BRICS 2024 RUSSIA

JUST ENERGY TRANSITION REPORT

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ENERGY RESEARCH COOPERATION PLATFORM

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ABSTRACT

The report on the outcomes of the BRICS Energy Platform Research includes an overview of energy sectors of the BRICS member states, their vision of concept of just energy transition in a view of national targets and priorities for sustainable economic development. It identifies the principles of just energy transition in order to ensure access to affordable, reliable, sustainable and modern energy for all, which is essential for social stability and national security. The report also identifies the areas and directions of mutually beneficial energy cooperation. The report was prepared by the experts of BRICS Energy Research Platform based on the information provided by the relevant ministries and agencies of BRICS member states and with their active participation.

The research consists of two sections. The first section includes an overview of energy sectors of BRICS member states as well as the targets, tasks and procedures for implementation of just energy transition, taking into account national circumstances of the BRICS member states. The second section describes conclusions and recommendations for further actions and cooperation between the countries of the association.

The outcomes of the research are intended for use by the government officials, science and business community and also may be used for education purposes.

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CONTENT

MR. ALEXANDRE SILVEIRA DE OLIVEIRA

Minister of Mines and Energy
the Federative Republic of Brazil

The transition to sustainable energy supply is one of the most pressing challenges of our time, being essential for mitigating climate change, reducing pollution, and ensuring a stable energy supply for future generations. For Brazil, a country with abundant natural resources and significant potential for renewable energy, this transition is not only an environmental necessity but also a social and economic opportunity.

Brazil is already a global leader in energy transition, with renewable sources making up nearly 50% of our energy matrix and almost 90% of the electricity matrix, alongside diversification and complementarity of options. However, achieving further advancements requires not only national efforts but also international cooperation, especially with other BRICS countries.

The BRICS nations, as emerging economies with significant influence on the global stage, play a crucial role in advancing the global energy transition. Their collaboration can drive technological innovation, as they share best practices, and create financial mechanisms to support sustainable energy projects.

Our collaboration can significantly enhance our countries' renewable energy capacity by facilitating the transfer of cutting-edge technologies, making renewable energy projects more efficient and affordable. Joint ventures and knowledge exchange programs can provide us with access to the latest advancements in solar, wind, hydro, and bioenergy technologies, driving our energy transition forward.

Furthermore, collaborative efforts can help Brazil scale up its renewable energy installations and improve grid integration. By promoting decentralized renewable energy solutions, Brazil can reach remote and underserved communities, ensuring that the benefits of the energy transition are widely shared across the country.

By fostering international cooperation and leveraging the strengths of each member nation, the BRICS can lead the way in creating a more reliable, sustainable, just, and inclusive world. This report represents a step forward in collaborative work, unifying the efforts of BRICS members to face the new challenges regarding energy transition. Through this unified approach, Brazil and its BRICS partners can not only address their own energy needs but also contribute significantly to global sustainability goals.

MR. ZHANG JIANHUA

Administrator of the National Energy Administration
People's Republic of China

The BRICS countries represent the major emerging markets and developing countries globally, characterized by rapid economic growth and strong energy demand. While facing challenges of energy supply security, we also confront the urgent task of energy transition.

Achieving a just energy transition is a shared goal of the BRICS countries and a concrete practice of our active participation in addressing global climate change challenges. This aligns with the international community's vision of accelerating clean, low-carbon, inclusive, affordable, just, and sustainable energy transformation. China remains committed to extensive international energy cooperation, injecting the «Chinese momentum» into global green development. At the same time, China is vigorously developing clean energy, steadily advancing the energy transition, with the goal to increase the share of non-fossil fuels in primary energy consumption to around 25% by 2030 and over 80% by 2060. In 2023, the proportion of clean energy consumption in China reached 26.4%. China ranks first position regarding the scale of investment in energy transition among major economies in the world.

The year 2024 marks the first year after BRICS expansion, with cooperation across various fields entering a new starting point and advancing to a higher level. We believe that strengthening energy cooperation among BRICS countries will have a profound impact on global energy trade, the supply-demand landscape, and related industrial chain collaboration. China will continue to uphold the BRICS spirit of openness, inclusiveness and win-win cooperation, work with other member countries to advance a just energy transition, and promote global energy governance in a fairer and more equitable way, contributing to global sustainable energy development and to building of a community with a shared future for mankind.

H.E. DR. MAHMOUD MOSTAFA KAMAL ESMAT

Minister of Electricity and Renewable Energy
Arab Republic of Egypt

It is my great honor to engage in this essential report to express the future of energy transition, especially in the context of Egypt and its role within the BRICS framework. Egypt, like many other nations, faces the pressing challenge of balancing economic growth and sustainable energy development. We are aware of the significance of just energy transitions as a critical pathway to achieving both economic progress and environmental sustainability. Egypt is committed to this mission, as demonstrated by our substantial efforts in transitioning towards renewable energy, diversifying our energy mix, and enhancing energy efficiency.

Our Integrated Sustainable Energy Strategy to 2035, recently updated to 2040, outlines ambitious targets for renewable energy development. We aim to achieve 42% of our electricity generation from renewable sources by 2030, accelerating our commitment from the original 2035 target. This commitment reflects Egypt's determination to address the growing global demand for clean energy and to actively contribute to the international community's climate change goals.

Egypt is blessed with significant renewable energy resources, particularly solar and wind. These resources position us as a key player in the global energy landscape. Our partnerships with BRICS countries, including China, India, and Russia, in various renewable energy projects and initiatives, underscore our collaborative spirit in driving forward energy innovations.

Furthermore, we recognize the need for a balanced approach that ensures energy security, affordability, and inclusivity. Egypt's National Hydrogen Strategy, launched recently, positions us as a future leader in green hydrogen production, leveraging our geographical advantage and expertise in energy infrastructure.

As we embark on this journey together, let us emphasize the need for collaboration, technology transfer, and knowledge sharing. The transition to a cleaner, more sustainable energy future cannot be achieved in isolation. Our collective efforts will be critical in overcoming the challenges posed by the global energy transition and ensuring that no nation is left behind.

In conclusion, Egypt remains fully committed to its role in advancing the just energy transition, fostering sustainable development, and enhancing regional and global cooperation in the energy sector.

Thank you.

H.E. ENG. KARIM BADAWI

Minister of Petroleum and Mineral Resources
Arab Republic of Egypt

First, I would like to seize this opportunity to acknowledge the BRICS countries decision to accept Egypt's membership to this important group, and to commend the valuable efforts of Russia for chairing the BRICS countries for the year 2024.

The global energy landscape is undergoing a profound transformation, and the BRICS countries are at the forefront of this pivotal shift. As major emerging economies with diverse energy portfolios and unique developmental challenges, the BRICS nations play a crucial role in shaping the future of global energy systems. The theme of this year's report for the Just Energy Transition under the BRICS Energy Research Cooperation Platform comes at an important juncture as countries are navigating their energy transition pathways to overcome the energy trilemma of securing energy resources sustainably and affordably.

In this context, developing countries face a triple challenge: pursuing low-emission development with rising energy demand and limited access to affordable capital. Shaping a just energy transition that supports equitable growth requires a comprehensive approach that considers social, economic, and environmental factors of the transition. This comprehensive and inclusive approach is necessary to avoid the risk of unequal benefits of the energy transition.

As signatory of the Paris Agreement on climate change, Egypt recognizes the importance of climate action, especially according to the principle of differentiated responsibilities and respective capabilities. Egypt's success in hosting COP27 on behalf of the African continent, as well as organizing the first ever Decarbonization thematic day championed by the Ministry of Petroleum and Mineral Resources, demonstrated Egypt's commitment to climate action and underscored the critical need to work towards enhancing collective and urgent action to address the challenge of climate change. Furthermore, the Egyptian Government continues to be leading economic reforms and driving the country's efforts towards green economy.

Egypt's energy sector is a key driver of economic growth and an engine for sustainable development. Egypt's energy sector will continue to fulfil the country's energy demands through all available energy resources and leverage Egypt's key role as an energy hub, with a focus on reducing emissions and energy transition.

Recognizing that strong collaboration between all stakeholders of our energy industry is essential to effectively address the energy transition challenge, especially within "South-South" partnerships to achieve national development goals, this report will support the BRICS countries to align around a common vision and shared objectives for navigating our countries' specific pathways to achieve a just energy transition that leaves no one behind.

H.E. DR. ING. HABTAMU ITEFA

Minister of Water and Energy
Federal Democratic Republic of Ethiopia

Ethiopia is endowed with a variety of renewable and clean energy resources potential, including hydro, wind, geothermal, solar, bio-energy and fossil fuels. Despite our vast energy resources, the majority of our energy consumption currently relies on biomass (greater than 86%), highlighting our significant journey toward a sustainable energy transition. Access to electricity and clean cooking solutions remains a critical priority for Ethiopia. By 2030, we aim for 100% access to modern, affordable, and renewable energy for all our citizens, in alignment with the 2030 Agenda for Sustainable Development Goals.

Ethiopia faces many challenges, including its vulnerability to climate change, limited institutional capacity, technology and finance shortages with some of the BRICS countries sharing some of these problems as well. These factors hinder our ability to transition to sustainable energy systems while addressing the urgent needs of those still lacking access to electricity and clean cooking energy access. It is imperative that our initiatives to enhance modern energy access also promote renewable energy scaling and energy efficiency.

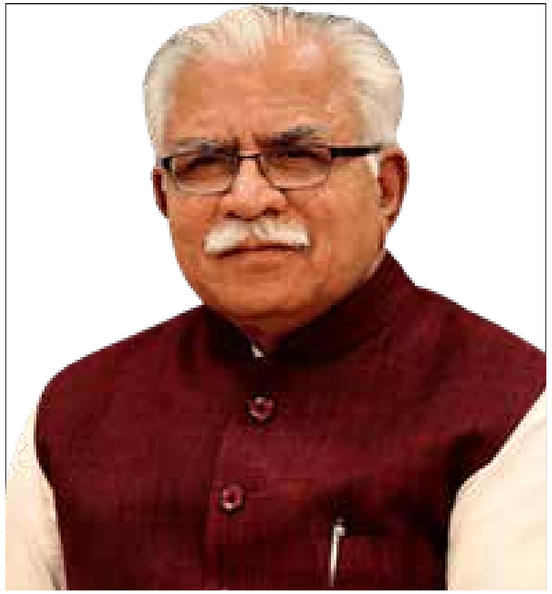
Our Long-Term Low Emission Development Strategy (LT-LEDS) serves as a roadmap until 2050 for decarbonization and climate-resilient growth. It aligns our Nationally Determined Contributions (NDC) with the long-term goals of the Paris Agreement, focusing on seven priority sectors, including energy and transport.

We are committed to diversifying our renewable energy mix, capitalizing on our extensive hydro, wind, geothermal, and solar resources. This diversification is essential not only for our national energy independence but also for fostering regional stability and cooperation through power interconnection. By embracing renewable energy, we aim to reduce our carbon footprint and build a sustainable future for generations.

In our pursuit of becoming a renewable energy hub in East Africa, we must enhance regional power interconnection. By collaborating and integrating our energy systems, we can optimize resource sharing and improve efficiency. This regional approach will strengthen our resilience, allowing us to respond more effectively to energy demands and market fluctuations.

Energy efficiency is another vital component of our strategy. By implementing innovative practices and technologies, we can maximize our existing resources and minimize waste. This commitment not only benefits our environment but also enhances our economic competitiveness.

Together with all BRICS countries, let us strive for a just energy transition that secures a sustainable and prosperous energy future for our population and the planet.



MR. MANOHAR LAL

Minister of Power and Housing and Urban Affairs
of the Republic of India

In a world increasingly defined by rapid technological advancements and shifting environmental and social priorities, the role of energy has never been more crucial. As many nations face the dual challenge of promoting economic growth while advancing energy transitions, ensuring energy security remains a critical concern for emerging and developing economies.

As one of the leading members of BRICS, India has made significant strides in expanding its renewable energy capacity and driving innovations in the transition to clean technologies. India's efforts to enhance energy access and promote clean cooking, particularly in rural areas, reflect its commitment to equity and inclusion.

India has set ambitious targets for achieving energy independence by 2047. Diversifying energy sources, investing in energy infrastructure, and strengthening supply chains are key pillars in ensuring a resilient energy future.

I would like to express my gratitude to the Russian Federation for presenting the BRICS report on Just Energy Transition, which explores the complementarities within the BRICS energy landscape. The report analyzes current trends, challenges, and opportunities for member nations in making the energy transition just and inclusive.

This report will inspire policymakers, industry leaders, and stakeholders to collaborate on a sustainable and inclusive energy future, harnessing the strengths of the BRICS partnership to drive sustainable progress across all sectors of society.

H.E. MR. ABBAS ALIABADI

Minister of Energy
Islamic Republic of Iran

Islamic Republic of Iran finds BRICS a determinative platform for deepening multilateral cooperation in the energy sector, which can have a decisive effect at the global level. Iran intends to actively take part in BRICS joint activities and, due to its position in the global energy, Iran can bring more added value to this distinguished entity. I warmly welcome the selection of the «Just Energy Transition» as a key focus area within BRICS under the Russian presidency in 2024. The «Just Energy Transition» encompasses a diverse range of sectors, several of which hold considerable significance for Iran, including ensuring energy security, facilitating investment in energy infrastructure, improving electricity affordability, boosting social equity, and reducing environmental impact.

To move towards the «Just Energy Transition,» BRICS can have a pivotal role in ensuring technology neutrality, investment facilitation, nondiscriminatory access to financial sources and technology, and international cooperation, particularly in the energy sector. I believe that sharing the best practices in energy studies will promote solidarity and unity among BRICS countries and will be beneficial to all the member states. Scientific research, and industrial and financial collaboration will play a pivotal role in achieving these goals.

While providing a platform for sustained engagement among national experts, the BRICS «Just Energy Transition Report» helps to comprehend and enhance social equity, economic fairness, environmental justice, inclusive policymaking, and sustainable development in BRICS countries.

Islamic Republic of IRAN acknowledges the efforts of the BRICS 2024 Russian chairmanship for uniting BRICS countries in a common program, leveraging collective strengths to promote the «Just Energy Transition».

MR. SERGEY TSIVILEV

Minister of Energy
the Russian Federation

The energy sector has always been of a special importance within BRICS cooperation frameworks as a driving force for enhanced cooperation between our countries.

The 2024 is a milestone year, when the BRICS family has doubled. The enlargement of the BRICS community contributes to its firm position in the world. As of now, altogether it accounts for 45 per cent of the world population and 37 per cent of global GDP at purchasing power parity. Our countries hold the leading positions both in traditional and renewable energy resources.

The humanity faces a challenge to ensure a balance between reducing the negative impact on climate6 on the one hand, and meeting the growing need in affordable, reliable, sustainable and modern energy for all, on the other hand.

In this regard, in the year of the Russian Federation Presidency in BRICS, a report on the just energy transition was developed within the BRICS Energy Research Platform. It is the first time that the report is published with the contribution of the new BRICS member states.

The Russian Federation supports a balanced and constructive approach to energy transition, which allows us to continue pursuing the Sustainable Development Goals, meet the interests of both producers and consumers of energy as well as to exclude the use of the climate agenda as a political and economic instrument for non-competitive struggle in the world markets.

I am confident that the results of the report will contribute to the enhancement of a all-round and comprehensive cooperation and promote our joint vision of the future in a view of building an equal, balanced and sustainable global energy development pattern, taking into account national conditions and priorities the basis of mutual respect for everybody's interests.

H.E. DR. KGOSIENTSHO RAMOKGOPA

Minister of Electricity and Energy
Republic of South Africa

With the evolution of the global energy landscape moving towards modern and sustainable energy sources, South Africa stands at a pivotal crossroads given its highly coal-dependant power generation sector. This is a legacy that has been informed by our abundant coal reserves. The country has, to this end, taken energy policy and regulatory review initiatives aimed at incorporating cleaner energy sources into its energy mix, including nuclear. South Africa also explicitly recognises the imperative of a just energy transition and has already undertaken several measures towards this direction

For South Africa, the Just Energy Transition (JET) represents not just a shift in energy generation and consumption, but a comprehensive approach in addressing climate change, energy security and affordability while ensuring the attainment of socio-economic benefits of this trajectory to all South Africans in a fair, equitable and inclusive manner.

At the heart of the JET is the recognition that transition towards a sustainable energy future must prioritize the livelihoods and well-being of workers and communities affected by this change. This involves upskilling and reskilling programs for those in traditional energy sectors, creating new job opportunities in cleaner energy sectors, and ensuring that local communities have a voice in energy planning and implementation.

In addition, the energy landscape in South Africa is currently undergoing transformation in several areas. These changes will not only provide the country with the opportunity of addressing and shaping its own prospects for development and growth, but the broader Southern Africa Development Community (SADC) sub-regional and wider Africa continental energy dynamics.

While we go through transformation of energy systems especially for us as developing countries carrying the burden of energy poverty, it is important to consider the financial costs and the need for the broader global community to ensure that access to affordable financial capital, technology and capacity building is enabled. As South Africa we remain committed to JET, we emphasize the need to transition at a pace, scale and cost that is affordable and support the broader developmental trajectory of each country and the global community in accordance with principle of common but differentiated responsibilities and respective capabilities..

Lastly, the importance of intergovernmental collaborations within the BRICS grouping for a joint JET initiatives cannot be overstated. By working together, we can build a resilient energy system that not only meets our current energy needs, but also that will safeguards the environment for future generations.

H.E. MR. SUHAIL MOHAMED AL MAZROUEI

Minister of Energy and Infrastructure
United Arab Emirates

The UAE has adopted a balanced, proactive, and positive approach to the energy transition that drives a new low-carbon, high-growth economic model. Our commitment has been made clear in our Energy Strategy 2050, where we announced targets of tripling our renewables capacity and increasing the share of installed clean energy capacity in the total energy mix to 30% by 2030.

The UAE is actively spearheading the deployment of renewable energy solutions, with numerous mega-projects. Today, the UAE is home to three of the world's largest and most cost-effective solar plants.

The UAE has achieved significant milestones in increasing its renewable energy capacity. Between 2019 and 2022, we doubled our renewable energy capacity, and by 2023, we witnessed an additional 70% growth in the installed renewables capacity. Additionally, we raised our target for energy efficiency to 45% by 2050 on the national level, implemented building retrofit programs, upgraded equipment standards in buildings, issued green building codes, and introduced initiatives for clean mobility and regulating energy efficiency in industrial facilities.

We are taking confident steps in deploying low-emission hydrogen. The National Hydrogen Strategy 2050 targets the production of 15 million tonnes of low-emission hydrogen per annum by 2050.

With a diverse energy mix, including gas, nuclear, waste, and solar, the UAE has invested in clean technologies to ensure reliable power and water supply. In 2023, UAE ranked second globally in the Energy Transition Index (the Green Future Report).

The UAE has been financing clean energy projects for over 15 years and has invested over USD 40 billion in the sector to date. Current projections indicate that the production capacity of clean energy will reach 19.8 GW by 2030. The UAE actively supports green infrastructure and clean energy projects worldwide, having invested USD 50 billion in renewable energy initiatives in 70 countries, with a particular focus on developing nations' clean energy capacity.

The UAE took the center stage by hosting COP28 which marked a transformative approach to global climate discussions, focusing on inclusion and collective efforts towards combating climate change.

The UAE Consensus includes an unprecedented reference to transitioning away from all fossil fuels in energy systems, in a just, orderly, and equitable manner during this critical decade.

As the way forward, the UAE is committed to continuing on the same path, driving a robust energy transition at the scale and pace needed to meet climate commitments and achieve net zero by 2050.

INTRODUCTION

Like any other economy sector, the energy sector has its specific cycles and regularities in the dynamic development marked by long and ultra-long iterations and changes in technology paradigms and production processes. The transformations are triggered by the shifts in options and patterns for fuel and energy resource treatment that are commonly referred to as energy transition.

The changes that occur in the energy transition process re-structure existing models for access and consumption of energy resources, leading to a growing share of new energy sources and a gradual substitution of conventional sources in entire energy consumption. At the same time, up to now there is no single definition of the *energy transition* concept, and the numerous existing interpretations are indicative of its high complexity and multifaceted nature.

Generally speaking, the structure of global energy consumption is undergoing continuous changes. Since 1800 to present, the global energy mix has been alternately dominated by various sources of energy, such as (woody) biomass, coal, oil and natural gas. A significant impact on the global energy mix has been also made by the nuclear power.

The energy transition has been traditionally driven by a progress in science and technology, technical revolutions, and breakthroughs that improved the availability and economic attractiveness of new energy sources.

Today in turn we witness a new era of global energy system transformation that is mainly driven by international environmental and climate agenda focused on reducing its negative impact on the environment.

Rapid development and dissemination of new technologies result in new energy formation that is based on clean and low-carbon solutions, the widespread deployment of renewable energy sources on the basis of biomass, ammonia, water, wind and solar power, as well as the use of fossil fuels that emit less greenhouse gases associated with carbon capture, utilization and storage technologies.

Energy transition is usually accompanied with large-scale socio-economic, technology and environmental transformations. Therefore, the aspects of current energy transition in modern international energy agenda must be considered in a close conjunction with sustainable development.

The issues of energy transition are widely discussed on various international platforms and among diverse groups of countries.

The United Nations pays great attention to energy transition, so far as it is a part of the 2030 Agenda for Sustainable Development supported by all UN Member States and adopted by the UN General Assembly on September 25, 2015 № 70/1 .

The 17 Sustainable Development Goals (SDGs) are multidimensional and indivisible in nature, and they maintain the balance between social, economic and environmental components. The goals and objectives of the energy policy are set forth in the Sustainable Development Goal 7 (SDG 7), which calls for ensuring universal access to affordable, reliable, sustainable and modern energy for all.

In addition to the UN platform, the concepts and pathways for energy transition are discussed at the venues of key international energy organizations, including Organization of the Petroleum Exporting Countries (OPEC), Gas Exporting Countries Forum (GECF), International Energy Forum (IEF), International Renewable Energy Agency (IRENA), International Energy Agency (IEA), and within the groups of countries such as G20, the East Asia Summit, and the APEC.

BRICS also pays close attention to the energy transition issues, which are reflected in the Declarations of the BRICS Summits, and in the Communiqué of the BRICS Energy Ministers Meetings.

The BRICS partners have an adamant stance that just energy transition should be guided by a right for free and independent choice of energy transition pathway, energy balance formation and energy development priorities based on specific national features and priorities. Every year, in final documents of the Energy Ministers meetings emphasized the need to use all available energy sources and technologies, and the interconnection between energy transition, energy security and access to energy.

A stronger and deeper energy cooperation within the BRICS countries requires a more profound understanding of the challenges related to the just energy transition and the ways to overcome them.

In this regard the BRICS countries, who are the world largest energy powers that account for almost a half of global primary energy production and consumption and play an important role in global energy agenda, made a decision to undertake within the frameworks of the BRICS Energy Research Cooperation Platform a study with the aim at analyzing the BRICS countries' approaches to just energy transition. ■

REVIEW OF THE BRICS COUNTRIES' ENERGY SECTORS

BRAZIL

OVERVIEW OF THE ENERGY SECTOR

Brazil has a vast territory, measuring 8,510,418 km², bathed to the east by the Atlantic Ocean with more than seven thousand km of coastline. The country borders the following ten nations: Uruguay, Argentina, Paraguay, Bolivia, Peru, Colombia, Venezuela, Guyana, Suriname and France (French Guiana), reaching almost 17 thousand km of land border.

Brazil has 26 states, in addition to the Federal District, which make up the Federative Republic of Brazil.

In the global energy context, Brazil stands out as the first producer of niobium and iron ore (2021), eighth in oil production (2022), tenth in oil exports (2021), second largest producer and consumer market of biofuels in the world, second in hydroelectric generation (2022) and fifth in wind energy generation (2022).

The energy and power matrices of Brazil are known for being quite renewable compared to the world average. Around half of the energy matrix is made up of renewable sources, with emphasis on hydroelectricity and biomass, which together make up around 44% of the matrix. Our main biomass comes from sugar cane, used both to produce ethanol and for generating electricity. However, the growth in ethanol production from corn is evident: in 2023 reached around 16% share in total ethanol production. The biodiesel production, mainly from soybean oil, is also quite significant. The final consumption of biodiesel in Brazil in 2023 increased by around 20% compared to the previous year.

Since April 2023, the mandatory blending content of biodiesel in diesel oil has been increased to 12%. As well as the progressive evolution of this percentage, which should reach 15% by the year 2026.

In Brazil, gasoline sold to the end consumer (regular gasoline) has a mandatory ethanol mix of around 27%. Vehicles with internal combustion engines, in general, can be fueled exclusively with ethanol.

Transport activity is part of the energy sector and is responsible for around half of the sector's emissions. However, measures such as the mandatory obligation to add biodiesel to fossil diesel and ethanol to gasoline contribute significantly to reducing greenhouse gas emissions.

The fossil source with the largest share in our energy matrix is oil and its derivatives, with around 36% share. National oil production in 2023 was 198 million m^3, or 176 million toe (ton of oil equivalent), with around 47% of this total being exported. Our main petroleum derivative, in terms of final consumption, is diesel oil, with the equivalent of 47 million m^3 produced in our refineries and around 14 million m^3 imported in 2023.

