BRICS Renewable Energy Report 2022

BRICS
ENERGY RESEARCH
COOPERATION PLATFORM

BRICS 2022 CHINA

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INTRODUCTION

Today's world is undergoing major changes unseen in a century. The global energy landscape is going through profound adjustments with an increase in trend towards multipolarity. Emerging economies in the Asia-Pacific region have become the main forces for energy demand growth. With global demand for energy continuing to grow, problems concerning energy resources and the environment are becoming increasingly prominent. Consequently, countries around the world have taken more active measures than before to deal with climate change. Achieving clean and low-carbon energy transition has become a global consensus. With a new round of energy technology revolution emerging, we see an increasingly prominent energy trend for low-carbon and electric structure and clean and intelligent technology. Renewable energy has become the dominant direction of global low-carbon energy transition.

In this report, analysis is conducted from the perspectives of resource overview, industry policies, development status, industrial advantages and features, development prospects and visions in light of renewable energy development in the BRICS countries. The BRICS countries adopt policies to support the steady advancement of renewable energy according to their respective resource endowments. They also increase international energy cooperation and promote the development of a more mature global renewable energy industry chain based on their respective industrial advantages and features.

In order to boost the promotion and application of innovative energy technologies in the BRICS countries, it is recommended to establish a cooperation mechanism for demonstration projects, to regularly organize and carry out exchanges on renewable energy technologies in focused areas and renewable energy policy systems. In this way, the promotion and application of innovative technologies in the field of renewable energy can be pushed ahead.

With the accelerated advancement of responses to climate change and the implementation of carbon neutrality goals, it has become the general consensus and concerted action of all countries in the world to step up the global energy transition and promote the development of renewable energy. Seeking cooperation opportunities in the field of renewable energy will become one of the main themes of the BRICS energy cooperation. On the basis of summarizing the current situation of global renewable energy development, in the BRICS Renewable Energy Report, the basis, policies, advantages, features and prospects of renewable energy development in the BRICS countries are analyzed and studied, covering conventional hydropower, pumped storage, wind power, solar power, biomass, geothermal energy, new energy storage and hydrogen.

The report is the first BRICS cooperative research in the field of renewable energy. This study will lay the foundation for setting the priority areas and models of renewable energy cooperation among the BRICS countries.

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Chapter 1

Global Renewable Energy Development

[I]

OVERVIEW OF GLOBAL RENEWABLE ENERGY DEVELOPMENT AND UTILIZATION

The world is undergoing profound changes unseen in a century, so is the global energy landscape with an increase in trend towards multipolarity. Emerging economies in the Asia-Pacific region have become drivers of energy demand growth. As the global energy demand continues to grow, issues concerning energy resources and the environment become increasingly prominent. Countries around the world have taken more proactive measures to tackle climate change, and it has become a global consensus to pursue clean and low-carbon energy transition. As the new round of energy technology revolution unfolds, we see a more prominent trend toward a low-carbon and electrified energy mix and cleaner and smarter energy technology. Renewable energy has become the dominant driver of global low-carbon energy transition.

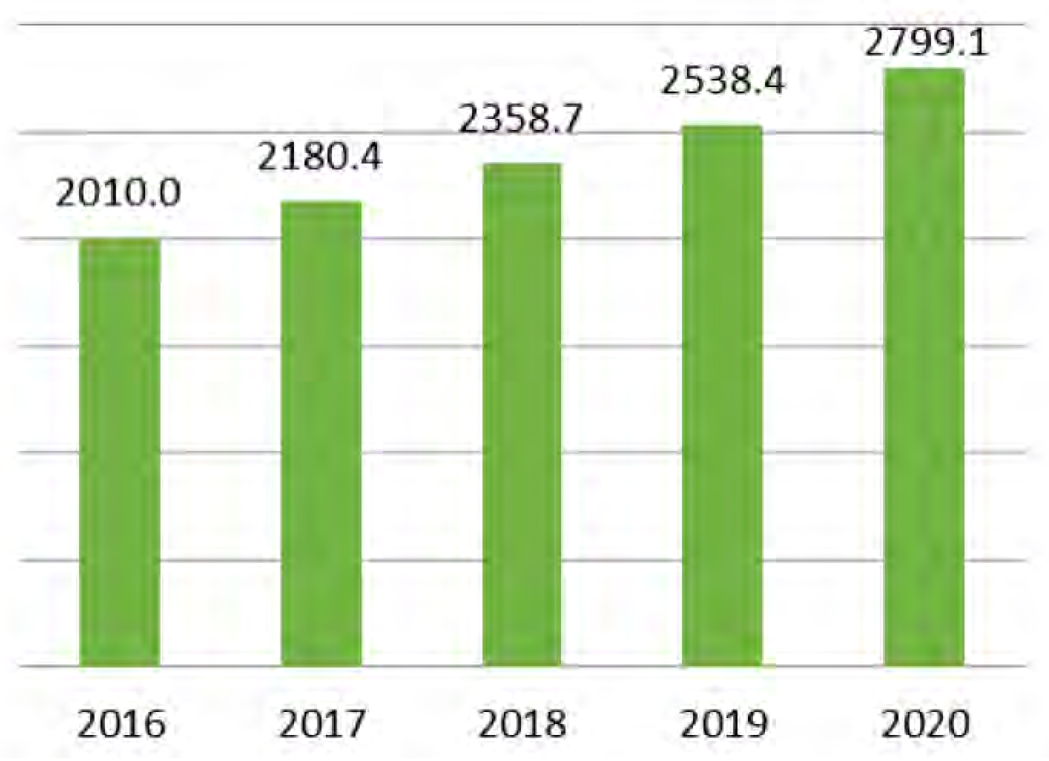
I. OVERVIEW OF RENEWABLE ENERGY UTILIZATION

At the end of 2020, the world's installed capacity of power generation from renewable sources hit 2,799 GW, increasing by 260 GW over 2019. China's installed capacity was 934 GW, a year-on-year increase of 139 GW and a significant contribution to the global renewable energy growth. Hydropower remained the largest source of renewable energy, with a total installed capacity (excluding pumped storage) of 1,210 GW, increasing by 20 GW compared with the figure in 2019. In terms of regional distribution, the three regions with the highest cumulative installed capacity were Asia (501 GW), Europe (194 GW) and North America (177 GW).

Solar photovoltaic (PV) power and wind power developed rapidly to keep up with hydropower, with the total installed capacity of solar PV reaching 707 GW, up by 126 GW from that of 2019. The three regions with the highest cumulative installed capacity of solar PV energy were Asia (406 GW), Europe (161 GW) and North America (82 GW). The total installed capacity of wind power hit 733 GW, up by 111 GW from that of 2019. From the perspective of regional distribution, the three regions with the greatest installed capacity were Asia (332 GW), Europe (207 GW) and North America (139 GW).

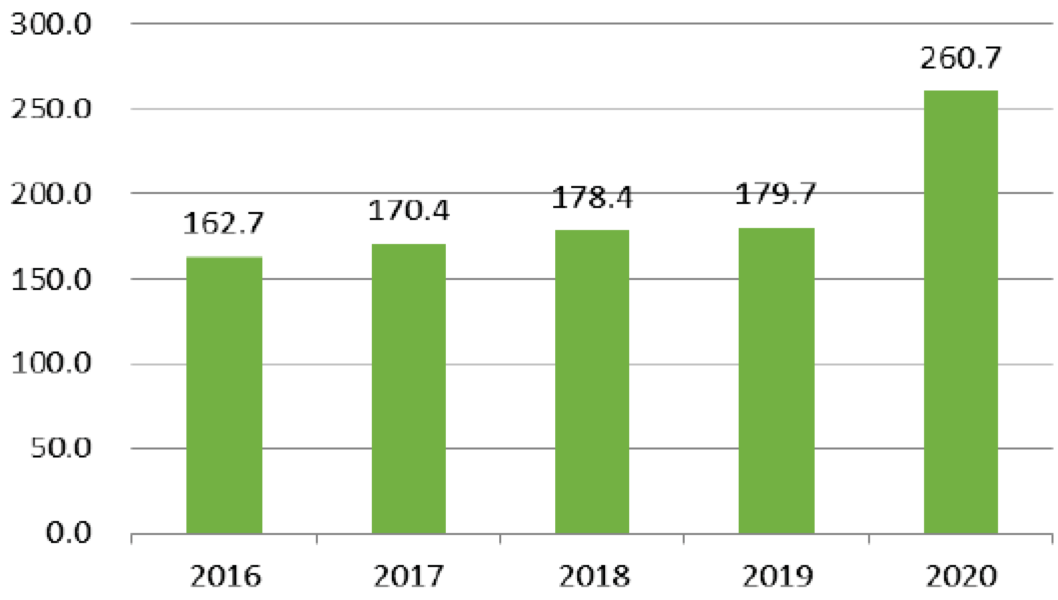
For other renewable energy sources, by the end of 2020, the global cumulative installed capacity of solar thermal energy reached 6 GW, that of biomass energy 126 GW, and that of geothermal energy 14 GW. In addition, other renewable energy sources, such as hydrogen from renewable energy and marine energy, also drew increasing attention from all countries.

Figure 1.1-1 Global cumulative installed capacity of renewable energy in recent 5 years (GW)



In terms of increment, the global installed capacity of renewable energy in 2020 increased over 260 GW, hitting another record high, including 20 GW from hydropower, 126 GW from solar PV energy, 111 GW from wind power, and 2 GW from other renewable sources, such as solar thermal energy, biomass energy and geothermal energy.

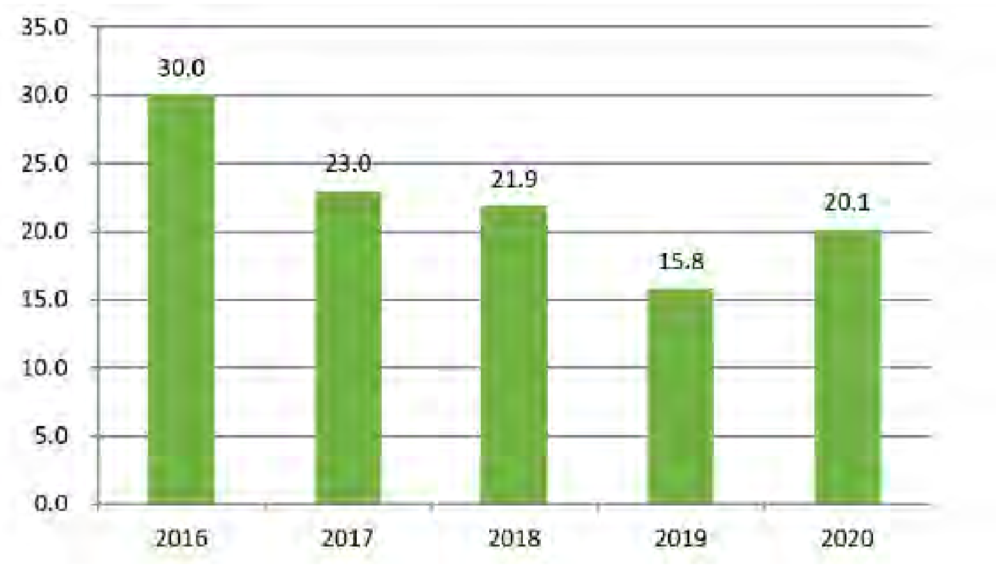
Figure 1.1-2 Global Installed capacity of renewable energy in 2016-2020 (GW)



II. HYDRO

Hydropower is an important pillar of energy transition and economic development in many countries. According to the research by the International Renewable Energy Agency (IRENA), the global newly installed capacity of hydropower has been decreasing for four consecutive years from 2016 to 2019, dropping from 30 GW to 15 GW. In 2020, the global installed capacity of hydropower increased by 20 GW, registering an uptick for the first time in the past five years. China saw the largest increase in installed capacity of hydropower in 2020, which was mainly attributed to the commissioning of the first units of Wudongde Hydropower Station (10 GW). Other major countries in Asia also saw growth in the installed capacity of hydropower, including the Laos, India, Nepal, Vietnam and Indonesia.

Figure 1.2-1 Global newly installed capacity of hydropower in 2016-2020 (GW)



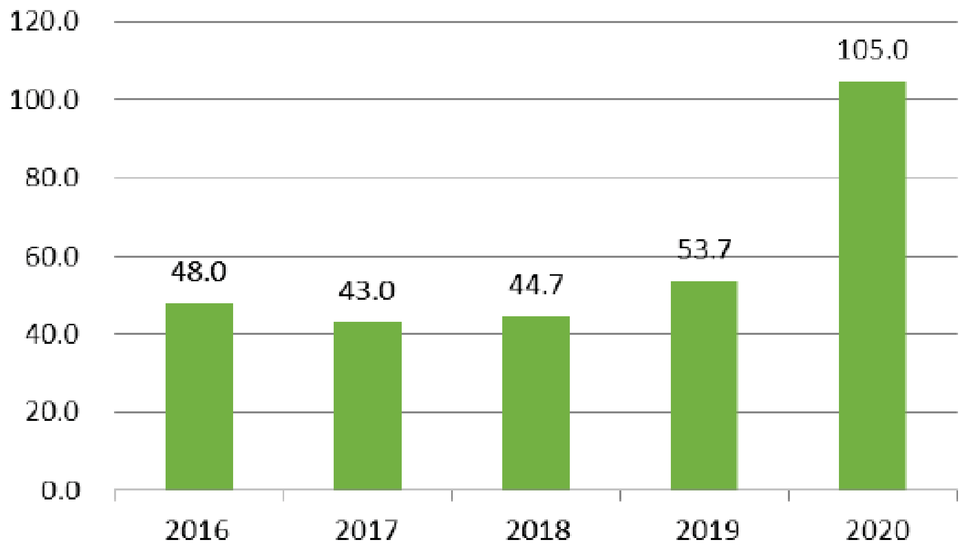
III. WIND

As development costs fall further, wind power has been playing an increasingly important role in the global renewable energy development. In 2020, although the upstream and downstream supply chains of some wind projects were disrupted due to the impact of COVID-19 pandemic, resulting in plant shutdown or project delay, the global installed capacity of wind power still saw significant increase in growth rate. According to the IRENA, the global installed capacity of wind power increased by 111 GW in 2020, a further increase of about 90 percent over the increment of 58 GW in 2019, recording the largest increment since 2016.

1. Onshore Wind Power

After a slowdown in construction in the first quarter of 2020, onshore wind developers and equipment manufacturers quickly adapted to the new normal of COVID-19 pandemic, and stepped up construction since May that year. In general, the global newly installed capacity of onshore wind power hit 105 GW in 2020, a nearly doubled YoY increase, while the figure in 2019 was 53 GW. China contributed about 70% of the global growth in installed capacity of onshore wind power, while the United States saw an increment of more than 40% and Europe’s contribution to the global growth was at a historical low.

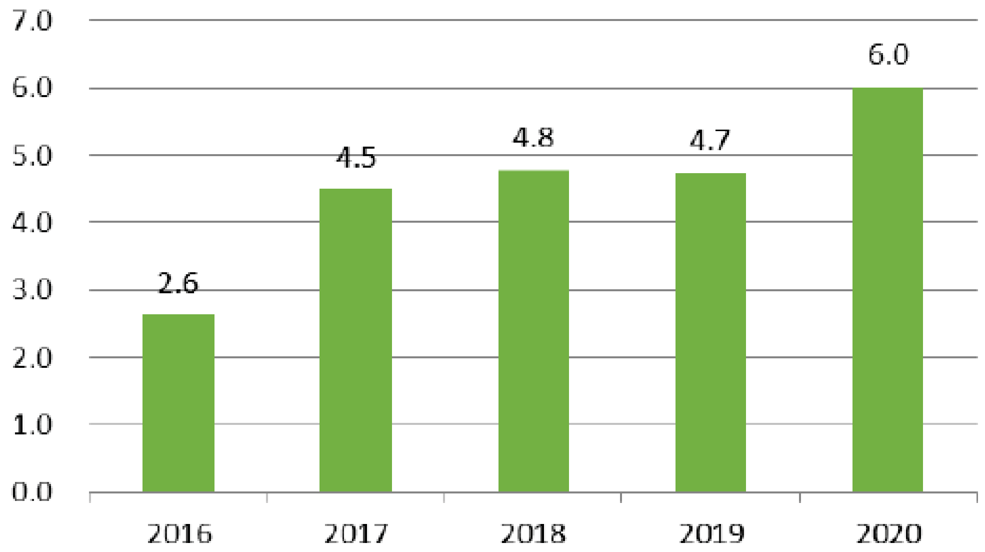
Figure 1.3-1 Global newly installed capacity of onshore wind power in 2016-2020 (GW)



2. Offshore Wind Power

In 2020, offshore wind power maintained steady growth, as the offshore wind power projects in China, the United Kingdom, Germany, Portugal, Belgium, the Netherlands and the United States were put into operation successively, increasing the installed capacity by 6 GW. China, for the first time, contributed more than 50% of the global growth of offshore wind power, with the rest contributed by Europe and America.

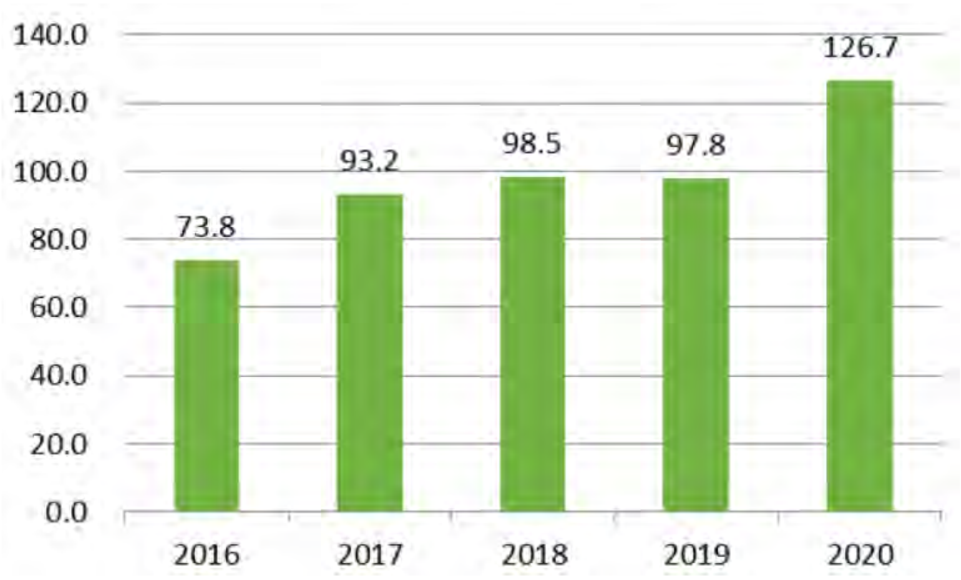
Figure 1.3-2 Global installed capacity of offshore wind in 2016-2020 (GW)



IV. SOLAR

With technological advances and economies of scale, solar PV energy, as a clean and cost-effective energy source, has overtaken hydropower and onshore wind power as the largest driver of global renewable energy growth since 2016. Despite the slow-down in March and April, 2020 amid the pandemic, the new PV projects around the world have been recovered rapidly since the mid-May. As a result, solar PV power continued to lead the growth of renewable energy in 2020. According to the IRENA, global newly installed solar PV capacity hit 126 GW in 2020, accounting for 48% of the world's total newly installed capacity of renewable energy. As the global energy transition speeds up, solar PV power will continue to drive the growth of power generation from renewable energy.

Figure 1.4-1 Global newly installed solar PV capacity in 2016-2020 (GW)



V. BIOMASS

In 2019, biomass consumption accounted for 5% of the global end-use energy consumption, and half of end-use renewable energy consumption. In the power sector, biomass power generation grew 6% to 602 TWh in 2020, with China remaining the largest biomass power producer, followed by the United States and Brazil.

VI. ENERGY STORAGE, GREEN HYDROGEN AND OTHER ENERGY SOURCES

1. Energy Storage

In 2020, the total storage scale of all types of energy sources worldwide hit 191 GW. As the predominant way to store energy, pumped storage saw an installed capacity of 14 GW, followed by thermal storage with an installed capacity of 3 GW.

Battery storage projects in many countries were affected by the COVID-19 pandemic in the first half of 2020, and the scale of new projects put into operation decreased compared with the same period in 2019. According to statistics from the global energy storage project database of China Energy Storage Alliance (CNESA), in the first half of 2020, the global installed capacity of new projects put into operation reached 591 MW, a decrease of 26%. The global market of battery energy storage began to recover from the second half of 2020. The previously stagnant or postponed projects gradually got back on track, and project construction was scaling up.

2. Green hydrogen

Hydrogen has become a new focus on the current international agenda. According to the China Hydrogen Alliance Research Institute, among over 20 countries which contribute 44% of global GDP, 9 of them have developed complete national hydrogen strategies and 11 are in the process of developing. In addition, 14 countries, accounting for 38% of global GDP, are supporting pilot and demonstration hydrogen projects even in the absence of hydrogen development strategies.

