energy servers. It gives the theoretical framework for the HI and summarizes theoretical contributions with policy implications. The innovative paradigm is very complex of total innovation, open innovation, strategic innovative and collaborative innovation. The study supports technological innovation in management and supports the implementation of innovation strategy. The energy system is improving by the new technologies and creating an important role in the development of the energy system. The technology innovation and the increasing energy consumption promote energy to achieve a reasonable system (JinChen, XimingYin, & LiangMei, 2018).

The Energy Information Technology Service (EITS) is the systemic perspective for innovation by comprising all the aspects of the energy transformation, including demand and supply in all stages of the technology development process. It also includes feedbacks, networks, innovation processes and actors. The analytical framework describes the drivers and
features of energy innovation. The ETIS is given by using the investment in the energy effective functioning. The study proves that energy technology is reducing the emission by recognizing the transition of sustainable and lower carbon. It also creates the demand to clean the strategic investment in development and research. An assessment of the ETIS has quantitatively or quantitatively approached. The study also has the empirical and literature discussion having data and information required for the technology innovation (Gallagher, Grubler, Kuhl, & Nemet, 2012)

Recently, energy systems also have incorporated communication system to ensure different operations involved in decision-making processes. The study explains the interconnected networks with changes in manners. As in energy system, the demand-supply method for the electricity have innovative technologies used for the development these days. It also promotes energy efficiency and sustains growth. It gives opportunities to the business to improve energy corporations related to traditional techniques. It also has technical problems, which include shortage and supply opportunities. This study also discusses the challenges and the opportunities of the demand-oriented policies which allows recommendations for increasing effectiveness (Boon & Edler, 2018).

The distribution of electric power needs proper operation, planning and the innovation in different ways for contending changing nature of electricity system, opportunities and resources. A distributing energy has a future to lead the changing needs and paradigms in innovation and planning through distribution utilities. A changing paradigm has local and balancing control of the distributor’s resources. The changes in the nature of customers and resources have different business models. In innovation and learning the changes need, which includes handling of two-way in interconnecting the electric and storage vehicles, changes the demand resources. The study shows the power system, which is evolving at the accelerating rates. Interaction of the electric vehicle and cooling and heating infrastructure with electric power represents different opportunities. The self-balancing usually occurs at the geographical level having a distribution system for the transmission network. DSO usually starts to balance and integrate the variable distributed controlled and flexible loads (Martinot, Kristov, & Erickson, 2015)

The development of the new technologies and the investment in the new infrastructure modernize the energy systems. The new distribution energy systems that include the high-efficiency wind generators, reciprocating engines, PV systems, fuel cells, energy storage system, micro-turbines, and the plug-in electric vehicles support in improvement of the reliable and the safe distribution of the energy resources. These advanced technologies help to address and resolve the issues that exist in the traditional energy systems that are of power quality, operating behaviour and the voltage limits. These new technologies ensure no jeopardy in the reliability and the safety of the energy systems and warrants high protection. The advancement in the technologies also results in the innovation of the new protective devices and the hardware’s that safeguards the continued energy systems reliability, protection and the operational efficiency, likewise guarantees the line voltages of the energy remain within limits throughout a day. The other advanced technologies like the local sensors, static intelligence and the electro-mechanical devices support the engineers of the energy systems to predict the loads. This improves the automation in the distribution of the energy and the performance of the systems. The technologies like fuses, relays and the breakers also ensure the protection of the energy systems. So, this shows that the smart technologies impose a significant positive impact on the effectiveness of the energy systems. These systems ensure high protection and operations of the energy system as they maintain the power quality, safety and the reliability that improve the operations and protection of the energy systems (U.S. Department of Energy, 2015)

The distributed ledgers and the blockchain are the emerging technologies that gain the high interest of the energy supply companies, start-ups, national government, financial institutions and the technology developer. The numerous studies show that the blockchain brings significant innovations and the benefits to the energy systems. By using the block-chain technology, the development, protection and the operations of the energy systems improve. With the help of the blockchain, the transparency and the security is attained that ensure the business growth (Andoni, et al., 2019)