The second fossil source the largest share in the total energy supply was natural gas, with 31 billion m^3 or 30 million toe, with around 19% of this energy value being imported, coming mainly from Bolivia.

Mineral coal, which is one of the world's main energy sources in terms of its share, corresponds to less than 5% of the total energy supply in Brazil, with more than 78% of this coal being imported.

In terms of electricity, the Brazilian territory is connected through an extensive basic transmission network, the Brazilian Interconnected System – SIN, reaching more than 170,000 km in length. The SIN is made up of four subsystems: South, Southeast/Central-West, Northeast and most of the North region.

The interconnection of power systems through the transmission network facilitates energy transfer between subsystems, allows synergistic gains to be obtained and exploits the diversity between the hydrological regimes of the basins. The integration of generation and transmission resources allows us to serve the power market safely and economically.

The SIN's installed generation capacity is mainly made up of hydroelectric plants distributed across sixteen river basins in different regions of Brazil. In 2023, around 72% of SIN's electricity generation came from hydroelectric plants.

In recent years, the installation of wind and solar plants, mainly in the Northeast region, has shown strong growth, increasing the importance of these renewable sources in serving the market. Thermal plants, generally located close to the main load centers, play a relevant strategic role, as they contribute to the security of the SIN. These plants are dispatched depending on the current hydrological conditions, allowing the management of water stocks stored in the hydroelectric plants reservoirs, to ensure future service. Transmission systems integrate different sources of energy production and enable supply to the consumer market.

The last few years have been more favorable for the generation of hydroelectricity compared to 2021, when there was a scenario of water scarcity. When there is a reduction in the participation of the hydraulic, biomass and wind sources, mainly, increase their participation, in order to meet the national electricity demand. Wind and solar shares have increased over the years due to the increase in the installed capacity of these sources, mainly due to solar through distributed generation (DG).

DG growth is a result of public policies to encourage renewable energy sources and distributed micro and mini generation, such as Law No. 13,203/2015 and Law No. 14,300/2022. Considered a DG legal framework, this last law ensured exemption from the Distribution System Usage Fee (TUSD) until 2045 for systems implemented or with access requests filed by January 7, 2023, in addition to allowing partial exemption from this tariff for systems implemented until December 31, 2028, in a staggered manner, according to the transition rule.

Brazil has nuclear energy production technology as well, currently having two nuclear plants, Angra 1 and Angra 2, installed in the state of Rio de Janeiro. The third plant, Angra 3, is being built on the same site. Currently this source corresponds to around 2% in our electrical matrix.

1 ENERGY PRODUCTION, ENERGY CONSUMPTION, ENERGY TRADE

1.1 Energy Sectors

Brazil has one of the most renewable energy matrices in the world. In 2023, 49.1% of the Total Energy Supply (TES) came from renewable sources. Hydropower continues to play a prominent role in the renewable energy matrix, accounting for 12.1% of the total and an even larger share in the electricity matrix at 58.9%. However, other sources such as biomass, wind, and solar have been gaining traction in the energy matrix, representing 32.6%, 2.6%, and 1.4%, respectively.

The structure of Brazil's TES in 2023 was 314.0 million tonnes of oil equivalent (Mtoe). This figure represented an increase compared to 2022 (303.2 Mtoe), driven by growth in consumption during the same period. Energy losses for the year remained stable compared to the previous year (10%). Compared to 2014, a record year for TES (306.1 Mtoe), there was an increase of approximately 2.6%.

Final energy consumption in Brazil in 2023 reached 282.5 Mtoe, marking a 4% increase from 2022. This consumption represented 90% of the TES, with the remaining 10% corresponding to losses in transformation, distribution, and storage. In 2021, losses accounted for 12.9% due to increased use of thermal generation, driven by water scarcity affecting the country. In 2023, losses accounted for 10.0%.

1.2 Coal

Brazilian coal production reached 6.5 million tonnes in 2023, mainly due to coals with a calorific value between 3,100 and 5,200 kcal/kg for use in electricity generation. However, most of the coal used is imported, with a calorific value above 6,000 kcal/kg. Imports in 2023 reached 14.5 million tonnes, mainly used in coke ovens to manufacture pig iron and steel.

The coal supply corresponds to around 4.4% of the Brazilian energy matrix and 1.9% of the electricity matrix.

Brazil occupies the 10th position in terms of reserves, having 1% of the world total, and it has reserves of peat, lignite and hard coal, totaling to 32 billion tonnes, 27 billion of steam coal and 5 billion of metallurgical coal of reserves mainly in the following states: Rio Grande do Sul (89.25%), Santa Catarina (10.41%) and Paraná (0.32%).

In Rio Grande do Sul, the coal is processed by jig, and the production goes to the industry for power and steam generation. Some of the production also goes to Santa Catarina for blending. All mines are open-pit operations.

In Santa Catarina, the run-of-mine (ROM) is processed by jig and dense media separation (DMS) and 95% of production goes to the 740 MW Jorge Lacerda Plant (CTJL). Its consumption per year is 2.4 Mt (metric). The coal goes there by train, is unloaded, and then stored in a pile for later reclaiming. As previously stated, CTJL consumption represents 95% of the total production in this state. Part of the production goes to small ceramics and coke industries.

In Paraná, the coal production is the smallest in Brazil. All the production is directed to the Figueira Power Plant (20 MW). Paraná State has only one mine and its operation is underground, room-and-pillar.

In Santa Catarina, the Energy Transition Program is underway, supported by federal and state law (14.229/22 Just Energy Transition Law), and provides for the maintenance of the current power plant until 2040. At the same time, CO2 capture processes and new products from coal waste are being studied, in a way that allows the extension of the coal industry in the State. All mines are underground with room-and-pillar method, no pillar retreating.

1.3 Oil

The oil sector plays a crucial role in the energy matrix of the BRICS countries, especially in Brazil, and a detailed analysis of this resource is essential to understand the dynamics of production, consumption and trade.

Oil exploration is essential to maintain reserves and production levels. In Brazil, the development of the pre-salt is a significant milestone, with estimates pointing to a peak production in 2029 of around 5.4 million barrels per day. After this peak, a phase of decline is expected, which makes the exploration of new frontiers, such as the Brazilian equatorial margin, crucial. This region presents promising geological conditions, similar to significant discoveries in Guyana and Suriname, which have more than 13 billion recoverable barrels.

Despite global energy transition ambitions, oil will continue to be an economic driving force. In this context, Brazil has important competitive advantages, such as geopolitical stability and operations with one of the smallest carbon footprints in the world. These characteristics are fundamental to attract investment in a highly globalized industry and contribute to energy security and sustainability during the global transition.

Oil and its derivatives represent around 35% of the Brazilian energy matrix. In 2023, average daily production was 3.4 million barrels, with around 47% being exported. This increase in production was driven by investments in the pre-salt, resulting in revenues exceeding R$140 billion in royalties and special participations. Crude oil exports totaled US$18.7 billion, representing 11.3% of national exports.

Compared to 2022, proven oil reserves increased by 7.0% in 2023, totalling 14.9 billion barrels. National production grew by almost 13%, reaching 4 million barrels per day, with the Pre-salt contributing 77% of this total.

Oil and natural gas production in Brazil increased by 54% in the last decade, rising from 2.8 million barrels of oil equivalent per day (BOE/day) in 2013 to 4.3 million BOE/day in 2023. This growth is attributed mainly to the discovery and development of pre-salt fields in the Santos Basin.

At the same time, offshore production from post-salt reservoirs suffered a reduction of 56%, from 1.9 million BOE/day in 2013 to 827 thousand BOE/day in 2023. Onshore production also decreased, from 315 thousand BOE/day in 2013 to 213 thousand BOE/day in 2023. With the new investments, onshore production is estimated to grow by more than 40% by 2030, reaching around 300 thousand BOE/day.

Although the Exploration and Production (E&P) sector in Brazil includes 86 companies from 22 countries operating in 18 states, there is a high concentration of activities in Rio de Janeiro, responsible for 84% of national production, with Petrobras as the stronger player, with 66% of the total. The expansion of these activities to other regions of the country can promote the economic development of needy areas, not only through taxes and government participation, but also through the creation of an industry of local goods and services, generating employment and income for the populations.

The sustainable development of the oil sector in Brazil is vital to meet global energy demand and support the national economy. Continuous investments in exploring new frontiers and making better use of existing resources are essential to maintaining competitiveness and ensuring energy security during the transition to cleaner energy sources. The diversification of production activities can bring significant economic benefits to the entire Brazilian territory, promoting more balanced and inclusive development.

1.4 Natural Gas

In recent years, the natural gas sector in Brazil has been transformed following the opening of the gas market promoted by Law No. 14,134/2021, which expanded private participation in the natural gas market in the country.

In 2023, the National Energy Policy Council (CNPE) established, via Resolution No. 1/2023, the Working Group of the Gas for Employment Program (GT-GE), to prepare studies aimed at promoting the best use of the natural gas produced in Brazil, through the development of proposals to: a) increase the Union's natural gas supply in the domestic market; b) improve the use and socioeconomic return of national natural gas production, seeking to reduce reinjected volumes; c) increase the availability of natural gas for the national production of nitrogen fertilizers, petrochemical products and other productive sectors, reducing external dependence on strategic inputs for national production chains; and d) integrate natural gas into the national energy transition strategy to contemplate synergies and investments that favor the development of low-carbon solutions, such as biogas/biomethane, low-carbon hydrogen, industrial cogeneration and carbon capture.

Brazilian natural gas production began in the 1970s, taking around 50 years to reach the current level of gross gas production of approximately 140 million m^3/day.

In 2023, net natural gas production corresponded to 32% of total production, with reinjection being the biggest reducing factor, reaching 53% of the amount produced.

As the largest Brazilian productions are associated with Pre-salt offshore reservoirs, the assessment of gas availability based on the understanding of natural gas shares is a relevant topic for the country.

In the forecasts of the 2032 Ten-Year Energy Expansion Plan (EPE, 2023), national natural gas production should follow an increasing trend, reaching levels of around 323 million m^3/day in ten years.

Gas associated with oil represents the largest proportion of natural gas to be produced in the decade, with contributions from the Campos and Santos basins

together corresponding to approximately 92% of the total forecast for 2032, much of which comes from pre-salt accumulations. In the case of non-associated natural gas, the predominant influence of the production units in the Campos, Parnaíba, Santos, Sergipe-Alagoas (SEAL) and Solimões basins remains.

The forecast for net natural gas production shows a smooth level in the first 5 years and an accelerated increase from 2026 onwards due to the entry of new production units (UP). The behavior of the net production curve does not follow gross production during the period, due to the characteristics of offshore fields, where high natural gas injection rates are considered. Injection is used as a solution for removing high levels of CO2, increasing oil recovery and maintaining pressure in reservoirs.

However, such needs compromise the monetization of natural gas in the supply of the domestic market, with net production of less than 140 million m^3/day, even though it represents more than double the net production of 2023.

In April 2024, the Energy Research Company – EPE (a body for studies and support of sectoral planning linked to the Ministry of Mines and Energy – MME) published extensive documentation on «The Role of the Oil and Natural Gas Sector in the Energy Transition» (https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/o-papel-do-setor-de-petroleo-e-gas-natural-na-transicao-energetica), aiming to support dialogues at the MME to build a fair, inclusive and balanced transition, which is briefly discussed below.

In Brazil, the energy transition is discussed, based on the paradoxical concept of three options that need to be met, although they may seem contradictory to each other, forming the Energy Trilemma, which seeks balance between the three vertices of complex dimensions, endowed with own attributes and objectives to be achieved and met for the benefit of the Brazilian population. The Energy Trilemma is conceived as follows: (1) Energy Security; (2) Energy Equity; (3) Environmental Sustainability, as set out in Table 1, below.

Dimensions	Attributes	Objectives to be Achieved
Energy Security	**Capacity**	to meet demands
	Resilience	adaptation to adverse situations
	Dependency	in terms of imported energy
Energy Equity	**Range**	inclusive and democratic
	Accessibility	reduced costs
	Quality	efficiency and modernity
Environmental Sustainability	**Resource productivity**	maximizing results with fewer resources
	Decarbonization	reduction of carbon footprint
	Emissions and pollution control	reduction of environmental impacts

Table 1: *Energy Trilemma.*

According to the EPE study (2024), Brazil has allocated investment resources to the government program called New Growth Acceleration Program (New PAC) – budgeted at R$ 1.7 trillion. The New PAC is the investment program coordinated by the federal government, in partnership with the private sector, states, municipalities and social movements, to accelerate economic growth and social inclusion, generating employment and income, and reducing social and regional inequalities. Of this total, investments in the **Transition and Energy Security** axis estimated in that study were R$ 565.4 billion, with the **oil and natural gas sector** contributing around R$ 360.2 billion. The oil and natural gas sector accounts for 64% of actions aligned with energy transition and security and for 21% of investments in the new PAC.

According to EPE, considering the horizon until 2050, the potential for investment in the exploration and production of oil and natural gas is estimated at R$7 trillion (US$1.31 trillion), distributed as follows: a) 2024-2030 (US$312 billion); b)2031-2040 (US$468 billion) and; c) 2041-2050 (US$529 billion).

Between 2013 and 2022, around R$ 10 billion were invested in RD&I for technologies aimed at energy transition, such as biofuels, wind energy, solar energy, hydroelectricity, oil, natural gas and other renewable energies, whose **resources came from the oil and natural gas sector**, considering provisions in sectoral regulation. In 2024 alone, around **207 projects** will be underway in the areas of solar energy, hydrogen, wind energy, carbon capture and storage, modeling and prevention of environmental impacts, totaling more than R$ 1 billion, financed with resources of RD&I in the oil and natural gas sector, whose investments in technologies related to the energy transition enable the expansion of that oil and natural gas sector, also **enabling sectoral decarbonization and fair, inclusive and balanced energy security and transition in Brazil.**

In the aforementioned EPE study, the importance of the oil and natural gas sector is highlighted, with relevant impacts on tax collection and the Brazilian trade balance. In the event of a reduction in the opening of new fields and oil discoveries, the country could move from its current status as an exporter to that of an oil importer, which would make it difficult for Brazil to achieve self-sufficiency in the production of natural gas. Therefore, long-term decisions on new frontiers of discoveries of oil and natural gas fields and deposits become important to guarantee the country's self-sufficiency in both oil and natural gas, so that medium and long-term national objectives can be achieved.

Regarding international trade, it is reported that Brazil imported, in 2022, on average, 24.04 million cubic meters per day (MMm^3/day) of natural gas, with 17.51 MMm^3/day from Bolivia and 6.53 MMm^3/day via LNG. In 2023, on average, 16.96 MMm^3/day of natural gas were imported, 15.43 MMm3/day from Bolivian gas and 1.53 MMm^3/day via LNG.

As mentioned about the Working Group of the Gas to Employ Program (GT-GE), one of its reports deals specifically with the role of natural gas in the energy transition, in particular, regarding the objectives of identifying strategies and mechanisms for alignment with the energy transition associated with the efforts of private participation in the natural gas market and attraction of investments in Brazil.

One of the strategies would be to identify the most noble use of natural gas as an input for production processes (in petrochemical industry – through the use of natural gas liquids) and not just as energy in the various segments and sectors of the national economy.

The possible alignments and synergies in the production of biomass, biogas and biomethane with the market and the infrastructures of the natural gas pipeline network are also considered, when evaluating the local, regional and national contexts, regarding the sharing of such infrastructures of natural gas with biomethane. There are ongoing discussions with economic sectors regarding the potential for expanding the use of natural gas, replacing more carbon-intensive inputs and energy sources, such as in the transport sectors (road, rail, urban, vehicular, river and sea transport), industrial and electrical.

In this context, there are strategies that enable cost reduction in the energy transition, through investments in resilient infrastructure, also covering biomethane, hydrogen, the capture, use and storage of CO2 or even natural gas, in natural or artificial reservoirs, ensuring that fugitive emissions of methane (CH4) are avoided, which are already reduced in the exploration and production of natural gas, but which still occur in other methane-producing sources such as landfills and biomass production.

Natural gas has excellent attributes that can contribute to the industrial sector, either by replacing the most polluting fossil energy sources such as coal, coke, fuel oil, among others, or as a transition fuel for biogas, biomethane and hydrogen from low carbon emissions.

The Brazilian electricity sector faces several challenges, mainly those related to its modernization, aiming to reduce distortions and promote adjustments in a context of increasing participation of renewable sources. This new reality requires, at the same time, flexibility to guarantee operational safety of the systems, largely achieved by natural gas thermoelectric sources, whose attributes complement intermittent renewable sources.

This can be observed in times of water crisis, which restricts the generation of electrical energy from hydraulic sources, as occurred in 2021 in Brazil.

In 2021, the share of hydraulic sources stood at 53.4% of total electrical generation, with fossil fuels accounting for 19.7%. The participation of natural gas stands out, which was 12.8% of total electrical generation. In the following year, reversing the situation of the water crisis, generation from hydraulic sources represented 61.9%, while fossil fuels reduced to 9.9%. Natural gas represented 6.1% of the total, reducing its share by 52.3%. There is still room for greater decarbonization of the electricity sector, by replacing the most polluting fossil sources such as coal and oil derivatives with natural gas.

1.5 Power Sector

In 2023, electricity production from Brazil's generation plants reached 708.2 TWh, about 4.6% more than in 2022, when it was 677.2 TWh (+22.6% compared to 2013). The main energy source in the country's electricity matrix is hydropower, which accounted for 58.9% of the total; followed by wind power, with 13.2%; biomass, responsible for 8.0%; and solar power, which reached 7.0%. Natural gas accounted for 5.3% of the matrix, making it the non-renewable source with the largest share, followed by mineral coal and nuclear, both with 2.0%, and generation from oil derivatives, with 1.4%.

Given the large share of renewable sources in electricity generation, the Brazilian electricity matrix achieved a renewability index of 89.2%, reaching 93.0% when only

the SIN is considered. This index is much higher than the figures presented by the world for 2021, at 28.7%, or even by OECD countries for 2022, at 32.5%. The very different reality experienced by Brazil, in terms of the abundance of energy options, makes the country one of the major protagonists of the energy transition process, with an energy sector that is already quite mature in terms of the use of renewable sources.

In terms of installed capacity, the country has reached 225.9 GW, 9.4% more than in 2022 and around 78.3% more than in 2013. As the main source of electricity generation, hydroelectricity naturally has the largest installed capacity, with 109.9 GW, representing 48.6% of the total. In terms of structure, the other renewable sources also stand out, with solar power, the country's second-largest installed capacity, reaching 37.8 GW – 16.8% of the total, wind power reaching 28.7 GW – 12.7%, and biomass with 16.9 GW – 7.5%. Non-renewable sources, natural gas, oil derivatives, coal, and industrial effluents amount to 30.5 GW – 13.5% of installed capacity, with nuclear energy reaching 2.0 GW – 0.9%. As with the electricity matrix, Brazil's electricity generation has a high renewability rate, reaching 85.6%.

The strong growth of intermittent renewable sources in the country is mainly based on the implementation of incentive policies for these energy vectors, attracting robust investments and significant increases in generation power. Compared to 2013, solar installed capacity saw a significant increase of 5 MW to 37.8 GW in 2023, while wind power expanded from 2.2 GW to 28.7 GW in the same period, demonstrating the leading role that these two sources have played in the expansion of the generation park.

1.6 Nuclear Energy

Faced with an electricity generation scenario where intermittent renewable sources such as solar and wind power are increasingly involved, thermonuclear generation plays an important role among Brazil's energy vectors by providing clean, constant and predictable electricity production, an increasingly relevant attribute in discussions about the energy transition. In practice, because it does not generate emissions during its electricity production process, nuclear energy acts as a baseload source, helping hydroelectric and other thermoelectric generation in times when solar and wind generation are not available.

Recently, international organizations such as the International Energy Agency (IEA) have indicated that nuclear generation will play a fundamental role in the energy transition process, acting as a bridge to decarbonize the world.

Located in the city of Angra dos Reis, Rio de Janeiro, the Admiral Álvaro Alberto Nuclear Power Plant (CNAAA) is home to Brazil's two operating nuclear power plants, Angra I and II, as well as a third under construction, Angra III. The location of the plants was influenced by the equidistant proximity of the country's three main electricity consumption centers, the states of São Paulo, Belo Horizonte and Rio de Janeiro, and the availability of water resources due to their proximity to the sea, which are necessary for the plants to operate.

The first to be built and put into operation, Angra I is a plant that uses pressurized light water technology - PWR, and began commercial operation in 1985, with 640 MW of installed electrical capacity. Angra II also uses a PWR reactor, supplied by Siemens/SKU, with a nominal power of 1,300 MW. Its start-up was important during the early 2000s, with electricity rationing experienced in the country at the time. The partnership between Brazil and Germany, for the Angra II and III plants, was important for the country's nuclear technological development, which came to dominate a large part of the stages in the uranium production cycle, joining countries such as the United States, France, Germany, the Netherlands, the United Kingdom, China, Russia, Japan, Argentina, India, Pakistan and Iran, which also have uranium enrichment facilities with different production capacities, according to the World Nuclear Association. Angra III is considered a «twin sister» of Angra II in terms of technology, although it has a higher nominal power of 1,405 MW. The project is currently 65% complete. When Angra III is completed, the total power of the Brazilian thermonuclear park is expected to reach 3.4 GW.

Recently, as part of the discussions on the Modernization of the Electricity Sector, Brazil observed the main obstacles and discussions regarding the adoption of Small Modular Reactors – SMRs, identifying challenges and recommendations for the energy sector regarding the use of technology, especially isolated systems and regions that are outside the SIN. In addition, to modernize the structure of the nuclear sector, the country separated the activities of teaching, research, and development of nuclear technologies from the activities of regulation, monitoring, and inspection, creating the National Nuclear Safety Authority (ANSN), separate from the National Nuclear Energy Commission (CNEN), which concentrated all these attributions.

1.7 Renewable Energy

Brazil's energy sector is one of the least carbon-intensive in the world, as renewable energy accounts for nearly half of the total energy supply (49.1% in 2023) and reaches

89.2% in electricity supply. The significant share of renewable energy contributes to Brazil's low greenhouse gas emissions, with a notable presence of solid and liquid bioenergy, exceeding 20% and 7% of final energy consumption, respectively.

BIOMASS

Electricity generation from biomass corresponds to approximately 8% of our electricity supply, generating more than 50,000 GWh per year.

Biodiesel production in 2023 saw a notable increase of around 20% compared to the previous year. Starting in April 2023, the mandatory blending requirement of biodiesel in diesel oil was increased to 12%, with a progressive evolution planned to reach 15% by 2026. Resolution CNPE No. 3, dated March 20, 2023, established new guidelines for this mandatory blending. In December, CNPE approved the anticipation of a 14% biodiesel blend mandate for diesel by March 2024 and 15% by March 2025. The growing use of biodiesel to replace fossil diesel contributes to the reduction of greenhouse gas emissions.

Brazil stands out globally for its use of ethanol in the transportation sector. In the country, vehicles with internal combustion engines can generally be fueled exclusively with ethanol. Additionally, gasoline sold to consumers includes a mandatory blend of 27% ethanol. In 2022, Brazil consumed 16.9 billion liters of hydrated ethanol and 12.2 billion liters of anhydrous ethanol, primarily in the transportation sector.

SOLAR ENERGY

In 2023, the installed capacity of distributed solar generation (DG) in Brazil grew by 58.2% compared to December 2022. Centralized solar installed capacity also advanced, with a 55.3% increase compared to the same period of the previous year. In 2023, approximately 4 GW of centralized solar capacity and 9 GW of DG were commissioned. This growth reflects public policies that incentivize renewable energy sources and Micro and Mini Distributed Generation.

WIND ENERGY

In 2023, wind energy supply increased by 17%, reflecting successive increases in installed capacity. During the year, 5 GW of wind power capacity came online, marking a 65% increase compared to the previous year. This robust growth underscores Brazil's attractiveness for wind energy investments and the importance of public policies in renewable energy.

1.8 Hydrogen

Low-emission hydrogen is one of the technological solutions considered in the carbon neutrality scenarios proposed for Brazil by 2050, a result that could signal some opportunities for creating domestic demand for its use as an energy vector. Applications in refineries (for fuel specification) and in the chemical industry (ammonia production) are the main destinations, while hydrogen can also be used for the production of advanced fuels, electrofuels and directly in fuel cells in the transportation sector. There is also the possibility of exporting hydrogen produced from the electrolysis of water.

The diversity of energy resources in Brazil favors the adoption of different opportunities for the development of the hydrogen economy in the country, based on different technological routes.

According to the Ten-Year Energy Expansion Plan 2031 (MME, 2022), Brazil has technical potential for hydrogen production estimated at 1.8 gigatonnes/year, including exploration from energy resources that still require technological developments to reach commercial scale, that including: 350.4 Mt/year from offshore wind; 60.2 Mt/year from fossil sources; 50.5 Mt/year off biomass; 6.9 Mt/year off nuclear; 18.1 from onshore wind, solar and hydroelectric.

