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REVIEW

# Assessment of Renewable Energy Production Capacity of Asian Countries: A Review

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**Abstract:** Most Asian countries have the capacity of renewable energy, including solar, hydro, wind, etc. Asian countries are geographically placed in an area with various climatic circumstances including tropical, and humid. Hence, easy access is provided to various renewable energy sources. The energy policies have been initiated by Asian governments for encouraging individuals and industries for employing renewable energy powered systems in power applications. There are large potentials of sustainable energy sources in Asian countries. Nevertheless, owing to different challenges, they globally perform in renewable energy deployment. The present paper deals with a comprehensive and updated overview of the renewable energy status in the Asian countries along with the present installed renewable energy capacities. The energy setup and renewable energy made in Asian countries are briefly described in this paper. Studying the years 2000 to 2019 comprehensively, the results revealed that China, India and Japan had the most renewable energy capacity in Asia with 790000 MW, 133000 MW and 120000 MW in 2019 respectively. Also the energy produced by renewable energy for these countries in 2019 was 1739400 GWH, 288622 GWH and 190587 GWH respectively.

**Keywords:** Renewable energy, Asia, Energy production, Energy model

## 1. Introduction

Eighty percent of world energy consumption is oriented by fossil fuels as the pollution origin, which quicken global warming. Moreover, based on the climate changes, the present environment and energy equilibrium is not sustainable. Now, energy policies need to combine climate change strategies for saving the environment for living the people. This is crucially challenging for a single country as well as the world. Therefore, by unsustainable patterns of energy consumption and production in any countries, quality of life and human health are threatened while affecting ecosystems and contributing to climate changes. Here, a question is arisen that who will sustain or save our planet for the future generations? Who will pay for the appropriate maintenance of the planet? Will sustainable energy progresses be an engine for (un)sustainable future?

Over the last decades, the world has encountered a

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sharp increment in renewable energy (RE) capacity as a result of RE promotion, actions for making energy more secure against climate changes and a sharp reduction in costs of RE technology [1]. This will be encouraging since by renewable energy solutions, important environmental, economic, and social benefits can be yielded including removal of pressure on important ecosystems and allowance the electrical grids of the countries to be reliable and stable engines of economic growth [2].

The excessive greenhouse effect and global warming are the main causes for investigating and incorporating clean fuel technologies and novel energy sources all over the world [3-5]. By such environmental issues along with the fast depletion of fossil fuels, different organizations and countries have been encouraged to achieve highly efficient green power plants [6,7]. By technological advancements, some means of harvesting energy from the renewable sources can be achieved and used as the source of novel, sustainable, and clean energy for meeting the demands of the world [8-12]. By regenerative renewable energy resources that are not depleted over time, improved energy security of the countries is ensured worldwide and carbon emissions are reduced.

Developing renewable energy technologies is now extensively characterized as a critical component to provide a combined solution for limiting greenhouse gas emissions [13]. It makes a key opportunity for fostering innovation, promoting economic growth, and improving access to affordable clean, and secure energy [14]. Repeatable and inexhaustible alternative energy sources like biomass wind, solar, and hydro are sought in developing countries such as India, Sri Lanka, Pakistan, and Bhutan. Theeconomic development and rapid population growth in South Asian countries have increased the energy demands [15]. Recently, several efforts have been initiated by the South Asian countries to move toward alternative types of energy, particularly renewable energy, for reducing overdependence of South Asian countries on fossil fuels and managing the energy growing demands [16].

Furthermore, today, in South Asian countries, energy sources are still based on non-renewable and limited conventional energy origins. Regarding the national energy mix, energy sources are extracted from two primary sources of renewable energy and conventional energy. Conventional energy such as gas, coal, and oil is quite limited and non-regenerable. Such energy sources are injurious to the environment and will deplete sooner or later, however, sustainable energy is generated from natural sources such as solar, wind, water, and biomass. They are always accessible with no damage on the environment [17]. The over-dependence on fossil energy sources is one of the main problems in satisfying national energy requirements. Some former studies indicated that the primary energy supply is mainly from fossil energy like petroleum, coal, and natural gas. Reaching the total portion of the energy source to 90% [18] becomes a common threat and challenge for meeting national energy requirements. The energy sources generation capacity is not proportionate to the national energy consumption level, which is sharply increasing [19-21].

One of the most popular models in experimental energy is the acceptance of the EnergyPLAN model [22]. It is a deterministic modelling instrument for input/output energy system [23]. The main inputs include the system demands, renewable energy resources capacitiesnon-renewable energy station capacities, costs of energy sources, and some economic regulation and optional technical strategies. EnergyPLAN has considered three primary main sectors of any regional and national energy system including the electricity sector, the transportation sector, and the heat sector. Figure 1 represents the EnergyPLAN model structure. As seen, the EnergyPlan Outputs are the total annual productions and balance energies, net electricity import and export, overall primary fuel consumption, and the total energy costs such as income from electricity exchange via electric network or from outside the system [24].

In Southeast Asia, MAMAT et al. [25] has explored Renewable energy. Liu et al. [26] studied Renewable energy sources in South Asian countries. In India, Raghuwanshi et al. [27] described potential of RES and region-wise installed capacity. Shi X et al. [28] explored the VRE development in the 2000s and studied the effect of the cost reflective feed-in-tariffs (FITs) in Sri Lanka. Kashif et al. [29] presented a complete methodology for evaluating and forecasting the present and future accessibility of selective crop residue for generating renewable energy in Pakistan. Poudyal et al. [30] presented an up-to-date perspective on the present energy crisis in Nepal. Norouzi et al. [31] provided a meta-analysis of renewable landscape energies in Iran. Baky MA et al. [32] presented a systematic review of the future potentials and present status of renewable energy sector in Bangladesh. In eighteen southern cities of Kyushu, Japan Noorollahi et al. [33] studied the modeling of the quantity of energy demand and supply.

This review paper provides a comprehensive overview of the energy production of 20 Asian countries using renewable energy sources in the years 2000-2019.

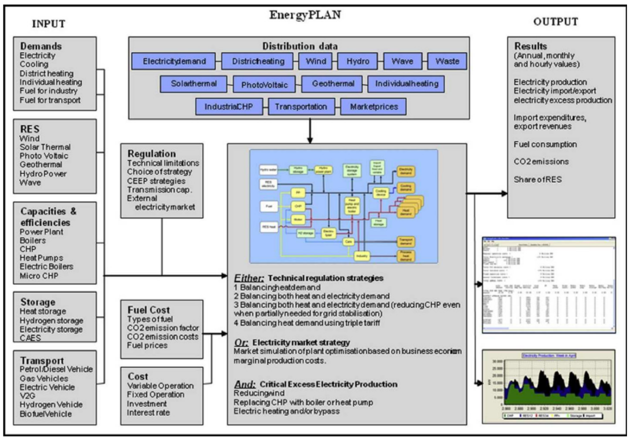


**Figure 1.** The structure of EnergyPLAN model [24].

## 2. Data

Though most Southeast Asian nations are still reliant heavily on traditional energy for domestic needs, efforts have been made by the government to deal with the incrementing energy demands [34]. More currently, some governments respond to the rising pressures on energy demands for developing eco-friendly and sustainable energy sources [35]. The area in Southeast Asia is still stable in terms of energy since the present policy is utilized for stabilizing secure economic growth and energy.