In recent years, electrolytic hydrogen production projects have been growing rapidly in terms of both number and scale. In 2021, China launched its first 10,000-ton solar PV-based green hydrogen demonstration project, including a PV power plant with a newly installed capacity of 300 MW and an annual generating capacity of 600 million kWh, an electrolytic hydrogen plant with an annual production capacity of 20,000 tons, a spherical hydrogen storage tank with a storage capacity of about 210,000 standard cubic meters (SCM), a hydrogen pipeline with a transportation capacity of 28,000 SCM per hour and supporting power transmission and transformation facilities. The project is expected to be completed and put into operation in June 2023.

3. Geothermal Energy

According to statistics available, about 100 MW of geothermal power generation projects were completed and put into operation in 2020, with the global installed capacity hitting about 14 GW. Compared with recent years, the year 2020 saw a lower increase in installed capacity due to the COVID-19 pandemic, with almost all new projects located in Turkey, the US and Japan.

4. Marine Energy

Marine energy is the smallest source of renewable energy in the market. Most of the marine energy projects are demonstration and pilot ones with an installed capacity of less than 1 MW. In 2020, an additional 2 MW of marine power was installed worldwide.

Chapter 2

Profile of the Renewable Energy Development in BRICS Countries

[II]

BRAZIL

I. OVERVIEW OF ENERGY RESOURCES

The discussions about the use of non-renewable energy resources and their socio-environmental impacts have grown in recent years. Actions to promote the energy transition are being discussed, from changes in the energy matrix (accelerating the elimination of coal) to the transition to zero emissions in vehicles (insertion of more electric vehicles).

Amid the resumption of global discussions on the final bases of the Paris Agreement at the Conference of the Parties (COP26) in Glasgow, Brazil maintained its leadership position in the context of the energy transition, not only expanding its commitments assumed in the National Determined Contribution (NDC) of December 2020, to achieve carbon neutrality by 2060, for more ambitious targets: reducing 50% carbon emissions by 2030 and achieve carbon neutrality by 2050, 10 years before what was agreed previously, as well as actively participating in the construction of the carbon market created at the conference.

Brazil has one of the most renewable energy matrices in the world, according to the National Energy Balance - BEN of 2022, 44.7% of the domestic energy supply comes from renewable sources and reached almost 50% in 2020. The diversification of the energy matrix contributes for this result, such as the expansion of the supply of sugarcane derivatives, wind energy and biodiesel, starting in 2015. Hydraulic energy still has a prominent role in the renewability of the energy matrix with 11%, and even greater in the electrical matrix with 53.4%. However, the entry of other sources, such as those already mentioned, and solar energy has been gaining strength and already represent 25.1% of the total energy.

The expectation for the next 10 years is to reach 48% of renewable energy matrix and 84% for the electricity matrix. For this, investments of the order of more than 3.2 trillion over the next 10 years, of which R$2.7 trillion is related to oil, natural gas and biofuels, and almost

R$530 billion to the generation and transmission of electricity, against the backdrop of an estimated economic growth of 2.9% per year.

II. RECENT INITIATIVES IN ENERGY

The Brazilian government has been working to maintain and expand the renewable and safe energy matrix. In this sense, there are some programs and actions such as the National Hydrogen Program - PNH2, Decree 10,946 of January 2022, regulating offshore electricity generation and RenovaBio for Biofuels that already contribute or will contribute to further leveraging renewable sources in the energy matrix.

1. National Hydrogen Program - PNH2

In 2021, the National Energy Policy Council - CNPE approved the resolution that determines the proposal of guidelines for PNH2. Also, during 2021, Brazil co-led the United Nations High-Level Dialogue on Energy, having presented an energy pact on hydrogen.

The Program aims to contribute significantly so that the country walks on the path of sustainable development with increased competitiveness and the participation of hydrogen in the Brazilian energy matrix and the recognition of the relevant role that the production and use of hydrogen can play in a trajectory of net carbon neutral emissions, given their economic, social and environmental importance for development.

The Program proposes to define a set of actions that facilitate the joint development of three fundamental pillars for the success of a trajectory of development of the hydrogen economy: public policies, technology, and market. Among these actions is the valorization of the national potential of energy resources for obtaining hydrogen, recognition of the diversity of energy sources and available or potential technological alternatives, alignment with the ambitions of the economy’s decarbonization, appreciation and encouragement of national technological development, development of a competitive market, search for synergies and articulation with other countries and recognition and promotion of the national industry.

2. Offshore Electric Power Generation

The potential for generating electricity offshore in Brazil is enormous, the area known as the Blue Amazon has 7,400 km of coastline and 3.5 million km^2 of maritime space to be used, in addition to the production of oil and gas. Decree 10,946 of January 2022 brought the necessary regulatory framework for it to be possible to develop electricity generation projects in these areas.

According to Energy Research Office– EPE in its Roadmap, just for the offshore wind potential, it showed that Brazil has a potential of almost 700 GW along the coast, this is equivalent to almost 10 times the planned expansion for the installed power capacity for the next 10 years in Brazil. In other words, this initiative is in agreement and can greatly help the neutrality goal by 2050. In addition, the entire production and logistics chain (ports, transport, transmission lines) can benefit from this new market, bringing more investment to the sector and greater energy security.

Onshore wind power already represents the second source of the Brazilian electricity matrix with 11% and according to the 2022 Global wind report, Brazil occupies the 6th place in the world ranking with 21.5 GW of onshore installed capacity.

3. RenovaBio

Since the beginning of the 21st century, the Brazilian government has used public policies to stimulate the biofuels market, such as the insertion of vehicles with flex fuel technology, the mandatory blending of anhydrous ethanol in gasoline, the National Production Program and Use of Biodiesel (PNPB) and, more recently, RenovaBio and the Fuel of the Future Program. It is observed that public policies to stimulate the market for renewable fuels in Brazil date back to the 1930s.

RenovaBio, established by Law No. 13,576/2017, is the National Biofuels Policy and sets annual national decarbonization targets for the fuel sector, in order to encourage increased production and participation of biofuels in the country's transport energy matrix. Through the certification of the production of biofuels, they will be attributed to each producer and importer of biofuel, in an amount inversely proportional to the carbon intensity of the biofuel produced (Energy-Environmental Efficiency Note). The score will accurately reflect the individual contribution of each producing agent to the mitigation of a specific amount of greenhouse gases in relation to its fossil substitute (in terms of tonnes of CO^2 equivalent).

The mandatory use of biodiesel in the mixture with fossil diesel was determined by law. Initially, the addition of 2% of biodiesel to fossil diesel was authorized, becoming mandatory in 2008. The percentage reached 5% in 2010 and, since then, there has been a rapid evolution, which reached 13% in March 2021, with a schedule to advance to 15% in 2023.

Among the objectives are to provide an important contribution to the fulfillment of the commitments determined by Brazil under the Paris Agreement; Promote the adequate expansion of biofuels in the energy matrix, with emphasis on the regularity of fuel supply; and Ensuring predictability for the fuel market, inducing gains in energy efficiency and reduction of greenhouse gas emissions in the production, commercialization and use of biofuels

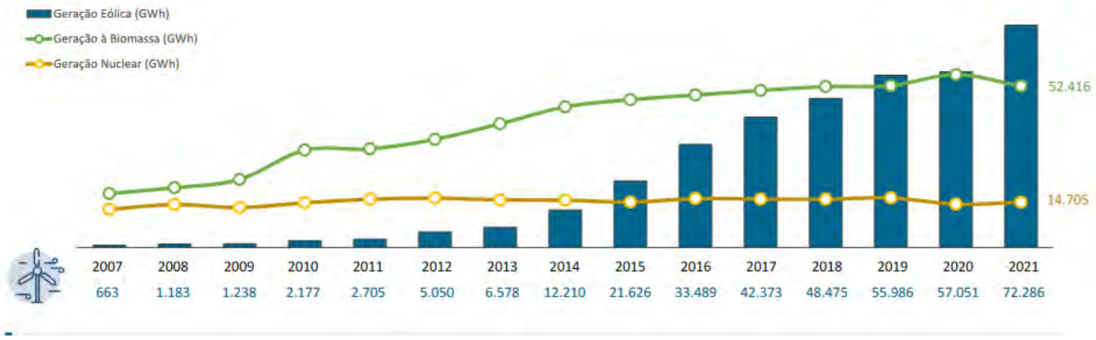
III. DEVELOPMENT OF RENEWABLE ENERGY

1. Wind Power

Brazil expanded its total electricity generation by 56.2 TWh from 2018 to 2021, with wind generation accounting for 43% of this expansion. In 2021, Brazil generated 657.6 TWh, and wind participated with 11%. The generation increased from 48.5 TWh in 2018 to 72.6 TWh in 2021, showing an expansion of 24.1 TWh (50% increase).

The cumulative wind generation from 2019 to 2021 was 185.6 TWh. The avoided emissions would be 155 million tCO_2, equivalent to 41% of the total emissions in Brazil in 2020 due to energy use (parameter: if this generation was done in coal-fired plants with 40% efficiency).

Figure 2.3-1 Evolution of wind generation (GWh)



In 2020, wind generation enabled the Northeast Region to become a net exporter of electricity, with total generation exceeding total demand by 12%. In 2000 the region's deficit was 21% and in 2019 it was 3%. Wind expansion has made a difference over the years, and it already has a proportion of more than 40% in the current generation matrix in the

Northeast.

In 2021, Brazil's total installed capacity reached 190.7 GW, with a wind power ratio of 11%.

Wind installed capacity increased from 14.4 GW at the end of 2018 to 21.0 GW in 2021, with an expansion of 6.6 GW (a 46% increase). This expansion required investments of around 30 billion reais, generating more than 200,000 jobs during construction.

According to the Global Wind Report 2022, Brazil, with 21.5 GW of installed capacity, occupies the sixth position in the world ranking for onshore wind turbines. Also, according to the Report, in 2021, it was among the 5 largest markets in the world for new installations, ranking third, behind only China and the United States.

Brazil has 1187 projects (812 in operation and 375 that are yet to be built or under construction) totaling almost 35 GW of power granted, that is, in addition to the 21.5 GW we have another 13 GW of wind power to enter the system. In view of this, the role of the Northeast stands out, with more than 1000 projects and responsible for more than 30 GW of the power granted.

Regarding offshore wind, there are still no wind farms installed in Brazil, however there are more than 100 GW of projects with a license request from IBAMA, spread along the Brazilian coast.

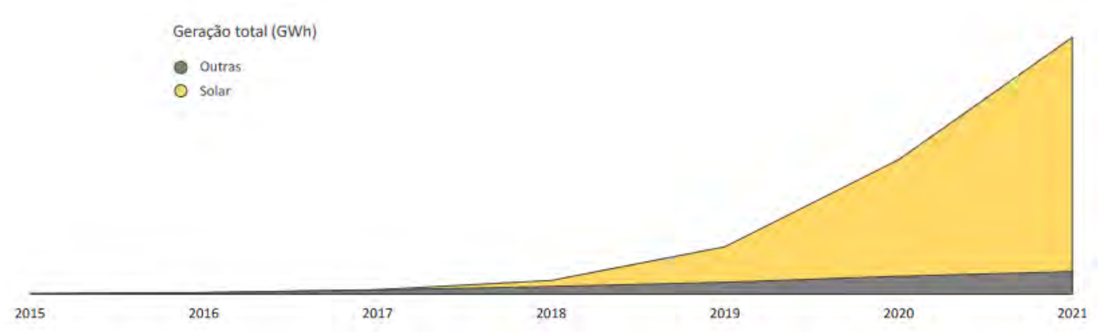
2. Solar Power Generation

In 2021 solar generation reached 16.8 TWh (centralized generation and Distributed Micro and mini-generation - MMGD), which represented an increase of 55.9% in relation to the previous year.

The MMGD has grown in Brazil, and solar energy leads this market. In 2021, it showed an increase of 84% compared to 2020, from 5,346 GWh to 9,810 GWh. And solar energy has the highest percentage among the sources, with 88.3%.

This fact has been built up over time, note that the evolution of MMGD indicates the continuous growth trajectory of photovoltaic solar generation at a higher rate than other sources.

Figure 2.3-2: **Evolution of solar generation (GWh)**



MMDG based on photovoltaic solar generation reached 8,771 MW of installed power and 9,019 GWh of generation in 2021.

In terms of centralized generation, Brazil has 12,579 projects (11,264 in operation, 127 under construction and 1188 construction not started) totaling almost 60 GW of power granted, that is, in addition to the 5 GW already inserted in the electrical system, there are another 55 GW of solar installed capacity to enter in the system.

3. Biofuels

In 2020, the ethanol production decreased 7.2% compared to 2019, reaching 32.6 billion liters (the Covid-19 pandemic impacted the fuel market, including biofuels), Corn ethanol production reached 2.4 billion liters, a rise of 82% compared to the previous period. Although, a positive balance in the international ethanol trade was maintained as observed in 2019. Hydrous ethanol average price decreased 6.4% in 2020 compared to the previous year, while gasoline C dropped 10.7%, constant value of December 2020, which resulted in relative price (EP / GP) of 68.9%, higher than the value in 2019, 66.4%, still favorable to biofuel.

New vehicle licensing was 27% lower than in 2019.Thus, the consumption of hydrated ethanol decreased by 14.7%, reaching 19.8 billion liters, the demand for gasoline C also dropped to 36 billion liters, which resulted in a 9.2% reduction in total demand for the Otto cycle, and recorded 49.8 billion liters of gasoline equivalent.

For bioelectricity, from sugar-energy plants injected into the National Interconnected System, was similar to the amount 2019, 2.6 GWméd.

In relation to biodiesel, the mandatory percentage was raised to 12% in March 2020, according to the schedule provided for in the legislation. In this way, its production registered a new record of 6.4 billion liters, 10% higher than 2019.

Emissions avoided by the use of ethanol, biodiesel and sugarcane bioelectricity in 2020 were 46.8 MtCO2eq, 18.1 MtCO2eq and 2.4 MtCO2eq, respectively, adding up to 67.3 MtCO2eq.

Concerning biogas, the installed capacity in distributed generation keep increasing from 2019 to 2020, reaching 42 MW, using as input mainly agroindustrial, animal and waste residues. In addition, its participation in the internal energy supply (0.1%) has been growing by 27% p.y. in the last five years.

4. Hydrogen

In this aspect, Brazil is making great strides, there are already efforts in research and development, carried out by Furnas and EDP Brasil, the first one evaluating its use in a fuel cell at UHE Itumbiara, and the second as a partial substitute for coal in thermoelectric generation, both as hydrogen and ammonia. Angra I and II also have a hydrogen production plant, with a production capacity of 150 kg/day. Table 2.3-1 summarizes the low carbon hydrogen projects announced in the country in 2021, with their characteristics and scales.

Table 2.3-1

Project	Company	Location	Escale	Stage
Purification of generated H2	Eletronuclear	Angra I e II - RJ	150-300 kg H_2/d	R&D
H_2V	PTI	Porto do Pecém - CE	Pilot	R&D
H_2V hibrido (UHE e FV)	Furnas	Itumbiara-GO	Pilot	R&D
Steam reforming bioCH_4 to produce bioH_2 and NH_3V	Yara with CH_4 Raízen	SP	20.000m3/d	Comercial in 2023
H_2V for public tranportation	Neoenergia	CE		MoU
Fertilizer (NH_3V)	Unigel	Camaçari – BA	Comercial	Conversion at the end of 2022
H_2V e NH_3V de eólica	Enterprize Energy	RN	Comercial	MoU
H_2V	Fortescue	Porto do Açu - RJ	Comercial (300 MW è 250 kt NH_3)	MoU
H_2V	Fortescue	Porto do Pecém - CE	Comercial	MoU
H_2V	Enegix	Porto do Pecém - CE	Comercial (600 kt H_2)	MoU
H_2V	Qair	Porto do Pecém - CE	Comercial (540 MW)	MoU
H_2V	White Martins (Linde/Praxair)	Porto do Pecém - CE	Comercial	MoU
H_2V	EDP	Porto do Pecém - CE	Comercial (250 m^3 H_2/h)	MoU
H_2 azul e verde	Qair	Porto de Suape - PE	Comercial (540 MW)	MoU

Project	Company	Location	Escale	Stage
H_2V	Neoenergia	PE	Pilot	MoU

IV. ADVANTAGES AND FEATURES

Brazil is a privileged country with regard to natural resources, among which energy resources are included. The country has one of the largest hydroelectric potentials on the planet, the best quality winds for onshore and offshore wind generation, abundant solar irradiation, uranium resources in significant quantities, mineral coal, huge resources of oil and natural gas onshore and mainly offshore distributed along the coast.

In addition, Brazil has a thriving agribusiness of global relevance, a context in which bioenergy is inserted in its most varied forms. An in-depth look at Brazilian energy resources allows us to verify that we have high potential and great diversity, including both renewable and non-renewable sources, or in other words, both clean and fossil sources.

The trajectory of the Brazilian energy sector development has led us to have a high share of renewable sources as in the energy matrix (Brazil 45%, World 14%) as in the electricity matrix (Brazil 78%, World 27%), in supplying the needs of the country, especially when compared to other relevant economies. Of note are sugarcane biomass, hydroelectricity and, more recently, wind and solar. On the other hand, fossil fuels represent a significant part of the matrix, being essential for many sectors of the economy, such as transport and industry.

With regard to solar energy, the success of its use for electrical generation is a combination of factors. First, the font is no longer new in Brazil. We have overcome the initial phase of implementation of the first projects, and here it has been consolidating and maturing. This process took relatively little time. The second factor is that the solar source has become competitive in relation to other sources in the national market. Along with wind energy, it has been the most competitive source in recent years. Last year, solar energy was the most competitive energy source in our energy auction for new energy.

Solar energy prices have decreased from 70% to 80% since 2014. Every year we have centralized energy auctions where local distribution companies purchase long-term ppa. For solar power, they are usually 20 years old. In 2019, the average price in energy auctions was between 14 and 17 us$/mwh. This is due to the worldwide trend of cost reduction.

It is also interesting to point out that the irradiation is well distributed throughout the territory. Naturally, there are regions that are more suitable for generating solar energy, especially in the states located in the center and northeast of the country. Even so, the potential is good in most regions.

To illustrate, considering the most suitable locations, there is potential for installing 300 gwp of solar generation. To put this in perspective, our current total installed capacity considering all sources is approximately 180 GW. Thus, it is possible to verify that we have good prospects.

In these circumstances, solar generation advanced with centralized and also distributed generation. In total, it reached 10.8 GW of installed capacity in September this year.

I would also like to mention some other points, which are general to our energy sector and which we believe are differentials to attract investments: all energy purchased by pmds through centralized auctions, long-term contracts, ppas are concluded in 4 to 6 years with prior to the start of operation of a new plant.

We have policies and incentives to promote solar and other renewables, but now their expansion is happening more as a result of market forces than as a result of incentives.

The installed capacity of centralized solar energy already represents 2% of the total installed capacity. It might be considered a small participation, but it is a photograph of a rapidly rising curve.

When we look only at distributed generation, it represents 65% of the total, with 7 GW. This is in line with the market reform that is being debated, where we intend to give consumers real power of choice and allow them to participate more actively in the market.

For the next 30 years, most of the scenarios we have indicate installed solar capacity to reach between 30 and 90 GW in 2050, considering only centralized generation. This will represent between 5% and 16% of the total. In some scenarios, it reaches more than 100 GW.

At the same time, it is also clear that the challenges we will face are different and more complex than we have faced in the past. One of the main problems that we have to face in the next ten years is the adequacy of the generation. This is not only related to solar energy, but to all sources with variable generation.

Historically, hydroelectric plants were used to provide energy and also for peaks in demand, as there was the possibility of storing water in reservoirs. Now that we have more run-of-river hydroelectric plants, we have lost the ability to regulate water use for over a year. Furthermore, the relative share of hydropower plants is expected to decrease in the future, and the sources of greatest expansion are precisely wind and solar.

V. PROSPECTS FOR DEVELOPMENT

It is important to highlight the diversification of the matrix based on investments in renewable sources in addition to hydroelectric plants, such as wind, biomass and photovoltaic, complemented by the expansion of dispatchable generation, such as natural gas thermoelectric plants. The water source, which at the beginning of the century represented 83% of installed capacity, should reduce its relative share in the 2031 Ten Year Energy Expansion Plan (PDE 2031) to 46% by the end of the horizon (also considering the growth of distributed generation).