Considering the technologies already operational in Brazil and those having technical and economic viability in other countries, Brazil has technical potential for hydrogen production exceeding 480 megatonnes/year.

In 2023, Brazil already had 30 billion dollars in low-carbon hydrogen projects announced for the country, most of them aimed at the production of green hydrogen, in different stages of implementation.

Projects with higher levels of maturity have established Memorandum of Understanding (MoU) or pre-contracts, and most of them are located in existing port facilities along the Brazilian coast.

In April 2021, the National Energy Policy Council determined, through resolution CNPE #06/2021, the establishment of guidelines for preparation of the National Hydrogen Program (PNH2), under the responsibility of the Ministry of Mines and Energy with support from EPE. As result, the set of guidelines proposed in July of the same year established, as a principle, that the general rules must be: (i) comprehensive in terms of technologies, (ii) aligned with the economy's decarbonization ambitions and that they were (iii) capable of encouraging national technological development.

The National Hydrogen Program, implemented in 2022, through CNPE Resolution #6/2022 and revised by CNPE Resolution #4/2023, was structured into thematic axes that gave rise to the action fronts of the Three-Year Hydrogen Plan. The first version of the plan identified, among the priorities for the 2023-2025 cycle, the need to define a national legal-regulatory framework. This choice resulted from a series of discussions and mapping within the Regulation Chamber, which identified the need to establish some regulatory competencies, in addition to establishing governance for certifying the intensity of emissions in the hydrogen product chain to be produced, exported or consumed in the country[1].

There was a consensus in the regulatory discussions of the national hydrogen program that the best use of national potential would occur with an interoperable certification system compatible with the systems of other countries, focused on the emissions intensity in the hydrogen chain and with the broadest possible scope.

On August 2024, the regulatory framework for hydrogen in Brazil was published. The Hydrogen Law was numbered Law # 14,948/2024 and includes high-level guidelines to foster low-emission hydrogen produced by different sources; the definition of the Hydrogen Regulator in Brazil; the creation of the Brazilian Hydrogen Certification System (SBCH); the creation of the Special Incentive Regime for the Production of Low-Carbon Hydrogen (Rehidro), among other definitions. Full text of the Law is available at https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2024/lei/l14948.htm (Portuguese only).

Other financial incentives to the sector are now being discussed under Law Project #3027/2024, including 18.2 MM BRL (3.3 MM USD) to foster hydrogen projects in the country, expected to be approved soon.

[1] – It is important to highlight that there is a set of technical standards in the country, relating to transport and safety relating to hydrogen, and it is estimated that approximately 700 thousand tonnes of hydrogen are produced and consumed in the country per year, mainly in the steel, refining, chemicals and petrochemicals.

2 POLICY, GOALS, OBJECTIVES AND INSTRUMENTS FOR IMPLEMENTATION OF JUST ENERGY TRANSITION IN BRAZIL

The Sustainable Development Goal 7 (SDG-7) is based on the balance between the pillars of the energy trilemma, as are the Brazilian policies that guide the National Energy Transition. Supported by the pillar of energy equity, the term «just energy transition» includes actions and planning for the energy transition to provide low-carbon energy to as many people as possible, including those in vulnerable conditions, at an affordable cost and with less impact on communities.

This section provides national perspectives respective to the guidelines and progress made towards the established goals for a just energy transition. Additionally, it presents policies, committees and mechanisms for implementing the national policies in alignment with the SDG-7.

2.1 Ensuring Accessibility of Energy

In accordance with Brazilian legislation, free connection is guaranteed to low voltage consumers who request access, under conditions established in the regulations. In urban areas, access to energy is universalized in all the country. In rural areas, distributors continue to execute their Universalization Plans in accordance with the deadlines and conditions established the regulation.

The National Program for Universal Access and Use of Electric Energy («Luz para Todos»), is intended to support the Universalization Plans and provide electricity services to the rural population and the population residing in remote regions of the Legal Amazon that do not have access to the electrical energy distribution service.

The initiative aims to democratize access to electrical energy, combat energy poverty, and promote social and productive inclusion in vulnerable communities.

The goal for 2024 is to bring electricity to 75,723 families through the New PAC. In 2023, the objectives were exceeded by 24%, with 64,592 consumer units benefiting. In the states of Amapá and Pará, the connections were made remotely, with the installation of individual solar energy kits. In Acre, Bahia, Maranhão, Piauí and Rondônia, communities benefited from the extension of the network to rural areas.

In 2024, the Energias da Amazônia program was established (Decree 11.648/2023), with the aim of reducing the use of diesel oil in electricity production in the Legal Amazon region and, consequently, reducing greenhouse gas emissions by replacing the energy generation process with renewable sources. Around R$5 billion in investments are planned to enable the transition of the isolated systems in the Amazon.

The program was designed with the focus on guaranteeing the quality and safety of the electricity supply for the more than 3.1 million people who are served by Isolated Systems, which are cities and towns whose electricity is supplied by local generations and do not have a connection to the SIN, like the rest of the country.

According to 2022 generation data, it is estimated that the current 211 isolated locations, which are not connected to the SIN, emit around 2.3 million tonnes of CO2 annually.

By leveraging clean and renewable energy sources, the government seeks to enhance the quality of life for Brazilian populations in rural areas and the Amazon Legal region. Sustainability and continuity in public energy distribution services are also prioritized, alongside the preservation of the Amazon biome.

2.2 Ensuring Energy Security

2.2.1 INTRODUCTION

Initially, it is important to construct and understand a broader concept of energy security before going into the relevant aspects of the Brazilian energy sector. Thus, according to the International Energy Agency (IEA), energy security can be understood as «the uninterrupted availability of energy sources at an affordable price». It is related to short-term security, directed at responding to specific or structural alterations that affect the supply of energy on an immediate level; and long-term security, already related to the adequacy of investments and expansion of the energy sector to the economic, social, and, in a more recent view, environmental development of the country.

2.2.2 HISTORICAL FACTS

Brazilian energy development included physical, economic, environmental, social, technological, regulatory, and institutional dimensions, having the figure of the MME as the coordinator and guide. Not by chance, the first experiences with prospective energy studies, which can be called Integrated Energy Planning, date back to the early 70s, when in consonance with the Ministry of Planning, the project called Brazilian Energy Matrix was carried out, with the subsequent adoption of the Brazilian Energy Balance (BEB). The same period was marked by strong Brazilian economic progress, demanding a great expansion of the electric energy sector. This resulted in the construction of several works in the country, such as the Itaipu Hydroelectric Power Plant, at the time the largest hydraulic power plant in the world, and Angra I and II nuclear power plants. In this period the expansion of the sector was concentrated in the state figure, holder of the sector monopoly.

In line with the short and long-term vision of energy security, the seventies also saw the most solid steps towards the diversification of the Brazilian Energy Matrix, aiming at making it less dependent on petroleum product imports, which at the time of the second oil crisis, represented 85% of the dependence on this source. Programs such as the Brazilian Ethanol Program (Pro-Alcohol) of 1975 already indicated the willingness to follow this diversification, however, it was the Brazilian Energy Model (MEB) of 1979 that was constituted as an instrument with goals to decrease the dependence, affecting both the petroleum sector and the production of mineral coal, firewood, and alcohol until 1985. Most of the goals were achieved, with external dependence on oil reducing to 43%. Thus, an important instrument for the concretization and presentation of the potential paths for the sector resided in the figure of integrated energy planning, with sectoral plans and policies walking together in the process.

In the ‘90s, new challenges arose, mainly due to a decrease in the State’s investment capacity in the face of successive economic impacts that occurred between the ‘70s and ‘80s, demanding a readjustment of the sector’s structure, guided by a process of de-verticalization, creation, and strengthening of a competitive wholesale market and the progressive liberalization of consumers. Law 9,074/1995, with the so-called Brazilian Electricity Sector Restructuring Project (Re-Seb), instituted this restructuring.

The 90 decade would also be permeated by the institution of several actors currently present in the Brazilian energy sector, such as:

- The Brazilian electricity system regulator: Brazilian Electricity Agency (Aneel) in 1996;
- The advisory body to the President for energy policies formulation and guidelines: Brazilian Energy Policy Council (CNPE) in 1997;
- The oil, gas, and biofuels sector regulator: Brazilian Petroleum, Gas and Biofuels Agency (ANP), also in 1997;
- In addition, the generation and transmission facilities operation controller of the SIN, the Brazilian System Operator (ONS), in 1998.

Although the 1990s decade kept challenges on the country's horizon, demonstrating the the need for more significant structural changes, the consolidation of the CNPE favored the coordination of energy policy with industrial, agricultural, and transportation policies[2], given the interministerial character of the Council.

It is relevant to mention that, in the responsible law for the CNPE and ANP creation, there was the Brazilian Energy Policy (PEN) objectives definition, and it is quite clear that these definitions are aligned with the strengthening of the energy sector in the country, covering various aspects of energy security, whether in the expansion of supply and potential energy vectors, or in guaranteeing and improving existing and established energy chains, or in the alignment between expansion and the aforementioned economic, social and environmental development.

Later, in 2004, a more comprehensive legal framework was established for the new model for the electricity sector, through Law n. 10,848/2004, which sought to ensure greater competition in the expansion of supply and the possibility of negotiating energy in the free environment, addressing challenges that had arisen during the 1990s and the first restructuring of the sector. The stimulus for greater competition and plurality of options for the energy matrix was placed even more at the core of the Brazilian energy policy.

Also in 2004, the Brazilian Research Company (EPE) was created, with the purpose of «providing services in the area of studies and research to subsidize the planning of the energy sector». The planning goes hand in hand with the development of the sector, and it would be in the hands of the EPE and the MME the construction of the two main sectoral plans: the Brazilian Energy Plan (PNE) and the Brazilian Ten-Year Energy Expansion Plan (PDE).

The PNE explores, through scenarios, the existing perspectives of different energy vectors for 30 years in an indicative way. In this sense, it is a plan that dialogues more with trends and panoramas, being, in some cases, a stimulator of discussions about technologies in their early stages. As for the construction of scenarios, one upper and one lower visions are generated about aspects of the expansion and how each source and technology is inserted, both through «path maps», which present obstacles and potential solutions for each niche, and simulations, which illustratively evaluate the evolution of the matrix in the long term under different trajectories. The most recent publication is the PNE 2050, published by EPE in 2020.

Unlike the PNE, the PDE is a publication with short and medium-term indications for the Brazilian energy sector, a ten-year vision. Thus, despite remaining an indicative plan, the shorter planning period allows the realization of a measurable plan, with more targeted analyses of the impact of policies and programs on the route already taken by the country. It is noteworthy that both plans are indicative, given the participation of the private sector, built since the 1990s and 2000s, thus making sectoral planning more concerned with presenting perspectives and «clarifying the path» than determining precisely the investments and necessary expansion, which is up to the market to measure jointly. The most recent publication is the PDE 2034, in the preparation stage.

2.2.3 GOVERNMENT OBJECTIVES AND POLICY

As presented, the objectives of the Brazilian Energy Policy are the great beacon for the government's actions in the construction of advances in the Brazilian energy sector, including policies and actions for the promotion of energy security. In this context, it is important to present the objectives mentioned in the legal framework:

- to preserve the Brazilian interest;
- to promote development, expand the job market, and value the energy resources;
- to protect the consumer's interests concerning the price, quality, and supply of products;
- to protect the environment and promote energy conservation;
- to guarantee the supply of petroleum derivatives throughout the entire Brazilian territory;
- to increase, on an economic basis, the use of natural gas;
- to identify the most adequate solutions for the supply of electrical energy in the various regions of Brazil;
- to use alternative sources of energy by making economic use of available inputs and applicable technologies;
- to promote free competition;
- to attract investments in energy production;
- to increase the Brazilian competitiveness in the international market of all energy sources;
- to increase, on economic, social, and environmental bases, the participation of biofuels in the Brazilian energy matrix;
- to ensure the supply of biofuels throughout the Brazilian territory;
- to encourage the generation of electricity from biomass and biofuel production, due to its clean, renewable, and complementary character to the hydraulic source;

- to promote the competitiveness in the international biofuel market;
- to attract investments in infrastructure for biofuel transportation and storage;
- to foster research and development related to renewable energy;
- to mitigate the emissions of greenhouse gases and pollutants in the energy and transportation sectors, including the use of biofuels.

In practice, even though energy security is not nominally described in the PEN, its transversal influence on the objectives is clear. It is also possible to observe some aspects that punctuate the construction of policies and influence the promotion of energy security and independence of the country: the incentive to diversify the energy matrix; the rational, efficient and timely use of energy resources, economic inputs, and technologies available to expand supply; and the economic, social and environmental development from the preservation of the nation's interests and the main potentials that the country has. Thus, the following are examples of policies, strategies, and programs already in place that talk to these aspects mentioned, thus generating an interface with the promotion of energy security.

Following the success of the Pro-Alcohol program, responsible for building a strong economic chain for ethanol, and considering the broad protagonism that Brazil had in the field of agriculture and cattle raising, there were other advances in the policy framework regarding the promotion of biofuels in the Brazilian energy matrix. Initially, the expansion occurred through the Brazilian Program for Biodiesel Production and Use (PNPB), in 2004, which not only fostered the construction and subsequent expansion of the use and production of biodiesel, but also inserted family farming in the process, making it central as a production figure of the inputs for the production of the fuel. In 2017, the framework was reinforced through the Brazilian Biofuels Policy (Renovabio), which sought to increase the participation of biofuels in the country's productive sectors, expanding the competitiveness and predictability of different types of biofuels in the market and contributing to meeting Brazil's commitments under the Paris Agreement within the United Nations Framework Convention on Climate Change. In 2021, the Brazilian Biokerosene Program was created, aiming to foster the use of the fuel in the aviation sector and its future sustainability, since it is part of a sector that is difficult to decarbonize worldwide.

Besides biomass, the promotion of renewable sources started in 2002, through the Incentive Program for Alternative Energy Sources (Proinfa), being considered one of the largest incentive programs for the use of these sources worldwide. For perspective purposes, by 2011, Proinfa had implemented 119 projects, representing 2,649 MW of installed capacity divided into biomass thermal plants, small hydropower plants, and wind power plants, with the promotion of about 150,000 direct and indirect jobs, and вместо with an estimated emissions reduction of 2.5 billion tonnes of CO2/year. Even though it has not been solely responsible for the transformation, Proinfa was one of the driving forces behind the diversification of the Brazilian electricity matrix, which has generally maintained a renewability profile above 80%, even with a significant deconcentration of hydraulic generation, which went from almost 89% of the matrix in 2000 to about 64% in 2020.

As part of using its resources in a timely manner, Brazil also sees the relevance of its potential in other energy vectors, other than those strictly renewable. In this case, it is worth citing the recent New Gas Market Program, of July 2019, which sought take measures for the design of the new natural gas market, seeking to build a more competitive and open market for the use of the fuel. The Program continued a process of opening that had already been started in the figures of the Petroleum Law (Law n. 9. 478/1997) and Gas Law (Law n. 11.909/2009), that brought incentives for the promotion of new agents, although they have proven to be insufficient. Another potential source is nuclear generation, with the observance of its non-emission character. Currently, the Brazilian Nuclear Policy (PNB) of 2018 is in force, «consolidating a set of guiding guidelines, with the purpose of orienting the planning, the actions, and the nuclear and radioactive activities in the country, in observance of Brazilian sovereignty, with a view to development, the protection of human health, and the environment».

Recently, focusing on the perspective of energy sources for the future, the Brazilian Hydrogen Program (PNH2) was constructed aiming at the organization of actions and strategies for the development of the hydrogen economy in the country. Hydrogen is considered a fuel with great potential for use in sectors that are difficult to decarbonize and where Brazil can exert a great international role, given its generation park that is widely renewable.

The examples mentioned demonstrate a broad view of potentials explored by Brazil in the scope of its policies, focusing mainly on the diversity of options that the country has in its territory, but also on the mitigation of potential «technological lock-ins» that may occur in the planning. A technological lock-in can be understood as a technological route that proves to be mistaken and extremely costly to readjust. However, energy security is also related to competitiveness and advances in the sector, as well as adjustments in the expansion based on planning for demand management, that is, thought from the point of view of energy efficiency. The theme of energy efficiency will be treated in a separate

topic; however, the market adjustment can be treated from the perspective of the recent Modernization of the Electricity Sector.

The Modernization of the Electricity Sector project was instrumentalized in 2019, through institution of a Working Group, responsible for indicating proposals for modernizing the sector based on the pillars of governance, transparency, and legal-regulatory stability. At the end of its work, the Group presented an Action Plan with proposals for normative acts relevant to the modernization, with short, medium, and long-term measures, generating a document with 88 actions acting on 15 fronts, including the construction of a specific committee for the adoption of proposals, the Modernization Implementation Committee (CIM).

2.2.4 AUCTIONS

The Brazilian Constitution determines that the provision of public services is attributed to concessionaires or permission holders always through bidding, if not carried out directly by the State, giving ANEEL the authority to promote, through delegation, based on the grant plan and guidelines approved by the Granting Authority, the bidding procedures for contracting public service concessionaires and licensees for the production, transmission and distribution of electrical energy and and to grant concessions for the use of the hydraulic potential.

The government's actions in the energy sector have undergone transformations due to the growing complexity of the systems of production, transport and distribution of energy, which can be further enhanced due to the prospects of greater decentralization, liberalization of choices of the sector's actors and energy markets. The configuration of the Brazilian energy sector, with the need to attract the private sector to promote energy expansion, impacts the way the government acts, with the PNE pointing out a set of guiding principles to direct the improvement of the legal and infra-legal framework for the sector: technological neutrality, free competition, isonomy, efficiency, predictability, simplicity, transparency, coherence, sustainability, precaution.

Generation Auctions

AANEEL organizes auctions to contract the purchase of electricity by utilities, permit holders and authorized parties of the public electricity distribution service by delegation and in accordance with MME guidelines. To carry out the auctions, ANEEL has the support of the Electricity Trading Chamber – CCEE. CCEE holds auctions for contracting energy for the regulated environment. The objective of the negotiations is to ensure that energy demand is met in advance, through the signing of long-term contracts between consumers (mainly distributors) and generators. Electricity purchase auctions aim to:

- Contract energy at the lowest possible price (low tariffs);
- Attract investors for building new plants to expand generation; and
- Retain the existing generation

Transmission Auctions

The Granting Authority, represented by the MME, is responsible for planning the expansion of the electricity sector. In this way, the MME prepares the planning and consolidates it in reports and studies that are part of the «Electric Energy Transmission Grants Plan – POTEE» determining which works and transmission projects must be tendered or authorized.

Thus, by delegation and in accordance with MME guidelines, ANEEL organizes auctions to contract new concessions for the provision of public electricity transmission services.

Distribution Auctions

ANEEL is responsible for promoting bidding procedures to contract public service concessionaires and licensees for the distribution of electricity, based on the grant plan and guidelines approved by the Granting Authority.

Each type of auction aims to meet a specific need, from long-term planning to support load expansion, to the diversification of the Brazilian electrical matrix.

Likewise, the auction mechanism seeks to achieve competitive equity between agents, distributors and traders, regarding the lots of energy offered by federal, state and private generating companies.

2.3 Ensuring Energy Efficiency and Energy Saving

The history of energy efficiency in Brazil can be traced back to the early 1980s when the country began to formalize its efforts to reduce energy consumption and enhance efficiency, being one of the first countries around the world to take such measures. One of the key milestones was the establishment of National Program

for Electricity Conservation – PROCEL in 1985, which focused on promoting the rational use of electricity and reducing waste in various sectors. Furthermore, from its creation until 2022, PROCEL had invested around R$4.22 billion and saved approximately 240 billion kWh, with annual gains of 22 billion kWh since 2018. Over the years, numerous policies and programs were introduced, such as the CNPE in 1997 and the Energy Efficiency Law (Law 10,295) in 2001, which defined the setting of minimum energy performance standards for appliances and buildings.

Brazil has been using ODEX (Overall Energy Efficiency Index) as the main indicator to track energy efficiency progress in Brazil. ODEX combines data from various sectors, such as industrial, residential, and transport, to provide a comprehensive picture of the country's energy efficiency improvements. A decrease in ODEX indicates an improvement in energy efficiency, while an increase suggests a decline. Brazil has seen a significant reduction in its ODEX, as the calculation for 2022 show that the country has been around 8.6% more energy efficient than it was in 2005, reflecting advancements in energy-saving technologies and more efficient energy use practices across different sectors*[1].

In recent years, Brazil has implemented several major projects aimed at improving energy efficiency. The Energy Efficiency Program (PEE), regulated by ANEEL, mandates that distribution utilities invest a portion of their net operating revenue in energy efficiency projects. Since 2008, this program has resulted in significant investments in low-income residential projects, public buildings, and industrial sectors. The Minimum Energy Performance Standards (MEPS), established by Law 10,295 in 2001, plays a crucial role in regulating the energy efficiency of various appliances and equipment, including light bulbs, refrigerators, freezers, air conditioners, gas stoves and ovens, and fans. These standards ensure that only products meeting specific energy performance criteria are available in the market. The synergy between MEPS, the Brazilian Labeling Program (PBE), and endorsement seals have proven to be a highly effective energy efficiency policy. Appliances that meet MEPS guidelines are integrated into the PBE and carry endorsement seals, indicating their compliance with energy efficiency standards. Additionally, the residential sector also benefits from energy efficiency seals specifically designed for buildings.

Several strategic programs and partnerships have been crucial in driving energy efficiency in Brazil. The Brasil Mais Produtivo – Eficiência Energética (B+P EE) program, Aliança program and PotencializEE program for instance, focus on enhancing energy efficiency in the industrial sector by providing technical support and promoting the adoption of efficient technologies. Another significant initiative is the Energy Efficiency Networks for Industry and Public Buildings, which fosters collaboration among businesses and public entities to share best practices and implement energy-saving measures.

All these efforts are complemented by research and development investments, which have seen nearly R$ 5 billion directed towards energy efficiency projects over the past decade. Overall, Brazil's approach to energy efficiency encompasses a mix of regulatory measures, financial incentives, and collaborative initiatives aimed at reducing energy consumption and enhancing productivity. The ongoing efforts and significant investments in energy efficiency projects not only contribute to economic growth but also help to address environmental concerns. The combination of policy support, technological innovation, and stakeholder engagement is crucial in achieving sustainable energy use and economic development.

2.4 Ensuring Environmental Friendliness and Reducing Climate Impact

Aligned with to the Environmental Sustainability pillar, The National Policy for Climate Change (PNMC) guides national efforts to mitigate climate impacts. Given the cross-cutting and wide-ranging nature of climate issues, the Government established the Interministerial Committee on Climate Change (CIM) to comprise various sectors involved in climate-related matters. The CIM's objective is to monitor and promote the implementation of public actions and policies within the scope of the federal Executive Branch related to the PNMC.

At the end of 2023, the Interministerial Committee started to design the action plan to execute the PNMC's policies entitled as Climate Plan (Plano Clima). Its structure considers the participation of 18 ministries, Rede Clima and the Brazilian Climate Change Forum.

(1) – This edition of the Energy Efficiency Atlas underwent methodological changes aimed at improving the representativeness of the sectors in the ODEX, as well as its calculation. Therefore, variations in the historical data of the ODEX, observed in this edition compared to previous editions, can be justified by the following main changes:

- *updates to the historical data series used in the calculation of the ODEX;*
- *use of a 3-year moving average for the ODEX across all sectors, in line with the methodology proposed by the Odyssee database;*
- *improvements in the selection of indicators used for calculating the ODEX for the residential and transport sectors.*

The Forum is used as a tool to allow and encourage direct communication with society, understanding that popular participation is relevant to a more accessible and democratic drafting process. The plan is structured by two Temporary Working Groups (GTT): Adaptation GTT and Mitigation GTT. Representatives of many sectors compose those groups, and their goal is to gather information and insights on potential changes to Brazil's sectors, aiming at a positive impact on climate. The MME participates in both groups and is responsible for delivering insights on the energy transition processes. The energy sector is coordinated by the Ministry of Mines and Energy and is composed of agencies and public companies.

Consistent with the objectives of reducing national net Greenhouse Gas (GHG) emissions, the Ministry of the Environment and Climate Change (MMA) is the federal entity responsible for coordinating the Climate Plan, aiming to guide the national actions towards reducing climate impact in a sectorized perspective. The Plan is built in view of scenarios for the adaptation process to climate changes and for the mitigation of Greenhouse Gas emissions.

To support the policies and plans, such as the National Energy Transition Plan (PLANTE) and the Climate Plan, guiding the national energy transition, the EPE provides forecasts of the Brazilian energy scenario and fundamental technical inputs. Among their products are the PDE, the National Energy Plan (PNE), and the BEB.

The Brazilian electricity sector is in an advanced stage in terms of the energy transition process, with almost 90% of its electricity supply coming from sources classified as clean. Among these clean sources, the hydropower, wind and renewable thermal plants account for more than 80% of the electricity supply.

Still, there is a noticeable increase in the participation of solar sources in the electricity matrix in the format of Distributed Mini and Micro-Generations. Although it is a renewable source, its characteristics of unpredictability in generation associated with the difficulty of stocking the produced energy and managing these sources external to the SIN, raises substantial concerns on the energy security pillar. Consequently, the search for sources that offer consistent energy dispatch increases and the plants that best meet this requirement are Thermoelectric Power Plants (UTE's), including nuclear plants.