Southeast Asian countries, different approaches were adopted in to develop renewable energy, which include unregulated laws and agreements for generating renewable energy along with carbon taxes and incentives. Nevertheless, the regulations and policies made are fragmented highly, needing a complete analysis. South east Asian countries are shown in Figure 2.

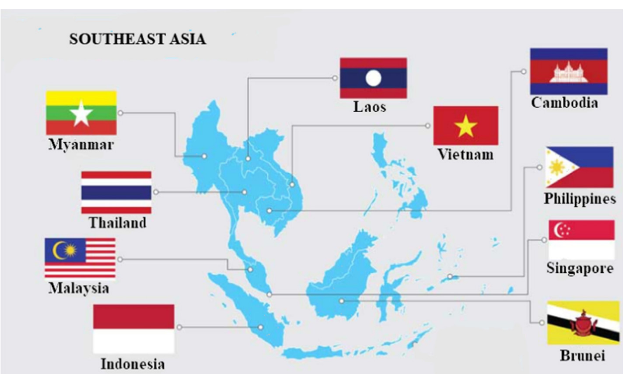


**Figure 2.** ASEAN countries.

### 2.1 Salient Properties of Renewable Energy Procedures in Southeast Asia

#### 2.1.1 Energy Policies in Indonesia

Indonesia with a population of 238 million has an increase growth with a rate of 1.9% in 2010. It is estimated that the population is about 265 million by 2020 and 306 million by 2050. Domestic energy consumption will increase to three times by 2030 from 2010 by growing the population. In 2006, a national energy policy was enacted by the Government of Indonesia. Different laws, actions, regulations, and targets have been established by policy for effective implementation [36,37]. The target adjusted by the Indonesian government is to achieve optimum renewable energy uses at the national levels by 2025. The increased renewable energy aims to reduce reliance on oil, coal, and gas that is implementing low. A reduction of 20% was approximated for oil, 33% for coal, and 30% for gas. The renewable energy share such as geothermal and biofuel will increment by 5% each and for wind power, biomass, hydropower, nuclear, and solar power it was about 5% and for liquid fuels approximately 2%. The energy policy aims at maximizing the utilization of sustainable energy sources at the national level. It is anticipated that the use of domestic energy demand is anticipated to triple or increment by 15%, in comparison to 2005 in 2025 [38-41].

#### 2.1.2 Energy Policies in Brunei

A roadmap “Brunei Vision was prepared by the Brunei Government in 2025” on using renewable energy. The implementation of sustainable energy approaches is supported by Brunei Darussalam including energy security, energy efficiency, energy conservation, and diversification of supply. The Government is proposed to expand the energy mix via concentrated efforts to develop renewable energy sources for power generation [42]. Non-governmental organizations have been also involved in the government including the Brunei’s National Energy Research Institute (BNERI), Brunei Energy Association (BENA), and the Energy Efficiency Conservation Committee (EECC) to conduct joint research on renewable energy sources. Both renewable energy on ocean and land are included in the policy. Though, renewable energy is not completely utilized in Brunei Darussalam at present ocean [43].

#### 2.1.3 Energy Strategies in Myanmar

Various national-level energy strategies have been made by Myanmar to maintain the increased use of renewables and energy dependence of the country for meeting domestic household requirements [44,45]. Myanmar has tried to facilitate the ongoing expenses of environmental integration and development [46,47]. The Myanmar government has developed the National Energy Management Committee (NEMC) and an Energy Development Committee (EDC) to guarantee the energy sector development and oversee all activities performed on using and developing renewable energy under one umbrella. Grid-quality electricity has been accessible for only 34% of the residents in Myanmar [48,49]. Various activities associated with renewable energy are undertaken for rural power generation by various organizations such as the Myanmar Engineering Society (MES), Union of Myanmar Federation of Commerce and Industry Chamber (UMFCCI) for addressing the electricity shortage in the area [50].

### 2.1.4 Energy Policies in the Philippines

Philippine government acted in 2008, within the overall framework for promoting the renewable energy use [51]. It was designed for accelerating the state renewable energy sources development, and the renewable energy management bureau establishment for supporting the implementation. There are different legislations especially for the energy department [52]. Moreover, sub-committees and numerous working groups are created by the national renewable energy board for facilitating the creation of guidelines, mechanisms, and rules on renewable portfolio standards (RPS), Clean Metering, Renewable Energy Representative Funds, Options for Green Energy, and FITs [53]. The renewable energy roadmap of Philippines has included industrial, development and energy (PCIERD) as the basis for research. The roadmap combined (2019) all studies performed by several institutes and academic sources. A renewable energy framework was made by the Philippine government in 2008, which internationally collaborated on technological evaluation of renewable energy technologies including tidal energy and wave energy [54]. The Philippines' government incorporated the framework into a roadmap (2011), with the theme of Green Energy Roadmap 2011. The aim of National Renewable Energy Program (NREP) was to achieve the target of installation of renewable energy capacity of 15,304 MW by 2011 [55].

### 2.1.5 Energy Policies in Cambodia

No specific policy exists in Cambodia, on developing renewable energy. Nevertheless, the policy is framed targeting the utilization of renewable energy at remote areas power plants. Furthermore, another policy has been made by the Cambodian government, which is more strategic for the electricity sector to encourage the usage of renewable energy as a part of the energy mix in the area. For rural areas, a framework is made for planned renewable energy development, aimed to provide electricity from reliable renewable energy technology via Renewable Electricity Action Plan [56,57]. A renewable energy plan (2013) has been made and developed by the Government of Cambodia for national strategy developers with a goal vision of 2030. Seventy percent of the total number of households in all villages has to be completely powered By 2030, through the grid electricity. A "Strategic Plan was proposed by the Government for green growth by 2030" establishing a national Roadmap [55].

### 2.1.6 Energy Policies in Laos

A complete renewable energy development policy has been planned by the Laotian government similar to other countries. Nevertheless, renewable energy sourced from the ocean is not included by the plans setting a 30% renewable energy share and energy consumption of 10% through biofuel [58,59]. A project was also built by Laos for village electrification serving to deal with increasing electrical energy for remote areas in the country [49].

### 2.1.7 Energy Policies in Singapore

Singapore government aimed at reducing GHG emissions by 16% in 2020 by creating a global agreement [60]. Nonetheless, the Singapore government initiated various efficient steps and strategies for achieving efficient renewable energy, hence, the impetus of 7% and 11% was obtained for reductions of emissions at the BAU level by 2020 [61]. Though no policy has been established on renewable energy regulation at the national level, academics and research institutes continue to assess and perform research on renewable energy potential [62-64]. A fast progress exists in Singapore on renewable energy development activities. Discussions with various Energy Market Authorities (2013) were held by the Government of Singapore, over an international energy week concentrating on renewable energy. More currently, signatories are concerned with an international cooperation consistency with the Institute's energy research institute at University Technological Nanyang [65]. The National Research Foundation declared a call subsequently, for a competitive research grant for supporting the Energy Innovation Research program focusing on electrical energy development systems from renewable energy except solar [66].