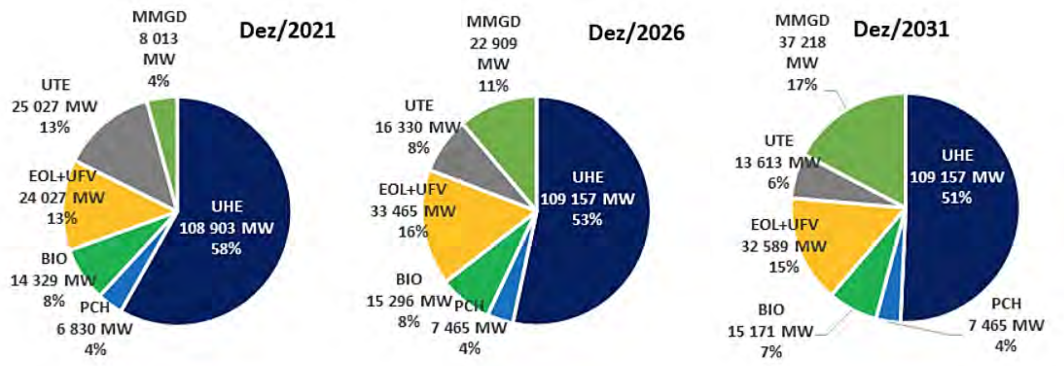
On the other hand, as the configuration of the generating complex changes, new challenges arise to guarantee future supply. Among the lessons learned in the 2020/2021 biennium, the situation of water scarcity showed how the different uses of water impact the management of reservoirs and brought to light that the way in which the operational restrictions of the large hydroelectric power plants (UHE) are represented in the energy models can be improved.

The expansion studies of centralized generation were carried out in the period when the Brazilian electrical system was facing the biggest water scarcity in its history. In this sense, one of the main objectives pursued was the incorporation of lessons learned, which point to structural planning solutions, and which are placed for broad debate with society through this report.

Initially, it is important to highlight the diversification of the matrix from investments in renewable sources in addition to hydroelectric plants, such as wind, biomass and photovoltaic, complemented by the expansion of dispatchable generation, such as natural gas thermoelectric plants.

It can be seen in the chart below that the absolute hydroelectric participation in the matrix remains practically unchanged. On the other hand, there is significant growth in wind and centralized photovoltaic solar sources, which together add around 9 GW to the installed capacity already under implementation, from December 2021 to the end of 2031.

Figure 2.5-1: Evolution of the Existing and Contracted Installed Capacity of the National Interconnected System



EOL+UFV is wind and solar photovoltaic, MMGD is mini and micro distributed generation, UHE is large hydroelectric plants, PCH and CGH are small hydroelectric plants, UTE is thermoelectric plants and BIO is biofuels, mainly ethanol and biodiesel.

Expectations of energy consumption matrix evolution between 2021 and 2031 corroborate the trend of growth in the importance of electricity in the country, with an average annual increase of 3.5%, contributing to the reduction of GHG emissions.

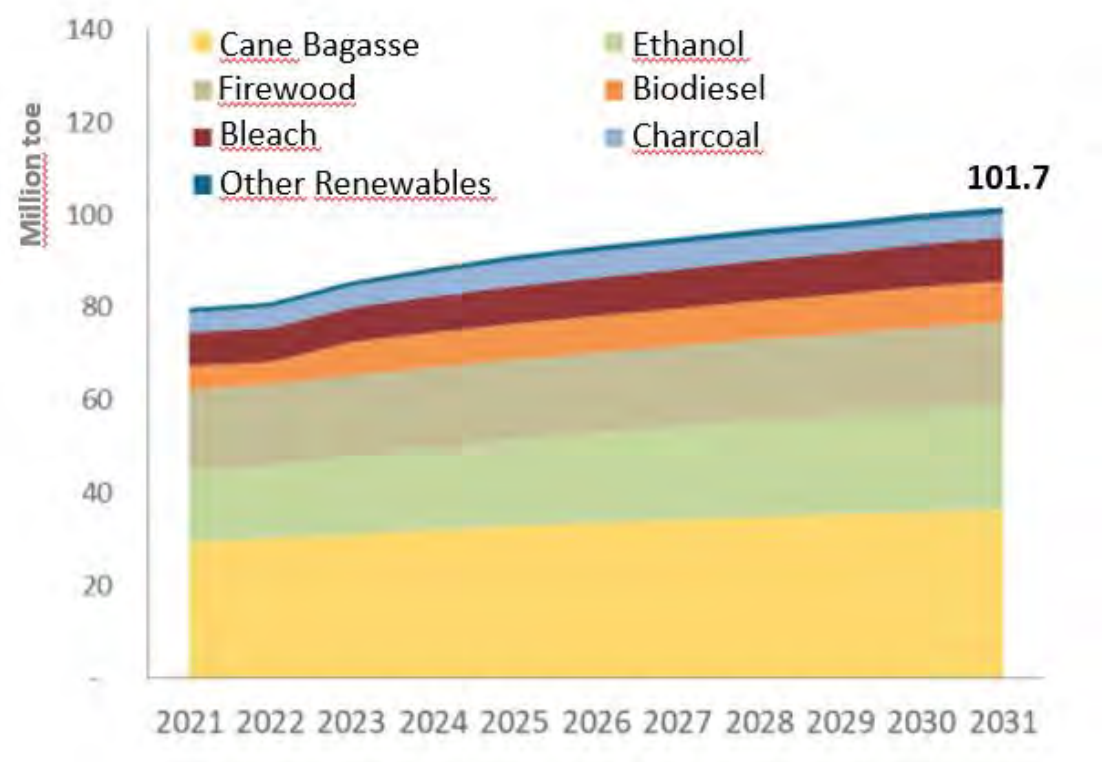
As for biofuels, those that most grew in importance in terms of final energy consumption in the analyzed period are ethanol (4.1% per year), lye (2.8% per year), from cellulose production, and biodiesel. (3.7% per year).

The demand for biodiesel is catalyzed by the premise of increasing its share of commercialized diesel oil, which jumps from 11.2% in volume in 2021 to 15% in 2031. Hydrous ethanol is growing in importance in light vehicles, at the expense of automotive gasoline.

In the period 2021-2031, ethanol has a significant increase in final consumption, with a good part of this increase coming from hydrated ethanol (6.6% per year), to be used basically in Otto cycle vehicles.

BRAZIL

Figure 2.5-2 **Final consumption of biofuels by source**



[III]

RUSSIA

I. RESOURCE OVERVIEW PRESENT

Key provisions of the Russian renewable energy development state management system are determined by the Federal Law “On the Electric Power Industry”[1], according to which renewable energy sources include: solar energy, wind energy, water energy[2], tidal energy, energy of water body waves, geothermal energy, low-grade heat energy, biomass including plants grown especially to produce energy, as well as biogas and gas emitted by waste at landfills, etc.[3]

It should be noted that large hydroelectric power plants with an installed capacity exceeding 50 MW are not included in the list of technologies covered by the support measures to incentivize investment in generating facilities operating on the basis of renewable energy sources. In this regard, large hydro power plants (HPPs) are in general not taken into account in the official statistics as part of RES generation, but they significantly contribute to the country's power system and provide about 19% of the cumulative power consumption. Taking into account large HPPs, the cumulative installed capacity of renewable energy generation facilities amounts to 56 GW, which corresponds to approximately 22% of the

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Abbreviations for Chapter 2 Russian part
SPP – Solar Power Plant
WPP – Wind Power Plant
sHPP – Small-Scale Hydro Power Plant
BioPP – Biofuel-Power Plant
Tidal PP – Tidal Power Plant
GeoPP – Geothermal Power Plant

[1] Federal Law No. 35-FZ dated March 26, 2003 “On the Electric Power Industry”

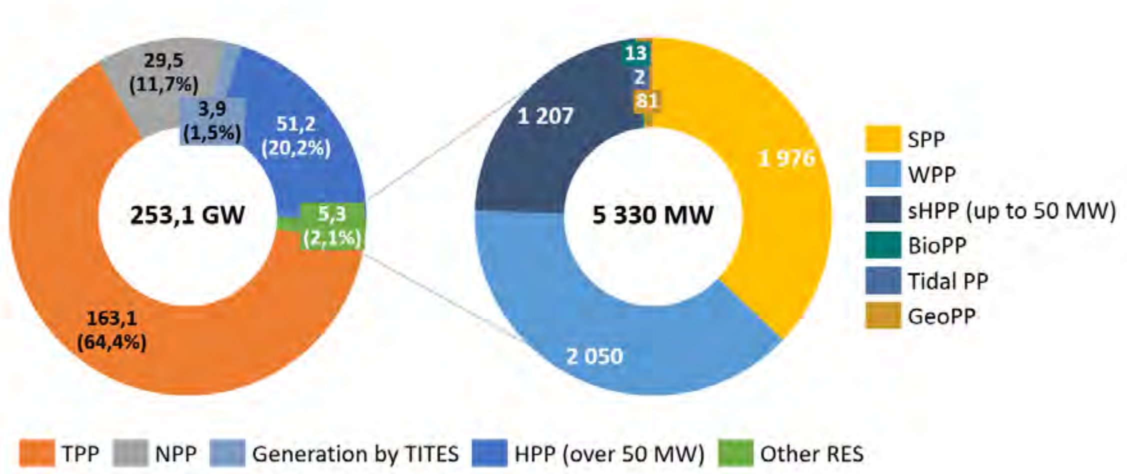
[2] including wastewater energy, except when such energy is used at pumped storage power plants.

[3] In addition, RES in Russia include the production and consumption of waste, with the exception of waste from the use of hydrocarbon derivatives and fuel, as well as gas generated at coal mines.

total installed capacity of the Russian energy system.

By the end of 2021, the cumulative installed renewable power generation capacity[4] in Russia reached 5.33 GW, which is equal to around 2.1% of the total installed power capacity of the Russian energy system (Figure. 3.1-1). Thereby 3.6 GW or 1.5% of the total capacity is provided by renewable energy power plants built under the support program for RES in the wholesale market (CSA RES[5]).

Figure. 3.1-1 Installed capacity of RES generation facilities in Russia (by the end of 2021), MW



Source: RREDA, SO UPS JSC, NP Market Council

In the structure of the installed renewable power generation capacity wind and solar energies are taking up a leading position (with a capacity of about 2 GW respectively) followed by small hydroelectric energy with an installed capacity of up to 50 MW – 1.2 GW aggregated. In addition, there are power plants operating on the basis of biomass, biogas, landfill gas, tidal energy, and geothermal energy, with a cumulative capacity of about 100 MW.

Today, renewable energy sources in the Russian Federation provide approximately 9 billion kWh of electricity per year, which equals about 1% of the total power generation and

[4] HPPs with an installed capacity exceeding 50 MW are not taken into account for the purposes of this report.

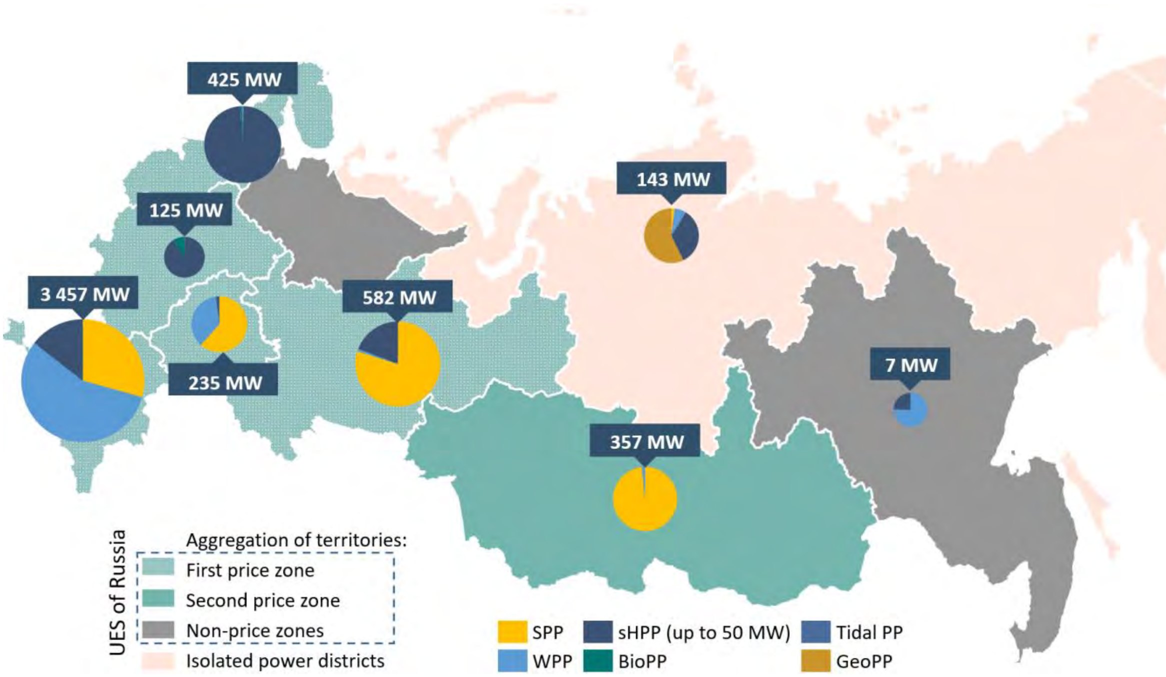
[5] CSA RES – RES Capacity Supply Agreements, a program to incentivize investment in RES generation facilities on the wholesale electricity and capacity market. The support is provided on a competitive basis to investment projects with the lowest specific capital investment (cost of power generation – for projects selected from 2021) through capacity payments for 15 years.

consumption in the Russian Federation.

The power system of the Russian Federation consists of the Unified Energy System (UES) and Technologically Isolated Territorial Energy Systems (TITES). The UES territory is divided into two price zones (the first includes the European, Urals, southern and northwestern territories of Russia, and the second one is Siberia) and non-price zones (Arkhangelsk and Kaliningrad regions, the Komi Republic, regions of the Far East), where market relations in the electricity industry are not yet possible for technological reasons. In the price zones of the wholesale market, electricity and provision of capacity are sold using the existing market mechanisms.

Over 97% of renewable energy generation facilities (5.19 GW) are located in the UES of Russia, with 65% of the total renewable energy capacity operating in the south of Russia, about 11% – in the Urals, and 7–8% – in the integrated energy systems of the Russian North-West and Siberia (Figure.3.1-2).

Figure 3.1-2 Chart for distribution of RES generation by energy systems (zones) of Russia, MW

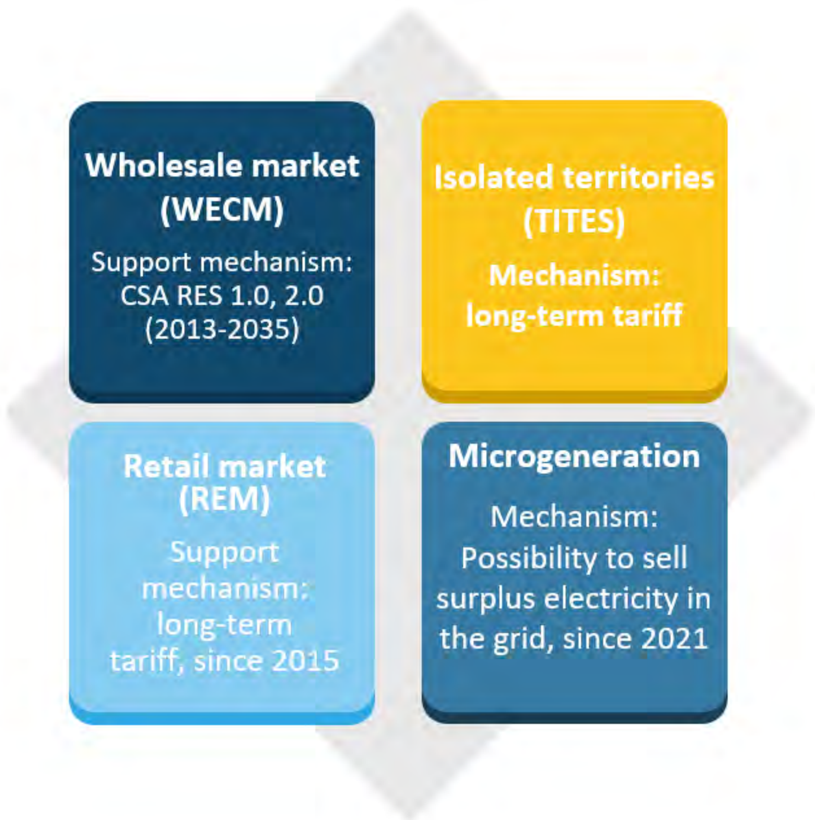


Source: RREDA

II. INDUSTRIAL POLICY

A system of regulatory support measures operates in order to incentivize investment in the development of the renewable energy sector in Russia, including tendering mechanisms to select and support investment projects on the wholesale electricity and capacity market (WECM) by capacity payments under Capacity Supply Agreements (CSA RES), and selections of investment projects on the retail electricity markets (REM) for further priority sale of renewable energy in order to compensate grid losses of electric grid companies, as well as a mechanism for "balancing" electricity generation by microgeneration facilities and consumption of energy by residential and commercial consumers under 15 kW. For technologically remote and isolated energy systems (TITES), there is a mechanism for return on investment for replacing expensive fuel generation in accordance with energy service contracts (Figure. 3.2-1).

Figure. 3.2-1 Segments of the RES market in Russia and existing support tools



Source: RREDA

1. Wholesale electricity and capacity market – WECM

Since 2013, the mechanism has been functioning on the wholesale electricity and capacity market to incentivize investments in renewable energy generation by paying for the capacities of such facilities. Investors are granted the right to enter into capacity supply agreement (CSA RES), which guarantees payments for installed capacity for 15 years in addition to the revenue from the sale of electricity at free prices on the day-ahead market, which provides for the return on invested capital and the rate of return of 12%[6].

The right to enter into a CSA RES is given to the winners of the tenders for RES investment projects, which are held annually based on quotas approved by the Government of the Russian Federation[7]. Before 2020 inclusively, tenders for renewable energy investment projects were held based on the main criteria of minimizing capital costs for their implementation. The Government of the Russian Federation sets an individual cost limit for each technology, which cannot be exceeded. Entering into the CSA RES the investor receives the obligation to build a power plant in compliance with the capacity and commissioning period specified in the application. Among other things, payment for capacity is calculated on the basis of indicators of the capital expenditures for the construction of a generation facility, which were announced for the tender. The investor shall be penalized for a violation of capacity supply obligations (within the period prescribed by CSA RES) or a failure to comply with the requirements to achieve the minimum capacity factor. One of the key criteria for receiving full payment for capacity with an appropriate rate of return is reaching the target indicators of the production localization (local content requirements – LCRs) for elements of the main and auxiliary equipment of a RES generation facility[8].

From 2013 through 2020, annual tenders were held according to the rules of the first renewable energy generation support program CSA RES 1.0 with the planned start of power supply from 2014 through 2024. By the end of 2024, the total installed capacity of power plants built under CSA RES 1.0 will be 5.43 GW (SPP – 1.79 GW, WPP – 3.43 GW, sHPP – 0.21 GW).

In 2021, the Government of the Russian Federation decided to extend the RES generation support program beforeuntil2035. The second stage of the support program was named CSA RES 2.0 in the expert community. The CSA RES 2.0 program, unlike the CSA RES

[6] 12% is the basic rate of return on an investment project, calculated on the basis of indicators announced at the tender. If the project is actually implemented with more efficient indicators, the real rate of return could be higher.

[7] Decree No. 1-r of the Government of the Russian Federation dated January 8, 2009, “On the Main State Policy Sectors to Improve Energy Efficiency of the Electricity Industry Based on the Use of Renewable Energy Sources for the period up to 2035”

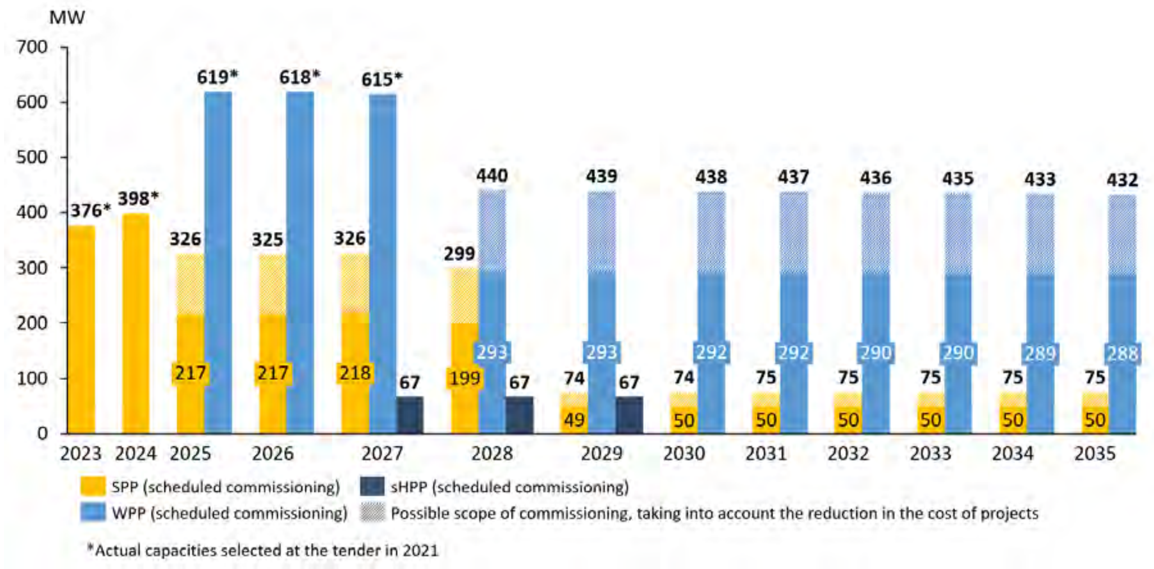
[8] For projects selected before 2020 inclusively, the maximum values for local content requirements by equipment types are established at the levels: WPP – 65%, SPP – 70%, sHPP – 65%.