Although Brazil has an enormous potential for oil extraction, in 2022, while the world had 14% of primary energy generated from renewable sources on average, the percentage of the renewable energy in of the Brazilian energy mix reaches 47% with roughly 35% coming from oil and its derivatives. In 2021, OECD countries reported a renewable energy composition of 12% in their energy mix, while the global average, according to the IEA, stood at approximately 14%.

Despite fossil sources still representing a significant portion of the energy generated for the TES, national efforts are focused on reducing dependence on emission-intensive sources. Representing of those efforts to reduce demand for gasoline, some programs have encouraged the usage of alcohol-based fuels in automobiles. The promotion of alcohol as an automobile fuel is particularly compelling for several reasons, including its notably less polluting production process due to Greenhouse Gas captured in the plantations from which the alcohol is extracted and its economic viability, as it introduces a competitive substitute for gas.

The Energy sector guidelines for mitigating GHG emissions indicate the priorities for actions such as: Increasing the Participation of Clean, Renewable and/or Low Carbon Technologies and Sources; Expanding Energy Efficiency actions; Reducing Emissions in the upstream and midstream of the O&G industry; Enabling the development of markets for low-carbon hydrogen and Enabling advanced technologies to remove CO2 from the atmosphere.

Through the MME, Brazil is also developing the PLANTE. The national action plan aims for an effective implementation of changes in the energy matrix that are foreseen in the National Energy Transition Policy (PNTE). The PNTE is also aligned with SDG-7's framework and, therefore, aims at a benefit to the environment. As an integrative plan of action, PLANTE also makes use of other policies related to the transition process, such as the National Policy for Climate Change (PNMC), the main guideline for the Climate Plan. To foster a more democratic development, the plan's creation processes are designed to promote interaction with society through the National Energy Transition Forum (FONTE).

2.5 Scientific and Technological Base

2.5.1 SMART GRIDS

Brazil has a vast interconnected system for the production and transmission of electrical energy, known as the SIN. It is a large system, with a predominance of hydropower plants and multiple owners. The National Interconnected System is made up of four subsystems: South, Southeast/Central-West, Northeast and a large part of the North region. The operation involves complex simulation models that are under the coordination and control of the ONS, which, in turn, are supervised and regulated by the ANEEL.

The interconnection of electricity systems, through the transmission network, provides the transfer of energy between subsystems, allows synergistic gains and exploits the diversity between the hydrological regimes of the basins. The integration of generation and transmission resources allows us to serve the market safely and economically.

The basic transmission network consists of 185,224 km (2023 data), distributed in networks of 230 kV (38%), 345 kV (6%), 440 kV (3.7%), 500kV (39%), 600 kV DC (6.9%), 750 kV (1.4%) and 800 kV DC.

The sector has been undergoing major transformations, with the increasing participation of non-dispatchable renewable sources such as wind and solar, which adds greater complexity to the management of the system. Over the ten-year horizon, significant growth is expected for solar and wind generation, both in the centralized environment and in autoproduction and distributed generation.

With the modernization of the electricity sector, the Brazilian consumer is gradually assuming a less passive role and also becoming an energy producer or managing its demand based on economic stimuli and in a decentralized manner. In this sense, Law No. 14,300, dated January 6, 2022, established the legal regime for microgeneration and distributed minigeneration, the Electric Energy Compensation System (SCEE) and the Social Renewable Energy Program (PERS).

Prior to the legal framework for microgeneration and distributed minigeneration, as a public policy for the development of smart grids, we can mention Ordinance MME nº 440, dated April 15, 2010, where a Working Group was created with the objective of analyzing and identifying necessary actions to support the establishment of public policies for the implementation of a Brazilian Smart Electric Grid Program – «Smart Grid».

In another initiative, with resources from Eletrobras, Petrobras and the META Project, led by the Ministry of Mines and Energy and the World Bank, the Electric Energy Research Center (Cepel) inaugurated, in December 2021, the Smart Grids Laboratory. This installation allows the definition and experimental evaluation of connection requirements that allow for the optimal integration of high levels of distributed energy resources, such as distributed solar photovoltaic generation, wind generation, battery storage and plug-in electric vehicles. This guarantees more control over electrical networks and maintains their reliability and robustness.

Brazil follows the advancement of new technologies that can be applied in Smart Grids and has developed projects in partnership with other countries. In December 2017, one of the largest ultra-high voltage direct current (UHVDC) transmission lines in the world came into operation in Brazil, the first with this technology, +-800 kV, with a length of 2,076 km, designed to transmit up to 4 GW of electrical energy. It is responsible for transporting part of the energy generated by the Belo Monte Hydroelectric Plant, in the north of Brazil, to the Estreito substation, in the southeast region. Among the advantages of this technology is that it allows the economical transmission of large blocks of energy over long distances and can be used to connect two desynchronized alternating current systems or those with different frequencies.

In September 2020, Companhia Paranaense de Energia (Copel) started the Smart Grid program. With the new system, consumer units receive digital meters, which communicate directly with Copel's operations center.

The technology reduces shutdown time caused by weather and other factors external to the system. Furthermore, it allows consumption to be read remotely and allows the customer to have the autonomy to monitor their energy consumption in real-time, among other benefits.

The Smart Grid materializes with the application of sensors and remote control devices that allow it to reconnect in most cases and, if this does not happen quickly, Copel can immediately detect and resolve any disconnection problems at the Company's Integrated Operation Center Distribution in Curitiba.

Therefore, when technical intervention is necessary to repair the network, the operation center knows how to indicate the exact point that caused the power outage. This eliminates the need for a team to traverse the entire affected network to identify where the problem occurred. Consequently, the time for energy replacement drops drastically, which makes a big difference in the lives of communities in general and agribusiness in particular. The smart grid also has automatic voltage regulators.

PROSPECTS FOR THE DEVELOPMENT OF SMART GRIDS

(1) **Flexible alternating current transmission systems**

The EPE has been monitoring ongoing studies on the application of new technologies for the transmission system, such as FACTS devices (Flexible Alternating Current Transmission Systems) and DC/AC converters, through VSC (Voltage Source Converter) solutions.

FACTS devices are technologies based on power electronics developed with the aim of improving system control and stability, make it possible to increase the energy transfer capacity between certain points in the network.

(2) **Energy Storage Systems**

Energy storage technologies, such as electrochemical batteries, electrochemical capacitors, among others, can provide various services in the transmission sector.

Such technologies provide multiple applications, including: load balancing, frequency control, voltage control, and network stabilization, among others.

Despite the technical possibility and legal provision, in Brazil, the use of batteries in consumer units, «behind the meter», still has low use due to their still high cost.

2.5.2 ADVANCED BIOFUELS

Green diesel

With a similar composition to fossil diesel oil, green diesel can be added to mineral diesel in any proportion and even be replaced completely.

Green diesel is regulated by ANP resolution 842 dated 05/14/2021. According to the text, green diesel is defined as «biofuel composed of paraffinic hydrocarbons intended for vehicles equipped with Diesel cycle engines» and produced from the following routes, and from raw materials exclusively derived from renewable biomass:

I – hydrotreatment of vegetable and animal oil;
II – synthesis gas from biomass;
III – fermentation of sugar cane juice; and
IV – oligomerization of ellic alcohol (ethanol) or isobulic alcohol (isobutanol)

There is still no legal provision for the mandatory adoption of green diesel in the country. However, the first tests with the fuel are already being carried out, and a plant in Manaus is expected to come into operation in January 2025, with a production capacity of 500 thousand tonnes of fuel per year.

2nd Generation Ethanol

Second-generation ethanol (E2G) is an advanced biofuel that has the same chemical composition as regular ethanol (E1G). The difference is that it uses the remaining bagasse from the production of sugar and common ethanol to produce more ethanol.

Projections indicate that second-generation ethanol may be more economically viable from 2025 and equal the production of regular ethanol in 2030.

2.6 Instruments for a Just Energy Transition

In Brazil, the energy transition process is being conducted fairly, considering the social, economic and environmental impacts. To achieve this, appropriate instruments are being used and developed to promote an equitable and inclusive energy transition.

The Ministry of Mines and Energy has already identified that the energy transition cannot be understood merely as a process of technological replacement. It's necessary to make sure that it epresents a new model of economic and social development.

The National Energy Transition Policy – PNTE – approved on August 26 2024 encompasses a series of objectives aimed at promoting sustainability, security and reducing energy poverty, in addition to promoting a fair and inclusive energy transition and reducing greenhouse gas (GHG) emissions.

Among the main objectives of the PNTE, – are coordinated actions in different areas, such as the electricity, oil and gas (O&G) and mining sectors, with the aim of promoting sustainable and resilient economic development in the face of environmental challenges, without neglecting energy security.

To achieve these objectives and others related to the PNTE, mentioned earlier, two main instruments have been established: Plante and Fonte.

Plante represents a national strategic planning instrument, created with the purpose of structuring and consolidating the Federal Government's initiatives aimed at promoting the energy transition. Furthermore, Plante plays a role of supporting the integration of these initiatives with actions developed by subnational entities and has been conceived as a long-term plan, with implementation cycles of programs and actions scheduled for the four-year period.

Fonte will have a consultative nature, representing one of the pillars of the National Energy Transition Policy. This forum will be established as a permanent body, with the aim of fostering, expanding and democratizing the debate on energy transition, establishing a communication channel between the MME and other sectors, such as social movements, civil society organizations, labor unions, academia, the productive sector and government agents, in favor of the development and improvement of the energy transition.

In line with PNTE guidelines, Fonte will function as a platform for political-democratic dialogue, providing an atmosphere of critical and creative discussion, receptive to members' proposals for advancing the energy transition and Plante.

The Energias da Amazônia Program aim to strengthen the energy transition in the supply of electricity to the population of the Amazon region supplied by the isolated grids, i.e. systems that are not integrated into the National Interconnected System (SIN) for technical and/or economic reasons. The main objective of Energias da Amazônia Programm is to promote greater coordination and improvements in the regulatory instruments applied to Isolated Systems to allow greater insertion of supply solutions with greater participation of renewable sources in generation, summarized as:

- Reduce carbon emissions associated with high diesel generation;
- Improve the quality and safety of electricity supply; and
- Reduce Fuel Consumption Account (Conta de Consumo de Combustíveis – CCC, in portuguese) expenditures.

In 2023, 211 locations were identified in the Amazon region, which had not yet been connected to the SIN and which emitted about 2.3 million tons of CO2, based on 2022 generation data. With a high level of losses and 80% share of diesel oil in the generation supply, whose consumption represents 1.3% of the national demand for diesel oil. The costs of generating electricity to serve the population living in these communities and cities were R$ 12.1 billion, with a direct impact on the CCC of R$ 10 billion resulting from the payment of reimbursement to energy distribution concessionaires, based on data processed by CCEE in 2022. CCC's resources originate from the Energy Development Account – CDE, a sectoral fund created in 2002, through Law No. 10,438/2002, whose resources are used to finance a series of public policies, mainly through the granting of subsidies in energy tariffs.

Therefore, CCC costs affect the CDE's budget and, consequently, the tariff paid by energy consumers across the country. The project will be carried out by the Ministry of Mines and Energy, in partnership with the institutions of the electricity sector, involved in the planning of the isolated systems: EPE; ANEEL; ONS and CCEE. The actions and activities will be implemented annually until 2030. It will benefit 3 million people who live in communities and cities in the Legal Amazon, whose electricity generation service is provided by local generating units, the vast majority of which are thermal power plants powered by diesel oil.

It will benefit 3 million people who live in communities and cities in the Legal Amazon, whose electricity generation service is provided by local generating units, the vast majority of which are thermal power plants powered by diesel oil. Identification of prioritization of the instruments provided for in the legal and normative arrangement for the service of isolated systems (Law No. 12,111/2009, Decree No. 7. 246/2010, article 7 of Law No. 1,016/2022, and Decree No. 11,648/2022) that allow the execution of identified actions with the potential to achieve the program's objectives. Coordination of the activities necessary for the application of the instruments and improvements to the regulatory framework, when identified. Including meetings, technical workshops, workshops and other activities that allow the exchange of ideas and identification of opportunities.

Preliminary data and studies show that the emission of about 1.5 million tons of CO2 can be avoided, resulting from the reduction or replacement of diesel oil as the main source for electricity generation in the Amazon region. R$ 5 billion is expected as necessary investments to make this transition viable, with the potential to reduce 70% by 2030 the share of diesel fuel in the generation of electricity to serve the locations that still remain isolated.

The deliverables of Energias da Amazônia Programm includes enable the contracting and installation of renewable solutions, completion and authorization of new interconnections, dissemination of data, identification and availability of financing lines for projects, in a short-term perspective (until 2024). In a medium-term perspective (2025-2026), the development of actions and delivery of products of international partnerships; completion of studies and authorisation of new interconnections; Start of operation of authorized hybrid plants in 2024. Finally, in long-term (2030) strengthening synergies between public policies; improvements to the regulatory framework; completion of interconnection works and authorisation of new interconnectors; operation of hybrid plants contracted by 2024. ■

CHINA

1 OVERVIEW

1.1 General Descriptions

China has made remarkable advancements in its energy sector in terms of production support capacity, green and low-carbon transition, energy technology innovation, institutional mechanism reform and international cooperation.

1. Steady improvement in energy production capacity. In 2023, China's primary energy production was 4.8 billion tonnes of standard coal, which increased by about 4% year on year; the production of raw coal was about 4.7 billion tonnes; the production of crude oil was about 210 million tonnes; the production of natural gas – above 230 bcm; and the electricity generation – about 9,500 TWh.

2. Accelerated green and low-carbon energy transition. In 2023, China's cumulative installed capacity of renewables reached 1500 GW, including hydropower, wind power and solar power, accounting for more than 50% of the total installed capacity, consisting of: solar power about 610 GW, an increase of 55.2% year on year; wind power 440 GW, an increase of 20.7% year on year. In 2023, the share of coal consumption in total energy consumption in China decreased by 0.7%, while clean energy consumption increased by 0.4%.

1.2 Current Status

1. COAL

In recent years, the coal industry has integrated development and safety, strengthened the construction of supply capacity, accelerated green and intelligent development, and actively promoted the clean and efficient utilization of coal. The supply guarantee capacity has been continuously strengthened, and the effectiveness of green and intelligent development has been remarkable. As of the end of April 2024, China has accumulated more than 1,900 intelligent coal mining workings and more than 2,100 intelligent digging workings. In 2023, China's output of coal bed methane was nearly 12 bcm, which was more than three times that of 2014, becoming an important supplement to domestic natural gas supply.

2. OIL

In 2023, China's output of crude oil was about 210 million tonnes, and the annual oil consumption was about 800 million tonnes.

3. NATURAL GAS

In 2023, China's natural gas production was 230 bcm, an increase of over 10 bcm for 7 consecutive years.

4. ELECTRIC POWER

By the end of 2023, the cumulative installed capacity in China was about 2,900 GW, an increase of 14% year on year, including: solar power – about 600 GW, an increase of 55% year on year; wind power – about 400 GW, an increase of 21% year on year. In 2023, the total energy output was nearly 9,500 TWh, an increase of 7% compared with 2022.

In recent years, the development of green and low-carbon power generation has accelerated, and the dominant role of wind, solar and other new energy in the share of installed capacity additions has been further consolidated. By the end of 2023, the installed capacity of hydropower generation was 420 GW. The total grid-connected installed capacity of wind power generation and solar power generation in China was 1050 GW, accounting for 36% of the total installed capacity.

In 2023, China imported over 7 TWh of electricity and exported nearly 3 TWh electricity.

5. NUCLEAR POWER

In 2023, there were 55 nuclear power units under operation in China, with a total installed capacity of 57 GW. In addition, there are 36 nuclear power units under construction or in the process of approval, with a total installed capacity of 43 GW. The annual nuclear energy output was over 430,000 GWh, accounting for nearly 5% of the cumulative energy output in China, equivalent to 130 million tonnes saving of standard coal and carbon dioxide emission reduction by 350 million tonnes.

China always deems nuclear safety to be the lifeline throughout nuclear power development, and always sticks to laying equal stress on development and safety. Up to now, the nuclear power units in operation in China mainland have maintained safe and stable operation, without any operational incidents/accidents rated at Level 2 and above as specified in the International Nuclear and Radiological Event Scale User's Manual (INES), without any adverse impact on the public and the environment. Meanwhile, China has maintained a good performance in nuclear power operations, and the total number of annual operation incidents decreased year by year from 1.45/reactor in 2013 to 0.39/reactor in 2023. According to the statistics of 12 indicators specified by the World Association of Nuclear Operators (WANO), 70% of the performance indicators for China's nuclear power plants have reached advanced levels, and the trend of continuous improvement was noticed.

6. RENEWABLE ENERGY

By the end of 2023, the cumulative installed capacity of hydropower in China was 420GW, an increase of 1.8% year on year, and the cumulative installed capacity of wind and solar power was 440 GW and 610 GW, an increase of 20.7% and 55.2% year on year respectively. In 2023, the installed capacity additions of renewables in China contributed more than half of the total additions of renewables installed capacity in the world. In terms of power generation, the annual renewable electricity generation in China was about 3,000 TWh in 2023, accounting for about 1/3 of the total electricity consumption, including wind plus solar, nearly 1,500 TWh accounting for 16% of the total electricity consumption, – higher than the global average of 13%.

In the past two decades, China has made many key technological breakthroughs through leapfrog development, our industrial chain has been getting matured day by day. The innovation capability of renewable energy technologies and the technological equipment autonomization has been greatly improved.

In the hydropower sector, the technologies of conventional hydropower units and pumped storage hydropower units are becoming mature, gradually reaching the international leading level in terms of design and manufacturing capability, manufacturing technology of supporting equipment and equipment technology of hydraulic metal structures, etc.

In the wind power sector, the manufacturing of wind turbine equipment has realized serialization, standardization and type spectrum, forming a number of wind turbine technology routes adapted to different environments. The technologies of low wind speed, high altitude and typhoon resistance have reached the international first-class level.

In the solar power sector, the innovation ability of PV cell technology has been greatly improved, and the international leading edge in PV has been further consolidated and strengthened. The cell conversion efficiency numbers contributed by PERC cells, TopCon cells, heterojunction, etc. have repeatedly set new world records. The PV production line equipment has basically been indigenous.

In the biomass sector, the domestic technology of biomass boiler has been mature, the efficiency is improving, and the key technology of biomass gas is accelerating upgrading. Domestic biomass boilers have obvious advantages in multi-species straw mixing and burning, with strong fuel adaptability.

In the hydrogen sector, the renewable energy based hydrogen technology has reached the international advanced level, and the renewable energy based hydrogen industry has entered the demonstration stage. The hydrogen storage technology has made initial progress, the research and development of low-temperature liquid storage and transportation of hydrogen has been actively followed up. The solid hydrogen storage technology shows strong potential.

2 CHINA'S POLICIES, OBJECTIVES AND PATHWAYS FOR JUST ENERGY TRANSITION

2.1 Energy accessibility

As the largest developing country, China is committed to improving energy access based on the people-centered development philosophy. In 2015, China historically realized 100% electricity accessibility nationwide. China creatively combines energy popularization with poverty alleviation, and promotes the PV poverty alleviation project nationwide. As so far, China has constructed solar power stations with a cumulative installed capacity of more than 26 GW targeting poverty alleviation, which are benefiting more than 4 million households. In addition, China has also launched the «Actions for Wind Power Generation in Thousands of Rural Areas with Right Conditions». On the one hand, this action helped adjust the rural energy structure and facilitate the realization of goals of carbon peak and carbon neutrality; on the other hand, it helped create more channels for increasing the rural incomes of village collectives and farmers.

China's achievements in energy accessibility are the result of three measures. Firstly, an integrated mechanism in which central and local governments cooperate with each other was established. Through formulating practical and effective energy development plans in phases, China clarified implementation entities and supportive measures in energy access projects. Secondly, some categorized measures which accord with local conditions were formulated. Based on different economic and demographic characteristics of the eastern and western regions, China adopted diversified ways, including national grid extension, countryside power grid rehabilitation or upgrading, and distributed renewable energy power generation. Thirdly, a cooperative model between governmental and social funds was established. Energy enterprises took mitigating non-accessibility as their social responsibility.

2.2 Energy security

After years of development, a strong energy supply system made of diversified types including coal, oil, natural gas and non-fossil energy, etc., has been formed in China, which effectively ensures economic and social development and people's demand for energy. However, China can see that as we face an array of interwoven new emerging risks and existing risks, regional and temporal energy supply and demand tensions occur now and then, and non-traditional security risks such as network security are becoming increasingly prominent.

To enhance the capacity of ensuring energy security in all aspects, China addresses the building of «Two Capacities and One System» to improve the stability and security of the energy supply chain. We should enhance the capacity of strategic energy security. Multiple measures need to be taken to enhance the capacity of oil and gas supply security, such as expanding domestic oil and gas exploration, raising reserve capacity, strengthening international energy cooperation, etc. We should improve the capacity for maintaining smooth and stable operation of the energy system. In line with resource endowments, coal-fired power generation should underpin the energy security to mitigate regional and temporal conflicts between energy supply and demand. In addition, renewable energy should play a full role in ensuring a secure and reliable energy supply.

2.3 Energy efficiency

In the long run, the Government of China has attached great importance to energy conservation. **Outline of the 14th Five-Year Plan for National Economic and Social Development** and **the Long-Range Objectives through the Year 2035 of the People's Republic of China** requires that «the allocation of energy resources should be more reasonable and the utilization efficiency be improved significantly», and specifies that «the policy in favor of energy conservation should be adhered to, and energy conservation in industries, building, transportation and other sectors and public utilities should be deepened to promote energy efficiency in emerging industries such as 5G and big data centers».

With regard to the industry sector, China has been strengthening energy conservation and environmental protection sectors, and promoting green and low-carbon transformation of the key sectors. The energy efficiency of major high energy consumption products keeps upgrading, and the energy consumption per added value of industrial enterprises with annual revenues above the designated size has dropped. With regard to the building sector, great efforts have been made to construct green buildings and promote energy-saving renovation of existing buildings. For new residential buildings in severely cold and cold regions, the 75% energy-saving design standard has been fully applied. In the transport sector, efforts are made to adjust the transport structure, with priorities given to green and low-carbon vehicles. The development of efficient transport, such as railways and waterways is accelerated. With continuous revolution in urban public transportation systems, the share of urban green travel keeps rising, and the efficiency of vehicles keeps upgrading.

In 2022, the Government of China promulgated **Action Plan for Improving Industrial Energy Efficiency**. The primary goal is that: by 2025, the energy efficiency of pillar industries will be improved in an all around way; the energy efficiency of key sectors such as data centers will be improved significantly; the utilization share of green and low-carbon energy will be improved significantly; state of arts, technologies and equipment in terms of energy-saving and efficiency-improving will be used nationwide; standards, services and supervision systems will be improved gradually; energy efficiency rates of key products such as steel, petrochemical, chemical, non-ferrous metal and building materials will reach international advanced level; and the ratio of energy consumption per unit of the added value of industrial enterprises with annual revenue above designated size will decrease by 13.5% compared with Year 2020. The plan focuses on key energy-consuming industries, key energy-consuming sectors and key energy-consuming equipment. Different policies will be implemented against different industries based on categories so as to systematically improve the industrial energy efficiency level. The energy management will be strengthened throughout the whole chain, all dimensions and whole process. Standard guidance and energy-saving services will be reinforced, so as to jointly improve the energy efficiency level of large, medium and small-sized enterprises and industrial parks. Overall planning and optimization of the industrial energy consumption structure and digital empowerment will be conducted for the promotion of energy conservation and efficiency improvement so as to provide concrete foundation for industrial energy efficiency advancing.

China continues to vigorously promote energy conservation and improve energy efficiency, well implements a dual-control system of energy consumption, uplift energy utilization efficiency, speeds up economic and social green and low-carbon transition, continuously enhances the quality and outcome of economic and social development, and lays the groundwork for peaking carbon dioxide emissions and achieving carbon neutrality.

2.4 Just energy transition

China has been further advancing ecological progress and accelerating the optimization and adjustment of energy structure, and has become an important diver of the world's energy development and transition in response to climate change.

China commits to promoting ecological civilization. All the goals, consistent with China's «ecological civilization», are pursued via just transition, including environmental protection, job market stability, social inclusion and poverty eradication.

The speech delivered by President Xi Jinping at the **Leaders Summit on Climate** in 2021 emphasized that the green transition must adhere to the people-centered approach and explore the synergy between environmental protection and economic development, job creation and poverty eradication. **The White Paper, Responding to Climate Change: China's Policies and Actions** published in 2021, also established a «people-centered» approach as one of the five pillars of China's new responses to climate change.

China upholds the concept of energy development for the people, relying on the people and serving the people; prioritizes the energy supply to guarantee the well-being of people and covering the poor in the process of energy development; strengthens the construction of energy facilities closely related to well-being of people; and, upgrades public service and energy service performance. China combines the energy development with rural revitalization, and gives full play to the fundamental role of energy facilities and energy supply in rural and agricultural development.