### 2.1.8 Energy Policies in Vietnam

Vietnam is aimed at increasing the renewable energy share by 5% in 2020. It was estimated to increment by 11% in 2050 [67,68]. Several activities have been undertaken by Vietnamese government for biofuel development. In the country, numerous research institutes and academic organizations and people, are interested in studying renewable energy [69].

### 2.1.9 Energy Policies in Malaysia

Five prevent of renewable energy use has been targeted by Malaysia for nationwide electrical energy requirements by 2030 [70,71]. By 2012, the task was assigned by the authority of sustainable energy developers (SEDA) for regulating the renewable energy growth. Feed-In Tariffs (FIT) was introduced to develop of Renewable energy and benefit the developer. To perform marine surveillance on renewable energy potential from the Malaysian seas, the Directorate of National Authority (NOD) was allocated. The preparation of Renewable energy technology roadmap was undertaken by Malaysia (2016), which included the ocean and land potential [72,73].

### 2.1.10 Energy Policies in Thailand

The Thai government drafted the law 3% to 5% of renewable energy use for all power generation capacity projects. Geothermal energy has been categorized by Alternative energy development planning (AEDP) along with the energy from the tidal wave of the sea as a renewable energy source. It is estimated that power generation from tidal current and wave energy reaches 2 MW. Nevertheless, it could not be used for power generation until now [74,75].

In Southeast Asia, transportation is the sector with the highest renewable energy use share. Moreover, biofuels possess the higher demand-driven potential for sustained power supply and urban transport. The incremented use of biofuel is the main preferred concentration area of the transportation policy. However, public transport and electric vehicles (EV) are also included in the policy. In Southeast Asia and the fastest growing economic sector in all countries, the transportation sector has become more leading. Additionally, with numerous industries engaged in developing renewable energy especially geothermal energy, solar, wind, biomass, and hydropower employment opportunities for the community can increase. The RE total installed capacity in Southeast Asia is shown in Table 1.

**Table 1.** The RE total installed capacity in Southeast Asia [25].

| Country | Solar power Potential GW | Wind power GW | Hydro power GW |
|---|---|---|---|
| Malaysia | 5.47 | - | 182 |
| Indonesia | 12 | 0.1 | 5.26 |
| Brunei | 1 | - | - |
| Singapore | 57 | - | - |
| Myanmar | - | - | 3.14 |
| Thailand | 1.6 | 22.3 | 4.51 |
| Philippines | 132 | 38.7 | 4.24 |
| Cambodia | 6 | 0.1 | 1.27 |
| Vietnam | - | 13.5 | 15.2 |
| Laos | 1 | - | 4.17 |

## 2.2 Renewable Energy Potential for South Asian Countries

There is a huge potential for renewable energy sources in South Asian countries. Table 2 represents the renewable energy potential for hydro power, wind power, and solar power [26]. Nepal alone possesses a huge hydropower potential of 83,000 MW, and even if energy demand increments at a rate of 10%. By 2025, domestic demand will reach only 3500 MW. A lucrative opportunity is presented for Nepal for energy trade assisting in improving the energy security in the South Asian countries [76,77]. Likewise, the South Asian region can be helped by the massive solar power potential in India as well as wind power potential in Afghanistan go a long way in satisfying its energy requirements. South Asian countries are shown in Figure 3.

**Table 2**. The renewable energy potential [78].

| Country | Solar power Potential GW | Wind power GW | Hydro power GW |
|---|---|---|---|
| India | 802 | 202.778 | 150 |
| Sri Lanka | 20.8 | 24 | 2 |
| Pakistan | 270 | 231.8 | 59 |
| Afghanistan | 220 | 158 | 25 |
| Nepal | 166 | - | 83 |

### 2.2.1 Energy Policies in India

Developing and implementing energy management and renewable energy technologies are the commitment of Indian Government. By running renewable energy technologies, cost would be reduced, influencing the economic progress and enhancing the human health. Although contribution is small at present renewable energy, however, prospects for RES are gradually improved in India towards a great future. It is intended to take a dominant role in the global renewable energy development towards sustainable maturity. It will be mostly to achieve these improved goals based on the dynamic participation of all groups such as government agencies, R & D institutions, NGOs, financial institution for developing novel breed of energy entrepreneurs [27].


**Figure 3.** South Asian countries.

### 2.2.2 Energy Policies in Sri Lanka

It is difficult to develop policy for variable renewable energy (VRE), such as solar power and wind energy in developing countries with limited capacity, fiscal resources, and limited technical. Sri Lanka contains such a condition. It has a potential for developing the VRE, however, the development was neither adequate nor smooth [28].

### 2.2.3 Energy Policies in Pakistan

It was approximated that more than 11,000 MW of sustainable and renewable energy can be created in Pakistan utilizing five major crops (maize, wheat, sugarcane, cotton, and rice) residue in terms of crop yield data for 2017—2018. According to forecasting in terms of the historical trends of crop production and yield, this capacity could be increased to about 15,000 MW by the year 2034—2035 [29].

### 2.2.4 Energy Policies in Afghanistan

Despite the extensive difference between renewable energy resource potential estimations for Afghanistan, the country nonetheless appears to have the potential for generating more power than it will consume for decades. In principle, imported power and its own fossil fuel reserves could have a role in providing the essential base load, as for distributed storage, which was not discussed here. It remains to be observed is the relative weight presented to various options, renewable and non-renewable, as the country continues to develop. Likewise, the extent for occurring energy sector development in a complex organizational and institutional framework should be also observed. Possibly, in any scenario, the case for distributed renewables is still strong, mostly when considering the engagement of the communities to meet the need for infrastructure maintenance [79].

### 2.2.5 Energy Policies in Nepal

Particularly, the renewable power plants are not always operating at their full generation capacity mostly owing to the changing weather conditions. To present reliable renewable power sources with the good quality and stable output, the energy storage tools and the conventional generators should be utilized for mitigating supply outages [30].

### 2.2.6 Energy Policies in Bangladesh

The main energy supply sources in Bangladesh Natural gas are coal refined and petroleum products. Natural gas has a role in a major portion of the total power generation after the refined petroleum products (diesel and furnace oil). With the present reserve and the consumption rate, it is expected that natural gas will be dried out within the next 10~12 years. Therefore, the diversification of source is required for power generation. A huge deal of time and strong initiatives would be required for a lower middle income country incorporation of renewable energy in the main energy supply [32].

## 2.3 Other Countries

### 2.3.1 Energy Policies in Iran

The use of solar energy and wind in Iran is higher over other renewable energies [80]. Considering the present restraints and higher costs of generation of geothermal energy, now its use has less economic justification for Iran [81]. Using such energy can be regarded in limited conditions in designing eco tourist, recreational, and residential complexes. Utilizing solar energy, biomass, and wind on a local scale is a very operational and economical solution [82]. Based on the environmental and geographic circumstances of the Middle East and Iran's adjacent countries, there is a great variety in the types and amounts of RE potentials. Iran contains a huge deal of potential for transferring solar and wind energy from the east, hydroelectric power from the southwest, and wind power from the northwest and northeast of the country. Iran should consolidate its RE regulations and laws. Hierarchy and convergence of documents and programs should be also reviewed. Some road maps and operational strategies are required between the major documents and the executive documents associated with the renewable energies field in the country [83].