1.0 program, does not provide exact scope indicators for the installed capacity of renewable energy generation. At the Russian Federation Government order level, only the scope of support is limited (payment for capacity under CSA RES). The scope of support until 2035 is fixed at the level of RUB360 billion in 2021 prices. At the maximum values of the electricity price, the designated funds should have been enough to build 5 GW of renewable energy generation. Also, the projects under the second program are selected based on the facility's efficiency indicator declared by the participants (i.e., a straight-line rate), and not by the magnitude of capital expenditures. This change in the project selection principles is intended to incentivize the most efficient projects in terms of the amount of electricity production.

With decreasing electricity costs as the projects are selected, the cumulative installed capacity of investment projects implemented under the support program increases. This innovation has already demonstrated its efficiency: at the 2021 tender, due to the lower electricity cost in applications by more than 50%–70% of the limits, the cumulative output capacity increased by almost 100%. Based on expert assessments, taking into account the lower electricity price in applications within the framework of tenders, the cumulative capacity built up under the CSA RES 2.0 program will be 9–10 GW by 2035 (Figure. 3.2-2).

Another innovation during the second stage of the support program is the requirements to intensify the equipment production localization and to attract as many Russian enterprises producing renewable energy equipment components as possible. Export requirements have also been introduced, which should incentivize greater competitiveness of Russian generating equipment both in domestic and foreign markets. Implementation of the CSA RES 2.0 program will allow localized industries to continue their technological development, and will also help achieve the target indicators of the share of RES in the energy balance: up to 6% by 2035. The renewable energy generation facilities built under CSA RES programs will reduce annual CO_2 emissions in the amount of about 20 million tons by 2035.

Figure. 3.2-2. Scopes of commissioning for RES technologies under CSA RES 2.0 (forecast), MW



Source: RREDA

2. Retail electricity market – REM

The basis for the RES support mechanism in retail markets is laid down in the Federal Law "On the Electric Power Industry", which provides the norm for mandatory priority purchase of renewable electricity by grid companies in order to compensate for their losses in electrical grids. The mechanism entered into force in 2015 with the adoption of a resolution that determined the sequence for procedures required for the renewable energy generation facilities to sell electricity at regulated tariffs.

Within the framework of the annual technologically neutral tenders organized by Russian Federation constituent entities' agencies, the competition is among projects based on solar and wind generation, small hydroelectric power generation, biomass, biogas, and landfill gas with a capacity of 300 kW to 25 MW. In contrast to the wholesale market, the target indicator for the scope of capacity additions have not been established in the retail market. The Russian Federation Government only limits the planned scope of electricity production by such tariff-rated facilities to 5% of the predicted grid losses of grid companies within a RF subject entity. The cumulative scope of this market throughout Russia is estimated at 3 to 4 GW.

Based on such tenders, renewable energy generation facilities, for which the minimum prices for electricity were indicated in the applications, receive the right to include a renewable energy generation facility in the Electricity Development Plan and Program for the Region, based on which the regulatory agency sets a tariff for such a facility for subsequent sales of electricity to a grid company.

In 2022, the mechanism for supporting renewable energy investment projects in retail markets was extended until 2035, which should contribute to the sector's further development. Renewable energy market participants, together with authorities and infrastructure organizations, are also working on the possibility of raising the threshold limit of grid losses for project implementation in retail markets under the support program from 5% to 10% (15%).

3. Microgeneration

Another promising area for renewable energy development is the microgeneration support mechanism adopted in 2021, which provides electricity consumers with the opportunity to sell surplus electricity in the amount of no more than 15 kW to the common grid based on mutual offsetting or so-called balancing. The microgeneration market in Russia can be divided into two parts: households wishing to become prosumers, and small enterprises that can install microgeneration facilities as cost-effective, given the current electricity tariff level. According to RREDA estimates, the annual commissioning of RES based microgeneration facilities in Russia was about 50 MW in 2020–2021, and it is predicted that over the next five years, these figures will increase to 150–200 MW per year, while the market turnover will reach about RUB10 billion.

4. Technologically isolated territorial energy systems – TITES

RES development in technologically remote and isolated energy systems is also one of the priorities for the renewable energy industry in Russia, as reflected in the Energy Strategy of the Russian Federation before 2035. In these territories, renewable energy generation projects can be implemented according to the principles of the support mechanism in retail markets with a number of differences: TITES do not have electricity cost restrictions (the main factor is that electricity generation at a new renewable energy generation facility reduces power supply costs) and does not have restrictions on the rates of electricity production by renewable energy generation facilities, and it is the local guaranteeing supplier and not the grid company that is obliged to purchase all the electricity. Long-term electricity tariffs are also set as a result of the tender. Another option for implementing renewable energy generation projects in TITES is to enter into energy service contracts with energy supply organizations operating there to replace the fuel (diesel) generation. In this case, the return on investment is provided by savings on fuel costs.

5. Hydrogen energy

One of the areas for reducing emissions is global introduction of the low-carbon closed-loop economy concept, where hydrogen plays role of an important tool in reducing greenhouse gas emissions, and decarbonizing the power, transport, and industry sectors. Currently, Russia has adopted regulations and is developing various strategic documents aimed at stimulation the development of the domestic market as well as at the possibility of entering the global hydrogen market.

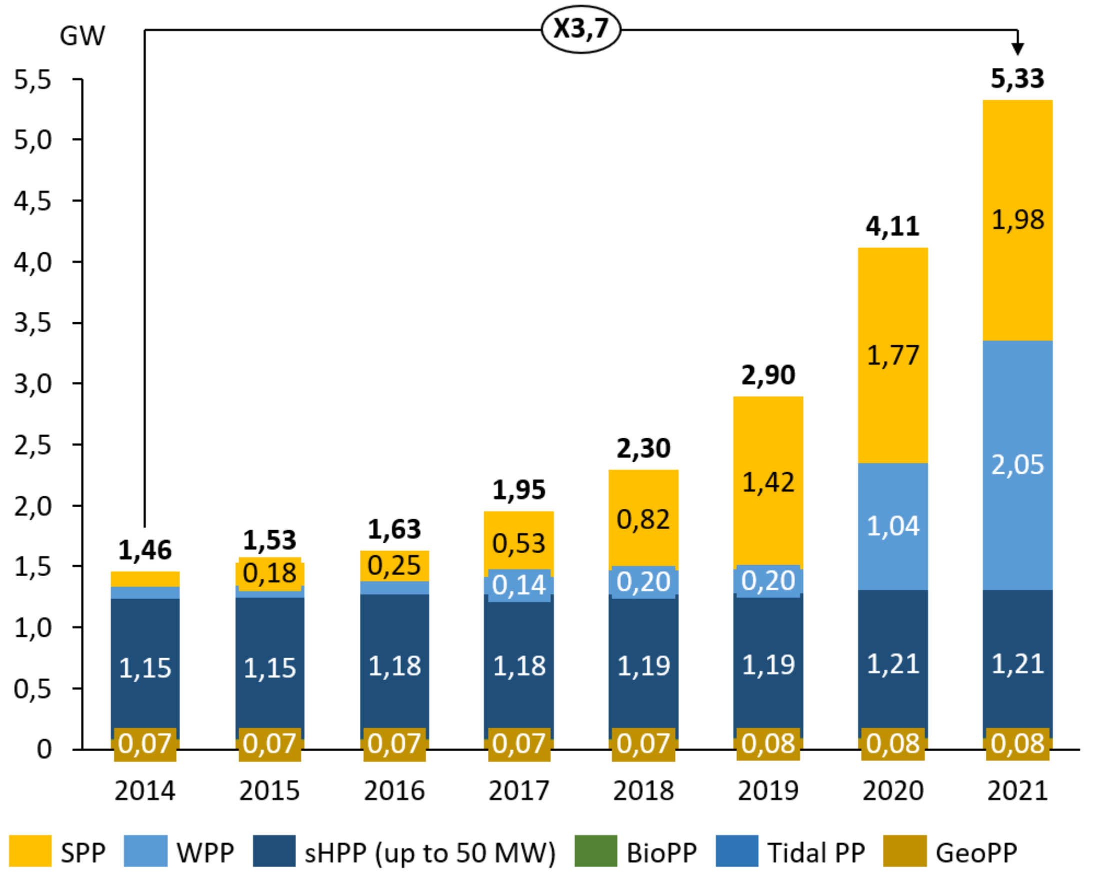
One of the important documents incentivizing the development of hydrogen energy in Russia is the Strategy for Socio-Economic Development of Russia with Low Greenhouse Gas Emissions before 2050. Thus, to implement the target scenario of the Strategy, it is planned to create complexes for the production of low-carbon hydrogen, developing an export sector to enter the international market, and increase the share of hydrogen in exported products.

In October 2020, the Action Plan (roadmap) “Development of Hydrogen Energy in the Russian Federation until 2024” was adopted, which provides for a sequence of measures in key areas for the development of hydrogen energy. In August 2021, the Russian Federation approved the Concept for the development of hydrogen energy in the Russian Federation stipulating serial and large-scale application of hydrogen technologies in various sectors of the economy in 2025–2035. Then, in December 2021, the Roadmap “Development of hydrogen energy and decarbonization of industry and transport on the basis of natural gas” was adopted. This document addresses exploration of geological frameworks for CO2 injection and storage, development of domestic hydrogen production technologies, and launch of pilot projects. For 2022, it is planned that the Government of the Russian Federation will adopt a Strategy for the development of the low-carbon hydrogen energy industry until 2050, in accordance with which large-scale measures are planned to incentivize the development of the equipment manufacturing sector, industrial hydrogen clusters and R&D.

III. DEVELOPMENT SITUATION

According to the 2021 results, the cumulative installed capacity of renewable energy generation facilities in Russia (including wholesale and retail markets and isolated energy systems) exceeds 5.33 GW (Figure.3.3-1), which corresponds to a growth rate of more than 3.5 times over the past 7 years.

Figure. 3.3-1. Cumulative installed capacity of RES-based power plants in Russia, GW

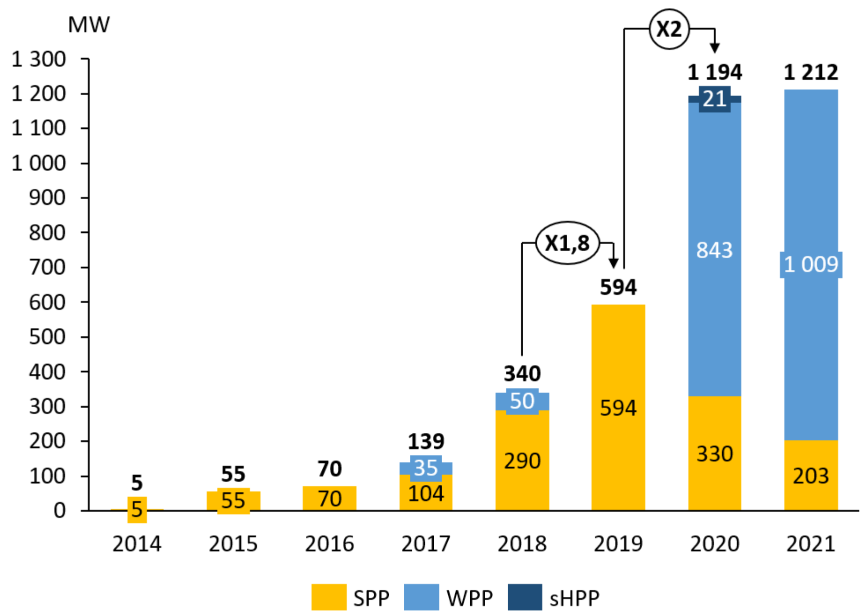


Source: RREDA, SO UPS JSC, NP Market Council, Association «Hydropower of Russia»

Cumulative capacity of small hydroelectric power generation increased by 21 MW in 2020, and the remaining facilities of this category (over 100 small HPPs with a cumulative capacity of about 1.2 GW) operate stably outside of support programs and play a historically important role in the power system of many Russian regions. Geothermal power stations in Russia are also an important electricity source for isolated energy districts, and operate successfully in the Sakhalin Region and the Kamchatka Territory. The largest increase in capacity in recent years was demonstrated by solar and wind generation facilities built as part of the CSA RES: at least a twofold increase in the pace of construction of new "green" facilities was observed on the wholesale market almost every year.

In 2020, the annual scope of commissioning of new renewable energy generation facilities in Russia exceeded 1 GW for the first time. In 2021, the capacity of CSA RES projects increased by 1,212 MW. The wind energy market saw an increase in construction rates for the second year in a row, with wind farms for 1,009 MW starting to supply electricity to the wholesale market in 2021. Over the same period, capacities for 203 MW were built in the wholesale solar generation market (Figure. 3.3-2).

Figure. 3.3-2. Commissioning dynamics of RES-based power plants (CSA RES), MW



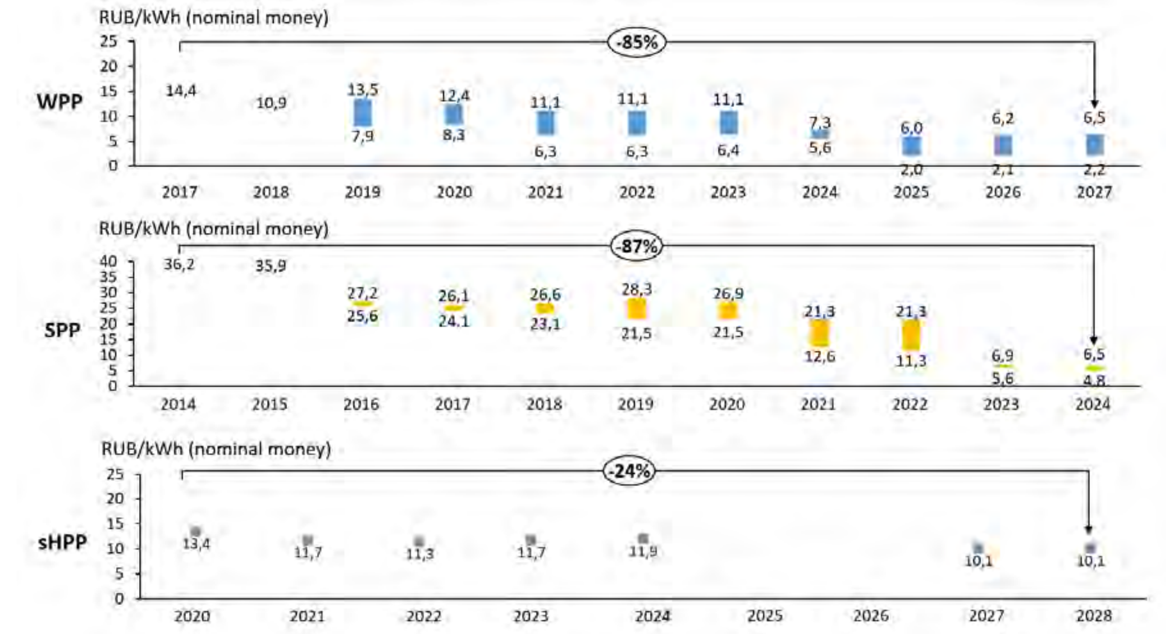
Source: RREDA, SO UPS JSC, NP Market Council

Over 90 renewable energy power plants with a cumulative capacity of 3,609 MW were commissioned on the wholesale electricity and capacity market under the CSA RES according to 2021 results, including: 69 SPPs – 1,650.7 MW, 22 WPPs – 1,937.7 MW, three sHPPs – 20.9 MW. At the same time, the share of generation of these facilities in power generation and consumption in the UPS of Russia was 0.5% in 2021. Over the past eight years of commissioning, market participants have been actively improving their expertise and have already implemented two-thirds of the selected investment projects, successfully overcoming a significant number of barriers.

Despite the fact that for a long period of time during the implementation of the CSA

RES program, the cost of Russian renewable energy generation projects remained significantly higher than that of its global counterparts, including due to requirements for equipment localization, a lack of engineering expertise and design experience, the prices dropped to the best levels of our global counterparts at the last tender held in September 2021 (**Figure. 3.3-3**). During the 10 years of the support program implementation, the cost of WPP and SPP electricity has decreased by 85%, and the trend towards a lower electricity price declared in such projects will continue at least until 2030. As the 2021 tender showed, investors are interested in developing renewable energy in Russia, despite the extremely limited market size and the fiercest competition.

Figure. 3.3-3. Range of straight-line rates for RES generation (based on the results of project tenders under CSA RES)



Source: RREDA, JSC TSA

The results of the first selection of renewable energy investment projects under CSA RES 2.0, held in 2021, showed that the scope of commissioning renewable energy generation facilities within the second stage of support could be 9–10 GW.

Thanks to ongoing support programs, a high-tech industrial cluster has been formed in the country's renewable energy sector, and expertise has been created in the construction, operation, and management of the new generation type for the Russian energy sector.

IV. INDUSTRIAL ADVANTAGES AND CHARACTERISTICS

1. RES industrial cluster

One of the main goals of the RES support program in Russia is to create a domestic innovative power engineering industry for renewable energy. To this end, the established key criteria to receive full payment for capacity with an appropriate rate of return is achieving target indicators of the production local content requirements for the main and auxiliary equipment components of a renewable energy generation facility. At the moment, the local content requirements are 65–70% depending on the generation type; starting from the 2021 tenders, local content requirements have increased to the 87–120 point range, which is equivalent to an indicator of 85–90%. The result of the incentive policy set forth in 2013 was the emergence of a full-fledged power engineering cluster in the RES industry. Successful projects have been now implemented to create the production of high-tech power equipment. Domestic manufacturers have successfully mastered new technologies, including cooperation with foreign companies, and today they supply equipment not only for the domestic market but also for exports.

Figure 3.4-1 Industrial cluster of equipment production for RES in Russia

Source: RREDA

At the first stage of solar energy development in the Russian Federation, foreign technologies were actively transferred. Today, several technologies are represented on the localized equipment market: mono- and multicrystalline silicon, thin-film (amorphous silicon-based) and heterojunction (HJT) technologies. The current production potential of the plants created in the Russian sector of photovoltaic equipment exceeds 700 MW/year (**Figure 3.4-1**). The main investors in solar power plant projects are Hevel Group, Solar Systems, Fortum Group, and Vershina Development. Here, the main manufacturers of generating equipment for SPPs in Russia are: Hevel Group, Solar Silicon Technologies LLC, and HELIOS-Resource Ltd.

To implement the localization program, Russian wind generation investors have chosen foreign technological partners (vendors) and adopted their production processes. To date, several large consortiums have been formed that have launched the production of wind power equipment components in the Russian Federation. In Russia, wind power plants are produced with a unit power of 2.5 to 4.2 MW. Production of towers, nacelles, generators, hubs and blades for wind turbines has been localized (**Figure 3.4-1**). At the moment, three generating facility investors are taking up the leading positions in the wind energy industry: Fortum Group (together with RUSNANO Group), NovaWind (Rosatom's division), and Enel Russia.

The production of equipment for small hydroelectric plants in Russia has not developed at such a high pace as for solar and wind power, due to less activity from investors. Within Russia, solutions for sHPPs are developed at the enterprises of traditional manufacturers of hydropower units, where they produce hydropower equipment, hydroelectric generators, micro hydroelectric power plants, etc.

A total of 11,000 new highly qualified immediate jobs in the field of construction and operation of renewable energy generating facilities will be created as a result of the first support program CSA RES 1.0. Investment in the construction and development of industrial facilities for the production of localized high-tech products has exceeded RUB40 billion. Due to this investment, the production potential of renewable energy generation equipment reached 1.6 GW/year. The transition to the second stage of RES industrial cluster creation will provide up to RUB50 billion rubles in new investment in industry. Here, potential R&D expenses of companies with localized production are up to 5% of equipment sales revenue (up to RUB5 billion a year). The created equipment manufacturing capacities in total will provide about 5,000 additional permanent direct jobs. The educational system, which is developing in parallel with the industrial cluster, will annually provide over 1,000 highly qualified specialists in demand.

2. Resource potentials

Russia has a huge natural potential in almost any types of renewable energy sources. The distribution of wind energy potential is non-uniform across the territory of Russia. Promising regions for the development of wind power generation are the European territory of Russia (including the coasts of the Azov, Black and Caspian Seas, the Middle and Lower Volga), the Southern Urals, the south of Western Siberia, as well as almost the entire coast of the Far East, and the seas belonging to the Arctic basin (with optimal values of such a parameter as wind power density). The level of incoming solar radiation on the territory of Russia also varies significantly. Territories with the greatest potential for the development of solar power generation are: the south of the European part of Russia, of the Urals, of Western and Eastern Siberia, and of the Far East.

In Kamchatka, Chukotka and the Kuril Islands, there are conditions for developing geothermal energy, and in the southern part of the western and a number of Siberian regions, there are conditions for developing bioenergy based on the use of wood waste and low-grade wood. Due to its geographical location, the Russian Federation has a significant hydrological potential in bay water areas of numerous seas washing its shores. In the future, this potential could be used to build tidal power plants.