Energy transition shall also promote coordinated energy development both in urban and rural regions. In the new era, the energy industry should thoroughly implement a coordinated regional development strategy, coordinate ecological protection and high-quality development, balance regional energy supply and demand, optimize the layout of energy development and utilization, increase the efficiency of resource allocation. As the Western China is rich in fossil energy and renewable energy resources, it is necessary to adhere to the green and low-carbon development pathway, shift the development pillars to clean energy industry, and establish hybrid clean energy bases such as «wind, solar and water (for energy storage)» and «wind, solar and thermal (for energy storage)» bases. The Central and Eastern China focus on improving clean and low-carbon energy development. The development of distributed new energy, coastal nuclear power and offshore wind power should be accelerated in Beijing-Tianjin-Hebei region and its surrounding regions, Yangtze River Delta and the Guangdong-Hong Kong-Macao Greater Bay Area, so as to further enhance local clean energy self-sufficiency capacity. The evacuation potential of existing transmission channels should be further exploited. It is estimated that the west-east electricity transmission project will evacuate more than 360 GW by 2025. The newly-built transmission lines should evacuate the renewable energy at no less than 50% out of the total transmission capacity in principle. Energy supply services wherever in urban or rural regions should be improved in an all around way. Urban and rural energy supply facilities should be improved so as to meet people's diversified energy needs, such as electricity, gas, cooling and heating for the production and well-being of people. ■

EGYPT

OVERVIEW OF THE ENERGY SECTOR IN EGYPT

1 NATIONAL CONTEXT

Egypt is a developing country, with a fast-growing population. With an ambitious economic growth outlook, its demographics place considerable stresses on natural resources, employment, infrastructure, education, and healthcare. The Government of Egypt launched a comprehensive energy policy reform program in the energy sector that included substantial renewable energy and energy efficiency programs reflected in the Integrated Energy Strategy 2035[2].

To meet burgeoning energy demand, the Egyptian government has pursued an energy diversification strategy as Egypt's Vision 2030[3] aims to achieve a diversified, competitive and balanced economy within the framework of sustainable development which is known as the Integrated Sustainable Energy Strategy (ISES) until 2035 that was endorsed by the Egyptian Supreme Council of Energy (SEC) in October 2016.

[2] *According to Egypt's second updated NDC issued in 2023*
[3] *Announced in February 2016 and being indicative of the country's aspirations to achieve a competitive, balanced and diversified economy by 2030 to secure sustainable development in a protected environment for all Egyptians.*

The «ISES 2035» ensures continuous, diversified energy security and establishes the necessary conditions to enable the increased development of renewables through the engagement of all sectors. Moreover, the strategy confirms Egypt's ambition to become an energy hub between Europe, Asia and Africa by expanding grid interconnections across the Arab region and beyond.

This strategy involves stepping up the development of renewable energy and energy efficiency, in part through vigorous rehabilitation and maintenance programs in the power sector. The 2035 Integrated Sustainable Energy Strategy, which builds on previous strategies, emphasizes the importance of renewable energy. With the current update of the (ISES) until 2040, Egypt intends to increase the supply of electricity generated from renewable sources to 42% by 2030 instead of 2035, in order to change the pattern of intensive reliance on natural gas to generate electricity. With a view on reducing emissions and supporting climate action, coal is not an energy source in Egypt's energy mix and there are no coal-fired power plants.

A main premise for updating Egypt's Integrated Sustainable Energy Strategy until 2040 was the emergence of low-carbon hydrogen as a clean energy source. Actually, Egypt was an early pioneer in «green hydrogen», as hydrogen produced in 1960s at Kima Fertilizer company was powered by hydro-power from Aswan Dam.

Egypt has significant comparative advantages across the hydrogen value chain and recognizing the importance of developing a local low carbon hydrogen economy to capitalize on its comparative advantages. Egypt's huge potential in clean energy production enables becoming a global hub for green hydrogen production. Furthermore, hydrogen production aligns with Egypt's commitment to reducing greenhouse gas emissions and combating climate change.

Accordingly, a national strategy for low-carbon hydrogen was developed to be a key part of Egypt's energy sector strategies. Egypt's vision in the strategy is to become one of the global leaders in the low-carbon hydrogen economy. Egypt's low-carbon hydrogen economy can contribute up to $18 billion to Egypt's GDP and offer 100 thousand job opportunities by 2040.

The overall governance of the Egyptian energy sector is guided at the strategy and policy level by regulations and directions issued by the Supreme Energy Council (SEC) and is managed at the execution level by the Ministry of Petroleum and Mineral Resources and the Ministry of Electricity and Renewable Energy (MOERE). Both ministries work in cooperation with other relevant ministries and public entities.

The Supreme Energy Council (SEC) was established in 1979 under the Prime Minister's decree No. 1093 and was reformed in 2014. Headed and formed by the Prime Minister and including all relevant ministries, it is mandated to review and endorse national energy strategies and policies, monitor the sector's performance and energy pricing policies and approve policies and regulations on energy pricing and incentives for energy sector investments (including promotion of energy efficiency and renewable energy investment).

1.1 Petroleum Sector

Egypt enjoys a strategic geographic location that leverages its key role in international energy trade. This role becomes clear through the operation of two strategic energy routes in the region: the Suez Canal and the Suez-Mediterranean (SUMED) pipeline. The Suez Canal, connecting the Red Sea with the Mediterranean Sea, is an important north-bound transit route for oil and LNG shipments from the Persian Gulf to Europe and North America and southbound from the Mediterranean and North Africa to Asia. It is widely considered a reliable and shortest link between east and west. The Damietta and Idku liquefaction plants, which receive and liquefy natural gas before shipping it for export to importing markets, including Europe, are considered a key part of Egypt's strategy to grow its natural-gas exports and emerge as a regional energy hub by expanding the country's ability to export liquefied natural gas to European markets. Taking advantage of the Egyptian national gas grid (operated by Egyptian Natural Gas Company (GASCO)it which is the vital link in the energy chain between entry points and exit points, being one of the largest and longest in Africa and the Middle East.

Egypt is also considered one of the largest oil and gas producers in Africa. Nevertheless, since it is one of the most populated countries in the region, there is a huge energy demand that needs to be fulfilled. Most of the country's domestic energy needs are supplied by oil and gas, with natural gas as the largest single source. Natural gas is becoming Egypt's first fuel choice to complement its renewable energy generation.

Within the framework and key outcomes of Egypt's oil and gas modernization project launched in 2016, the Ministry of Petroleum and Mineral Resources developed a

strategy to support transforming Egypt into a regional energy hub, which was realized through 3 main tracks, including internal, political, and technical & commercial.

Decarbonisation and transition to low-carbon energy sources, including natural gas, have been core elements of the current update of Egypt's energy sector strategy. Energy subsidy reform, Energy Efficiency, and Hydrogen are additional key pillars of the energy sector strategy and have been tackled using separate strategies.

The Egyptian Petroleum Sector Energy Efficiency (EE) Strategy 2022-2035 introduces a two-stage approach. The Strategic Vision of the EE Strategy 2022-2035 is: «Supporting the economic improvement of energy efficiency in the petroleum sector while meeting the sustainability objectives of Egypt's vision 2030 and contributing to energy security and decarbonization.»

In the meantime, the government has been seeking to decrease the consumption of petroleum products in favor of decarbonized natural gas in recent years. In this regard, controlling domestic petroleum products consumption has become a priority issue for many countries. In 2014, the GOE initiated a comprehensive economic reform program to promote inclusive growth. As one of its key elements, the program includes the energy subsidy reform plus associated measures to counteract the expected negative effects for the most vulnerable households.

In the light of the above mentioned subsidy reforms, and faced with the high rates of growth in consumption, the government has been applying a quarterly price index mechanism on all petroleum products since the beginning of FY2019/2020. The Fuel Automatic Pricing Committee (FAPC) has been holding regular meetings at the beginning of each quarter since then to announce price changes within the range of ±10 percent in light of global oil prices and the foreign exchange rate, this will tend to curb the explosive growth and reallocate resources more effectively.

Egypt's energy sector is a pioneer of change since the discovery of oil more than 100 years ago, followed by gas in offshore fields that was deemed unusable back then. However, Egypt saw gas as a clean energy source and introduced a pivotal change, specifically the «gas clause» of 1980. Thereafter, it took a strategic decision to gasify the economy, with major gas discoveries followed. In the following 20 years, instead of only accounting for less than 40%, gas now accounts for 60% of the country's annual hydrocarbons consumption. Expanding the use of natural gas as the fuel of choice is one of the key pillars of decarbonization in Egypt's petroleum sector strategy for decarbonization and energy transition.

In addition to Egypt's Ministry of Petroleum and Mineral Resources engagement in the development of Egypt's national low-carbon hydrogen strategy, Egypt's petroleum sector is already taking concrete steps to translate Egypt's national hydrogen strategy into action through actual on-ground projects. This will be further detailed in section 2.3.

At the sectorial level, the Ministry of Petroleum and Mineral Resources heads the Egyptian petroleum sector. The Ministry of Petroleum and Mineral Resources developed the structure of the Egyptian petroleum sector through separating the activities of natural gas and petrochemicals from the activities of the Egyptian General Petroleum Corporation (EGPC) and establishing a strong entity for each of them. That strategy included drawing more attention to Upper Egypt through establishing an independent entity for this region.

The petroleum sector's structure consists of five major state entities: the Egyptian General Petroleum Corporation (EGPC), the Egyptian National Gas holding Company (EGAS), the Egyptian Petrochemicals Holding Company (ECHEM), South Valley Egyptian Petroleum Holding Company (GANOPE) and the Egyptian Mineral Resources Authority (EMRA). The EGPC is the national oil authority in charge of managing upstream and downstream activities in the oil sector as well as the exploration and production operations of more than ninety affiliated joint venture companies. It holds several exploration licenses in the Western Desert, Sinai and the Gulf of Suez. It also owns and operates much of the country's refining industries. The Egyptian Natural Gas Holding Company, EGAS, is the national company in charge of natural gas activities both upstream and downstream, most importantly through the management of exploration and production operations with a number of joint venture companies. GANOPE focuses on upstream oil activities and issues upstream licenses in the southern region, while ECHEM is responsible for developing the petrochemical sector, and EMRA assesses mineral resources and geological mapping of the country.

As will be further detailed in section 2.3, decarbonization and transition to low-carbon energy sources were integrated as core elements within Egypt's petroleum sector strategy. Accordingly, Egypt's petroleum sector is continuing to expand securing all energy resources while aiming to reduce emissions.

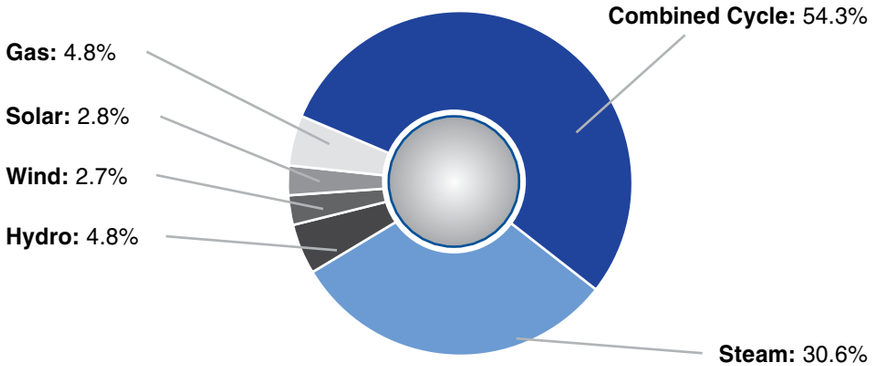
1.2 Electricity Sector

Egypt needs a powerful and reliable energy system to support its long-term, sustainable economic development that leads to the importance of updating the strategy of the electricity Sector. The main objectives of the updated strategy can be illustrated as follows:

- Providing the needed electricity for the socioeconomic growth;
- Consistent supply of electricity within economical operational standards;
- Diversifying the energy mix from all resources;
- Encouraging the private sector participation in generation and distribution;
- Developing the national grid to cope with the generation added from all the different resource technologies.

ENERGY BALANCE STRUCTURE, PRODUCTION AND ENERGY CONSUMPTION

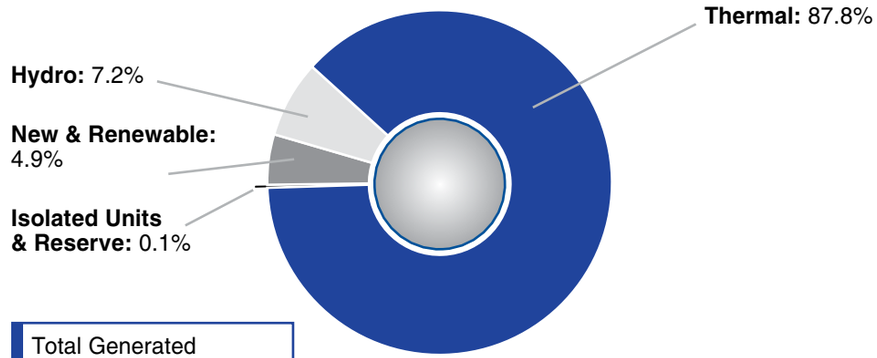
The total energy production in the Egyptian grid has been growing since 2020. The total installed capacity in 2022/2023 is about 59.4 GW as shown in the figure below, with different types of generation.



Total Installe Capacity = 59442.18 M.W

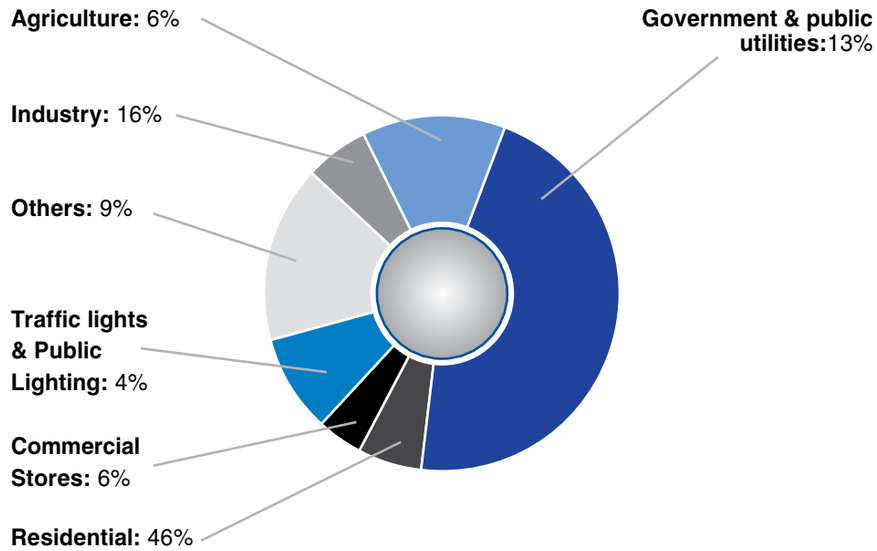
Installed Capacity by Generation Type (%) (2022 / 2023)

The total generated energy is about 216.3 TWH with about 12.1% share of Renewable Energy.



Total Generated Energy = 216252 G.W.H

The total energy consumption (total energy purchased by distribution companies) is about 171 TWH. The figure below illustrate the different sectors share.



SOCIAL, ENVIRONMENTAL, HEALTH, SAFETY & MONITORING MANAGEMENT SYSTEMS, AND PREPARATION OF PERFORMANCE & QUALITY MEASUREMENT REPORTS

The environmental & social policies of the Egyptian Electricity Holding Company (EEHC) state as the most important and prominent objective «protecting the environment, people and communities».

Therefore, EEHC's policies are implemented by all affiliated power plants' personnel as part of the Environment, Health, and Safety (EHS) management system that is inspected and monitored by EEHC and the Egyptian Environmental Affairs Agency (EEAA).

EEHC's policies are fully aligned with all requirements set out in the relevant international standards, including the standards for Environmental Management Systems (ISO-14001), Occupational Health & Safety Management Systems (OHSAS-18001) and the IFC Performance Standards for Environmental & Social Sustainability (IFC-PS), as these policies of EHS management systems are followed at all power generation plants in accordance with the executive regulations that are included in the power plants ESIA (Environmental & Social Impact Assessment).They also comply with the operational mitigation and monitoring commitments made in the ESIA as well as subsequent studies submitted and approved by EEAA. The implementation of the IFC-PS management system is aligned with Egypt's developmental and climate change policies and agreements (the United Nations Framework Convention on Climate Change (UNFCCC) and Paris Agreement ratified in 2017), so an MRV system (monitoring, reviewing and verifying) is applied in all the power plants as we receive data on the type of fuel, volume of the fuel consumed and whether there is any SF6 leakage taking place, and thus we have a system to calculate and publish the GHG produced from each power plant on an annual basis.

GHG reports contribute to the greenhouse gas inventory (GHGI), GHG Mitigation and Support requirements and assist in monitoring the performance of our power plants and to make sure of the presence of an effective monitoring, reporting and verification (MRV) system. This is to ensure that data is reported in a transparent, accurate, complete, comparable and consistent manner.

Management procedures were established by EEHC's Environment and Safety Management team in order to ensure and fulfil an adequate and ongoing implementation of the EHS management system as well as the regulations and policies set out within the national and international regulations, a matter which had required the creation and application of the following:

- An effective monitoring and reporting mechanism that was established over the past years, where all the operational E&S data and information are obtained and collected by EEHC's E&S Management team as this data is required to demonstrate the E&S performance and conformance to the Plant's operation management program (OMP) and all other commitments.
- EEHC's E&S Management system that was implemented in most of the affiliated power plants for managing a maintaining data requirement in relation to the power plants Environmental & Social Management Manual (ESMM) and related aspects of the management system as well as ensuring the accuracy of the records.

All monitoring requirements for the operational phase of power plants are consolidated into the Plant's Monitoring Program Manual (MPM), to define the parameters, responsible party and frequency of emission and ambient monitoring for the Plant, in alignment with monitoring requirements identified in individual OMPs.

All E&S monitoring activities are completed as identified in the MPM and individual OMPs. To ensure the adequacy of monitoring and measurement, the MPM details define the requirements for all calibration, inspection, and test equipment requirements as per the international and national standards.

2 TASKS AND OBJECTIVES IN NATIONAL ENERGY SECTOR

The vision of the Energy Strategy 2035 is «as Egyptians, we are committed to building an economically strong, efficient, secure, integrated, sustainable, transparent and more equitable Energy Sector that will help all our people achieve greater prosperity, higher living standards and achieve a future that they want without any detriment to our environment».

The Energy Strategy 2035 Goals are built on four bases as stated below. The sustainable development targets for Egypt as related to energy (Egypt Sustainable Development Strategy, Egypt Vision 2030, issued 2015) are:

Goal I – **Ensuring the security of supply:** The core objective is to ensure the availability of reliable energy supplies to satisfy the future development needs of the country through the adoption of a more diverse energy mix and direct investment to provide a range of fossil fuels, renewable and nuclear technologies. Moreover, this includes rationalizing the demand side and reforming energy subsidies without putting excessive financial costs onto citizens.

Goal II – **Ensuring sustainability:** The core objective is to achieve both the technical and financial sustainability of the energy sector, ensuring a sufficient supply of diversified sources that can be utilized to deliver energy, and achieving financial sustainability by being able to fund the necessary infrastructure and operating costs by ensuring sufficient income to maximize efficiency in all operations.

Goal III – **Improving institutional and corporate governance:** The core objective is to modernize the current institutional structure of public enterprises to cater for a more commercial framework by introducing the necessary technical assistance to responsible entities, along with action plans to enhance energy planning and energy efficiency.

Goal IV – **Strengthening competitive markets and regulation:** The core objective is to establish an environment that can help build competitive energy markets as a key step in driving down costs and promoting market liberalization to support greater transparency and efficiency within the electricity, gas and oil markets.

The Energy strategy the being updated until 2040 in light of global developments related to renewable energy, the development of energy storage technologies, and the new trend towards green hydrogen.

2.1 Petroleum Sector

Egypt's petroleum sector is a main driver of economic and social development. In order to modernize and enhance the sector's activities and performance, a comprehensive modernization project was launched in 2016 with the objectives of transforming to sustain the sector's achievements, improving activities within the entire value chain, developing agile structures and workflows, designing new ways of collaborative work, and enhancing the sector's economic contribution.

Accordingly, the sector's vision was collectively formulated to continuously unlock the sector's full value chain potential as a growth and a sustainable development engine for Egypt, achieve financial sustainability, become a leading regional Oil and Gas hub and a role model for the future of modernized Egypt.

In this respect, the Petroleum sector strategic pillars are centered around 3 main pillars as follows:

- Energy Security
- Financial Sustainability
- Sector Governance

Within the energy security pillar, the Petroleum sector continues to work towards boosting energy supplies, diversifying energy supplies and managing energy demand. As for the financial sustainability, the Petroleum sector aims to streamline financial interdependencies, reform energy subsidies, and maximize value added from oil and gas resources. Concerning sector governance, the Petroleum sector is strengthening governance through improved structures and workflows, capitalizing on the sector's human capital as the key resource and asset of the sector, and developing an attractive investment climate to boost private investments.

In line with the holistic approach to sustainable development, decarbonization and transition to low-carbon energy sources were embedded within these strategic pillars to complement Egypt's petroleum sector activities in this respect. Accordingly, the sector is working to promote decarbonization activities, monetize decarbonization opportunities and instil a sector wide focus on decarbonization.

2.2 Electricity Sector

TASKS AND OBJECTIVES

- **INCREASE RENEWABLE ENERGY CAPACITY**

  Objective:
  - Achieve 42% of electricity generation from renewable sources by 2030.

  Tasks:
  - Expand solar and wind farm installations
  - Implement more competitive bidding rounds for renewable energy projects
  - Enhance grid infrastructure to support increased renewable energy integration

- **DEVELOP GREEN HYDROGEN INDUSTRY**

  Objective:
  - Position Egypt as a global leader in green hydrogen production by 2040.

  Tasks:
  - Finalize and implement the National Low Carbon Hydrogen strategy;
  - Facilitate private sector investments in green hydrogen projects;
  - Develop necessary infrastructure for hydrogen production and export.

- **IMPROVE ENERGY EFFICIENCY**

  Objective: Reduce energy consumption by 18% by 2035 compared to 2010 levels.

  Tasks:
  - Implement energy efficiency measures across industrial, residential, and commercial sectors;
  - Promote the use of energy-efficient appliances and technologies;
  - Conduct awareness campaigns on energy conservation.

- **STRENGTHEN REGULATORY FRAMEWORK**

  Objective:
  - Create a stable and transparent environment for energy sector investments.

  Tasks:
  - Fully implement the 2015 Electricity Law;
  - Develop and enforce updated codes and regulations for the energy sector;
  - Establish a fully functional, competitive electricity market.

- **ENHANCE ENVIRONMENTAL AND SOCIAL MANAGEMENT**

  Objective:
  - Ensure all energy projects comply with international environmental and social standards.

  Tasks:
  - Strengthen the implementation of Environmental & Social Impact Assessments (ESIA);
  - Improve the Monitoring, Reviewing, and Verifying (MRV) system for greenhouse gases;
  - Develop capacity-building programs for environmental and social management in the energy sector.

- **PROMOTE INTERNATIONAL COOPERATION**

  Objective:
  - Leverage international partnerships to accelerate energy transition.

  Tasks:
  - Seek new international collaborations for technology transfer and capacity building;
  - Actively participate in global climate change initiatives and negotiations.

- **ATTRACT PRIVATE SECTOR INVESTMENT**

  Objective:
  - Increase private sector participation in the energy sector.

  Tasks:
  - Streamline processes for private sector involvement in energy projects;
  - Implement attractive incentive schemes for renewable energy and green hydrogen investments;
  - Develop public-private partnership models for energy infrastructure projects.

- **ENHANCE ENERGY INFRASTRUCTURE**

  Objective:
  - Modernize and expand energy infrastructure to support the transition.

  Tasks:
  - Upgrade the national grid to accommodate increased renewable energy input;
  - Develop smart grid technologies for improved energy management;
  - Invest in energy storage solutions to address intermittency issues of renewable energy.

CHALLENGES

1. Infrastructure Strain: Rapid population and economic growth place heavy demands on energy infrastructure.

2. Financing and Investment: Significant investment is needed for transition to renewable energy, requiring strong international and private sector support.

3. Regulatory and Policy Implementation: Ensuring the effectiveness of new policies and regulations, especially in fostering competition and transparency in the energy market.

4. Technological Advancements: Keeping pace with global developments in renewable energy technologies and energy storage solutions.

5. Environmental and Social Compliance: Maintaining stringent EHS standards and monitoring systems to meet international and national regulations.

The challenges highlight Egypt's strategic approach to achieving a sustainable energy future while acknowledging the substantial challenges ahead in terms of infrastructure, financing, regulatory frameworks, and technological advancements.

3 NATIONAL ENERGY POLICY IN THE CONTEXT OF JUST ENERGY TRANSITION

3.1 Petroleum Sector

The world demand for energy is increasing rapidly, being one of the main engines for economic development and the welfare of societies. However, to achieve sustainable development, energy sources must also be sustainable, meaning that it is all about energy transition: transitioning to produce more energy with fewer emissions. The energy transition is a crucial step in enhancing the energy system's global socio-economic footprint, global welfare, gross domestic product (GDP), and employment. Yet, the trilemma of providing affordable, reliable, and clean energy while tackling climate change is complex.