### 2.3.2 Energy Policies in Azerbaijan

Since renewable energy concept is quite young in Azerbaijan, apparent difficulties exist including costly renewable energy plants, institutional operation, along with other policy and economic obstacles obstructing the establishment of renewable and alternative energy sector and the implementing EE projects. Because the private businesses and companies are very meticulous at investing to the newly launched sectors, regulations should be simplified by Azeri government for seeking foreign investment attraction [84].

### 2.3.3 Energy Policies in China

Considering the plenty of water resources and appropriate geographic circumstances, China the as the second largest country of the world concentrated on wind energy, hydro-electric energy, and more solar energy than the other types of renewable energy. Based on the results, the unwillingness of the private sector for investments as a result of considerable expenditures and the late return of capital are the most important barrier to further renewable energy developments in such countries. In the study, it was suggested that governmental should guarantee and support the purchase of created electricity for resolving the problems to some extent [85].

### 2.3.4 Energy Policies in Japan

Reliable power supplies are provided by renewable energies share, enhancing energy security and also lowering risks of environmental pollutions by decreasing the need for fossil fuel resources. Energy demand for Ebino city in south Kyushu was analyzed and forecasted for future years up 2020 to 2030 [73]. Based on population reduction, the energy demand is also decreased by almost 2% per year. Renewable energy potential for other Asian countries (5 countries) is shown in Table 3.

**Table 3.** Renewable energy potential [31-33,84,85].

| Country | Solar power potential GW | Wind power GW | Hydro power GW |
|---|---|---|---|
| Iran | 200 | 100 | 29 |
| Bangladesh | 2.08 | 20 | - |
| Azerbaijan | 50 | 4.5 | 3.5 |
| China | 1200 | 350 | 1000 |
| Japan | 73 | 108 | 200 |

## 3. Results and Discussion

In this section, according to the data collected in the previous section, a diagram of the total renewable energy generation for 20 selected Asian countries is drawn. These graphs show the energy generated by new renewable power plants built for each country per year. The area below the charts also shows the total energy generation of that country up to the target year. Data and graphs are drawn based on the information of the energy organizations of each country in a period of 20 years, i.e. 2000 to 2019 for each country.

### 3.1 Renewable Energy in Southeast Asia

### 3.1.1 Renewable Energy in Indonesia

Figure 4 indicates the new operation of the total number of renewable power plants built each year for Indonesia and have a cumulative nature. For example, the operating capacity of renewable power plants built in 2002 is 240 GWH. In 2003, because a new power plant or a new phase of pre-built renewable power plants were not operated, the country's renewable energy capacity in 2003 is the same as 2002 is 240 GWH. The surface below this diagram shows the cumulative operating capacity of all the county's renewable power plants. For instance, the area below the graph of renewable power stations is 47410 GWH, which indicates the total energy produced by these power plants in Indonesia in 2019. The diagram also shows that in 2019, Indonesia generated 5926 GWH more energy from its renewable energy's power stations than in 2018.

### 3.1.2 Renewable Energy in Brunei

Figure 5 indicates the new operation of the total number of renewable power plants built each year for Brunei and have a cumulative nature. The first harvesting energy from the country's renewable energy was in 2007 and the energy generated was 0.025 GWH in that year. In 2009, 2010 and 2015 a new power plant or a new phase of pre-built renewable power plants were not added to the energy generation. The surface below this diagram shows the cumulative operating capacity of all the county's renewable power plants. The area below the graph of renewable power stations is 1.3 GWH, which indicates the total energy produced by these power plants in Brunei in 2019. The diagram also shows that in 2019, Brunei generated 0.15 GWH more energy from its renewable energy's power stations than in 2018.

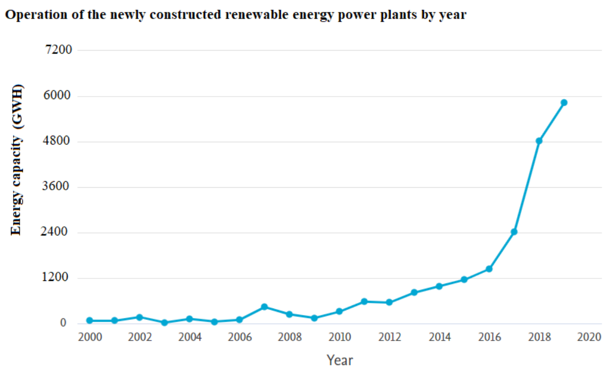


**Figure 4.** Total operating capacity of renewable power plants constructed per year in Indonesia.

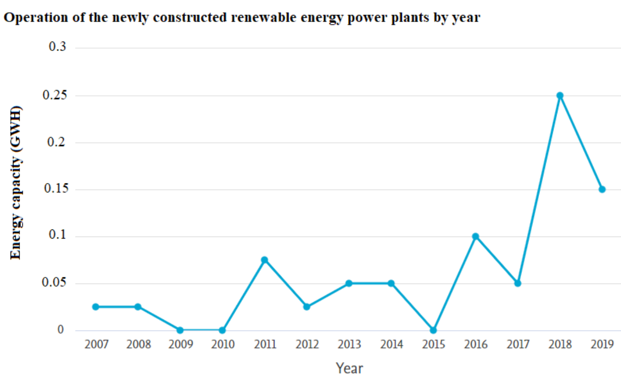


**Figure 5.** Total operating capacity of renewable power plants constructed per year in Brunei.

### 3.1.3 Renewable Energy in Myanmar

Figure 6 indicates the new operation of the total number of renewable power plants built each year for Myanmar and have a cumulative nature. The first harvesting energy from the country's renewable energy was in 2004 and the energy generated was 150 GWH in that year. In 2005, 2006, 2009 and 2012 a new power plant or a new phase of pre-built renewable power plants were not added to the energy generation. The surface below this diagram shows the cumulative operating capacity of all the county's renewable power plants. The area below the graph of renewable power stations is 11324 GWH, which indicates the total energy produced by these power plants in Myanmar in 2019. The diagram also shows that in 2019, Myanmar generated 1500 GWH more energy from its renewable energy's power stations than in 2018.