In addition, due to the resource potential of RES, Russia has every opportunity to take up a leading position in the promising market of “green” hydrogen and low-carbon hydrogen technologies. The competitive advantages of Russia, which create long-term prerequisites for the hydrogen industry development, are geographic proximity to hydrogen sales markets in Europe and Asia, the potential of low-carbon energy segments (hydropower, nuclear, solar and wind energy), R&D capacities in the field of production, transportation and storage of hydrogen, and existing transport infrastructure (new gas pipeline projects, growing LNG industry).

V. PROSPECTS

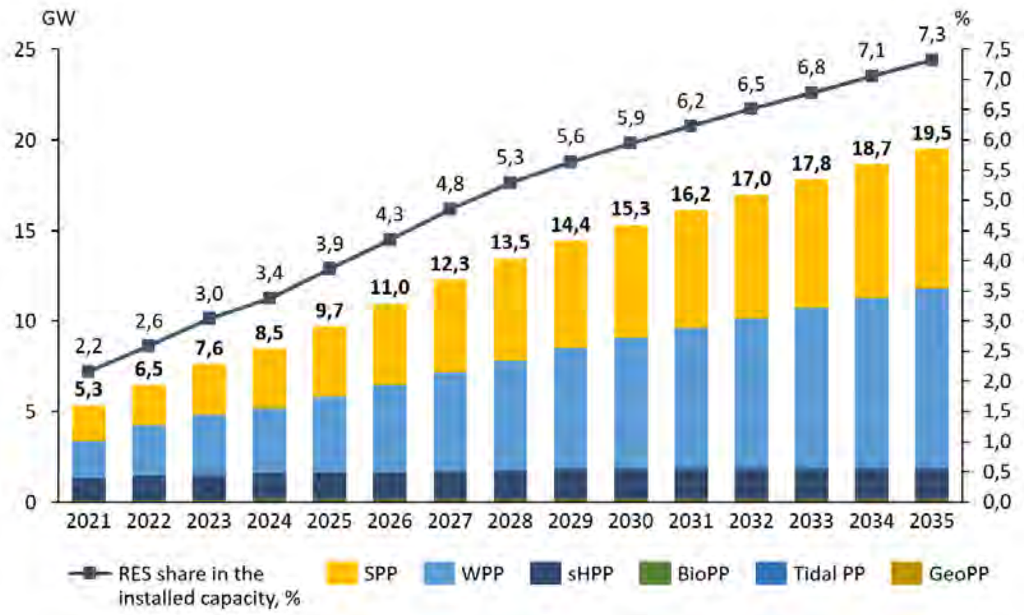
The current legal regulation in Russia reflects the global trend towards a decrease in greenhouse gas emissions and an increase in the share of renewable energy production in the energy balance in the context of the global energy transition. In 2021, the Russian Government approved the Strategy for Socio-Economic Development of Russia with Low Greenhouse Gas Emissions before 2050. Under the target development scenario, the benchmark for Russia is to achieve carbon neutrality by 2060.

At the same time, the share of renewable energy generation in Russia is significantly lower than in the countries that have been actively implementing an energy transition policy in recent decades. However, in 2021 there was a real tectonic shift in terms of the attitude towards the decarbonization of the economy since the carbon neutrality declared for 2060 can only be achieved taking into account the accelerated modernization of the energy sector, including the rapid development of renewable energy generation.

For the period up to 2035, the Government of the Russian Federation has set targets for the rates of power production and consumption using renewable energy (except for hydroelectric power plants with an installed capacity exceeding 25 MW) in the total energy balance. Thus, the minimum target share of renewable energy generation for 2035 is 6%.

According to forecasts, the cumulative installed capacity of renewable energy generation in Russia will approach 20 GW by the end of 2035 (**Figure 3.5-1**), which will be more than 7% of the installed capacity of all power plants and at least 3% of the total energy consumption. With an active development of low-carbon hydrogen energy, as well as renewable energy projects by industrial and domestic consumers so that they meet their own needs, the share of RES may increase even more.

Figure 3.5-1. Forecast for future installed capacity of RES generation in Russia before 2035



Source: RREDA, JSC TSA, SO UPS JSC, NP Market Council

The development of renewable and hydrogen energy will play an important role in the process of transformation and digitalization of the Russian power industry. Energy storage technologies, intelligent systems for generation and demand forecasting, predictive analytics of equipment condition, consumption management, and many others will be developed. One of the main goals of incentivizing investment in the renewable and hydrogen energy sector in Russia is the formation of a comprehensive scientific and industrial cluster providing for a production of competitive main and auxiliary generating equipment with a high degree of localization and a significant export potential. Russia is interested in strengthening partnerships with manufacturers of equipment for these sectors for the purpose of mutual technology transfer and creation of joint ventures to arrange large-scale production.

VI. OPPORTUNITIES FOR DEVELOPING RES IN THE CONTEXT OF PARTNERSHIP BETWEEN RUSSIA AND THE BRICS COUNTRIES

In the context of the energy transition and the need to ensure a sustainable power system and minimize the negative environmental impact, it is important to determine the most promising renewable energy generation clusters, and build effective cooperation between industrial enterprises and scientific centers of the Russian Federation and large foreign industrial companies in order to create in Russia the localized production of the most important equipment components for the renewable and hydrogen energy sector.

Russian companies already have successful experience in setting up production of components and equipment for renewable energy based generating facilities, and in transferring technologies to the domestic production base. The potential for further development of industrial cooperation and creation of new supply chains and logistics routes for a network of local assembly plants is very high. In the field of PV modules, products of Russian manufacture can be used in the BRICS countries, in particular, in Brazil and South Africa, which will provide the required capacities (industrial solar power plants, the best technical solutions for solar generation for households, transport and agriculture) in order to ensure a sustainable energy supply to consumers in the BRICS countries and an accelerated transition of the BRICS member states to a low-carbon economy. At present, a Russian company is already implementing one of the largest SPP projects with an installed capacity of 115 MW in South Africa under a corporate PPA (power purchase agreement) mechanism. It is advisable to organize an experience exchange between specialists in metal working, production of components from composite materials, and production of electrical engineering devices. Russian companies have extensive experience in developing geothermal and hydropower energy. A program has been developed for building new hydraulic power facilities (flood control HPPs) on the tributaries of the Amur River in order to regulate spillway during flood periods and provide electricity to nearby consumers.

At the moment, Russia has no experience in designing and building offshore wind power plants, however, the country has a significant natural potential in this area. Thanks to the long coastline, the BRICS countries have the richest natural potential for developing offshore wind energy. Due to the existing projects in China and the unique experience of developing deep offshore fields in Brazil, cooperation with these countries in developing offshore wind energy is also promising for Russia.

With regard to climatic features of the BRICS countries, it is advisable to organize cooperation in order to analyze and work through approaches to planning energy systems development, taking into account the integration of significant renewable energy generation scopes and providing optimal power reserves of weather-dependent renewable energy generation facilities. It is necessary to jointly consider the problems of forecasting long-term consumption and drawing up long-term power balances, taking into account renewable energy generation, as well as to analyze possible SPP and WPP participation in the regulation. The energy transition poses fundamentally new requirements for the organization and quality of management for dispatcher control of electric power regimes. In this area, Russia needs to exchange experience with countries where the share of renewable energy has reached significant scopes on the energy system scale, and where efficient generation regime control systems have been successfully launched.

It seems advisable to organize cooperation in the field of R&D to increase the efficiency of renewable and hydrogen energy equipment and to initiate innovative projects. As part of the exchange in knowledge and experience, it is advisable to arrange joint conferences and seminars, develop youth energy dialog and involve youth in research activities between the BRICS countries, including introduction of educational programs.

[IV]

INDIA

I. OVERVIEW OF ENERGY RESOURCES

India's total installed electricity generating capacity as of 31.03.2021 is 382151.22 MW, comprising Thermal 234728.22 MW, Hydro 46209.22 MW, Nuclear 6780.00 MW and 94433.79 MW from Renewable Energy Sources (RES). RES includes Wind, Small Hydro Project, Biomass Gasifier, Biomass Power, Urban& Industrial Waste Power & Solar Power. Generation from the RES was about 10.66% (147.25 TWh) of total energy generation in the Country during 2020-21. The source wise break up of cumulative RE Generation for 2020-21 is:

Table 4.1-1 Source wise break up of cumulative RE Generation for 2020-21

RE Generation Sources	Percentage
Solar	41.2%
Wind	40.85%
Small Hydro	6.97%
Biomass	2.39%
Biogasses	7.68%
Other	1.10%

Source: CEA Annual Report 2020-21, Central Electricity Authority, Ministry of Power,Government of India.

India has one of the world's highest growth rates for Renewable Energy. According to the Global Trends in Renewable Energy Investment 2020 report, from 2014 to 2019, India's renewable energy programs and projects attracted an investment of US$ 64.4billion. Renewable energy capacity in India has increased by 250% between 2014 and 2021. Today India stands at 4th position in the world regarding installed RES capacity, 5th in solar power and 4th in wind power in terms of installed capacity.

In line with the Hon'ble Prime Minister's announcement at the recently concluded CoP26, the Government is committed to achieving 500 GW of installed electricity capacity from non-fossil fuel sources by the year 2030.For sustainable development and economic growth, the focus of the Government of India is towards developing low carbon pathways for the Indian Energy Sector and shifting from the fossil fuel-based Energy to the non-fossil based Energy, which are cleaner, safer, environment friendly and more sustainable.

India is well on its way to achieving its ambitious climate goals. India's has achieved reduction of 24% in emission intensity of its GDP between 2005 and 2016", against the target of 45% by 2030 and coveted milestone of 100 GW of installed Renewable Energy Capacity, India has emerged as one of the few major economies globally to have achieved the commitments under Paris Agreement along with an exponential increase in renewable energy capacity.

II. RECENT INITIATIVES IN ENERGY

The Government of India (GoI) has been enacting favorable policies and regulations to boost the Renewable Energy sector, particularly in the last 6-7 years. India has been aggressively pushing for innovative market mechanisms and business models, institutional strengthening, capacity building, and demand creation measures to grow Renewable Power generation. Below are the major ongoing schemes in this direction

- PM-KUSUM scheme is one of the largest initiatives in the world to provide clean Energy to more than 3.5 million farmers by solarising their agriculture pumps. It aims to install grid-connected ground-mounted solar power plants (up to 2 MW) aggregating to a total capacity of 10 GW; install 20 Lakh standalone solar pumps; and solarize 15 Lakh grid-connected agricultural pumps. All components combined would support installing an additional solar capacity of 30.80 GW.

- Rooftop Phase-I of this program was launched on December 30th 2015 in which incentives and subsidies were provided for residential, institutional and social sectors. For the Government sector, achievement linked incentives were also provided. Rooftop Phase-II was launched in February 2019 to achieve a cumulative capacity of 40,000 MW by 2022. Under the rooftop solar scheme, Central Financial Assistance (CFA) of 40% for RTS systems up to 3 kW capacity and 20% for capacity beyond 3 kW and up to 10 kW is provided. For Group Housing Societies (GHS) and Residents Welfare Associations (RWA), CFA is limited to 20% for RTS plants to supply power to common facilities. So far, over 3.7 GW capacity of RTS capacity has been estimated to have been installed in the Country and over 2.6 GW of capacity is under installation in the residential segment.

- Establishment of 12 No. Renewable Energy Management Centers (REMCs) and 01 No. Energy Management Centre for facilitating forecasting and scheduling of
- Renewable Energy Generation.
- The Solar Parks program aims to facilitate solar project developers to set up projects in a plug-and-play model. The scheme for developing solar parks has a target capacity of 40 GW. All States and Union Territories are eligible for getting benefits under the scheme.
- Hon'ble PM of India has announced Green Hydrogen Energy Mission. Government of India has also come out with many enabling policy framework for RE generation which includes Green Hydrogen Policy with following promotional provisions for green hydrogen:
  - Hydrogen produced from biomass has also been defined as green hydrogen.
  - The waiver of transmission charges shall be granted to the producer of green hydrogen for a period of 25 years.
  - Safety aspects and standardization of product and processes of hydrogen should form part of deliberations.
  - Connectivity at the generation end and the green hydrogen manufacturing end to the ISTS for Renewable Energy capacity set up for the purpose of manufacturing green hydrogen shall be granted on priority under the Electricity (Transmission System planning, development and recovery of Inter State Transmission charges) Rules 2021.
  - Land in RE parks can be allotted to the producer of green hydrogen.
  - RE consumed in the production of green hydrogen shall count towards

Renewable Purchase Obligation (RPO) compliance of the consuming entity.

- The Government intends to fully convert Andaman and Nicobar, Lakshadweep islands to Green Energy, where RE sources will meet energy needs. The Greening of Islands program will deploy 52 MW of distributed grid-connected solar PV power projects by March 2021. The Ministry provides a 40% capital subsidy for projects under the scheme. Projects of 20 MW SPV with 16 MW/8MWH BESS in Port Blair, South Andaman; and a project of 1.95 MW with 2.15 MWH BESS in 4 Islands of Lakshadweep are expected to be commissioned by January 2022.
- Ministry of Power and Ministry of New & Renewable Energy have jointly floated an EoI for a scheme "Scheme for setting up of manufacturing zones for Power and Renewable Energy Equipment" as a pilot for experience within an indicative outlay of Rs 400 crore.
- The Government has committed nearly `1.97 Lakh Crore, over 5 years starting FY 2021-22, including `4,500 Crore for manufacturing of 'High-Efficiency Solar PV Modules' under the AtmaNirbhar Bharat Mission, which will be implemented by the Ministry of New & Renewable Energy where IREDA is the nodal agency to bring scale and size in Solar PV manufacturing, create and nurture global champions and provide Employment to youth.
- Other similar polices include the imposition of the Basic Custom Duty on import of solar modules & cells, setting an ambitious target of 30% electric vehicle penetration by 2030 to encourage further investments in indigenous technology under FAME (Faster Adoption and Manufacturing of Hybrid and Electric Vehicle) scheme and announcing the launch of Hydrogen Energy Mission in FY2021-22.

I. STATUS OF DEVELOPMENT

India has large renewable energy potential from wind, solar, biomass, and small hydro sources. As per estimates, India has a wind potential of more than 300 GW at a hub height of 100 metre, solar potential of ~750 GW, assuming 3% wasteland is made available, small hydro potential of~20 GW, and bio-energy potential of 25 GW. Further, there is a significant potential from decentralized distributed applications for meeting the hot water requirement for residential, commercial and industrial sectors through solar Energy and meeting cooking energy needs in the rural areas through biogas. Renewable Energy also has the potential to usher in universal 'energy access'.

The plans and accomplishments with respect to the different RES are below:

- **Hydro:** Out of total Installed Capacity of the Country, share of hydro power ~ 11.8%. Generation from hydro power plants during 2020-21 ~ 150 TWh. Per year addition of Hydro Capacity in the recent years are:

Table 4.1-1 Year wise added Capacity of Hydro

Year	Added Capacity (in MW)
2017-18	795
2018-19	140
2019-20	300
2020-21	510

Source: CEA Annual Report 2020-21, Central Electricity Authority, Ministry of Power, Government of India.

By 2025-26 it is likely to commission hydro capacity of 12663.5 MW. The estimated potential of small, mini and micro hydel projects in the country is 21,135.37 MW from 7,135 sites in different Indian states. The national target for SHP is to achieve a cumulative capacity of 5,000 MW by 2022. An aggregate capacity of 4,750.46 MW been achieved by December 31st 2020 through 1,134 small hydro power projects.

- **Solar**: Among the various renewable energy resources, the country's solar energy potential is the highest. In most parts of India, clear sunny weather is experienced 250 to 300 days a year. The annual radiation varies from 1600 to 2200 kWh/m2, comparable to radiation received in the tropical and sub-tropical regions. The equivalent energy potential is about 6,000 million GWh of energy per year. To establish India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible Government of India launched National Solar Mission. Recently, India achieved 5th global position in solar power. As on 31.12.2020, a total solar power capacity installed is 37.46 GW. It is expected to complete the target of 100 GW by 2022 fully. Based on the availability of land and solar radiation, the potential Solar power in the Country has been assessed to be around 750 GWp.

- Wind: The expansion of the wind industry has resulted in a strong ecosystem, project operation capabilities and manufacturing base of about 12,000 MW per annum. The Country currently has the fourth highest wind installed capacity globally with a total installed capacity of 39.25 GW (as of March 31st 2021). Through National Institute of Wind Energy (NIWE), the Government has installed over 800 wind-monitoring stations all over Country and issued wind potential maps at 50m, 80m, 100m and 120m above ground level. The recent assessment indicates a gross wind power potential of 302 GW in the Country at 100 meter and 695.50 GW at 120 meter above ground level. Most of this potential exists in seven windy States (Table).

Table 4.1-3 Wind potential

S. No.	State	Wind Potential at 100 m (GW)	Wind Potential at 120 m (GW)
1	Gujarat	84.43	142.56
2	Rajasthan	18.77	127.75
3	Maharashtra	45.39	98.21
4	Tamil Nadu	33.79	68.75
5	Madhya Pradesh	10.48	15.40
6	Karnataka	55.85	124.15
7	Andhra Pradesh	44.22	74.90
	Total 7 windy states	292.97	651.72
8	Others	9.28	43.78
	Total	302.25	695.50

Source: Annual Report 2020-21, Ministry of New and Renewable Energy, Government of India.

Based on the preliminary assessment from satellite data and data available from other sources, 8 (eight) zones each off the coast of Gujarat and Tamil Nadu have been identified as potential zones for exploitation of offshore wind energy. Initial assessment of offshore wind energy potential within the identified zones has been estimated to be about 70 GW off- the coast of Gujarat & Tamil Nadu only. In order to attract the large investment needed/required for development of the sector in India, Government of India has already announced its intention of developing 30 GW of off- shore wind energy project by 2030.

- Biomass Power and Bagasse Co-generation: The potential for power generation from agricultural and agro-industrial residues is estimated at about 18,000 MW. With progressive higher steam temperature and pressure and efficient project configuration in new sugar mills and modernization of existing ones, the potential of surplus power generation through bagasse cogeneration in sugar mills is estimated at around 8,000 MW. Thus the total estimated potential for biomass power is about 26,000 MW. Over 800 biomass power and bagasse/Non-bagasse cogeneration projects aggregating to 10170 MW capacity have been installed in the Country for feeding power to the grid. India has more than 540 Nos of sugar mills, out of which around 360 sugar mills have installed cogeneration power plant capacity of 7562 MW. The Installed Capacity of Biomass IPP is 1836 MW, whereas for Non-Bagasse Cogeneration, it is 772 MW

- Waste to Energy: India's total estimated energy generation potential from urban and industrial organic waste is approximately 7262 MW for 2022. Also, the potential for Compressed Bio-Gas production from various sources in India is estimated at about 62 million tonnes per annum. As of 31.07.2022, the total installed capacity is 476.75 MWeq including 223.41 MW of Grid-interactive Waste to Power projects and 253.61 MW of Off-grid Waste-to-Energy projects. To facilitate geographical mapping of the different types of waste availability and its energy generation potential across India, GIS-Based Waste Mapping Tool has been developed under GEF–MNRE–UNIDO PROJECT.

- Biogas: During the year 2020-21, 4 projects have been commissioned with a capacity of 300 kW and a corresponding biogas generation capacity of 2,500 M3 per day. With this, the cumulative total of 325 biogas-based projects with a total power generation capacity of 7.587 MW and a cumulative total biogas generation of 72,351 M3 per day have been set up in the country to 31.12.2020. Further against a target of sanction for setting up 50 new projects, 22 projects have been sanctioned for installation up to 31.12.2020.

III. ADVANTAGES AND FEATURES

- Research, design, development and technology demonstration for its validation are one of the core requirements for the growth of New and Renewable Energy. Ministry of New & Renewable Energy (MNRE) supports Research, Development and Demonstration (RD&D) to develop new and renewable energy technologies, processes, materials, components, sub-systems, and sets standards to enable indigenous manufacture of new and renewable energy systems and devices. MNRE initiates resource assessments to identify and con rm potential. The objective of the programme is to make the industry globally competitive in renewable energy generation, self-sustainable/portable and thereby contribute to increase share in total energy mix in the country. The RD&D efforts are continued with emphasis on cost reduction, reliability and efficiency improvement. The projects in accordance with the identified R&D thrust area of the Ministry in the areas of Solar Thermal, Solar Photovoltaic, Biogas, Wind, Wind-hybrid, Energy Storage, Small Hydro Power, Hydrogen and Fuel Cells, Geothermal, etc. are supported for RD&D activity. The projects in other areas not covered under the R&D thrust areas are also considered for financial support based on their applications and practical importance.