Countries across the World are envisioning a transition to a low-carbon economy in the context of climate change. The Paris Agreement marked the first global treaty to combat climate change, control greenhouse gas emissions, and limit the rise in global temperature. It was adopted by world leaders at the United Nations (UN) Climate Change Conference (COP21) in Paris in December 2015. Egypt signed the Paris Agreement in 2016 and ratified it in 2017. The agreement's goal is to substantially reduce global greenhouse gas (GHG) emissions to 2 degrees Celsius while pursuing efforts to limit the increase even further to 1.5 degrees Celsius.

The world needs more than one energy transition pathway to consider the different circumstances of all countries according to the principle of «Common but Differentiated Responsibilities and Respective Capabilities» (CBDR-RC). In 1992, the principle of CBDR-RC was officially formalized in the UN Framework Convention on Climate Change (UNFCCC). This principle recognizes that countries have different duties and abilities to address the negative impacts of climate change, but all countries have an obligation to address climate change.

Egypt is accelerating its decarbonization pace and working on energy diversification in line with the country's «Sustainable Development Strategy: Egypt Vision 2030» and Integrated Sustainable Energy Strategy. The Egyptian petroleum sector has a significant role to support these strategies through a number of projects as well as initiatives. The Ministry of Petroleum and Mineral Resources (MoPMR) also organized the «Decarbonization Day» at COP27, which highlighted the local, regional, and global success of decarbonization in the oil and gas sector as well as hard-to-abate industries.

As mentioned previously in section 2.2.1, decarbonization and transition to low-carbon energy sources were embedded within the Petroleum sector's strategic pillars to complement Egypt's petroleum sector activities in this respect.

Accordingly, Egypt's Ministry of Petroleum and Mineral Resources developed an integrated strategy for decarbonization and energy transition that is based on six main pillars encompassing the full value chain activities of the petroleum sector. These

six main pillars are energy subsidy reform, decarbonized natural gas to complement renewable energy, energy efficiency, carbon intensity reduction, renewables and Bio-based products, as well as low carbon hydrogen.

The Ministry has also inaugurated the sector's ***Center of Excellence for Energy Transition*** as the first strategic entity specialized in serving the petroleum sector and energy-intensive sectors in Egypt and the African continent to promote the transition to sustainable, low-carbon energy systems. This is one of the main elements in the petroleum sector's strategy to achieve emissions reduction and energy transition.

3.1.1 ENERGY SUBSIDY REFORM

In line with the economic reform program launched by the Government of Egypt, an energy subsidy reform program was implemented in order to address chronic challenges of the energy subsidies borne by the government and to ensure a more sustainable approach for fuel pricing. Such challenges included the heavy fiscal burden on the government's annual budget, the disproportionate benefit of rich households due to their relatively higher energy consumption, and the absence of a motive for energy efficiency.

Through the energy subsidy reform program, the subsidies are now specifically directed to low-income groups and enhanced programs for targeted social protection measures (social safety nets) have been implemented.

Moreover, prices of liquid petroleum products are now subject to quarterly review through the Automatic Fuel Indexation system. Egypt's successful implementation of the energy subsidy reform program received acclaim and recognition from leading international organizations.

3.1.2 DECARBONIZED NATURAL GAS TO COMPLEMENT RENEWABLE ENERGY

As a cleaner and more environmentally friendly fuel, Egypt took a strategic decision more than 20 years ago to use cleaner, less carbon-intensive, and more environmentally friendly fuels. Decarbonized natural gas increasingly became Egypt's fuel of choice to complement renewable energy generation, which is in line with Egypt's energy sector strategy for energy transition and boosting decarbonization.

The sector managed to place Egypt on the global map of major players in the natural gas industry, particularly in the East Mediterranean region, the country achieved self-sufficiency in natural gas in 2018 and resumed exports.

Natural gas consumption increased more than threefold from fiscal year (FY) 1999/2000 to 2022/23. This increase came in light of Egypt's vision to diversify its energy mix, enhance the transition towards green fuels, and boost decarbonization in the energy sector; 15 million households are now connected to natural gas, serving 62 million citizens. During the last 10 years, 9 million units (out of the 15 million) were connected, representing 60% of total units connected during more than 40 years. The sector also achieved unprecedented record rates of gas connections to households, reaching 1.2 million units annually. In addition, the sector is also supporting gas connections to villages within the Decent Life initiative, which was launched by His Excellency President Abdel Fattah El-Sisi in January 2019. This initiative aims to provide a decent life for the most vulnerable groups nationwide and contributed to enhancing quality of daily public services provided to citizens especially in rural areas. The sector managed to complete connections within this initiative to more than 520 villages serving 1.7 million families.

In line with expanding natural gas use in different sectors, including for sustainable mobility, close to 540 thousand cars were converted to CNG as a cleaner & environmentally friendly fuel for sustainable mobility. In addition, 1000 CNG fueling stations were established across the various governorates.

Natural gas usage has also expanded in other industrial sectors to increase its added value, including petrochemicals and fertilizers production.

3.1.3 ENERGY EFFICIENCY

Egypt's petroleum sector considers energy efficiency as the first priority and the most cost effective way to achieve emission reductions. The MoPMR announced the Egyptian petroleum sector Energy Efficiency Strategy 2022-2035 during the 27th session of the Conference of the Parties (COP27) held in Sharm El-Sheikh. This strategy aims to achieve the petroleum sector's vision of «supporting the continuous economic improvement of energy efficiency in the petroleum sector while achieving Egypt's 2030 sustainability goals and contributing to energy security and carbon removal.» As mentioned earlier, the strategy consists of two interconnected and overlapping phases. The first stage aims to achieve a 10% saving in energy consumption by the year 2027, and the second stage aims to achieve an 18% saving in the level of energy consumption by the year 2035 (the national goal).

The petroleum sector's energy efficiency strategy encompasses forty-eight objectives to ensure sustainable improvement in energy efficiency. An action plan and timetable were prepared. Subsequently, a strategy task force from the Petroleum Sector experts was formed for the strategy implementation.

The sector has managed to achieve significant successes and achievements under the Energy Efficiency Domain. For effective governance, a robust institutional setup for Energy Efficiency was established across the sector companies to enhance and support energy efficiency activities. In this regard, the MoPMR also organized three editions of the "Egyptian Petroleum Sector Energy Efficiency Conference". This is in addition to developing an energy efficiency capacity building plan for more than 1,000 trainees, and implementing the first energy efficiency middle management program for 247 Engineers. Several training programs were also implemented using the latest simulation systems, and a field visit was organized to Japan from the petroleum sector with the aim of learning about policies, services and technologies for improving energy efficiency and rationalization in Japan within a capacity-building project in the field of energy efficiency and rationalization in cooperation with the Japan International Cooperation Organization (JICA). A database for Energy Consumption and Emissions covering all sector operations was also established, which helps in continuous tracking of energy consumption and identifies energy-intensive companies, initiating projects to optimize their energy usage. Moreover, several energy audits were implemented across refineries, upstream and petrochemical companies that identified energy efficiency improvement projects with the potential to reduce energy consumption and emissions by 15%.

Within the energy efficiency pillar, the Petroleum sector is working with Turboden company for the supply of the largest high-temperature ORC system ever built, which, coupled with 20 MWe electric motor-driven compressors supplied by Siemens Energy, boosts the efficiency of the Dahshour Gas Compressor Station of GASCO (Egypt's Transmission System Operator). Dahshour Gas Compression Station project is a first of its kind, as it will exploit the heat from four existing gas turbines and from the new high efficient Gas Turbines with low emissions supplied by Siemens Energy. This integrated solution allows generating additional fuel-free electricity thus saving significant quantities of natural gas. Furthermore, the technology of Waste Heat Recovery is applied across several facilities of Egypt's Petroleum sector (including in LNG plants) in order to implement combined cycle power generation to optimize natural gas consumption for electricity generation and reduce emissions, thereby playing a key role in the sector's modern energy landscape.

3.1.4 CARBON INTENSITY REDUCTION

Reduction of the carbon intensity of the sector's hydrocarbon resources continues to be a key priority for the MoPMR, its State Owned Entities and affiliates.

In order to focus on decarbonization and energy transition, especially within the framework of Egypt's oil & gas modernization project, a new department was established at Egyptian Natural Gas Holding Company (EGAS) for Energy Transition and Sustainability.

A "Decarbonization Marginal Abatement Cost Curve (MACC)" for the Egyptian Petroleum Sector was developed. The petroleum sector is also working to implement decarbonization projects to progressively lower the carbon intensity (carbon footprint) of the hydrocarbon resources.

In line with Egypt's leading regional role in climate action, H.E. President Abdel Fattah El Sisi announced that Egypt joined the Global Methane Pledge in the oil and gas track at the Major Economies Forum on Energy and Climate Change in June 2022. Several methane measurement campaigns were also conducted at more than 30 facilities. Furthermore, the sector companies are implementing regular Leak Detection and Repair (LDAR) programs to make fast corrective action to reduce fugitive methane emissions.

Egypt also endorsed the World Bank initiative of "zero routine flaring by 2030" and the petroleum sector is cooperating with the World Bank and EBRD to achieve this target. In this respect, the sector succeeded in implementing more than 30 flare gas recovery projects, including zero routine flaring at the DISOUCO JV with Wintershall DEA, and several projects at Khalda JV with Apache. In addition, Egypt's updated NDCs include a target for reducing GHG emissions in the petroleum sector by around 1.7 MTCO2e in 2030 mainly through the recovery of associated gas.

Carbon capture, utilization, and storage (CCUS) is also considered another key decarbonization solution as it refers to a suite of technologies that can play a diverse role in meeting global energy and climate goals, according to the IEA. The sector is collaborating with its strategic partners to study the techno-economic and regulatory aspects of implementing CCUS projects, with a special emphasis on utilization of the captured CO2 to ensure a sustainable business model for CCUS.

3.1.5 RENEWABLES & BIO-BASED PRODUCTS

Egypt's Petroleum sector is actively working to boost the use of renewable energy across the sector's facilities in order to maximize the added value of the saved fuel projects, especially natural gas, and reduce the amount of diesel used to generate electricity at petroleum production sites, which also helps achieve optimal economic and environmental benefits for operations. The sector is also working to boost generation of solar energy at remote sites to provide alternative and sustainable energy sources, as well as save the consumption of petroleum fuels used in power generation.

Installing solar PV systems at offshore production platforms has been a common practice within the Petroleum Sector for decades. More than 30 projects have already been implemented to generate solar energy at production sites for petroleum sector companies in cooperation with small and medium sized private sector companies. These projects resulted in achieving savings in fuel consumption for electricity generation at petroleum sector companies, estimated at about $1 million annually.

In addition, renewable energy solutions are implemented at the administrative buildings of 21 companies in the petroleum sector with a capacity of 1.4 megawatts. There is also an ongoing initiation of renewable energy projects at Assiut Oil Refining Company and General Petroleum Company, with a total generation capacity of 16.6 MW.

The sector is also working to implement pioneering projects for the production of bioenergy and green petrochemicals. Through its affiliate, Wood Technology Company (WOTECH), the sector is contributing to support the government's efforts to transform rice straw from an environmental challenge (or burden) into an economic opportunity by producing medium-density fiberboard (MDF) wood, using 250,000 m3 of waste rice straw to produce 205,000 m3 of MDF. The produced MDF can cover part of the local market demand and will be used in various sectors like furniture, construction, and decoration. This is in addition to offering several job opportunities at Nile Delta's Beheira governorate.

In addition, a bio-ethanol project will be implemented with a production capacity of 100,000 tonnes per year using sugar beet molasses as a raw material. A project to produce biodegradable plastics is also being studied to support in reducing the negative impact of plastic waste.

To contribute towards supporting the achievement of decarbonization targets in the global aviation sector, which is one of the main hard-to-abate sectors globally, Egypt's Petroleum sector is studying the techno-economic feasibility of implementing a project aimed at the production of Sustainable Aviation Fuel (SAF) using advanced and proven technologies, based on Used Cooking Oil (UCO) as the feedstock.

As part of the sector's corporate social responsibility (CSR) projects, the Petroleum Sector is also working in collaboration with international energy companies to support implementation of biofuel production projects.

3.1.6 LOW CARBON HYDROGEN

As mentioned before, Egypt's Ministry of Petroleum and Mineral Resources was engaged in leading the development of Egypt's national low-carbon hydrogen strategy, with a vision for Egypt to become one of the global leaders in the low-carbon hydrogen economy.

The MoPMR was also actively engaged in developing the incentives package for green hydrogen projects and its derivatives that was issued by official decree, and has played a major role in developing the proposal for Egypt's National Council for Green Hydrogen and its Derivatives, which was recently established under the Chairmanship of HE The Prime Minister.

Regarding the emerging low-carbon hydrogen economy, Egypt has several assets and strong points for leveraging its hydrogen production potential, including a strategic location with access to potential global markets in Europe and East Asia, significant renewable energy resources, well-developed infrastructure, as well as capitalizing on Egypt's human capital. Accordingly, low-carbon hydrogen will be an integral part of Egypt's energy transition. Egypt has also been the location for the first green methanol bunkering operation in Africa and the Middle East region, which took place in August 2023 at East Port Said, and succeeded in exporting the region's first green ammonia in 2023.

In this respect, hydrogen is a key pillar in Egypt's petroleum sector decarbonization pillars to capitalize on the sector's expertise and potential across the hydrogen value chain.

To enhance collaboration with partners and share best practices, the MoPMR continues to cooperate with leading countries and entities to advance hydrogen efforts. The MoPMR co-signed a declaration of intent with the German Ministries of Economic Affairs and Climate Action, as well as Economic Cooperation and Development in the field of green hydrogen, emphasizing the common goal of creating a suitable

environment for sustainable economic and environmental development of both countries. The Petroleum sector entities also signed a number of MoUs with leading organizations to cooperate in the field of hydrogen.

Furthermore, the MoPMR is participating in the «Hydrogen for Development Partnership» that was launched by the World Bank during COP27. This initiative aims at developing human capacity, regulatory solutions, business models, and technologies toward the roll-out of low-carbon hydrogen in developing countries.

In partnership between the Egyptian Petrochemicals Holding Company (ECHEM), Misr Fertilizer Company (MOPCO) and Scatec, the sector is implementing its first Green Ammonia production project with a capacity of 150 KTPA and total investments reaching $900 million. where Damietta Green Ammonia Production Company was recently established as Egypt's first-ever company to be established digitally through the new online portal recently launched by Egypt's General Authority for Investment and Free Zones (GAFI).

At COP28 hosted by Dubai in December 2023, the project's shareholders agreement was signed between Misr Fertilizers Production Company (MOPCO), Egyptian Petrochemicals Holding Company (ECHEM) and Scatec.

MoPMR is collaborating through its affiliate companies with Scatec to study establishing Egypt's first green methanol utilizing biogenic carbon dioxide from the sector's bioethanol project, with total investments potentially reaching up to around 2 billion US Dollars for production of 200 Thousand tonnes of green methanol per year. The green methanol will be utilized as a green shipping fuel. On the sidelines of COP28, an MOU was signed between the Ministry of Petroleum and Mineral Resources, General Authority for Suez Canal Economic Zone and Scatec to cooperate for implementing green fuel bunkering activity at East Port Said Zone related to this project.

The project will leverage Egypt's potential as a hub for green bunkering and would support placing Egypt on the map of green shipping corridors, to capitalize on the importance of the Suez Canal as a navigation artery and a major path for global trade movement.

In 2023, a memorandum of understanding (MoU) between China International Energy Group (CIEG), the Egyptian General Petroleum Corporation (EGPC), as well as the North Abu Qir for Agricultural Nutrients Company was signed, aiming to establish a joint project to produce green hydrogen at the North Abu Qir Agricultural Nutrients Company. Another MoU was also signed in 2023 between the Abu Qir Fertilizers Company, ABB International Group, MPS Infrastructure Company, and Petrojet, which aims to supply the North Abu Qir for Agricultural Nutrients Company with the green hydrogen and renewable electricity needed to produce green ammonia for the production of green fertilizers.

All of the above efforts and on-ground activities support and reinforce the MoPMR vision for Egypt to become not only a leading regional energy hub, but a green and decarbonized regional energy hub, including for green hydrogen.

3.1.7 COP27 DECARBONIZATION DAY

Egypt successfully organized the 27th edition of the Conference of the Parties (COP27) in Sharm El Sheikh in November 2022, which witnessed the participation of over 100 heads of state and government, and more than 50,000 people. COP27 came as a key opportunity for strategists and experts to have open discussions on decarbonization, energy transition, and policy-making. The international community praised Egypt's success in organizing the COP27 climate conference.

Egypt's Petroleum sector is a strong advocate for the commitment of the energy industry to decarbonization to support the global effort of overcoming the energy trilemma. In line with this vision, and in close coordination with the COP Presidency, Egypt's petroleum sector succeeded in organizing the first ever «Decarbonization Day» as part of the official thematic days at COP27. This was the first time ever in COP summits that those who participated in COP27 had the opportunity to take part in Decarbonization Day – a day that not only seeks to highlight the importance of decarbonization as a cause but is a clear demonstration of Egypt's firm commitment to achieving the objectives of the Paris Agreement while pushing for a just energy transition.

The COP27 Decarbonization Day was inaugurated by H.E. Tarek El Molla, Minister of Petroleum and Mineral Resources, H.E. John Kerry, U.S. Special Envoy for Climate, and H.E. Gerd Muller, United Nations Industrial Development Organization (UNIDO) Director General. It covered eight sessions and showcased efforts, commitments, and enablers for accelerating decarbonization in hard-to-abate industries. This is in addition to 20 bilateral meetings with a number of ministers, officials from international companies, as well as leading experts from global and regional energy institutions.

Moreover, seven MoUs were signed between the petroleum sector and a number of international companies specializing in the energy transition, decarbonization, and hydrogen fields. The MoPMR also signed an MoU with the EU in partnership with the Ministry of Electricity and Renewable Energy on green hydrogen.

3.1.8 CENTER OF EXCELLENCE FOR ENERGY TRANSITION

The Ministry of Petroleum and Mineral Resources attaches utmost importance to the development of the human element as one of the most important reasons for success and to ensure continuous improvement in energy transition in the petroleum sector and all other energy-consuming sectors. Accordingly, and as mentioned earlier, the Ministry of Petroleum and Mineral Resources has inaugurated its ***Center of Excellence for Energy Transition*** as the first strategic entity dedicated to promoting the transition to low-carbon energy systems in the petroleum sector and energy-intensive sectors across Egypt and Africa.

The center's activities cover the comprehensive spectrum of decarbonization and energy transition, in line with global directions and key focus areas. This center provides innovative and modern energy transition services to support the energy transition in all energy sectors of Egypt and Africa, theoretical and practical training programs utilizing state-of-the-art techniques, simulation, and virtual reality, hands-on training on mini plants and simulation models, implementation of technical energy audits and establishment of energy management systems. In addition, it conducts economic feasibility studies and supports the development of its outcomes for energy transition projects. Furthermore, the center plays a vital role in conducting measurement campaigns for greenhouse gas emissions, qualifying companies for ISO 50001 certification in energy management systems and evaluating energy consumption rates to reduce emissions in alignment with international standards and technologies. The center's preparatory work was completed in coordination with JICA, and the initial training programs for the center's staff were conducted with the collaboration of project consultants and experts from Japan. The center established partnerships with leading energy transition entities like Carbon Limits especially within methane measurement campaigns and abatement, which the center has already started on several petroleum sector sites.

3.2 Electricity Sector

EGYPT VISION 2030: SUSTAINABLE DEVELOPMENT STRATEGY 2030

Egypt's vision is to achieve a competitive, balanced, diversified, and knowledge-based economy by 2030, characterized by justice, social integration, and participation, with a balanced and diversified ecosystem, benefiting from its strategic location and human capital to achieve sustainable development for a better life of all Egyptians.

Climate change efforts fall within Egypt's path toward sustainable and inclusive development that eradicates poverty and strives to achieve prosperity for future generations. It shall leverage Egypt's recent success in attaining pro-poor economic growth with the decline in poverty since 2020 for the first time in almost two decades and strengthening social safety nets to reach the most vulnerable.

The key sustainability enablers to accelerate the way forward to the 2030 horizon are data availability, financing, digital transformation, technology and innovation, legislative environment, supportive cultural values, and population growth management. In 2021, development partners provided $10.27 billion as support to Egypt in accelerating the achievement of its SDG vision. The collaboration with the international community is pivotal to realize a green and low-carbon future.

EGYPT'S INTEGRATED AND SUSTAINABLE ENERGY STRATEGY 2035

Egypt is rich in Renewable Energy resources, especially wind and solar that qualify it to be one of the major renewable energy producers. More than 40,000 square km have has been identified and allocated for implementing renewable energy projects to generate approximately up to 150 GW from solar and 120 GW from wind farms.

To utilize this potential and to accelerate the shift away from fossil fuel to clean energy, an "Integrated Sustainable Energy Strategy (ISES) 2035» was approved at 2016. ISES is a long-term national energy strategy. It sets the goals to be achieved in the energy sector. One of these goals is about efficient and rationalized use of energy, by adopting measures and procedures to be implemented across industry, buildings, tourism, public lighting, and transportation sectors. The target is to reduce energy consumption by 18% in 2035 compared to 2010. The strategy also has a target to develop renewable energy. Renewable energy capacity should contribute 20% of power supply capacity (maximum peak load) by 2020 and 42% by 2035.

Currently, the Energy Strategy until 2040 is being updated in light of global developments related to renewable energy technologies, energy storage and hydrogen.

Egypt affirmed its transition to Clean Energy by updating the Nationally Determined Contribution (NDC) on June 2023 to state that «Installing additional renewable energy (RE) capacities to increase electricity generation contribution to 42% of generation mix by 2030» instead of 2035. This update is based on the NWFE program, which aims at

decommissioning of 5,000 MW of existing inefficient oil and gas-fueled power generation capacity along with installing 10,000 MW of new renewable energy capacity to facilitate investments of more than 10 billion USD for implementing this capacity through the private sector in addition to facilitating the needed investment in strengthening the electricity transmission network.

It is worth noting that the NWFE Program receives great international attention and support as one of the pioneering initiatives to implement the climate agenda within the framework of the Paris Agreement.

PRIVATE SECTOR PARTICIPATION REGULATIONS

Egypt has adopted a full-scale program to encourage private sector participation in the energy sector projects. At the outset, the electricity sector has been restructured. This restructuring is a continuous process, which is working now towards introducing competition to improve the sector efficiency. It is believed that a stable, transparent and predictable energy policy as well as regulatory framework are basic requirements for efficient market operation and attracting investments. Several documents, codes and regulations have already been developed. These include market design documents, third-party access, transmission and distribution codes, codes for interconnections of wind and solar plants and regulatory frameworks to support roof top solar systems.

On the other hand, the Electricity law was issued in July 2015. This law will change the market shape from a regulated market to be deregulated taking into consideration the social impacts and poor people. The law assists: Transparency, establishment of Transmission System Operator, Third-Party Access, reinforcement of Regulatory body, energy efficiency, demand side management, Public Private Partnership and power generation from renewable sources. The law will establish a gradually liberalized electricity market regulated by Egypt ERA.

Also for encouraging the investment in the field of renewable energy a presidential decree was issued in October 2014 to modify the New & Renewable Energy Authority establishment law to allow it to establish companies by itself or in partnership with the Private sector to install, operate and maintain renewable energy projects as well as allowing New & Renewable Energy Authority to sell the generated electricity from its projects to Egyptian Electricity Transmission Company or other entities. In addition, another Law was issued on December 2014 to encourage generating electricity from RE sources through 4 schemes as follows:

- Governmental Projects scheme: by NREA via EPC contracts.
- Feed in Tariff scheme (FiT): Government of Egypt has announced a plan for 2015-2017 to contract both solar and wind energy developers at attractive prices. A central unit for FiT (One Stop Shop) has been established to provide the necessary support for the investors. In this regard, the Feed in Tariff program succeeded in attracting 32 international and local investors to implement Benban Solar Park project, the largest one in the Middle East and Africa located near the city of Aswan with a total capacity of 1,465 megawatts that reduce GHG emission by 2 million tonnes. This project won the best project prize worldwide by the World Bank.
- The competitive bids scheme: Under the framework of “Build, Own and Operate” (BOO). In this regard, there are many tenders announced and developed for wind and solar capacity based on the (BOO) scheme. The latest prices we got under the BOO Scheme are less than 2 dollar/kwh for solar and about 2.4 dollar/kwh for wind.
- Independent Power Producer IPP scheme: This mechanism allows the investor to sell the electricity generated from his project directly to the end user by using the national grid with a wheeling charge.

NEW TECHNOLOGIES: GREEN HYDROGEN DEVELOPMENT IN EGYPT

Green hydrogen is projected to grow rapidly in the coming years as a potential key accelerator of the energy transition and enabler for a wider global de-carbonization.