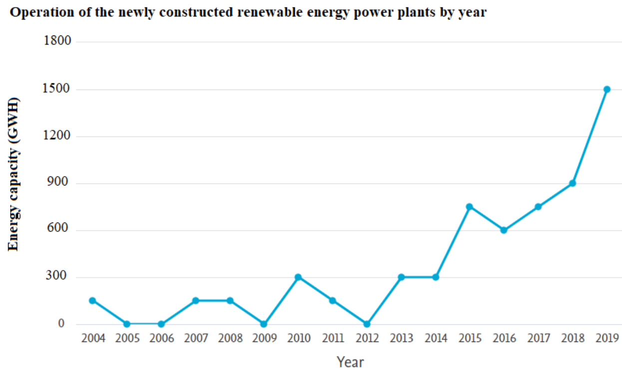


**Figure 6.** Total operating capacity of renewable power plants constructed per year in Myanmar.

### 3.1.4 Renewable Energy in Philippines

Figure 7 indicates the new operation of the total number of renewable power plants built each year for Philippines and have a cumulative nature. The operating capacity of renewable power plants built in 2018 is 1600 GWH. As can be seen in all these 20 years a new power plant or a new phase of pre-built renewable power plants were added to the grid of the country, so it means Philippines energy policy is toward developing more renewable energy capacity every year. The surface below this diagram shows the cumulative operating capacity of all the county's renewable power plants. The area below the graph of renewable power stations is 26437 GWH, which indicates the total energy produced by these power plants in Philippines in 2019. The diagram also shows that in 2019, Philippines generated 3060 GWH more energy from its renewable energy's power stations than in 2018.

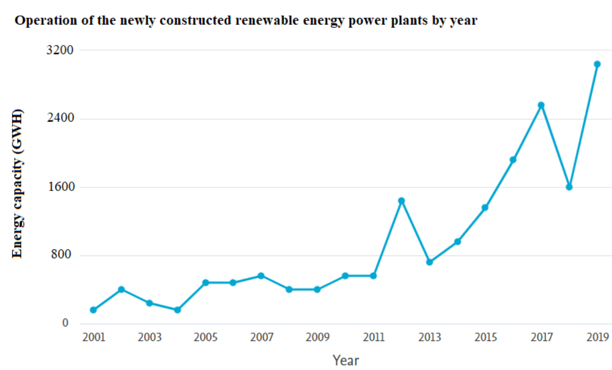


**Figure 7.** Total operating capacity of renewable power plants constructed per year in Philippines.

### 3.1.5 Renewable Energy in Cambodia

Figure 8 indicates the new operation of the total number of renewable power plants built each year for Cambodia and have a cumulative nature. The operating capacity of renewable power plants built in 2002 and 2003 is 10 GWH and 20 GWH respectively which means that in 2003 the energy generated from renewable energies is duplicated related to 2002. As can be seen in the years 2004 to 2009 no new renewable energy power plant was constructed so the energy generated until 2009 is still 20 GWH annually. The area below the graph of renewable power stations is 3169 GWH, which indicates the total energy produced by these power plants in Cambodia in 2019. The diagram also shows that in 2019, Cambodia generated 40 GWH more energy from its renewable energy's power stations than in 2018.

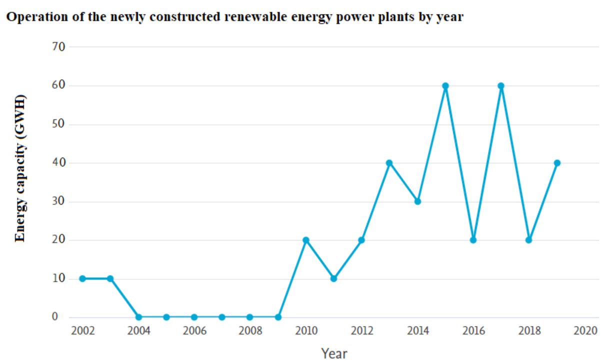


**Figure 8.** Total operating capacity of renewable power plants constructed per year in Cambodia.

### 3.1.6 Renewable Energy in Laos

Figure 9 indicates the new operation of the total number of renewable power plants built each year for Laos and have a cumulative nature. The first harvesting energy from the country's renewable energy was in 2002 and the energy generated was 400 GWH in that year. In 2003 and 2005 to 2008 a new power plant or a new phase of pre-built renewable power plants were not added to the energy generation. The area below the graph of renewable power stations is 21542 GWH, which indicates the total energy produced by these power plants in Laos in 2019. The diagram also shows that in 2019, Laos generated 800 GWH more energy from its renewable energy's power stations than in 2018.

### 3.1.7 Renewable Energy in Singapore

Figure 10 indicates the new operation of the total number of renewable power plants built each year for Singapore and have a cumulative nature. The operating capacity of renewable power plants built in 2001 and 2002 is 5 GWH and 10 GWH respectively which means that in 2003 the energy generated from renewable energies is 15 GWH. As can be seen in the years after 2004 new renewable energy power plants were constructed so the energy generated is growing annually. The area below the graph of renewable power stations is 988 GWH, which indicates the total energy produced by these power plants in Singapore in 2019. The diagram also shows that in 2019, Singapore generated 120 GWH more energy from its renewable energy's power stations than in 2018.

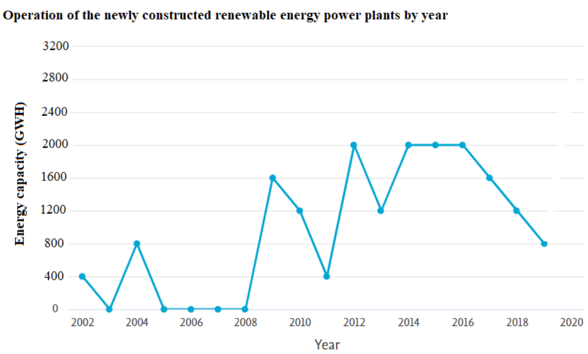


**Figure 9.** Total operating capacity of renewable power plants constructed per year in Laos.

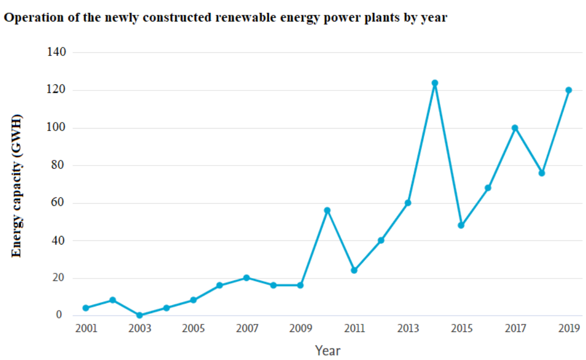


**Figure 10.** Total operating capacity of renewable power plants constructed per year in Singapore.

### 3.1.8 Renewable Energy in Vietnam

Figure 11 indicates the new operation of the total number of renewable power plants built each year for Vietnam and have a cumulative nature. The operating capacity of renewable power plants built in 2003 is 1200 GWH. In 2004 no new renewable energy power plant was constructed so the energy generated from renewable energies is also 1200 GWH. As can be seen in the years after 2005 new renewable energy power plants were constructed so the energy generated by them is growing annually. The area below the graph of renewable power stations is 76384 GWH, which indicates the total energy produced by these power plants in Vietnam in 2019. The diagram also shows that in 2019, Vietnam generated 9000 GWH more energy from its renewable energy's power stations than in 2018.