- In order to facilitate integration of large scale renewable generation capacity addition, the Cabinet Committee of Economic Affairs (CCEA) in FY 2015-16, approved the creation of Intra-State Transmission System in the Renewable Energy rich states of Andhra Pradesh, Gujarat, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Tamil Nadu. The Green Energy Corridor scheme includes establishment of grid sub-stations at different voltage levels with aggregate transformation capacity of approx. 22600 Mega Volt Ampere (MVA) and installation of approx. 9700 circuit kilo metres (ckm) of transmission lines in these eight states.

- National Wind-Solar Hybrid Policy's main objective is to provide a framework for promotion of large scale grid-connected wind-solar PV hybrid systems for optimal and efficient utilization of wind and solar resources, transmission infrastructure and land. The wind-solar PV hybrid systems will help reduce the variability in renewable power generation and achieve better grid stability. The policy also aims to encourage new technologies, methods and way-outs involving the combined operation of wind and solar PV plants.

- New National Biogas and Organic Manure Programme (NNBOMP) scheme aims for setting up small Biogas Plants in size range varying from 1 M to 25 M. The NNBOMP's objectives is to provide green and clean renewable gaseous fuel for cooking, lighting and small power needs of the potential farmers, cattle farmers/ users including individual households and to facilitate management and utilization of biogas plant produced slurry as an organic enriched Solid Biogas Fertilizer.
- Special attention is being given to the development of renewable Energy in the entire North Eastern region through a separate budgetary allocation of 10% under various Renewable Energy programmes for deployment of grid and o- - grid Solar Energy Systems, Wind Energy Systems, Small Hydro Projects and Bio-gas Plants among others, in the region. A total of estimated potential for renewable Energy in the North Eastern Region from Solar, Small Hydro and Bio-energy is around 65,837 MW, a substantial part of which is suitable for grid connected applications.

V. PROSPECTS FOR DEVELOPMENT

The Government of India is leaving no stone unturned towards strengthening availability of human and organizational capacities in the solar, financial and policy sectors and continuously improving business models and polices considering advances in solar technologies, investments and markets. As the economy grows, the electricity consumption is projected to reach 15,280 TWh in 2040 from 4,926 TWh in 2012. Though India lacks sufficient conventional energy resources compared to its required energy needs driven by huge population and rapidly increasing economy, India has been endowed with a wind power potential of around 695 GW at 120m above ground level and huge solar potential of about 748 GW assuming 3% of the waste land area to be covered by Solar PV modules. With vast potential in hydro sector being explored across states in the northeast, India highlights ~26% of the total installed capacity coming from Renewable Sources. Government of India is also promoting Energy Storage Systems (ESS). Formulation of Comprehensive Policy Framework to promote Energy Storage in Power Sector is under process. Safe disposal, recycling and reclamation of useful material from the end of life of batteries, solar panels and wind turbine blades and other power system wastes should be considered. Some of the major focus areas are brief below:

One Sun One World One Grid

Hon'ble Prime Minister has envisioned the concept of One Sun One World One Grid (OSOWOG), a transnational electricity grid supplying solar power across the globe in order to make use of availability of sunshine in different neighboring countries at different times. The concept is to interconnect generators and loads across continents with an international power transmission grid. A tripartite Memorandum of Understanding (MoU) between the International Solar Alliance (ISA), the Government of India, and the World Bank was signed on September 8th, 2020 to implement the OSOWOG initiative.

Green Hydrogen Mission

India is also working on a Green Hydrogen Mission to enable cost competitive green hydrogen production. Green hydrogen is going to shape the world’s energy transition towards a more sustainable path by enabling decarbonization of hard-to-abate sectors. The “Green Hydrogen Mission” will establish India as a global hub for green hydrogen production

Solar Power Development for a Carbon Neutral Ladakh

Ladakh has the highest solar insolation in India and therefore has a vast RE potential. However, evacuation of RE power available at such high-altitude Himalayan regions is challenging. An RE Park of 10 GW is planned in order to exploit Ladakh's vast RE potential and optimize the cost of evacuation. Solar Energy Corporation of India (SECI) is also planning to setup a 50 MW plant which will provide 20 MW (AC) and use balance energy for battery storage of 50 MWh at PhyangLeh. In addition, 1 MW Solar-Wind Hybrid plant at Nyoma will also be developed. Power Grid Corporation of India Ltd. (PGCIL) is developing a Detailed Project Report (DPR) for transmission infrastructure required to evacuate the 10 GW RE capacity that is planned to be set up in Ladakh. A Geothermal Power Project to conduct exploratory drilling and to set up of 1 MWe power project from geothermal Energy has been proposed by ONGC Energy Centre (OEC) in Puga Valley in the Union Territory of Ladakh. Depending upon the experience generated from this pilot project, prospects for setting up larger capacity geothermal plants will be explored.

Human Resources for Renewable Energy

India's ambitious targets necessitate development of Human Resources in adequate numbers to both install and maintain RE capacities. In the last six years, the Ministry has taken a number of initiatives for this purpose.

Below are related schemes:

- Short Term Training and Skill Development Programmes
- National Renewable Energy Fellowship (NREF) Schemes
- Support to RE Infrastructure in Educational & Research Institutions
- National Renewable Energy Internship Scheme

India is also focusing on “Just Transition” along with its commitments of achieving net zero emission target by the year 2070 i.e. India plans of greening its economy in a way that is as fair and inclusive as possible to everyone concerned, creating decent work opportunities and leaving no one behind

[V]

CHINA

I. OVERVIEW OF ENERGY RESOURCES

Energy has been driving the development of human civilization. As human civilization enters the stage of ecological development, it becomes a clear trend that global energy will transition from fossil fuels to green and low-carbon sources. It has become a general consensus and concerted action of the international community to vigorously promote renewable energy.

China announced at the UN General Assembly that it would strive to peak its carbon dioxide emissions by 2030 and achieve carbon neutrality by 2060. At the same time, it declared that by 2030, non-fossil energy would account for about 25% of primary energy consumption, and the total installed capacity of wind power and solar power would reach over 1,200 GW. China will scale up the development of renewable energy with a higher proportion in the energy mix and a market-based approach, promoting both large-scale development and high-level consumption while ensuring the stable and reliable supply of electricity.

1. Renewable Energy as a New Major Source of Energy in China

By the end of 2020, China had cumulatively contributed about one third of the world's total installed capacity of renewable energy, and more than half of the world's newly installed capacity of wind power and solar PV, becoming a backbone of the global renewable energy development. The large-scale development of renewable energy in China has accelerated the progress of energy technology mainly in wind power and solar PV power generation. With the fast drop of costs and rapid improvement of efficiency and competitiveness, renewable energy has emerged as a new major energy source in China, driving the vigorous development of the international renewable energy industry.

By the end of 2020, China's cumulative installed capacity of hydropower, wind power, solar power and biomass power generation continued to top the world, and the proportion of renewable energy in China's energy mix continued to rise, making it a major force in promoting clean and low-carbon energy development around the world.

2. Rapid Growth of Installed Capacity of Renewable Energy

By the end of 2020, the installed capacity of renewable energy for power generation was about 930 GW, accounting for 42.5% of the total installed capacity, a YoY increase of 17.5%, a sharp increase from 9% in 2019.

Of the installed capacity of renewable energy, hydropower registered 370 GW (including pumped storage capacity of 31.5 GW), accounting for about 17% of the total; wind power registered 280 GW, accounting for about 13% of the total; solar power hit 250 GW, accounting for about 11.5% of the total; and biomass reached 29.5 GW, accounting for about 1.5% of the total.

3. Steady Growth of Renewable Energy Power Generation

China's total power generation in 2020 was 7.6 trillion kWh, a YoY increase of 4%, of which 2.2 trillion kWh was generated from renewable sources. Renewable energy contributed about 29% of the total power generation in 2020, a YoY increase of 8.5%.

In terms of power generation from renewable energy, more than 1.35 trillion kWh was generated from hydro sources, accounting for 18% of the total; 470 billion kWh from wind, accounting for 6% of the total; over 260 billion kWh from solar energy, accounting for 3.5% of the total; and more than 130 billion kWh from biomass energy, accounting for about 1.75% of the total.

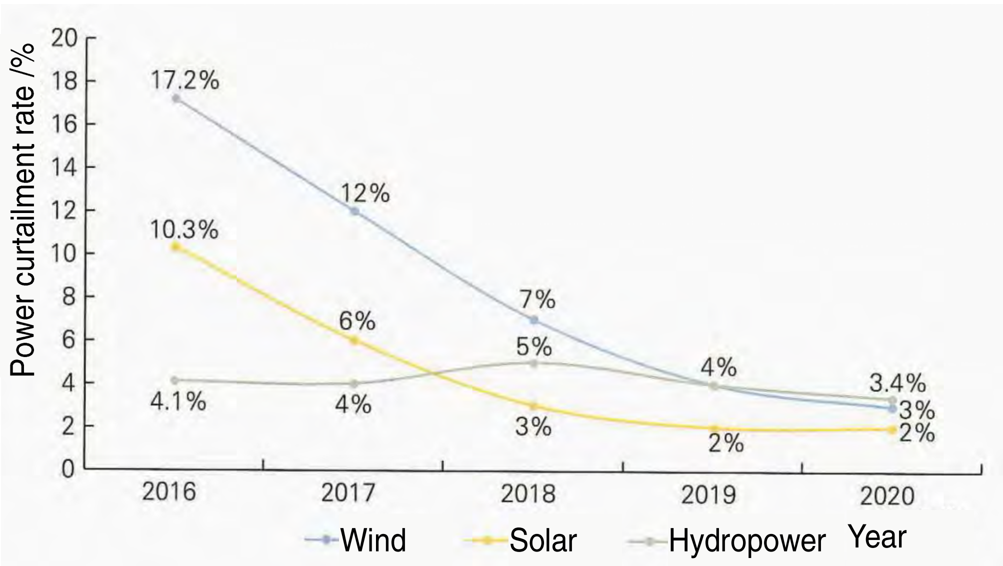
4. Modest Growth of Geothermal Energy and Other Renewable Sources

China saw modest growth in the scale of development and utilization of other renewable energy sources, such as geothermal and marine energy. In 2020, geothermal energy was mainly utilized directly. The shallow geothermal energy utilized for heating (cooling) covered a total floor area of about 860 million cubic meters, a YoY increase of about 2%, and the middle and deep geothermal energy utilized for heating in northern China covered a total floor area about 150 million square meters, making China the first in both shallow, middle and deep geothermal energy utilization in the world. By the end of 2020, the installed capacity of geothermal power generation totaled 45 MW. Marine energy was still at the initial stage of exploration, with a total installed capacity of 7.5 MW, of which 4 MW was generated from tidal power plants and 3.5 MW from tidal current and wave power plants.

5. Steady Increase in Renewable Energy Utilization Rate

In 2020, the average utilization rate of hydro, wind and solar power in China hit 96.6%, 97.0% and 98.0% respectively, much higher than that in the early period of the 13th Five-Year Plan, while the wind, solar and hydropower curtailment rates decreased significantly year by year, and the problem of hydropower curtailment was basically solved.

Figure 5.1-1 The trend of renewable energy utilization



II. RECENT INITIATIVES IN ENERGY

In September 2021, the Chinese government issued the Guidance for Carbon Dioxide Peaking and Carbon Neutrality in Full and Faithful Implementation of the New Development Philosophy. The purpose is to promote comprehensive green transformation in economic and social development and in-depth industrial restructuring, to accelerate the development of a cleaner, low-carbon, safe and efficient energy system and the building of a low-carbon transport system, to improve the quality of green and low-carbon urban-rural development, to make breakthroughs in key green and low-carbon technologies and to promote their application, to continue to consolidate and improve carbon sink capacity, to promote a green and low-carbon model of opening up, to improve laws, regulations, standards and statistical and monitoring systems, and to improve relevant policies and mechanisms. China aims at creating a framework for a green, low-carbon and circular economy by 2025, with greatly improved energy efficiency in key industries. Energy consumption per unit of GDP will be lowered by 13.5% from the 2020 level; carbon dioxide (CO2) emissions per unit of GDP will be lowered by 18% compared with 2020; the share of non-fossil energy consumption will reach around 20%; the forest coverage rate will reach 24%, and the forest stock volume will rise to 18 billion cubic meters. By 2030, the CO2 emissions per unit of GDP will drop by more than 65% compared with the 2005 level; the share of non-fossil energy consumption will reach around 25%, with the total installed capacity of wind power and solar energy reaching over 1.2 billion kW; the forest coverage rate will reach about 25%, and the forest stock volume 19 billion cubic meters. CO2 emissions will peak and keep stable with a slight decline. By 2060, China will smoothly realize its carbon neutrality goals, with energy efficiency reaching an advanced international level, and the share of non-fossil energy consumption being over 80%.

In December 2021, the Chinese government issued the *Opinions on Accelerating Rural Energy Transition and Development to Promote Rural Revitalization*. It is planned that by 2025, pilot projects will be built for green and low-carbon energy in rural areas, with a higher proportion of wind power, solar energy, biomass, and geothermal energy in the rural energy mix; the capability of rural power grids will be further secured and enhanced; and decentralized renewable energy will witness significant growth, with new models and forms of green and low-carbon businesses widely applied. The new energy industry will become an important supplement to the rural economy and an important source of income for farmers, and a green and diversified rural energy system will be formed at a faster pace.

In January 2022, the Chinese government issued the *Opinions on Improving the Systems, Mechanisms, Policies and Measures for Green and Low-carbon Energy Transition*. The purpose is to improve the mechanism of integrated implementation of the national energy strategies and plans, to refine the systems and policies to guide green energy consumption, to establish a new mechanism for green and low-carbon energy development and utilization, to enhance the mechanism for the construction and operation of a new electrical power system, to improve the supply system for green and low-carbon energy transition, to build up a sci-tech innovation system for green and low-carbon energy transition, and to provide fiscal and financial policy support for green and low-carbon energy transition. During the 14th Five-Year Plan period, China will establish an institutional framework for promoting green and low-carbon energy development, put in place sound systems for policies, standards, market and regulation, and create a mechanism for promoting green and low-carbon energy transition with a dual control on total energy consumption and energy intensity and a non-fossil energy target. By 2030, an institutional and policy system for green and low-carbon energy development will be established, and an energy production and consumption paradigm will be formed, in which non-fossil energy can both meet the increasing energy demand and replace fossil energy stocks on a large scale, and the capabilities to guarantee energy security will be comprehensively enhanced.

In April 2022, the Chinese government issued the *14th Five-year Plan for the Modern Energy System*. It is stressed that coordinated efforts would be made to promote low-carbon energy transition and supply security, to accelerate the restructuring of the energy system to adapt to large-scale development of new energy, to promote green development and lifestyle, to strengthen the leading role and strategic support of scientific and technological innovation, to comprehensively upgrade the energy industry and modernize the energy industry chain; and efforts should also be made to enhance the stability and security of the energy supply chain, to speed up the green and low-carbon energy transition, to optimize the overall plan of energy development, to modernize the energy industry chain, and to enhance the efficiency of energy governance, and create a new paradigm for open and win-win international cooperation in energy. The goal of the plan is that by 2035, a modern energy system will be basically established, with significantly improved capabilities to safeguard energy security, and widely-accepted green production and consumption pattern; the proportion of non-fossil energy consumption will further increase from 25% in 2030, with electricity generated mainly from renewable energy; and substantial progress will be achieved in developing the new power system.

III. DEVELOPMENT OF RENEWABLE ENERGY

1. Conventional Hydropower

China ranks first in the world in terms of exploitable hydro resources. According to the latest statistics, China has 690 GW of exploitable hydro resources that can generate about 3 trillion kWh of electricity annually. By the end of 2020, China had installed 330 GW of conventional hydropower capacity, mainly in the southwest, central, southern, eastern and northwest regions.

About 12 GW of conventional hydropower was put into production in 2020, significantly increasing from the 3.8 GW in 2019. By the end of 2020, China's large conventional hydropower plants under construction had a total installed capacity of about 48 GW, mainly in the southwest.

By the end of 2020, China's total hydropower capacity installed or being installed accounted for about 56% of that technically exploitable, with about 50% already installed and 7% being installed, and about 300 GW of hydro resources remaining to be developed.

By the end of 2020, the installed capacity of conventional hydropower in major river basins hit nearly 150 GW, accounting for about 45% of the country's total, of which more than 80% were in the areas with a high level of development along five rivers including Jinsha River and the upper reaches of the Yangtze River.

2. Pumped Storage

By the end of 2020, China has carried out site selection planning or adjustment of pumped-storage power plants in 25 provinces, autonomous regions and municipalities directly under the central government. According to statistics on the installed capacity of pumped-storage power plants constructed or under construction, and site selection planning of pumped-storage power plants approved by the National Energy Administration, by 2020, the total installed capacity of China's planned pumped-storage power plants has reached about 130 GW.

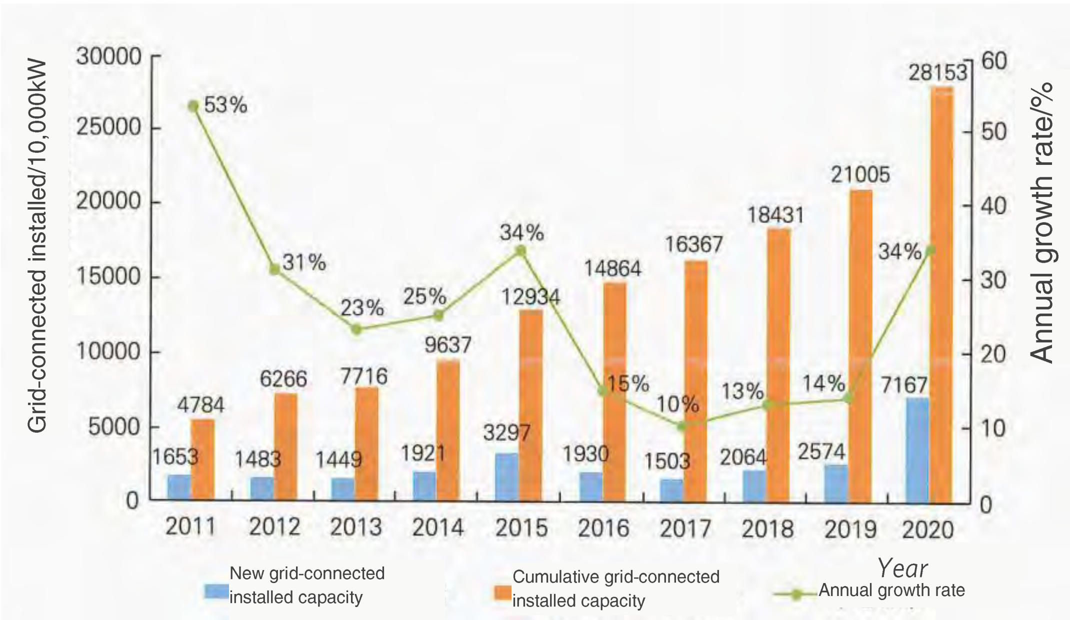
By the end of 2020, China's total installed capacity of pumped-storage power plants had reached about 30 GW. The East China Grid provided over 10 GW, taking up the largest proportion, followed by the China Southern Power Grid and North China Grid. In 2020, China's total installed capacity increased by 1.2 GW.

3. Wind Power

Newly installed capacity recorded a new high. In 2020, China's newly installed capacity of wind power broke a historic record, with the grid-connected installed capacity exceeding 70 GW, including over 55 GW in the fourth quarter of the year, accounting for about 80% of the total. The newly installed capacity of onshore wind power accounted for about 96%

of the year's total, and that of offshore wind power about 4%. By the end of 2020, China's total grid-connected capacity of wind power had reached 280 GW, up 34% YoY. The installed capacity of onshore wind power saw a YoY increase of about 34%, while offshore wind power grew about 52% over the last year. The grid-connected installed capacity of wind power accounted for about 13% of the total installed capacity of all energy sources, up 2.4 percentage points from 2019.

Figure 5.3-1 China's installed wind power capacity and the development trend in 2011-2020



Electricity generation continued to grow. In recent years, the proportion of wind power generation in China's total power generation has increased steadily, and the utilization of wind energy has been improving. In 2020, China's annual wind power generation exceeded 460 billion kWh, up 15% over the last year, accounting for 6% of the total annual power generation from all energy sources, 0.6 percentage point higher than that of 2019, coming the third after coal power and hydropower.