The Egyptian leadership urged the preparation of an integrated national strategy for the production of low carbon hydrogen as it is a promising source of energy for the near future. A lot of measures have been taken to develop hydrogen in Egypt, such as:

- A prime minister decree has been issued for forming a high-level working group from various ministries to set a road map for future steps for using hydrogen, which includes preparing a national strategy for hydrogen production in accordance with the requirements of the concerned sectors. The working group finished the final report and recommendations.
- On the 5th of March 2022, a MoU was signed with EBRD to provide finance for consultancy work regarding the National Hydrogen Strategy. On 27 February 2024, the Supreme Energy Council approved the National Low Carbon Hydrogen strategy.
- The strategy has a vision that “Egypt will be one of the global leaders in the low carbon hydrogen economy, utilizing the world’s leading

expertise and innovation in hydrogen and derivatives production/export, the excellent renewable resource, and its strategic location".

- Egypt will take advantage of its competitiveness to fulfil its ambitious plans for the hydrogen sector, targeting up to 8% of the global tradable market by 2040.
- It is expected that by 2040 over 100,000 jobs will be created, a large proportion being highly skilled. With the right training, many of these will be taken by the domestic workforce.
- On 27 January 2024, a law was issued regarding incentives for green hydrogen production projects and its derivatives.

TAX INCENTIVES

- Green hydrogen incentive with a value between (33% - 55%) of the tax paid.
- Exemption from value-added tax for Equipment, tools, machines, devices, raw materials, and supplies.
- Zero value-added tax for exports of green hydrogen projects and its derivatives.
- The project company is granted a 25% reduction in the usufruct fees for the industrial area allocated to establish a factory for the production of green hydrogen and its derivatives, and 20% of the usufruct right for the lands of storage in warehouses at ports.

NON-TAX INCENTIVES

- The project company will obtain a single approval in accordance with the regulations contained in the Investment Law.
- Allowing the project company to import, by its own or through others, what it needs to establish, expand or operate the project. It also has the right to export its own products, on its own or through others.
  The project company has the right to employ foreign workers within the limits of 30% of the total number of its employees, during the first ten years.
- The project is allowed to establish special customs departments for the project's exports or imports in agreement with the Minister.

GREEN HYDROGEN PROJECTS

- In parallel with strategy preparation, we are working with private companies in the field of hydrogen projects. In this regard, 27 MOUs have been signed with some major international developers. During COP27 Activities, 11 partnership agreements were signed with a qualified international developer.
- It is worth mentioning that Egypt witnessed the commissioning of the first phase of the green hydrogen plant in Ain Sokhna on the 8th of November during COP27 Activities. The project is the first integrated green hydrogen plant in Africa, and when fully developed will consist of 100 MW of electrolyzes, powered by 260 MW of solar and wind plants.
- In addition, During COP27 activities, the completion of a demonstration project where a GE LM6000 gas turbine at the Sharm El Sheikh Power Plant was adapted to successfully run on hydrogen-blended fuel for the very first time on the African continent. Moreover, the project was accomplished at tremendous speed, in less than 5 months.

GREEN HYDROGEN INTERNATIONAL COOPERATION

- During COP27 activities, the European Union and the Arab Republic of Egypt signed MoU regarding the strategic partnership in the field of green hydrogen. This MoU aims to develop the production, consumption and trade of renewable hydrogen as well as its derivatives between both sides.
- In addition, a Joint Declaration of Intent (JDoI) between Egypt and Germany was signed to cooperate in the fields of green hydrogen. The JDoI aims at securing clean energy supplies, achieving sustainable development and confronting climate change.
- Also, a MoU was signed between Egypt and France to provide technical assistance and a capacity-building program on green hydrogen.

3.3 Achieving a Just Energy Transition

The world needs a reliable, affordable, and sustainable energy system. The demand for energy services is growing, especially for developing countries, and will be met by different types of energy. Energy security is essential for economic growth and prosperity across the world. It is imperative to recognize that different solutions and energy transition pathways are required for different countries, particularly within the principle of «Common but Differentiated Responsibilities and Respective Capabilities».

As mentioned previously, Egypt recognizes the importance of climate action according to differentiated responsibilities and respective capabilities. Egypt also succeeded in hosting COP27 on behalf of the African continent, and achieving outcomes relevant to African countries especially for the loss and damage fund. At COP27, Egypt's MoPMR and MoERE organized a decarbonization and energy days for giving a seat to energy industries to be part of the solution and discussions.

Egypt has growing energy demands due to a growing population, we are working on energy security and sustainability in parallel. The Egyptian Government continues to be leading economic reforms and driving the country's efforts towards green economy through:

- Improving the investment climate, supporting the private sector to attract more investments in clean energy projects.
- Updating NDCs in 2023 to reflect an ambitious target of 42% renewable electricity to be achieved by 2030 instead of 2035.
- Issuing the region's first sovereign green bonds to finance projects in clean transportation and sustainable water management.
- Ambitious targets for low-carbon hydrogen to capitalize on its unique assets of strategic location, energy sector expertise and low carbon energy sources.

Egypt's energy sector focus is continuing to supply all energy resources in more environmentally responsible ways to support economic growth and prosperity.

Shaping an inclusive energy transition that supports equitable growth worldwide requires a comprehensive approach that considers social, economic, and environmental factors. This comprehensive and inclusive approach is necessary to avoid the risk of unequal benefits of the energy transition. Within the context of a just energy transition, it is important to adopt a people-centered approach that addresses the socioeconomic implications of the energy transition.

Developing country governments face a triple challenge: pursuing low-emission development with rising energy demand and limited access to affordable capital. It is often the case that Environmental, Social, and Governance (ESG) measures primarily emphasize environmental factors, and often neglect equity in the energy transition. In addition, an equitable energy transition has been traded off rather than enabled by the recent focus of countries on security and sustainability. There is a need in the Global South to prioritize the sustainable use of all domestic energy resources, including hydrocarbons, for supporting development before prioritizing the transition to alternative energy sources.

As a developing country, Egypt faces several challenges in achieving a just energy transition. Access to concessional finance remains a key challenge in this respect. It has been recognized that capital costs for renewable energy projects in emerging and developing economies remain at least double of those in advanced economies. There is also limited access to critical technologies and opportunities for technology transfer as well capacity building for the developing economies that need them to support the energy transition.

Accelerating deployment of clean energy technologies at scale, particularly in emerging and developing economies where they are needed the most, requires the following:

- Mobilizing substantial concessional finance
- Significant reduction in cost
- Formulation of new business models
- Supportive government policies
- Institutions and markets that support innovation and allow for technology transfer

Synergy and collaboration between all energy industry stakeholders, including governments, private sector and international financial institutions remain crucial to support achieving a just, balanced and orderly energy transition that leaves no one behind, especially for the developing countries like Egypt.

Within this cross-cutting requisite collaboration between all stakeholders, the role of governments is key to supporting the energy transition ecosystem through:

- Setting achievable and realistic energy transition targets
- Setting policy & incentives to encourage decarbonization & energy transition
- Planning & developing the right infrastructure to support clean energy uptake.

At the same time, business and private sector have a key role in realizing a just energy transition through:

- R&D activities to optimize the cost of green technologies
- Offering offtake agreements to stimulate demand
- Mobilizing private finance needed for investments in green projects
- Assisting in technology transfer and localization of equipment manufacturing for developing countries.

International financial institutions, including Multilateral Development Banks, also play a critical role in supporting & achieving a just energy transition through:

- De-risking investments in low-carbon energy technologies through the support of green energy projects
- Reducing the cost of capital by availing concessional finance
- Developing new & innovative financial tools to finance the energy transition.
- Achieving a just energy transition that is tailored to national circumstances and local needs.
- Focusing on Energy Efficiency: Implement measures across various sectors to reduce energy consumption and improve efficiency.
- Supporting Renewable Energy Projects: Continue to prioritize the development of renewable energy sources, such as wind, solar, and green hydrogen, to diversify the energy mix and reduce dependency on fossil fuels.
- Addressing Social Impacts: Ensure that the energy transition is inclusive and benefits all segments of society.
- Leveraging Technological Innovations: Investing in research and development to harness new technologies for energy storage, smart grids, and other innovations that support a sustainable energy future. ■

Additional References:

[1] - According to Egypt's second updated NDC issued in 2023

[1] - Announced in February 2016 and is indicative of the country's aspirations to achieve a competitive, balanced and diversified economy by 2030 to secure sustainable development in a protected environment for all Egyptians.

[2] - EEHC annual report of 2022-2023.

ETHIOPIA

1 OVERVIEW OF THE ENERGY SECTOR AND CLIMATE RESILIENCE

The development of the energy sector is one of the key drivers of Ethiopia's overall socio-economic development, to improve living standard and achieve sustainable development goals as indicated in the National Sustainable Energy Development Strategy of Ethiopia (N-SEDS) together with the long-term 10 Year Perspective Plan «Ethiopia 2030: Pathway to Prosperity (2021 – 2030)». Access to adequate, reliable, affordable, and environmentally sustainable energy is fundamental for enabling the structural transformation of the Ethiopian economy and society, and for promoting poverty reduction, industrialization and creating jobs for a young and fast-growing population.

While Ethiopia has made notable progress in expanding its energy sector, development the access to modern energy services remains one of the lowest in the world. The current electricity generation capacity is less than 6 GW. More than 56 million population (46%) lacking access to electricity and less than 10 of the population have access to clean cooking fuels. The Government of Ethiopia, understanding these pressing challenges is working to accelerate the energy transition towards sustainable energy in the future integrating, social, economic environmental and technology dimensions.

Although Ethiopia accounts for a negligible share for CO2 emissions, the country is highly vulnerable to the impact of climate change. To tackle this climate change our country is a frontrunner in initiating the Climate Resilient Green Economy Strategy, (CRGE) in 2011, which is the foundation of Ethiopia's Nationally Determined Contribution (NDC).

Our country also signed the Paris Agreement in 2015 and is among the first least developed countries to submit an ambitious National Determined Contributions (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC) and pledged to limit the annual emissions to 126 metric tonnes CO2 or lower by 2030, which would constitute a 278 metric tonne CO2 reduction for the business as usual (BAU) of 403 Mt CO2. The recent launch of Green Legacy Initiative and the impactful and transformational Long-Term Low Emission Development Strategy (LT-LEDS), which was launched on May 12/ 2023, will further demonstrate Ethiopia's global leadership on climate change.

The Ethiopian LT-LEDs Strategy will play an important role in driving the alignment of Ethiopia's National Determined Contributions and near term actions with longer term Paris Agreement Goals. The LT-LEDS provides a roadmap for long-term decarbonization and climate-resilient development for Ethiopia. LT-LEDS outlines ambitious scenarios to decarbonize seven priority sectors including energy and transport sectors.

When we look at the Climate interventions in the Energy & Transport sectors, the electrification of end-use sectors-such as transport, residential, commercial, and industr-will replace fossil fuels and traditional biomass fuels combined with expanding renewable power production. Energy sector interventions unlock additional growth and create employment at the same time contributing to the achievement of SDG 7 (affordable clean energy), SDG 8 (decent work and economic growth), and SDG 13 (climate action) targets as well as other SDGs.

2 ENERGY RESOURCES

Ethiopia is endowed with a variety of energy resources potential including hydro, wind, geothermal, solar, bio-energy and fossil fuels. The gross hydro-power potential of the country is estimated at more than 45,000 MW. The geothermal energy resource potential is estimated at about 7,000 MW. There is a significant wind potential greater than 100 G and solar potential is also massive. Ethiopia, receives an average solar energy potential of 5.2 kWh/m2 per day.

Ethiopia is also endowed with abundant biomass energy resources, primarily in the form of agricultural residues, forest residues and animal waste. These resources offer significant potential for bioenergy production.

In terms of fossil fuels, Ethiopia has reserves of coal, oil and natural gas resources. These fossil fuel resources are governed by the Ministry of Mines of the FDRE. Currently proven reserves of coal are estimated at 600 million tonnes, proven oil estimated at 1 billion tonnes and at present Ethiopia certified gas reserves show 7 trillion cubic feet (TCF) in Ogaden Basin. This is certified confirmation of natural gas volume and economic viability of the country. In addition, it helps to invite companies with technological, financial and investment potential at the international level. Natural gas can be used for domestic needs and export to the region. Further exploration for reserves is likely to increase available reserves.

Figure 1: *Coal reserves*
Coal reserves are found in Moye and Geba (west), Chilga (northwest) and Mush (central) parts of Ethiopia. Current estimates for total reserves is 600 million tonnes.

Figure 2: *Natural gas reserves*
Natural gas reserves are located in the southeast of Ethiopia. The main reserve locations are Calub (2.8 TCF), Hilala (1.3 TCF) and El-Kuran (1.5 TCF).

[1] - *Information gathered from Ministry of Mines Website.*

3 OVERALL ENERGY PRODUCTION AND CONSUMPTION

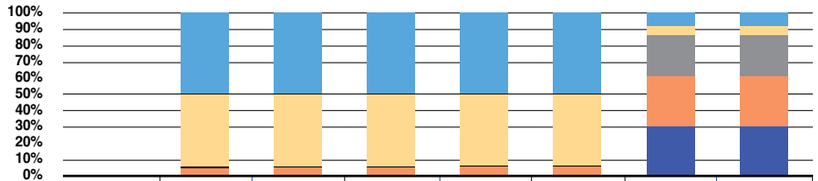
3.1 Energy Balance

Ethiopia's energy demand has been steadily increasing due to population growth, urbanization and industrial development. In 2019/2020, the total final energy consumption was estimated at 498TWh.

The country primarily relies on traditional biomass, such as firewood and charcoal, which constituted around 86% of total energy consumption in 2019/2020; the remaining 14% is supplied through coal (0.99%), petroleum fuels (10.87%) and electricity (2.65%). In terms of sectoral breakdown of the final energy consumption, household accounts for 85.7%, followed by transport 10.5%, industry 2.5%, agriculture and others 1.2%.

3.1.1 ENERGY SUPPLY TREND BY SOURCE

As per the International Atomic Energy Agency (IAEA) Energy Balance Studio Model, the share of bioenergy production is still dominant in the energy mix but the share is decreasing when we move from 2016 to 2020 as shown in Figure 1 because of the shift to electricity.



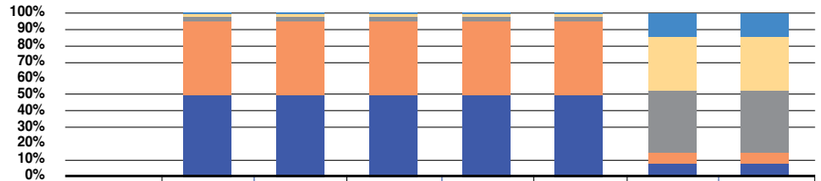
	2016	2017	2018	2019	2020	Average yearly added in %	Total added in %
	years					2016 - 2020	
- Total	461,72	48,19	493,80	511,12	528,14	3,60	14,39
- Bioeneergy	411,16	4212,35	431,39	441,31	451,49	2,45	9,81
- Electricity	9,76	11,23	11,78	13,50	14,01	10,91	43,62
- Oil & gas	37,41	45,24	46,38	51,42	5741,	13,36	53,43
- Coal	3,40	4,36	4,24	4,88	5,23	13,53	54,11

Figure 1: *Energy Supply by Source 2016-2020 GC in TWh*

The share of electricity is only 2.65 % from the total energy production in 2020 as compared to 2.11% in 2016 whereas the share of oil raised from 8.1% in 2016 to 10.9% in 2020. From the year 2016 to 2020 the energy production from electricity increased by 43.6%; however, bioenergy shows increments only in 9.8% and the rise in oil & gas is 53.4%. The improvement of coal use by industry makes up increments of coal import and own production by 54.1%.

3.1.2 TOTAL ENERGY CONSUMPTION BY SECTOR

From the year 2016 – 2020, the national energy consumption rose by 14.2%. The household energy consumption increased by 9.4%, whereas transport and industry sector increased by 60.6% and 52.1% respectively.

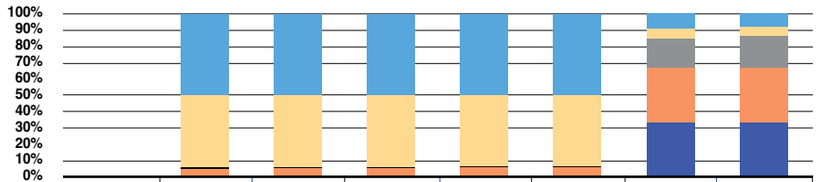


	2016	2017	2018	2019	2020	Average yearly added in %	Total added in %
	years					2016 - 2020	
- Other consumers	4,90	5,51	5,37	5,94	6,07	6,00	23,99
- Industry & construction	8,16	10,20	9,72	8,84	12,42	13,03	52,14
- Transport	32,66	37,95	42,75	47,18	52,45	15,15	60,61
- Householders	390,52	399,50	407,81	417,61	427,09	2,34	9,36
- Total	436,24	453,16	465,65	479,57	498,03	3,45	14,16

Figure 2: *Total energy consumption by sector in TWh, 2016 – 2020*

3.1.3 TOTAL ENERGY CONSUMPTION BY SOURCE

The total bioenergy consumption increased only by 9.78% whereas the electricity and coal increased by 28.36% and 53.42% respectively. Despite the fact that access to electricity is not growing as expected, data from figure 4 reveals that coal and electricity use are both rising significantly.



	2016	2017	2018	2019	2020	Average yearly added in %	Total added in %
	years					2016 - 2020	
- Total	436,24	4453,15	465,55	481,87	498,87	3,55	14,21
- Bioeneergy	387,07	396,41	405,77	415,03	424,93	2,45	9,78
- Electricity	8,49	8,58	9,25	10,56	10,90	7,09	28,36
- Oil & gas	37,29	43,80	46,39	51,39	57,22	13,37	53,46
- Coal	3,40	4,36	4,24	4,88	5,21	13,36	53,42

Figure 3: *Energy Consumption by Source in (TWh), 2016 - 2020*

In the case of oil and gas, Ethiopia is purely an oil importing country and as a strategy the transport sector is expected to reduce the use of petroleum products by introducing electric vehicles since the cost of oil in the international market is increasing and consumes almost the entire nation's foreign currency reserve. In Figure 4 the rise of the oil and gas is by 53.5% and needs to be solved so now Electric Vehicles (EV) are slowly gaining momentum on the roads of Addis Ababa and are anticipated to spread more widely while the demand for petroleum will get lower.

4 POLICY, GOALS, OBJECTIVES FOR IMPLEMENTATION OF JUST ENERGY TRANSITION IN THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

Energy Policy Goal

The main goal of the Ethiopian Energy Policy is to develop the country's energy resources in a sustainable and secure manner to ensure the benefit of its citizens and to support the country's home grown economic reforms as well as establishing needed structural change so that rapid and comprehensive prosperity can be achieved in the country. The Policy focuses on the following five major strategic priority areas.

Strategic Objective 4.1: Expanding Equitable Access to Modern Energy Services

4.1.1 ELECTRICITY ACCESS

The country has launched National Electricity Plan (NEP) in 2017 and 2019 and had set out an ambitious target for providing electricity access to all its citizens by 2030 through grid and off-grid technologies. Despite notable advancements, electricity remains inaccessible to over half the population, underscoring the urgency to support the expansion of the national electrification program.

According to the World Bank data, the average national electricity access rates in 2021 is estimated at 54.2% with significant disparity between urban settlements at 94.3% and rural areas at 42.8%. Annual per capita electricity consumption is not more than 93 kwh compared to the world average of 3,131 kwh . There is a strong determination from the government to further expand its renewable energy capacity and infrastructure, to address the current and future energy demand and electricity access.

Expanding access to equitable, reliable, affordable, and modern energy services plays a vital role for the sustainable development, improving living standards, promoting economic growth and job creation, as well as reducing poverty. The electrification

program emphasizes a multifaceted strategy, combining rapid grid expansion with off-grid solutions and promoting private sector participation, particularly in off-grid electrification to reach the unserved areas.

For decentralized solutions solar among other renewable energy resources is now becoming the new player in electricity and battery mini- grids are a significant part of the solution to both energy access and climate change challenges. So far we have implemented 16 pilot solar mini grids and started more than 100 solar mini-grids in different rural towns. We have designed and started implementing the distribution of renewable energy for agricultural modality (DREAM) program to address the water-energy-food nexus.

The Program will implement a sector-wide approach for the design, implementation, and syndication of financing requirements. This Program will also coordinate activities and investments leveraging public, private, and development partners' support. However, the issue of funding for sustainable energy transition is one of utmost importance for our country.

4.1.2 CLEAN COOKING ACCESS

Overall, the country's access to clean cooking energy in 2021 remains not more than 8% which is much less than the average rate reported for SSA region that stood at around 18%. The majority of our rural people mainly use firewood for their daily cooking and lighting. This is causing its own problems in the health of women and children, environment and economic development. Black carbon emitted from burning biomass fuels is a key contributor to climate change. The global warming contribution of a meal cooked using biomass can be significantly higher than one cooked using fossil fuels. As a result clean cooking is now being lifted to the top of global energy climate development agenda.

Ethiopia has a long history of promoting improved biomass cookstoves, which goes back as far as the 1970s, primarily focusing on lower-tier improved cookstoves where solid biomass fuel savings are lower than 40% and have minimal indoor-air pollution reduction potential.

However, from 2010 to 2022, through the Government and many development partners efforts, over 19 million biomass-efficient stoves were disseminated across Ethiopia. Of this, a notable recent experience is the National Improved Cookstoves Program (NICSP) which was launched in 2013 as part of the Climate Resilient Green Economy Strategy (CRGE).

Regarding the clean cooking intervention, the practice is very limited. Important recent examples in this regard is the National Biogas Program of Ethiopia (NBPE) which has been promoting the installation of domestic biogas technologies in rural areas since 2009 until now where more than 46,000 biogas digesters were installed. Biogas can contribute to reducing the heavy reliance on solid biomass energy sources, improving environmental sustainability, as well as the welfare of rural households. Biogas has the dual advantages of providing energy for rural households such as energy for lighting and for cooking, while at the same time providing a high quality organic fertilizer from the slurry produced after the gas is extracted. The organic content of animal refuse is usually wasted or burned, or used for cooking in direct combustion in open fire stoves. Bio-gas increases agricultural productivity as it provides the necessary organic fertilizer and it further improves the quality of life of rural households as it reduces indoor air pollution.

Universal access to clean cooking is an integral part of the Paris Climate Agreement transitioning to a just net zero emissions energy system by 2050. Households are considered to have gained access to clean cooking as per the SDG 7 target when they primarily or mainly cook with fuels such as LPG, Biogas, electricity, ethanol or very low emission biomass stoves meeting at least 3 or above the multi-tier framework.

Until 2030 our main goal is to eliminate cooking poverty by expanding the low emission improved cookstoves and clean cooking technologies and fuels in line with the SDG 7 target.

The efforts made so far have a lot of limitation such as imited technical skills and absence of a business model, poor product quality and the absence of a qualified accredited lab for implementation of standards, as well as the lack of innovation in terms of both financing mechanisms and technical design work as hindrance for a market based transformation. Institutional mandates and arrangements have often changed over the years leading to limited institutional memory, and loss of accumulated experience, resources, and capacity. These have negatively affected the clean cooking development program in the country.

Therefore, the Government is now developing a clean cooking roadmap which will serve as a communication tool, a high-level document that helps articulate strategic thinking – the why – behind both the goal and the plan for getting there.

Strategic Objective 4.2: Achieving and sustaining security of energy supply and related infrastructure

We are one of the few countries in the world which generates almost all its electricity (99%) from renewable sources, mostly hydropower based (92%). To improve our energy security and supply, we are aggressively working to diversify the renewable and clean energy mix using wind, solar, geothermal, bio-energy, natural gas, and nuclear technologies and to increase their share from the current 8% to 20% by 2030. During this time the hydropower share will decrease from the current 92% to 80%. Furthermore, it is important to expand and to strengthen the country's transmission, substation and distribution infrastructures to secure quality and reliable energy supply.

The other issue of diversifying our energy mix is because it is highly vulnerable to volatile petroleum fuels imports prices as well as climate change impacts. Enhancing energy security and resilience remains critical. By diversifying our energy mix, developing renewable energy sources Ethiopia can reduce its dependence on fossil fuels, enhance energy security and resilience and create a sustainable energy future.

Strategic Objective 4.3: Improve Energy Efficiency and Conservation

Ethiopia has been focusing on expanding energy access and renewable energy generation. Energy efficiency and conservation is also at the core of the national energy policy objective. The focus is on reducing energy wastage and promoting energy-efficient practices and technologies in various sectors, including households, industry, transportation, service and agriculture.

By using energy more efficiently, Ethiopia can reduce the overall energy demand. This can be achieved through various means such as adopting energy-efficient technologies, upgrading infrastructure, implementing energy efficiency standards, as well as raising awareness and promoting behavioural changes among consumers.

Strategic Objective 4.4: Regional Power Interconnection and Integration

Since Ethiopia is endowed with substantial renewable energy resources, it should exploit its energy resources not only to meet its own energy demand but also to export power, green hydrogen and green ammonia to stimulate economic growth and prosperity. Exporting electricity in turn would create regional economic integration and significantly contribute to geopolitical stability.