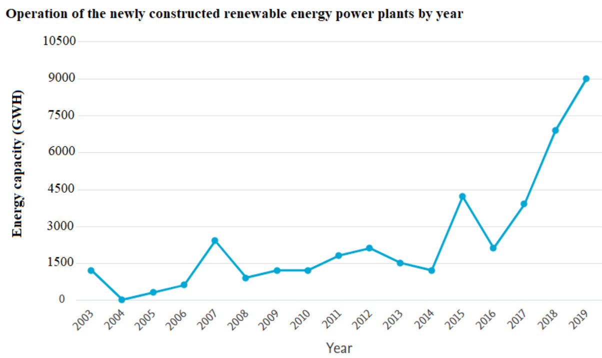


**Figure 11.** Total operating capacity of renewable power plants constructed per year in Vietnam.

### 3.1.9 Renewable Energy in Malaysia

Figure 12 indicates the new operation of the total number of renewable power plants built each year for Malaysia and have a cumulative nature. The operating capacity of renewable power plants built in 2000 is 55 GWH. As can be seen in all of this 20 years new renewable energy power plants were constructed so the energy generated by them is growing with a high slope annually except of 2012, 2015 and 2018 which the increase in energy production is decreased related to the years before them. The area below the graph of renewable power stations is 25789 GWH which indicates the total energy produced by these power plants in Malaysia in 2019. The diagram also shows that in 2019, Malaysia generated 3200 GWH more energy from its renewable energy's power stations than in 2018.

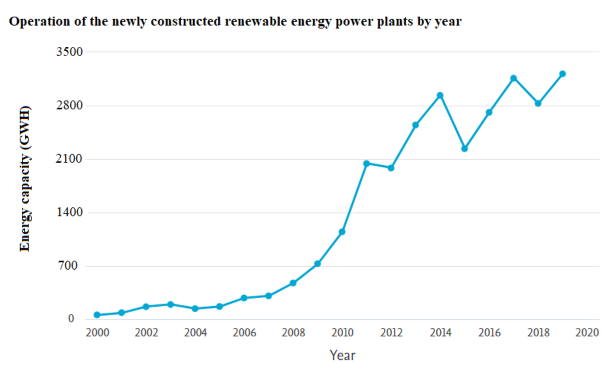


**Figure 12.** Total operating capacity of renewable power plants constructed per year in Malaysia.

### 3.1.10 Renewable Energy in Thailand

Figure 13 indicates the new operation of the total number of renewable power plants built each year for Thailand and have a cumulative nature. The operating capacity of renewable power plants built in 2000 is 15 GWH. As can be seen in all of this 20 years new renewable energy power plants were constructed so the energy generated by them is growing. Maximum new energy generated from renewable energies is in 2017 which is an increase of 4000 GWH related to 2016. The area below the graph of renewable power stations is 30056 GWH, which indicates the total energy produced by these power plants in Thailand in 2019. The diagram also shows that in 2019, Thailand generated 3600 GWH more energy from its renewable energy's power stations than in 2018.

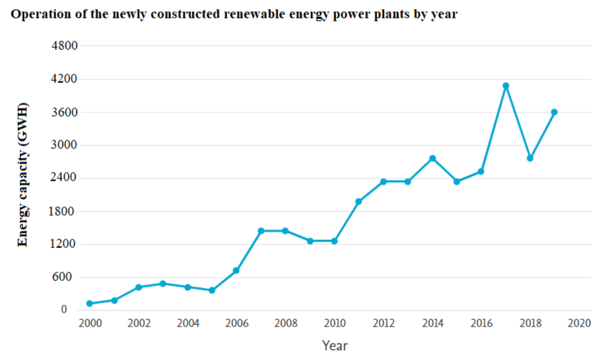


**Figure 13.** Total operating capacity of renewable power plants constructed per year in Thailand.

## 3.2 Renewable Energy in South Asia

### 3.2.1 Renewable Energy in India

Figure 14 indicates the new operation of the total number of renewable power plants built each year for India and have a cumulative nature. The operating capacity of renewable power plants built in 2000 is 1530 GWH and in 2001 is 1620 GWH which means the total energy production by renewable energies in 2001 was 3150 GWH. As can be seen the diagram is almost linear which means the energy policy in India for the last 20 years is the same and is to increase the renewable energy power plants with the same slope in every year. The area below the graph of renewable power stations is 288622 GWH, which indicates the total energy produced by these power plants in India in 2019. The diagram also shows that in 2019, India generated 35000 GWH more energy from its renewable energy's power stations than in 2018.

### 3.2.2 Renewable Energy in Sri Lanka

Figure 15 indicates the new operation of the total number of renewable power plants built each year for

Sri Lanka and have a cumulative nature. The operating capacity of renewable power plants built in 2000 is 120 GWH and zero in 2001 which means the total energy production by renewable energies in 2001 was 120 GWH. As can be seen except the year 2003, in all other years the energy capacity generated from renewable energies increased. The area below the graph of renewable power stations is 4740 GWH, which indicates the total energy produced by these power plants in Sri Lanka in 2019. The diagram also shows that in 2019, Sri Lanka generated 600 GWH more energy from its renewable energy's power stations than in 2018.

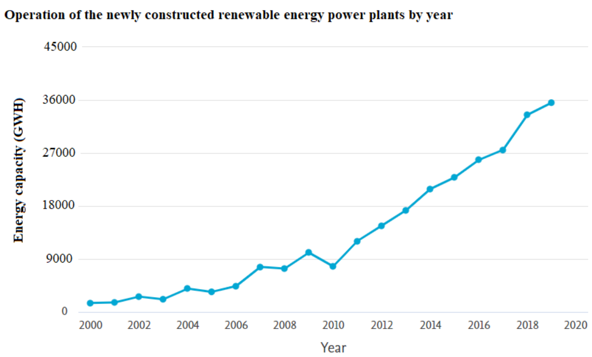


**Figure 14.** Total operating capacity of renewable power plants constructed per year in India.

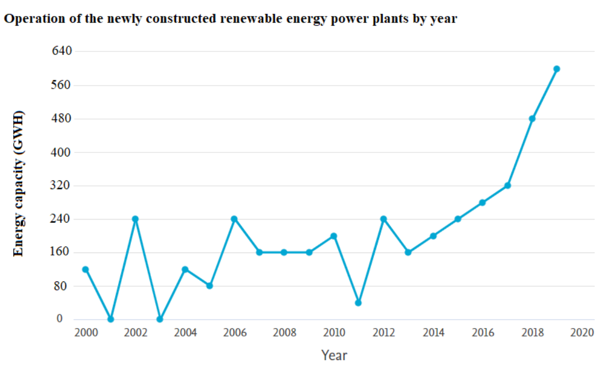


**Figure 15.** Total operating capacity of renewable power plants constructed per year in Sri Lanka.

### 3.2.3 Renewable Energy in Pakistan

Figure 16 indicates the new operation of the total number of renewable power plants built each year for Pakistan and have a cumulative nature. The operating capacity of renewable power plants built in 2002 is 40 GWH and is also increasing in all years except 2008 and 2017. As can be seen the peak of the diagram which means the highest newly constructed renewable energy power plants is in 2019. The area below the graph of renewable power stations is 44698 GWH, which indicates the total energy produced by these power plants in Pakistan in 2019. The diagram also shows that in 2019, Pakistan generated 5560 GWH more energy from its renewable energy's power stations than in 2018.