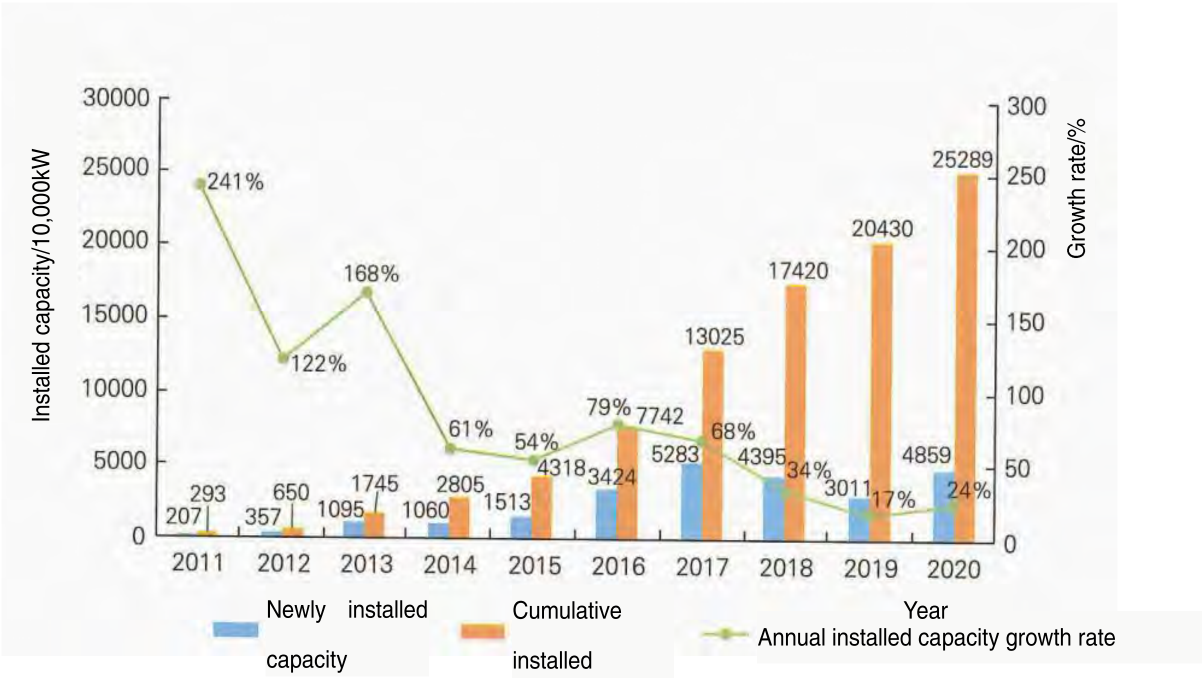
Figure 5.3-2 China's wind power generation and the development trend in 2011-2020

Offshore wind power development picked up pace. In 2020, China's newly grid-connected installed capacity of offshore wind power was 3.06 GW, accounting for 50.5% of the world's total, up 11% from 2019, ranking first in the world for three consecutive years. By the end of 2020, the world's accumulative installed offshore wind power capacity has exceeded 35 GW, of which 28% was contributed by China.

4. Solar Power Generation

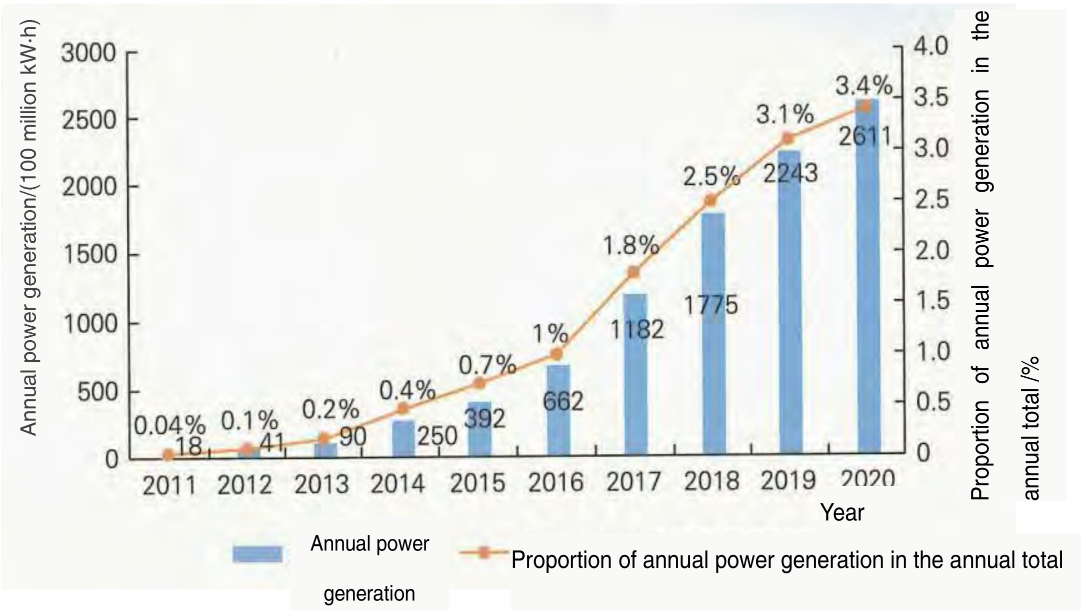
Installed capacity grew substantially. In 2020, the newly installed capacity of solar PV power generation hit 48.2 GW, a YoY increase of over 60%. The newly installed capacity of centralized solar PV power plants was 32.68 GW, up more than 80% over the last year, while that of decentralized solar PV power plants was 15.52 GW, up about 30% year on year. China's cumulative installed capacity of solar power reached more than 250 GW in 2020, a YoY increase of about 24%. The cumulative installed capacity of centralized solar PV power plants was 174.7 GW, up about 23% over the last year, while that of decentralized solar PV power plants was 78.2 GW, up about 25% YoY. The cumulative installed capacity of solar energy accounted for 11.5% of the country's total, up 1.3 percentage points over the last year. Both the newly and cumulative installed capacities of solar PV power remained first in the world.

Figure 5.3-3 China's installed solar PV capacity and the development trend in 2011-2020



Electric power generation continued to rise. The proportion of electric power generated from solar energy in China's total increased steadily. In 2020, China's solar power generation reached 261.1 billion kWh, up about 16.5% over the last year, accounting for about 3.5% of the total electricity generated from all energy sources that year, up 0.3 percentage point from 2019.

Figure 5.3-4 China's solar power generation and the development trend in 2011-2020



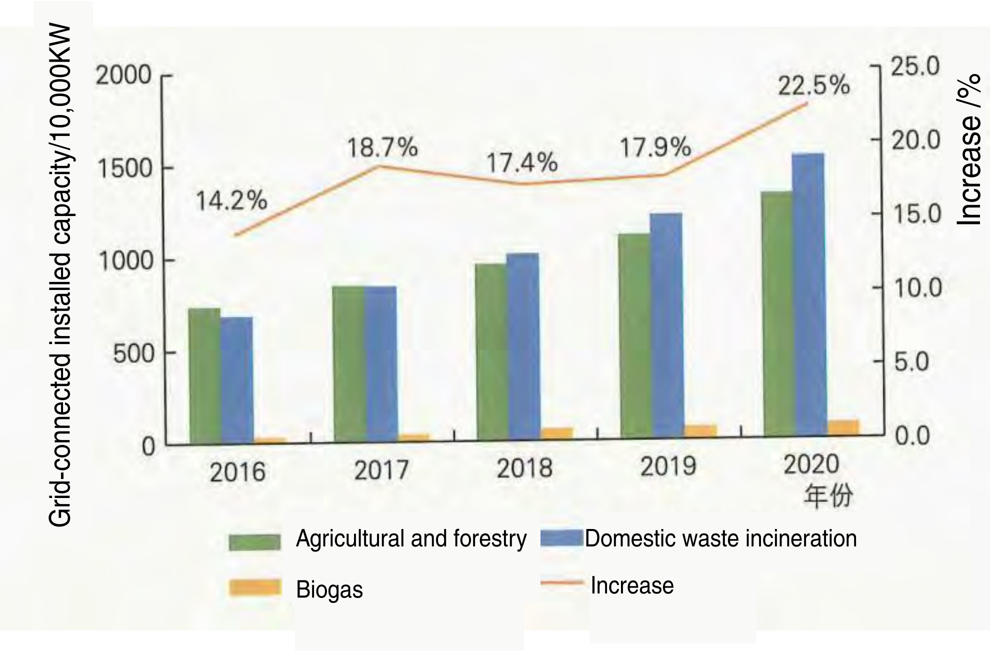
Total investment expanded significantly on a YoY basis. In 2020, China's total investment in solar PV power generation increased by RMB 180 billion, including RMB 130 billion for ground-based solar PV power plants and RMB 54 billion for decentralized solar PV power plants. Driven by the growth in installed capacity, the new investment in 2020 increased by about 40% over 2019.

5. Biomass Energy

By the end of 2020, China's total grid-connected installed capacity of biomass power generation hit about 30 GW, up 23% over the last year. The growth rate remained high with an average of about 18% in the past five years, ranking first in the world in installed capacity for three consecutive years. Over 13 GW of the total grid-connected installed capacity was from agricultural and forestry biomass, a YoY increase of 20%; over 15 GW from domestic waste incineration, up 25% from 2019; and 900MW from biogas, up about 19%.

In 2020, China's annual biomass power generation reached 132.6 billion kWh, an increase of 19% from 2019, accounting for 1.8% of the total electric power generated from all energy sources and 5% of that from renewable energy. Power generated from agricultural and forestry biomass annually reached 51 billion kWh, a YoY increase of 9%; that from domestic waste incineration hit 77.8 billion kWh, up 28% over the last year; and that from biogas was 3.8 billion kWh, up 12%.

Figure 5.3-5 Grid-connected installed capacity of biomass power generation in 2016-2020



6. Geothermal energy

Geothermal energy boasts a great development potential. In addition to deep geothermal resources, China's annual exploitable geothermal resources amount to more than 2.5 billion tons of coal equivalent (TCE), and the annual exploited geothermal resources amount to 25 million tons, less than 1%. The annual utilization of geothermal resources in China only accounts for 0.6% of the total domestic energy consumption, showing a great potential for development. In China's energy consumption mix, every one percentage point higher in geothermal energy utilization can replace 37.5 million TCE, reducing carbon dioxide by 94 million tons, sulfur dioxide by 900,000 tons and nitrogen oxide by 260,000 tons, bringing significant ecological and environmental benefits.

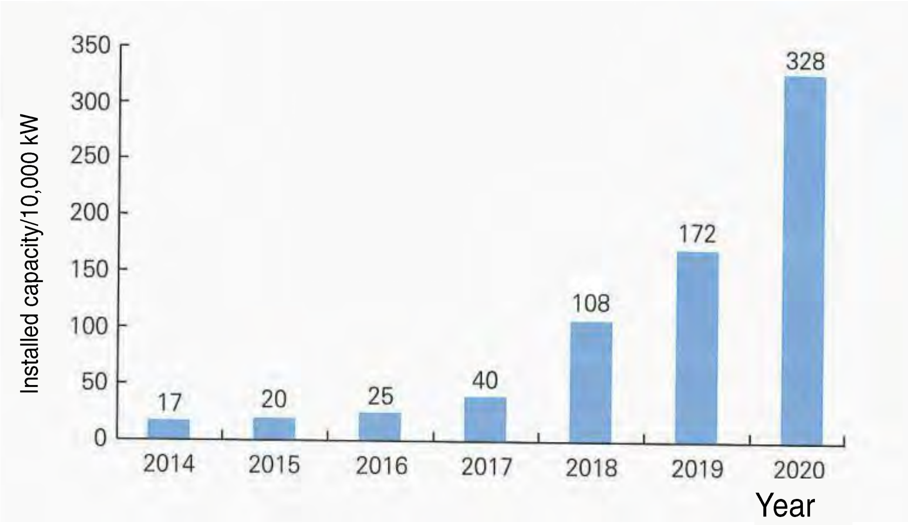
Investment in the geothermal industry continued to scale up. Investment in China's geothermal industry continued to grow during the 13th Five-Year Plan period, with about RMB 400 billion direct investment in the industry, providing nearly 800,000 job opportunities and drawing over RMB 1 trillion investment to the entire geothermal industry chain.

7. New energy storage

In recent years, China has witnessed a rapid increase in newly installed capacity of energy storage. In 2020, 1.56 GW of new energy storage installed capacity was put into operation, 2.4 times that of 2019, exceeding 1 GW for the first time. By the end of 2020, the cumulative installed capacity of new energy storage in China has reached about 3.28 GW.

Electrochemical energy storage remained the dominant form of new energy storage. By the end of 2020, the electrochemical energy storage systems accounted for 99.4% of all new energy storage projects in operation in China, while the energy storage of compressed air, flywheel, supercapacitor and superconducting accounted for less than 1%. Among all kinds of electrochemical energy storage systems, lithium-ion batteries accounted for 88.8% of the total installed capacity; and the proportion of lead batteries decreased from 17.8% in 2019 to 10.2% in 2020.

Figure 5.3-6 **Development of the installed capacity of new energy storage in 2014-2020**



8. Hydrogen

China, as the largest hydrogen producer in the world, boasts considerable experience and a good industrial base in hydrogen supply. China's hydrogen production capacity was about 25 million in 2020, up 8.7% over the last year. With the continuous expansion of renewable energy development in China, it has lifted the curtain on large-scale hydrogen production. At present, hydrogen is mainly produced from fossil energy and industrial by-product. As the world's largest contributor to renewable energy power generation, China has a solid foundation for the development of electrolytic hydrogen production. The alkaline (ALK) electrolytic hydrogen production dominates the market as the technology grows mature; proton exchange membrane (PEM) electrolysis technology is expected to achieve large-scale industrial application as it begins the industrial transformation and demonstration; and solid oxide electrolysis (SOE) technology remains in the R&D stage.

China is speeding up the construction of a hydrogen refueling network, and it ranks second in the world in the number of hydrogen refueling stations. By the end of 2020, a total of 128 hydrogen refueling stations had been built across the country, of which 59 were newly built in that year. In terms of technology, China matured in its technology of 35-Mpa hydrogen refueling stations, and began to focus on the technology of 70-Mpa hydrogen refueling stations, with the refueling capacity increasing from 500 kg/day to 1000 kg/day.

IV. ADVANTAGES AND FEATURES

1. New Energy Bases Combined with Ecological Restoration

In recent years, China has made sustained efforts to restructure industries and energy mix and energetically developed renewable energy. It has stepped up the construction of large-scale wind power and solar PV bases in deserts to increase clean energy supply for the deserts to meet the follow-up demand for desertification prevention and control, thus efficiently utilizing solar energy resources and turning deserts to oasis. It is an effective way for both desert governance and economic development. At the same time, China is actively promoting eco-friendly models of energy development, such as "solar PV + coal mining subsidence area" and "solar PV + agriculture and husbandry", making ecological rehabilitation and environmental governance an essential part in building new energy bases.

2. Remarkable Results in Developing New Energy Projects for Poverty Alleviation

Statistics show that nearly 760 million people in the world lack access to electricity. Countries have to address energy poverty and tackle climate change. As the largest developing country, China actively responds to the call of the United Nations, improving energy access while reducing poverty, and promoting PV projects for poverty alleviation across the country. By the end of 2019, all such PV plants for poverty alleviation have been fully completed, with a total installed capacity of 26.36 GW and an annual revenue of RMB 18 billion, benefiting about 100,000 villages and 4.15 million poor households.

3. Decentralized Solar PV Power in Parallel with Wind Power

China has adopted multiple ways to develop decentralized new energy. First, equal emphasis is placed on both centralized and decentralized power generation, both single-energy and multi-energy development, and both single and comprehensive scenarios. And the priority is given to the distributed development of solar PV and wind power in nearby areas. Second, decentralized wind power is developed in industrial parks, economic development zones and oil and gas mining areas around the load centers. Third, innovative investment and construction models and land use mechanisms are developed for wind power and solar PV. Special campaigns have been carried out to increase wind and solar power in rural areas. Fourth, the model of multi-energy complementation and multi-industry integration has been promoted to build in towns and villages independent micro-grids mainly depending on wind, solar and biomass with the support of energy storage and natural gas. This helps to create new energy micro-grids that are highly self-sufficient.

4. Integrated Development of Hydropower, Wind Power, Solar PV and Energy Storage, and Comprehensive Energy Development

To pursue green and low-carbon development, China has shifted the focus of development to the clean energy industry, giving priority to building clean energy bases integrating complementary energy sources such as hydropower, wind power, and solar PV energy (and energy storage), and speeding up the construction of large-scale wind power and solar PV projects mainly in desert areas. China has put in place a comprehensive development mechanism of renewable energy whereby solar thermal energy and energy storage could complement wind and solar PV power. More biomass and geothermal energy is being used for heating and gas production, thus gradually increasing the proportion of non-electric use of renewable energy.

5. The New Trends in Offshore Wind Power Development

As a key source of renewable energy in China, offshore wind power enters a new stage during the 14th Five-Year Plan period, showing new development trends. **First, the geographic layout of wind power plants has shifted from offshore to deeper waters.** With limited development potential of offshore wind power and limited resources of offshore areas, China is set to develop wind power in deeper seas. **Second, the projects have further developed into large-scale bases.** As the government is phasing out subsidies, large-scale bases help to reduce the construction cost of offshore wind power plants and promotes efficient utilization of marine resources to develop large-scale bases. An important trend in China’s offshore wind power development is optimizing the payout and scaling up. **Third, transition from single-energy to multi-energy utilization.** The integrated development of offshore wind power, “marine ranching”, oil and gas, seawater desalination, hydrogen, and energy storage helps improve the efficiency of the development of maritime space as well as the overall project performance This represents an important development direction of offshore wind power in the future. **Forth, shifting from subsidy-driven to market-driven development.** As government subsidies for offshore wind power are being phased out, enterprises will have to make more independent decisions based on the industry's technological level and their own conditions, which will give full play to the decisive role of the market in allocating resources.

V. PROSPECTS FOR DEVELOPMENT

1. A Bigger Role of Renewable Energy in Meeting Electricity Demand

In order to achieve the goals of "carbon peaking and carbon neutrality" and green and low-carbon energy transition, China will prioritize renewable energy in energy development. From 2020 to 2025, it is estimated that more than 70% of China's newly installed capacity will come from renewable energy, and the increase in renewable energy consumption will account for about 50% of the increase in primary energy consumption. By 2025, renewable energy is expected to account for more than 50% of China's installed capacity. Renewable energy will therefore play a leading role in energy transition by meeting new electricity demand.

2. A New Power System Dominated by New Energy

China set the goal to increase the share of non-fossil energy to about 20% of the total energy consumption by 2025. To meet the goal, new energy development and consumption will be significantly intensified from 2020 to 2025. The installed capacity of wind power and solar PV power will increase to more than 33% of the total, and their generation capacity will account for around 19% of the total electricity consumption. By 2025, the installed capacity of wind power and solar PV will account for more than 50% in northern China. New energy will develop on a large scale with more consumption, while ensuring safe and reliable supply of the power system. Therefore, it is necessary to accelerate the building of a new power system dominated by new energy. To develop and consume more renewable energy and ensure safe and reliable power supply, it is imperative to build a new power system dominated by new energy.

3. Innovative New Energy Development and Utilization and Expanded Scenarios of Renewable Energy Utilization

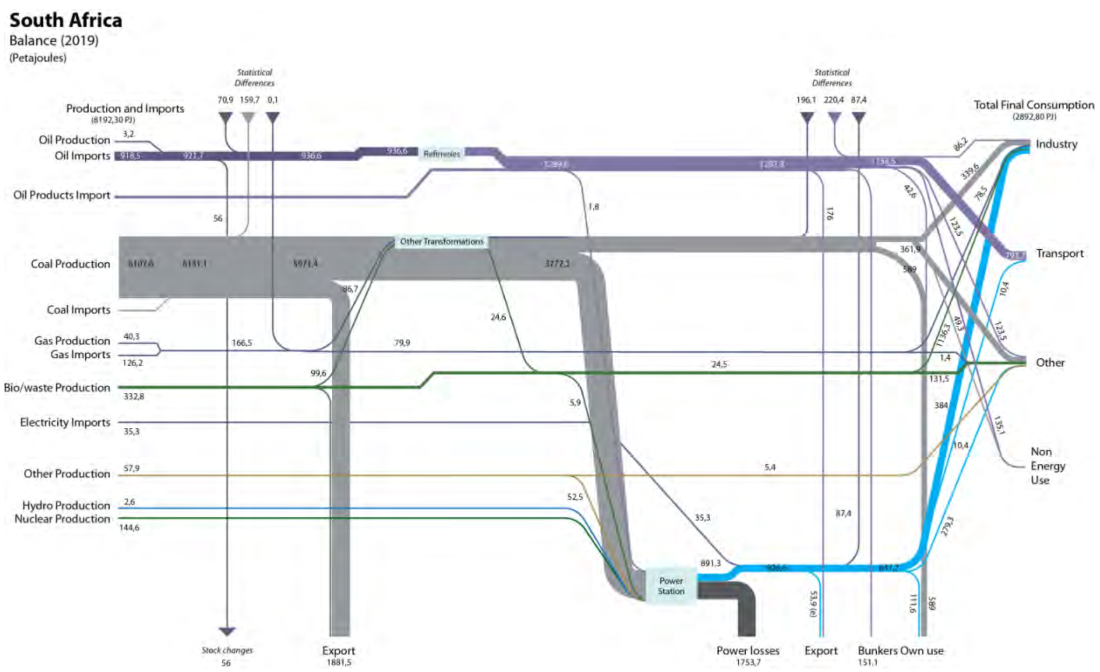
To support the large-scale development and high-level utilization of new energy, comprehensive development models will scale up, such as complementary development of agriculture and solar PV, complementary development of fishery and solar PV power, and desertification control based on solar PV power generation. New energy power generation will be integrated with the development of information industry, such as the 5G base stations and big data centers. New energy will be widely applied in the transport sector such as NEV charging piles, facilities along the railways, and expressway service areas. Direct power supply from new energy, as well as micro-grids, local area networks and DC distribution networks based on new energy will continue to scale up the application of decentralized renewable energy terminals. And in-depth integration of new energy with emerging technologies, new urbanization, rural revitalization and new infrastructure will be promoted, and new areas and scenarios for the development of renewable energy will be expanded.