The studies show that with the technological advancement, the energy systems are taking the drastic advances in the communication and the information. After technological advancement, the numerous innovative measurement devices are installed in the energy system that forms the distributed energy resources monitoring system, advanced metering infrastructure and the high frequency synchronized extensive area awareness systems. These systems with the great speed ensure generating the immense volume of the energy data that support in improving the features of the energy system for their better performance. The study indicates that the big data analytical tools support the designing of innovative energy systems. With the help of the big data analytical tools, the issues and the needs of the energy systems are identified and his help to improve the operations of the energy system, and as a result, the development and the high profits and growth is attained (Akhavan-Hejazi, Hamed, & Mohsenian-Rad, 2018)

5 Discussion and opinion

The studies show that the new innovations like the new technological development are required for the invention of the highly efficient, sustainable and an affordable energy system. Currently, the demand of the energy in the world increases. The improvements allow access to the energy, leading to enhancement of the peoples’ standards of living and likewise results to a rise in energy demand overtime. The fast-growing demands of energy enhancement and the need for a more innovative energy system that is efficient and capable of fulfilling the increasing needs, goes along with the consideration of the climate change challenges, as the new energy systems require to be efficient in the reduction of carbon emission. The technological advancement supports the
energy companies to make an efficient energy system that meet the rising production and supply-demand for energy resources and also ensure its eco-friendly operations (Strezov & Anawar, 2018).

The advanced technologies like the sensor systems, smart meters, efficient electric grids, storage devices, droop control systems, transmitters, awareness systems and the big data analytical tools etc. are considered as the innovation in the technologies that support the energy systems to work in the better manner. The technological advancement results in changing the operations, development, business and protection of the energy systems. They ensure the high energy and business protection. It ensures the efficient distribution system that helps to make a balance between the demand and supply and results in high development and business growth. With the technologies, the speed of production, supply, distribution and the maintenance improve thereby supporting the efficiency in the energy systems. From the technologies, the feedback is attained on content bases, and the communication is improved that ensure the protection and the operational efficiency of the energy system (Yu, et al., 2015).

Therefore, overall, from the review of the numerous past studies, it is revealed that the advancement in the technology changes the production, operations, protection, business and the development in the energy sector. It ensures the development of the innovative energy systems that ensure the balance between the supply and demand of the energy need in the global market. It also ensures the future development through enhancing the production capacity and the projection of the demand of the energy in the market. Through the incorporation of the innovative technologies in the energy systems, the businesses understand how they attain the high production efficiency and become able to predict the rising demand of the energy in the global world. With this, they make their future production, protection and operational strategies highly developed. It is also revealed that by using the technologies not only the operations and production of the energy systems improve but also the reduction in the cost and the carbon emission which concerns the ethical and social responsibilities of businesses, to their stakeholders, economic and the general environments. Overall, technologies support the development of innovative energy systems that ensure effective future of the world.

ACKNOWLEDGMENT
The authors wish to thank in deep appreciation the sources of information from which this research paper has based on. The document analyses from the sources made the research possible. Further, the authors which to thank Kingdom University who supports the publication of the manuscript in this journal.

REFERENCES


Websites:
[https://ourworldindata.org/renewable-energy](https://ourworldindata.org/renewable-energy)
[https://www.iea.org/statistics/?country=WORLD&year=2016&category=Renewables&indicator=RenewGenBySource&mode=chart&dataTable=RENEWABLES](https://www.iea.org/statistics/?country=WORLD&year=2016&category=Renewables&indicator=RenewGenBySource&mode=chart&dataTable=RENEWABLES)
[https://www.iea.org/statistics/?country=WORLD&year=2016&category=Renewables&indicator=SolarGen&mode=chart&dataTable=ELECTRICITYANDHEAT](https://www.iea.org/statistics/?country=WORLD&year=2016&category=Renewables&indicator=SolarGen&mode=chart&dataTable=ELECTRICITYANDHEAT)