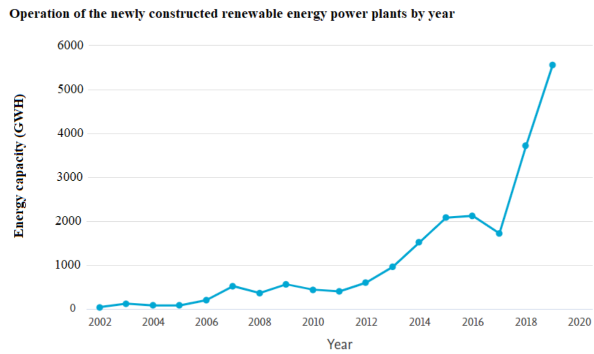


**Figure 16.** Total operating capacity of renewable power plants constructed per year in Pakistan.

### 3.2.4 Renewable Energy in Afghanistan

Figure 17 indicates the new operation of the total number of renewable power plants built each year for Afghanistan and have a cumulative nature. The operating capacity of renewable power plants built in 2001 is 0.025 GWH. As can be seen in the years 2002 to 2006 and 2008 there is no increase in the renewable energy capacity which shows that energy policy of the governments shows a little interest in renewable energies in Afghanistan. The area below the graph of renewable power stations is 1.2 GWH, which indicates the total energy produced by these power plants in Afghanistan in 2019. The diagram also shows that in 2019, Afghanistan generated 0.225 GWH more energy from its renewable energy's power stations than in 2018.

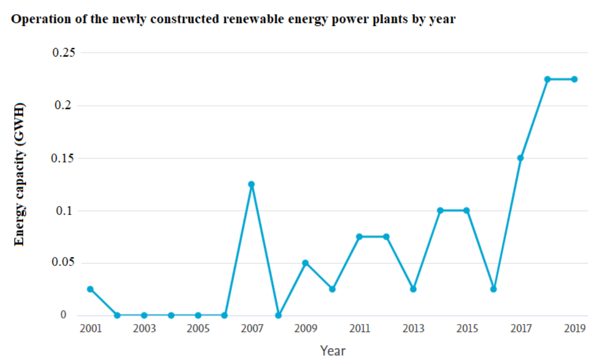


**Figure 17.** Total operating capacity of renewable power plants constructed per year in Afghanistan.

### 3.2.5 Renewable Energy in Nepal

Figure 18 indicates the new operation of the total number of renewable power plants built each year for Nepal and have a cumulative nature. The operating capacity of renewable power plants built in 2000 is 30 GWH. As can be seen in 2006 no new power plant or a new phase of pre-built renewable power plants were added to the grid. The area below the graph of renewable power stations is 3333.1 GWH, which indicates the total energy produced by these power plants in Nepal in 2019. The diagram also shows that in 2019, Nepal generated 420 GWH more energy from its renewable energy's power stations than in 2018.

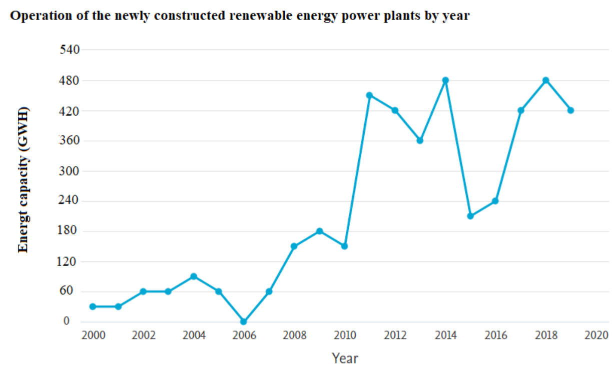


**Figure 18.** Total operating capacity of renewable power plants constructed per year in Nepal.

### 3.3.2 Renewable Energy in Bangladesh

Figure 19 indicates the new operation of the total number of renewable power plants built each year for Bangladesh and have a cumulative nature. The operating capacity of renewable power plants built in 2000 is 5 GWH and 7.5 GWH in 2001 which means the total energy production by renewable energies in 2001 was 12.5 GWH. As can be seen in all of the recent 20 years, the energy capacity generated from renewable energies has been increasing. The area below the graph of renewable power stations is 1419 GWH, which indicates the total energy produced by these power plants in Bangladesh in 2019. The diagram also shows that in 2019, Bangladesh generated 170 GWH more energy from its renewable energy's power stations than in 2018.

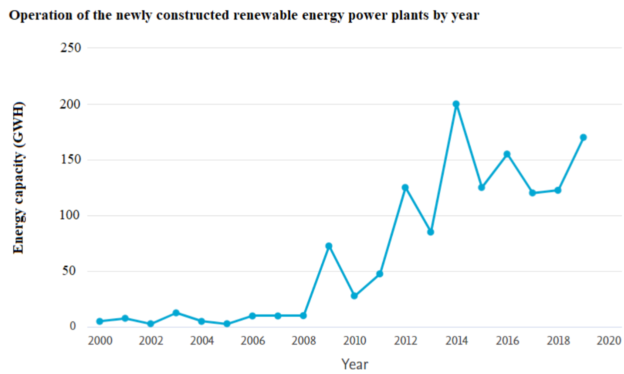


**Figure 19.** Total operating capacity of renewable power plants constructed per year in Bangladesh.

### 3.3 Renewable Energy in Other Asian Countries

### 3.3.1 Renewable Energy in Iran

Figure 20 indicates the new operation of the total number of renewable power plants built each year for Iran and have a cumulative nature. The operating capacity of renewable power plants built in 2000 is 20 GWH and in 2001 there is no increase in the renewable energy capacity so the energy generation by renewable energies in 2001 is 20 GWH. As can be seen since Iran is a developing country, its renewable energy capacity is increasing in each year. Only in 2011 to 2013 the slope of this increase, decreased but also in those years the capacity increased as well. The surface below this diagram shows the cumulative operating capacity of all the county's renewable power plants. The area below the graph of renewable power stations is 20052 GWH, which indicates the total energy produced by these power plants in Iran in 2019. The diagram also shows that in 2019, Iran generated 2520 GWH more energy from its renewable energy's power stations than in 2018.