[VI]

SOUTH AFRICA

I. RESOURCE OVERVIEW

The South African government believes that a low carbon economy can bring benefits and particularly support climate change mitigation measures. The South African Government has committed to reducing carbon emissions in line with specified targets for South Africa. As of 22 September 2021, the country's Nationally Determined Contribution (NDC) target range for 2025, has been updated from its original value of 398-614 Mt CO2-eq, to a range of 398-510 Mt for 2025. Of greater significance is the 2030 mitigation target range which has been updated from 398-614 Mt CO2-eq to a range of 350-420 Mt CO2-eq. In order to meet these emissions reduction targets, several strategies will need to be used towards meeting this goal.

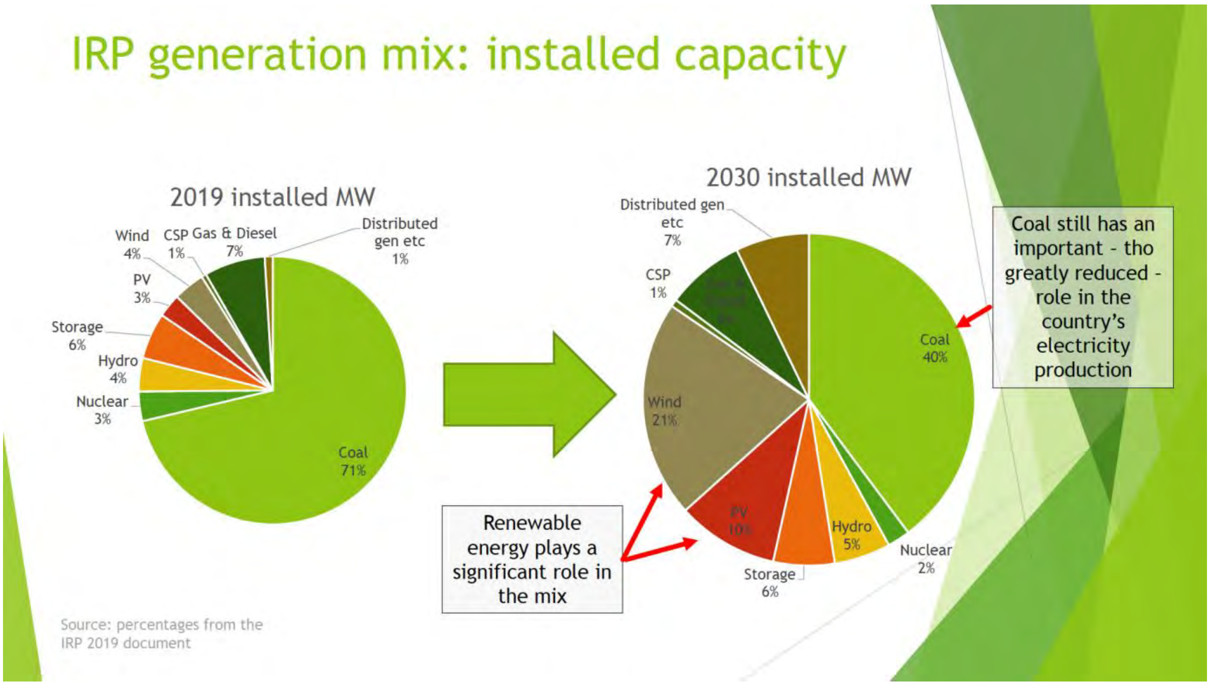


SA Energy Balance 2019 (Source: IEA)

The South African Integrated Resource Plan (IRP) gazetted in 2019 clearly outlines the expected energy blend scenario between 2020 and 2030. This plan takes into account all energy resources in a least cost modeling scenario. The policy adjustments required in order to meet to least-cost target include:

- Retention of annual build limits of renewable energy (smooth rollout)
- 1500MW of coal generators to support just-transition
- 2500MW of regional hydro imports
- Annual allocation of 500MW of 'own use' Distributed Generation

In addition to the above, Distributed Generation is considered to be 1 to 10MW generators and Small Scale Embedded Generation (SSEG <= 1MW) is deemed to be included in the low demand forecast, and was not quantified.



Key issues addressed in the IRP 2019 include:

- Load shedding (recognised as a priority)
  - *Immediate term: demand side measures and promote distributed generation*
  - *Power purchase programme launch*

- Fast changing technology and cost environment requires flexibility that is prioritised via:
  - *Few large, long-term commitments (in order to avoid stranded assets)*
  - *Rollout regulated by Ministerial Determinations as the situation merits*
  - *Regular review of the IRP*
- Job retention and creation (acknowledges that a 'just transition' is important)
  - *Inclusion of some new coal in energy mix for a programme of upliftment and reskilling*
  - *Transition of jobs to renewables (expected to create more jobs per unit energy)*
- Carbon emissions
  - *To meet international commitments (maintaining a peak-plateau-decline trajectory)*
- Electricity prices
  - *Despite least-cost focus electricity prices are likely to continue to rise*

While carbon free renewable power capacity has increased over the past few years through the implementation of the IRP2019 programme, there are a number of reliable fossil fuel technologies currently available that achieve GHG emissions reduction relative to current technologies used in SA, either through improved thermal efficiencies (High Efficiency Lower Emissions, or HELE technology), alternative fuel feedstocks, or removing the carbon emissions from the industrial plants through carbon capture processes and underground storage (CCS).

The implementation of many of the technology options are subject to having enabling infrastructure in place.

- Implementing gas to power technology and increasing natural gas utilisation in SA requires additional gas imports into SA. This requires LNG import infrastructure in ports and associated gas transmission pipelines.
- Similarly, SA's electricity transmission and distribution grid capacity needs upgrading and expansion to meet the additional generation capacity, especially for connecting the renewable power projects in Northern and Western Cape.
- Furthermore, green hydrogen and other sustainable fuels production processes require large renewable power inputs, which in turn requires

appropriate power transmission infrastructure to support it.

II. INDUSTRY POLICY

While the mining, industrial and transport processes associated with fossil fuels are prime sectors to target for GHG reductions in order to meet SA commitments for global GHG reductions, it must be acknowledged that these industries are significant contributors to SA GDP and employment opportunities. It is therefore a reality that fossil fuels are forecast to remain the major source of primary energy over the medium term. The transition to cleaner technology must therefore comprehend SA's economic reality and has to incorporate "just transition" principles.

Just transition is a framework that was developed to encompass a range of social interventions needed to secure workers' rights and livelihoods when economies are shifting to sustainable production, primarily combating climate change and protecting biodiversity2. Thus technology that prevented large scale losses of jobs, or has the potential to create many jobs, is ranked high.

The development of a biofuels industry, for example, has the potential for creating many jobs in the biofuel value chain, while at the same time leveraging SA's natural biomass resources and offsetting US$-based imports.

The suitability of developing renewable solar and wind power in SA is ranked high, because SA is richly endowed with solar and wind resources and large expanses of suitable land required for these technologies. It also has significant potential for employment creation3.

Generally large infrastructure development projects are major contributors to employment opportunities. Furthermore additional power capacity is critical for SA economic growth, which means further job opportunities. Thus most of the technologies considered are supportive of a just transition. In the technology discussions below, where a technology choice has a significant positive or negative impact for a just transition, it is highlighted for that technology.

Key policies affecting energy legislation are summarized below (taken from the South African Energy Sector Report 2019):

1. White Paper on the Energy Policy, December 1998

The White Paper on the Energy Policy was developed so as to clarify government policy regarding the supply and consumption of energy for the next decade. It was intended to address all elements of the energy sector as practically as it could. This White Paper gives an overview of the South African energy sector's contribution to GDP, employment, taxes and the balance of payments. It concludes that the sector can greatly contribute to a successful and sustainable national growth and development strategy. The main objectives of the White Paper are the following:

- Increasing access to affordable energy services
- Improving energy governance
- Stimulating economic development
- Managing energy-related environmental impacts
- Securing supply through diversity

2. White Paper on Renewable Energy, November 2003

The White Paper on Renewable Energy supplements the Government's overarching policy on energy as set out in its White Paper on the Energy Policy (as stated above), which pledges 'Government support for the development, demonstration and implementation of renewable energy sources for both small and large-scale applications'. This White Paper sets out Government's vision, policy principles, strategic goals and objectives for promoting and implementing renewable energy in South Africa. Additionally, it has the following two goals:

- to inform the public and the international community of the Government's goals, and how the Government intends to achieve them, and;
- to inform Government agencies and Organs of State of these goals, and their roles in achieving them.

3. Nuclear Energy Policy, October 2008

The nuclear sector in South Africa is mainly governed by the Nuclear Energy Act 1999, Act 46 of 1999 and National Radioactive Waste Disposal Institute Act, Act 53 of 2008. National Nuclear Regulator (NNR) Act 1999, Act 47 of 1999. The Cabinet approved the Nuclear Energy Policy for South Africa in October 2008. The Nuclear Energy Policy outlines the

South African government's vision for the development of an extensive nuclear energy programme by ensuring that Government's objective on the prospecting and mining of uranium ore and the use of uranium (or other relevant nuclear materials) as a primary resource of energy must be regulated and managed in a manner that will be for peaceful purposes. Through the Nuclear Energy Policy, Government aims to achieve the following objectives:

- Promotion of nuclear energy as an important electricity supply option through the establishment of a national industrial capability for the design, manufacture and construction of nuclear energy systems;
- Establishment of the necessary governance structures for an extended nuclear energy programme;
- Creation of a framework for safe and secure utilisation of nuclear energy with minimal environmental impact;
- Contribution to the country's national programme of social and economic transformation, growth and development;
- To guide in the actions to develop, promote, support, enhance, sustain and monitor the nuclear energy sector in South Africa;
- Attainment of global leadership and self-sufficiency in the nuclear energy sector in the longterm;
- Exercise control over unprocessed uranium ore for export purposes for the benefit of the South African economy;
- Establishing of mechanisms to ensure the availability of land (nuclear sites) for future nuclear power generation;
- Allow for the participation of public entities in the uranium value chain;
- Promoting energy security for South Africa;
- Improvement of the quality of human life and to support the advancement of science and technology;
- Reduction of greenhouse gas emissions; and
- Skills development related to nuclear energy.

4. Integrated Resource Plan (IRP) 2010-30

The IRP is an electricity infrastructure development plan based on least cost supply and demand balance taking into account security of supply and the environment (minimize negative emissions and water usage). When the IRP 2010-2030 was promulgated in March

2011, it was envisaged that it would be revised frequently due to the increasing demand of electricity in South Africa. The IRP, together with Ministerial Determinations issued in terms of Section 34 of the Electricity Regulation Act No. 4 of 2006, help investors to plan their investments in the country's energy sector and are used as a roadmap to meet the country`s electricity demand. In order to update and address gaps in the assumptions that were made in the IRP 2010-2030, the Department reviewed and updated the IRP and also extended the review period to 2050. The update process was mainly aimed at ensuring security of electricity supply, minimizing cost of electricity, minimizing negative environmental impact (emissions) and minimizing water usage. The updated 2018 IRP was published for public comments in November 2018 and interested stakeholders were given 60 days to submit their written comments to the Department. Following the consolidation of public inputs, the updated IRP has been presented to National Economic Development and Labour Council (Nedlac).

5. National Energy Act, 2008

The National Energy Act, 2008 (Act 34 of 2008) ensures that diverse energy resources are available in sustainable quantities and at affordable prices in South Africa. In addition, the Act provides for the increased use of renewable energies, contingency energy supplies, the holding of strategic energy feedstock and carriers, and adequate investment in energy infrastructure.

6. Petroleum Products Act, 1977

The aim of Petroleum Products Act, 120 of 1977, is to:

- Provide measures in the saving of petroleum products and an economy in the cost of the distribution thereof, the maintenance and control of a price, for the furnishing of certain information regarding petroleum products, and for the rendering of services of a particular standard, in connection with petroleum products;
- Provide for the licensing of persons involved in the manufacturing and sale of certain petroleum products;
- Promote transformation of the South African petroleum and liquid fuels industry;
- Provide for the promulgation of regulations relating to such licenses; and
- Provide for matters incidental.

7. Nuclear Energy Act, 1999

The aims of the Nuclear Energy Act, 1999 (Act 46 of 1999) are:

- To provides for the establishment of the National Energy Corporation of South Africa (Necsa) and defines its functions, powers, financial and operational accountability, governance and management;
- To provide for responsibilities for the implementation and application of the Safeguards Agreement and any additional protocols entered into by the Republic of South Africa and the International Atomic Energy Agency in support of the Nuclear Non-Proliferation Treaty acceded to by the Republic;
- To regulate the acquisition and possession of nuclear fuel, certain nuclear and related material and certain related equipment, as well as the importation and exportation of, and certain other acts and activities relating to, that fuel, material and equipment in order to comply with the international obligations of the Republic;
- To prescribe measures regarding the discarding of radioactive waste and the storage of irradiated nuclear fuel; and to provide for incidental matters.

8. The Gas Act, 2001

The aims of the Gas Act are as follows:

- To promote the orderly development of the piped gas industry;
- To establish a national regulatory framework;
- To establish a National Gas Regulator as the custodian and enforcer of the national regulatory framework; and
- To provide for matters connected therewith.

III. DEVELOPMENT SITUATION

Renewable Energy Independent Power Producer Procurement Programme (REIPPPP)

In 2003, Cabinet approved private-sector participation in the electricity industry and decided that future power generation capacity will be divided between Eskom (70%) and Independent Power Producers, or IPPs (30%). The National Development Plan required the development of 10 000MW additional electricity capacity to be established by 2019 against the 2010 baseline of 44 000MW. The Integrated Resource Plan (IRP) 2010 developed the preferred energy mix with which to meet the electricity needs over a 20 year planning horizon to 2030.

In line with the national commitment to transition to a low carbon economy, 17 800MW of the 2030 IRP targets expected to be from renewable energy sources, with 5 000MW to be operational by 2019 and a further 2 000MW (i.e. combined 7 000MW) operational by 2020. The REIPPPP is aimed at bringing additional power into the electricity system through private sector investment in wind, solar, photovoltaic, concentrated solar power (CSP), biomass and small hydro technologies. The REIPPP programme constitutes one of the energy mixes as outlined in the National Development Plan and the Integrated Resource Plan 2010.

In May 2011, the DoE gazetted the Electricity Regulations on New Generation Capacity (New Generation Regulations) under the Electricity Regulation Act (ERA) which enable the Minister of Energy (in consultation with NERSA) to determine what new capacity is required. Ministerial determinations give effect to components of the planning framework of the IRP, as they become relevant. The current new capacity determinations include 14 725MW of renewable energy, comprising of solar PV (6 225MW), wind (6 360MW), CSP (1 200MW), small hydro (195MW), landfill gas (25MW), biomass (210MW), biogas (110MW) and the small scale renewable energy programme (400MW);

The determinations have been implemented in rolling bid windows with seven (1, 2, 3, 3.5, 4, 1S2 and 2S2) bid windows successfully completed in the first five years. All projects in Bid Window 1 (BW1) and Bid Window 2 (BW2), and 10 projects in Bid Window 3 (BW3) are now operational. By the end of June 2017, the REIPPPP had made the following significant energy supply capacity impact:

- 6 422MW of electricity had been procured from 112 RE Independent Power Producers (IPPs) in seven bid rounds, that is, Bid windows 1, 2, 3, 3.5, 4 and smalls BW1 (1S2) & smalls BW2 (2S2)
- 3 976 MW of electricity generation capacity from 64 IPP projects has been connected to the national grid;
- 35 669 GWh of energy has been generated by renewable energy sources

procured under the REIPPPP since the first project became operational. Renewable energy IPPs have proved to be very reliable. Of the 64 projects that have reached COD, 62 projects have been operational for longer than a year. The energy generated over the past 12 month period for these 62 projects is 10 648 GWh, which is 96% of their annual energy contribution projections (P50) of 11 146 GWh over a 12 month delivery period. Twenty eight (28) of the 62 projects (45%) have individually exceeded their P50 projections.

In terms of national targets for renewable energy capacity, as defined by the IRP and National Development Plan, this represents 22% towards the 2030 target and 57% towards the 2020 target.

(Above taken from the South African Energy Sector Report 2019)

IV. INDUSTRY ADVANTAGES AND CHARACTERISTUCS

Notwithstanding the information presented above industry development still largely remains reliant upon the fossil fuel based economy of South Africa. However, over the past five years renewable energy resources or being increasingly looked upon with interest by various industry sectors in South Africa. This is not because of cost benefits associated with utilising renewable energy technologies rather than fossil fuel technologies, but instead because of the energy security required for industry to be able to execute profitable business practice and thus grow the economy. For example, multiple business cases have been made to shift towards alternate heat resources many of which come from renewable energies and it would appear that South Africa is on the precipice of taking advantage of these technologies based on energy security visa vie acceptable business case compliance.

Job creation and a shift towards the just energy transition, which includes skills development and capacity building, has a high potential for making a meaningful impact if the industrial sector of South Africa is targeted this would include the energy production and mining sectors as well as manufacture for the country. However, this would only be possible if the economic climate is conducive towards this shift being affected。

V. PROSPECTS FOR DEVELOPMENT

Prospects for renewable energy integration and deployment within South Africa remain bright. As per the above legislation and planning renewable energy is expected to increase in both on grid embedded generation and off grid scenarios moving forward. It's also evident from the address of the president of the of South Africa in the past months stating that additional capacity must be grid connected in order to support electricity security to the country. This security of supply is linked directly to economic growth, and as such is paramount in national government planning towards 2030 and 2050. Although the integrated resource plan of 2019 can be seen as a blueprint towards energy supplied targets for 2030 it is expected that the integration of renewable energies will continue to increase in South Africa into the short medium- and long-term electricity and energy supply chains.

The Minister of Mineral Resources and Energy budget speech of 19 May 2022, outlines the following prospects for electricity supply in the coming months:

Developments in the energy sector

Integral to reforms, the Electricity Regulation Act has been amended to create a transmission entity, to act as wheeler and dealer of electricity, competitively. The Bill, tabled in Cabinet in January 2022 and published for comments, is being finalised. It will be presented to cabinet for approval, with the intention to table it in Parliament by the end of July 2022. Alongside these, are amendments to the Electricity Pricing Policy which will also be tabled for final approval by Cabinet by the end of July 2022.

On electricity generation, aimed at the supply and demand deficit:

One thousand eight hundred and fifty (1 850MW) megawatts, from projects signed under bid window 4 of the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), were connected to the grid.

Two thousand six hundred (2 600) megawatts of renewable energy, or Bid Window 5, with the signing of Project Agreements planned for end of July 2022 and end of September 2022, was procured. These projects are expected to deliver power into the grid within 24 months from date of signing of Project Agreements.

A Request for Proposals (RFP) for the procurement of two thousand six hundred (2 600) megawatts of renewable energy under Bid Window 6 of the REIPPPP was issued.

Currently finalising, with Eskom (the buyer), the agreements with preferred projects procured as part of the two thousand (2 000) megawatts under the Risk Mitigation Independent Power Producer Procurement Programme.

Finalising additional Request for Proposals for issue in the current financial year, for the procurement of:

- Five hundred and thirteen (513) megawatts of Storage.
- Three thousand (3 000) megawatts of Gas
- Two thousand six hundred (2 600) megawatts of renewable energy under Bid Window 7
- One thousand five hundred (1 500) megawatts of Coal.
- These initiatives will bring online over thirteen thousand (13 000) megawatts.

Chapter 3

BRICS Cooperation on Renewable Energy Development

[VII]
KEY AREAS OF COOPERATION

I. COOPERATION ON DEMONSTRATION PROJECTS

In order to promote the popularization and application of innovative energy technology in BRICS countries, it is suggested to establish a cooperative mode for demonstration projects in key areas, including but not limited to, solar thermal power generation, comprehensive energy system with hydrogen as the core, micro-grid, and offshore wind power. The application and popularization of innovative technology in renewable energy can be promoted through project cooperation.

II. EXCHANGE ON RENEWABLE ENERGY TECHNOLOGY

At present, the rapid development of renewable energy technology has significantly driven the development of the industry. BRICS countries can organize regular exchanges on renewable energy technology, focusing on hot topics such as electrochemical energy storage, pumped storage and offshore wind power.

III. EXCHANGE ON RENEWABLE ENERGY POLICY SYSTEMS

New energy such as wind power and solar PV will be one of the top priority for the development of BRICS countries for some time in the future. However, the price of electricity generated from wind power and solar PV keeps breaking record lows all around the world. It is a problem to address how to leverage policies to support and guide the sound and rapid development of new energy. BRICS countries may exchange views on renewable energy policy systems to draw on each other's strengths and support follow-up development.

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