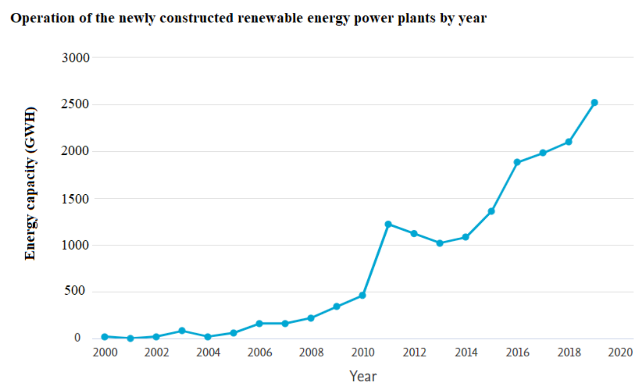


**Figure 20.** Total operating capacity of renewable power plants constructed per year in Iran.

### 3.3.2 Renewable Energy in Azerbaijan

Figure 21 indicates the new operation of the total number of renewable power plants built each year for Azerbaijan and have a cumulative nature. In 2002 energy generated by renewable energy power plants was 60 GWH as well as in 2003. In 2004, 2008, 2009, 2013 and 2014 a new power plant or a new phase of pre-built renewable power plants were not added to the energy generation. In

2005 to 2007 newly renewable energy capacity growth has the same slope and was 60 GWH each year and also in 2015 to 2018, this slope was 240 GWH. The surface below this diagram shows the cumulative operating capacity of all the county's renewable power plants. The area below the graph of renewable power stations is 2630 GWH, which indicates the total energy produced by these power plants in Azerbaijan in 2019. The diagram also shows that in 2019, Azerbaijan generated 300 GWH more energy from its renewable energy's power stations than in 2018.

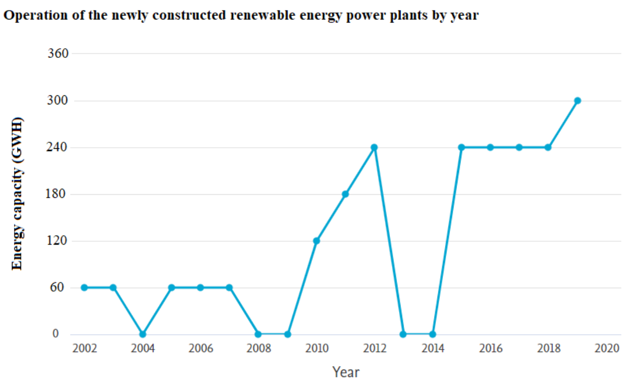


**Figure 21.** Total operating capacity of renewable power plants constructed per year in Azerbaijan.

### 3.3.3 Renewable Energy in China

Figure 22 indicates the new operation of the total number of renewable power plants built each year for China and have a cumulative nature. In 2000 energy generated by renewable energy power plants was 1750 GWH which is more than energy production in many other Asian countries by the year 2019. As can be seen the renewable energy capacity growth has even a steeper slope than linear slope for the last 20 years. The surface below this diagram shows the cumulative operating capacity of all the county's renewable power plants. The area below the graph of renewable power stations is 1739400 GWH, which indicates the total energy produced by these power plants in China and is the top country in energy production by renewable energies in the world in 2019. The diagram also shows that in 2019, China generated 210750 GWH more energy from its renewable energy's power stations than in 2018 which is the highest increase among all other countries.

### 3.3.4 Renewable Energy in Japan

Figure 23 indicates the new operation of the total number of renewable power plants built each year for Japan and have a cumulative nature. The operating capacity of renewable power plants built in 2000 is 1260 GWH. As can be seen in the figure the highest increase in renewable energy capacity is in 2012 with 21080 GWH related to 2011. The area below the graph of renewable power stations is 190587 GWH, which indicates the total energy produced by these power plants in Japan in 2019. The diagram also shows that in 2019, Japan generated 23220 GWH more energy from its renewable energy's power stations than in 2018.

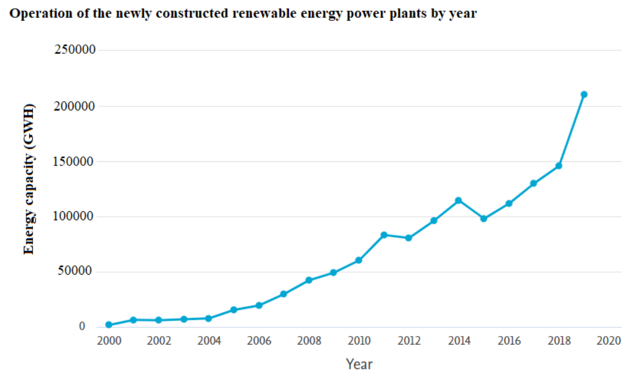


**Figure 22.** Total operating capacity of renewable power plants constructed per year in China.

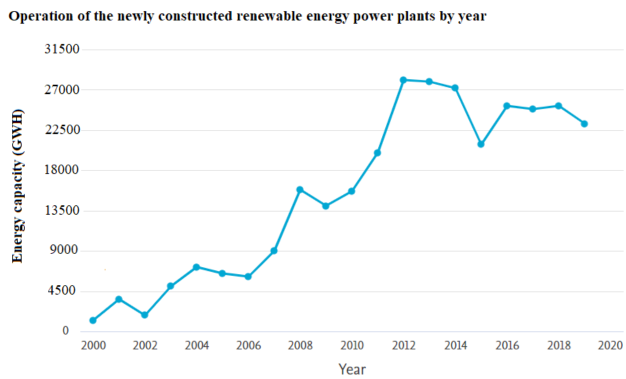


**Figure 23.** Total operating capacity of renewable power plants constructed per year in Japan.

## 4. Conclusions

In this work, the potential and policy of Asian readmission energy are examined. A target has been set by the Asian governments for renewable energy usage by 2030 to accelerate the race of sustainable energy development. Despite the fact renewable energy targets have to be recognized by all Asian countries, the area has yet to strictly harness its vast renewable energy potential. Regional and national policies can have a key role in supporting renewable energy development and implementation, assisting Asian countries for identifying pathways and priorities for renewable energy market. Their renewable energy roadmap is also expanded for considering other policies and measures for predicting problems resultant from higher share of renewable energy in the energy portfolio and appropriate solutions such as smart grid technologies. In this regard, international and national energy policies show a great effort obviously in energy scenarios; nevertheless, Asia region still contains a huge deal of potential to fully use renewable energy resources. Hence, more collaboration should be performed between government and public to guarantee a remarkable achievement. Renewable energy can attract investment, spur technological research, provide energy security through diversification, and improve stable economic growth at the Asia region level. Moreover, considerable cooperation among decision makers of the energy sector is required by incrementing the cost-effective penetration of renewable energy into the electricity supply.

The results of this paper gives a brief description about energy scenario and renewable energy constructed in Asian countries. The percentages of the renewable energy capacity (including the sum of hydropower, wind power, biomass and waste, solar power and geothermal) relative to the total energy capacity in 2019 for Asian countries are as follows:

South east countries: Indonesia (16.9%)- Brunei (0.2%)- Myanmar (53.8%)- Philippines (25.3%)- Cambodia (48.2%)- Laos (54.1%)- Singapore (2.6%)- Vietnam (39.6%)- Malaysia (14.7%)- Thailand (14.1%)

South countries: India (19.1%)- Sri Lanka (28.7%)- Pakistan (33.7%)- Afghanistan (0.8%)- Nepal (66.5%)- Bangladesh (2.8%)

Other countries: Iran (6.8%)- Azerbaijan (9.8%)- China (25.4%)- Japan (16%)

The comprehensive study for the renewable energy capacity for Asian countries in the years 2000 to 2019 shows that in the most of the Asian countries, renewable energy capacity is increasing and their energy policy is yet to go on.

## Conflict of Interest

There is no conflict of interest.

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