Promoting cross-border and inter-regional interconnection will ensure reliable and affordable supply of clean energy as a driving force for industrialization and regional development integration in Africa. That will be a cornerstone for attaining the «2030 Agenda» of the United Nations and the «2063 Agenda» of the African Union.

Strategic Objective 4.5: Governance and Capacity Strengthening

Enhancing energy sector governance and capacity strengthening is crucial for the sustainable development of the energy sector. This entails improving the management, transparency, accountability, and efficiency of energy institutions and processes.

This can be achieved through various measures such as structural, operational and regulatory reforms as well as streamlining the planning and implementation processes; institutional strengthening, enhancing the capacity of energy institutions; private sector engagement; and mobilizing sustainable energy financing as well as enhancing regional energy cooperation and integration. ■

INDIA

1 OVERVIEW OF INDIA'S ENERGY SECTOR

India aims to ensure energy security and provide reliable, affordable, sustainable and round-the-clock modern energy services to all citizens. Energy security is crucial for promoting economic growth, while meeting developmental priorities. At the same time, India is advancing several policy measures in line with its Nationally Determined Contributions (NDCs) to ensure that socio-economic development goals are met, while transitioning to clean energy, thereby securing a sustainable energy future for the country. Having surpassed its initial NDC targets well ahead of schedule, India enhanced its commitments at COP 26 by updating its NDCs to include reducing emissions intensity of GDP by 45% below 2005 levels by 2030 and ensuring 50% of electric power installed capacity from non-fossil fuel sources by 2030[1].

1.1 Energy Demand

India's energy demand is expanding rapidly, driven by robust economic growth, urbanization and industrialization. In 2022, the country's energy consumption was 618 million tonnes of oil equivalent (Mtoe), with the industrial sector being the largest consumer, accounting for nearly 45%, followed by transport, cooking, buildings, agriculture, telecom, and others[2]. This energy demand is expected to rise significantly to 1,102 Mtoe by 2032, representing a 78%[3] increase, with the industrial sector projected to be the largest consumer, accounting for nearly 50% of the total energy demand.

[1] - *https://pib.gov.in/PressReleasePage.aspx?PRID=1983201.*
[2] - *https://iess2047.gov.in/#?inputs*
[3] - *https://iess2047.gov.in/#?inputs*

India has witnessed a steady rise in power demand, increasing by 50.8% from 2013-14 to 2022-23[4,5]. In May 2024, the country successfully met its highest-ever peak demand of 250 GW[6]. Future growth of power demand is expected to accelerate further due to increased electrification of the economy, the adoption of electric vehicles, e-cooking, rising energy needs from data centres, heating and cooling needs and initiatives like green hydrogen.

According to projections from the 20th Electric Power Survey (2022)[7], peak electricity demand is forecasted to grow at CAGR of 6.42% during 2022-2027 and 5.74% during 2027-2032.

1.2 India's Diversified Energy Mix

India's energy landscape is intricate, reflecting its reliance on diverse sources of energy, and is undergoing significant transformation driven by economic growth and energy security as envisaged under Sustainable Development Goal 7 (SDG7). Despite these changes, India's per capita energy and electricity consumption remains well below the global average. The per-capita energy consumption has increased from 0.511 tonnes of oil equivalent (toe) in 2014 to 0.607 toe in 2023[8], an increase of 18.7 %, whereas the per-capita electricity consumption has increased by 45% in the corresponding period, from 957 kwh in 2014[9] to 1395 kWh in 2023[10].

India's primary energy mix relies mainly on fossil fuels. As on March 2023, the share of fossil fuels in the primary energy mix was about 84%[11], with Coal and Oil as main contributors with a share of 47% and 29% respectively (Figure:1). India currently imports over 40% of its primary energy requirements, worth over USD 90 billion every year[12]. India's energy consumption has doubled in the last two decades and is likely to grow by at least another 25% by 2030[13].

[4] - https://pib.gov.in/PressReleasePage.aspx?PRID=1988262.
[5] - https://www.mospi.gov.in/sites/default/files/publication_reports/EnergyStatistics_India_publication_2024N.pdf (March 24)
[6] - https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2022257
[7] - https://cea.nic.in/wp-content/uploads/ps___lf/2022/11/20th_EPS____Report___Final___16.11.2022.pdf
[8] - https://www.mospi.gov.in/sites/default/files/publication_reports/EnergyStatistics_India_publication_2024N.pdf.
[9] - CEA Inputs
[10] - https://cea.nic.in/wp-content/uploads/pdm/2024/08/Growth_Book_2024.pdf.
[11] - https://www.indiabudget.gov.in/economicsurvey/doc/eschapter/echap06.pdf
[12] - https://pib.gov.in/PressReleasePage.aspx?PRID=1937584
[13] - https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1937584

a) Coal: Coal continues to play a vital role in electricity generation and industrial applications such as steel, sponge iron and paper, among others. India has one of the largest deposits of coal and lignite in the world with estimated reserves of 389.4 and 47.3 billion tonnes (as of March 2024) respectively[14]. The power sector remains the largest consumer of coal, with a share of 70.4%. In FY 2024, the overall consumption of coal was 1,225 million tonnes with an import share of 261 million tonnes.

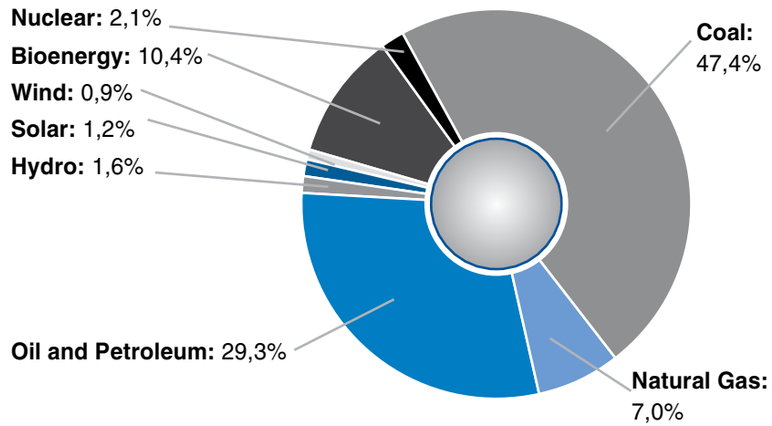


Figure 1: *Total Primary Energy Supply in FY 2023 in percentage (885 Mtoe)*

b) Oil[15]: India also depends on crude oil imports to meet the growing needs from transportation and the industrial sectors. During 2023, India's crude oil imports stood at 233 million tonnes against 185 million tonnes in 2013, representing an increase of 26%. The overall consumption of petroleum products in 2023 was 248 million tonnes against the 175 million tonnes in 2013, representing an increase of 42 %.

c) Natural Gas: At present, natural gas contributes 7% to India's total primary energy supply and is planned to grow to 15% by 2030. In 2023, the energy sector's use of natural gas accounted for 35.40 billion cubic meters (BCM), while non-energy sectors, particularly industrial processes, including chemical and fertilizer production, account-

[14] - https://iced.niti.gov.in/energy/fuel-sources/coal/reserve
[15] - https://iced.niti.gov.in/energy/fuel-sources/oil/consumption#sector-wise-consumption

ed for 23.29 BCM[16]. India is a significant importer of natural gas. The total import stood at 26.30 BCM[17] in 2023, playing a critical role in meeting the rising demand from power generation, industries and piped gas domestic distribution network.

d) Renewable Energy: India is diversifying its energy mix by increasing the share of renewable capacities. Over the past decade, India's renewable energy sector has experienced exponential growth. The installed renewable energy capacity has increased from 76.37 GW[18] in March 2014 to 203 GW[19] in October 2024, outpacing many developed economies. In the corresponding period, the proportion of thermal sources in the total installed electricity capacity has decreased from 68.9%[20] to 53.4%[21]. As of October 2024, India's total installed capacity stood at 454.5 GW, comprising 243 GW of thermal, 8.18 GW of nuclear and 203 GW of renewables including hydro, solar and bio energy (Figure 2)[22]. Initially viewed as a supplementary source of energy, renewables now constitute a crucial component of India's energy mix. The incremental

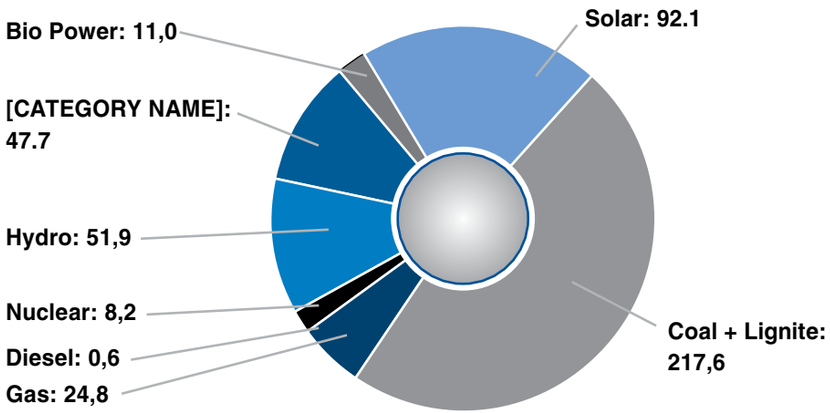


Figure 2: *Installed power capacities as on October 2024: 454.5 GW* ***Values in GW**

[16] - *https://iced.niti.gov.in/energy/fuel-sources/gas/consumption*
[17] - *https://www.mospi.gov.in/sites/default/files/publication_reports/EnergyStatistics_India_publication_2024N.pdf*
[18] - *MNRE Inputs*
[19] - *https://cea.nic.in/wp-content/uploads/installed/2024/06/IC_September_2024_allocation_wise.pdf*
[20] - *https://cea.nic.in/executive-summary-report/?lang=en*
[21] - *https://cea.nic.in/wp-content/uploads/installed/2024/08/IC_Sep_2024_allocation_wise.xlsx*
[22] - *https://cea.nic.in/wp-content/uploads/installed/2024/08/IC_Sep_2024_allocation_wise.xlsx*

annual additions to renewable energy capacity underscores India's steadfast commitment to energy transition.

India further aims to diversify its energy sources, including offshore wind, large and small hydro, green hydrogen, nuclear, energy storage and bioenergy. According to the National Electricity Plan issued in May 2023, India aims to reach an installed capacity of 900 GW by 2032[23], with non-fossil fuel-based capacity projected to reach 615 GW[24], comprising 68% of the total capacity—an increase from the current 46.5% (211.4 GW as of October 2024)[25]. These planned capacities and diversification will help in strengthening energy security while supporting low-emission pathways, in line with national commitments and priorities.

1.3 Ensuring a Just, Affordable and Inclusive Energy Transition

India's energy transition rests on three key pillars; Energy Access, Energy Security, and Energy Affordability with the goal of "Leaving No One Behind". India has aligned its national initiatives with the Sustainable Development Goals (SDGs). Since 2018, India has witnessed substantial progress in several key SDGs including access to affordable and clean energy.

1.3.1 ENSURING ENERGY ACCESS

Several initiatives, including investments exceeding US$ 22 billion in schemes like Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY), Integrated Power Development Scheme (IPDS), SAUBHAGYA, and Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY)[26], have been instrumental in improving electricity access nationwide. Under the SAUBHAGYA scheme, a staggering 28.6 million households of the country were provided electricity connection in a record time of 19 months, which the world community recognized as the largest and fastest expansion of energy access in the history of the power sector. Availability of power availability in rural areas has increased to 20.6 hours, and to 23.8 hours[27] in urban areas, resulting in reduced power shortage from around 4.5% in 2014 to less than 1% currently[28].

[23] - *https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1928750*
[24] - *CEA Inputs*
[25] - *https://cea.nic.in/wp-content/uploads/installed/2024/08/IC_Aug_2024_allocation.pdf*
[26] - *https://www.pib.gov.in/PressReleasePage.aspx?PRID=2003921*
[27] - *https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1992405*
[28] - *https://pib.gov.in/PressReleasePage.aspx?PRID=1997726*

India has also made significant strides in expanding access to clean cooking through initiatives like the UJJWALA (PMUY) scheme, which aims to provide Liquified Petroleum Gas (LPG), reduce reliance on traditional fuels, and improve indoor air quality. Over the last one decade, significant improvement has been recorded in the number of households with access to clean cooking fuel. Over this period, the LPG customer base has increased from 145 million to 324 million, wherein 103 million consumers have directly benefitted from the PMUY scheme. India's leadership in expanding clean cooking programmes in rural areas has resulted in a nearly three-fold increase in LPG imports over the past decade, with continued demand growth expected through 2030[29].

1.3.2 ADVANCING CLEAN ENERGY TRANSITION

India aims to achieve 500 GW non fossil fuel installed electricity capacity by 2030. A range of policy measures and initiatives have been implemented for creating an enabling ecosystem to foster widespread adoption of renewable energy in India. At present, globally India ranks fifth in terms of installed solar capacity of 92 GW[30] , set to rise to 280 GW by 2030, and fourth in wind energy with 47 GW[32] installed capacity, projected to reach 140 GW[33] by 2030.

To integrate this capacity, India is expanding its grid capacities with an estimated investment of USD 29.4 billion[34] . Further, measures including allowing 100% Foreign Direct Investment (FDI) under the automatic route, waiving Inter State Transmission System (ISTS) charges for solar and wind power and setting Renewable Purchase Obligation (RPO) trajectories up to 2029-30 have been undertaken. Initiatives like the Green Energy Corridor Scheme and Green Energy Open Access Rules have also been introduced with the aim to enhance transmission infrastructure for renewable power[35]. Some key initiatives are detailed below:

a) Production Linked Incentive (PLI) Scheme for High Efficiency Solar PV Modules[36]: Solar PV manufacturing remains a significant focus of the Government's efforts. The Government is committed to making India self-reliant (Atmanirbhar) in solar PV manufacturing and establishing India as a major player in the global value chain. This commitment is demonstrated by the USD 2.8 billion outlay for the PLI Scheme for High-Efficiency Solar PV Modules and additional policy interventions, such as the imposition of basic customs duties and domestic content requirements.

Since 2014, India's installed solar PV module manufacturing capacity has grown from 2.3 GW to approximately 67 GW, thanks to various measures under the "Make in India" initiative. This increase makes India capable of meeting domestic demand while also catering to exports. The country has seen rapid growth in solar PV module production capacity, jumping from 8 GW in 2021 to 67 GW per year in the last 3.5 years alone.

Furthermore, over 48 GW of fully or partially integrated solar PV module manufacturing projects are currently under implementation under the solar PLI scheme. Once completed, these projects will create direct employment for around 45,000 people. The solar PLI scheme will also bring cutting-edge solar PV module manufacturing technology to India, reducing the country's dependence on imports. With the solar PLI scheme and the Government's supportive policy framework, India is projected to achieve 100 GW per year of solar module production capacity by 2026, which will not only satisfy domestic demand but also contribute to earning foreign exchange through exports.

b) Scheme for Development of Solar Parks and Ultra-Mega Solar Power Projects[37]: To develop 50 solar parks with a cumulative capacity of 40,000 MW by 2025-26, schemes are being designed to facilitate plug-and-play infrastructure for solar project developers. Solar Projects of aggregate capacity of 11,819 MW have been commissioned in various Solar Parks, as of October 2024.

c) PM Surya Ghar: Muft Bijli Yojana[38]: The initiative aims to install rooftop solar systems in residential establishments, providing free electricity up to 300 units per month for 10 million households. The scheme will result in the addition of 30 GW of solar capacity through rooftop solar in the residential sector, generating 1000 BUs of electricity and resulting in a reduction of 720 million tonnes of CO_2 equivalent emissions over the 25 year lifetime of rooftop systems. It is estimated that the scheme will create around 1.7 million direct jobs in manufacturing, logistics, supply chain, sales, installation, O&M and other services.

d) PM KUSUM Scheme: The scheme is aimed at installing standalone solar pumps and to solarize existing grid-connected agriculture pumps. The scheme is one of the

29 - https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2003519
30 - CEA monthly report (August 24)
31 - https://pib.gov.in/PressReleasePage.aspx?PRID=1944075 (30 July 23)
32 - CEA monthly report (August 24)
33 - https://pib.gov.in/PressReleasePage.aspx?PRID=1903462
34 - https://powermin.gov.in/en/content/500gw-nonfossil-fuel-target
35 - https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1988293
36 - https://pib.gov.in/PressReleasePage.aspx?PRID=2058735#
37 - MNRE inputs
38 - https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2010278

largest agriculture solarization initiatives in the world aimed at providing 0.24 Million[39] farmers with access to clean energy for irrigation requirements.

e) Wind Energy Development[40]: India has initiated offshore wind energy projects and developed onshore wind energy projects, to harness India's coastal potential and in parallel promoted indigenization of wind turbine manufacturing. India has issued a 'Strategy for Establishments of Offshore Wind Energy projects' indicating a bidding trajectory of 37 GW by 2030 and various business models for project development. A Viability Gap Funding (VGF) scheme for offshore wind energy projects at a total outlay of USD 887 Million[41], has also been launched.

f) National Green Hydrogen Mission[42]: The mission is aimed at establishing India as a global hub for green hydrogen production, promoting electrolyzer manufacturing and setting up green hydrogen hubs, with an initial outlay of around USD 2.4 billion by 2030. By the year 2030, the Mission aims to achieve at least 5 MMT (Million Metric Tonne) of annual green hydrogen production with an associated renewable energy capacity of about 125 GW and 60-100 GW[43] of electrolyzer capacity.

g) National Biofuel Policy: The policy is aimed at promoting the production and use of biofuels to reduce fossil fuel dependency. This policy aims to achieve 20%[44] blending of ethanol by 2025 and has already achieved 15% ethanol blending during 2024. Over the past decade, this initiative has delivered significant benefits, including saving US$ 11.7 billion in foreign exchange, reducing CO2 emissions by 52 million metric tons and substituting 17.3 million metric tons of crude oil[45].

h) Energy Efficiency Programs[46]:Various initiatives have been launched to improve energy efficiency across sectors, including industrial energy efficiency, appliance standards, and building energy codes (for eg; Energy Conservation and Sustainable Building Code – ECSBC). These initiatives have resulted in total Energy Savings of 51 MTOE which is approximately 6.6% of total primary energy supply and reduction of about 306 Million Tonnes of CO2 emissions.

[39] - https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1944762
[40] - https://pib.gov.in/PressReleasePage.aspx?PRID=1992732
[41] - https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2042071
[42] - https://pib.gov.in/PressReleasePage.aspx?PRID=1888547
[43] - https://pib.gov.in/PressReleasePage.aspx?PRID=1937584
[44] - https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1982356
[45] - https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2050907#
[46] - BEE Reports

i) National Carbon Markets: India is currently working on establishing the Indian Carbon Market (ICM) as an essential element of its climate action strategy, focusing on energy conservation and reduction of GHG emissions. This carbon market is expected to facilitate the wide spread adoption of clean energy technologies across the country, ultimately contributing to the decarbonization of India's economy.

j) Transmission Plan and Revamped Distribution Sector Scheme (RDSS): India has made significant strides in its transmission, distribution and smart grid sectors, driven by its goal to modernize the power infrastructure and enhance energy access. The country has expanded its transmission capacity to integrate renewable energy, with major inter-regional links and green energy corridors (GEC) under development. GEC is a pivotal initiative by Government of India to create intrastate transmission systems of about 20,450 ckm for renewable energy projects across ten states.

In the last 9 years, with the addition of 1.87 lakh ckm (64.48% increase from 2015) the transmission network has grown to 4.85 lakh ckm[47] making it the largest national synchronous grid in the world. Further transmission network in the country will be expanded to 6.48 lakh ckm[48] by 2032. The inter-regional transfer capacity is set to expand from 119 GW to 168 GW by 2032. The policy aims to address the growing electricity demand, while supporting the integration of renewable energy and green hydrogen into the grid.

Distribution reforms, such as the Revamped Distribution Sector Scheme (RDSS) with an outlay of USD 36 billion over 5 years, aim to help distribution companies improve their operational efficiencies and financial sustainability. Under the scheme about 250 million[49] prepaid smart meters will be installed. Looking ahead, the country plans to deepen these initiatives, focusing on renewable integration, smart grids and leveraging digital technologies to achieve its ambitious net-zero targets by 2070.

These initiatives underscore India's commitment to achieving SDG 7 and transitioning towards a sustainable and inclusive energy future, requiring further collaborative efforts from policymakers, industry stakeholders, civil society, and international partners.

[47] - https://pib.gov.in/PressReleasePage.aspx?PRID=1992405
[48] - 100 days achievement of MoP
[49] - https://pib.gov.in/PressReleasePage.aspx?PRID=1992405

1.4 Technology Advancement and Modernisation for Energy Transition

India's focus on technology advancement within the energy sector is shaped by its unique national characteristics, capabilities and developmental objectives, including its commitment to achieving Net Zero goals by 2070. India has actively pursued the adoption and deployment of modern energy technologies, to enhance energy access, energy security and promote sustainability.

To bolster grid stability, manage renewable source intermittency and improve energy access in remote areas, India is increasingly integrating energy storage technologies such as battery storage, pumped hydro storage and thermal energy storage into its grid infrastructure. Advancements in battery technology, supporting energy storage solutions for electric vehicles (EVs), charging infrastructure and off-grid applications, is pivotal to India's energy transition agenda.

In tandem, initiatives like Smart Grid and Grid Modernization, incorporating advanced metering infrastructure (AMI), distribution automation, and demand response systems, are being implemented to enhance grid efficiency, reliability, and resilience. These efforts are crucial for integrating renewable energy, facilitating two-way communication between utilities and consumers and optimizing energy management.

However, India's dependence on fossil fuels, to meet its increasing energy needs will continue, along with policy initiatives to reduce emissions. The policy on Bio-mass Utilization for Power Generation through Co-firing in Coal based Power Plants mandates the thermal power plants to use 5% blend of biomass pellets made, primarily of agro-residue, further, to be increased to 7% from FY 25-26[50].

India is also exploring possibilities of implementing low-emission solutions, including Carbon Capture, Utilization and Storage (CCUS), clean coal technologies, coal gasification, and coal bed methane (CBM) extraction. These technologies not only mitigate carbon emissions but also stimulate economic growth and job creation in a just and sustainable manner.

Critical to the successful adoption of these technologies is access, sharing of technologies, best practices, concessional and low-cost financing and grant-based financial support from developed countries, pivotal for achieving the goals of the Paris Agreement. India is diligently addressing barriers such as financing constraints, policy and regulatory challenges, and technological hurdles to expedite deployment and widespread adoption of these technologies nationwide.

Collaboration with international partners, research institutions, and organizations is instrumental to access modern energy technologies, leveraging expertise, and facilitating technology transfer and capacity building. India plays a leading role in bilateral and multilateral initiatives including the International Solar Alliance (ISA), Clean Energy Ministerial (CEM), and Sustainable Energy for All (SEforALL), fostering knowledge exchange, technology sharing, and best practices in energy access and sustainability.

Looking ahead, India's focus on phased development of clean technologies is crucial for ensuring long-term energy security. This necessitates technology transfer from developed nations. Challenges associated with importing clean technologies, equipment, materials, and supply chain issues can be mitigated through enhanced international cooperation.

By integrating these efforts with the principles of Just Transition, countries can ensure an equitable transition based on equity and Common but Differentiated Responsibilities and Respective Capabilities (CBDR-RC). ■

[50] - *https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1945245*

IRAN

1 OVERVIEW OF THE ENERGY SECTOR

With estimated 209 billion barrels, Iran holds 12% of the world oil reserves. Moreover, Iran's natural gas reserves are estimated at around 32.6 trillion cubic meters, which accounts for 17% of the world's proven natural gas reserves.

As one of the largest oil and natural gas producers in the world, the energy sector has greatly contributed to Iran's economy. The energy sector which is primarily dominated by oil and natural gas production plays a significant role in generating revenue to boost national development and also accounts for a significant portion of the government's budget.

Iran is known for its diverse natural climate. While in some northern areas, the temperature drops to -20°C during winter, people in the south enjoy a bright sunny sky with temperatures exceeding +20°C. As expected, a reverse situation is witnessed in summer. Considering this significant gap in the climate, providing people and industries with sufficient energy has been a technical challenge that could not be addressed without vast and spacious gas and electricity networks as well as a large transportation system.

Along with fossil energy sources, Iran has considerable natural endowment regarding the renewable energy potential, mainly hydro, solar, and wind power. Iran generates the highest amount of hydroelectricity among the countries in the Middle East. However, the output of hydro power plants which are concentrated noticeably in the west and southwest of the country, has been affected by the regional droughts in the past recent years. In case of wind electricity, Iran is the only country in the Middle East with already installed large scale wind turbines. Local studies estimated that Iran has

47GW potential for wind-electricity. As for geothermal energy, studies show that 8.8% of total land in Iran has the capability of geothermal energy production. Solar potential in Iran comes from 300 clear sunny days and annual average 20-30 MJ solar radiation per square meter which makes its spacious sun-kissed land one of the best regions to harness solar energy. In recent years, higher emphasis has been put on diversification of the energy portfolio via exploiting these potentials to achieve rapid expansion in harnessing renewable potentials.

It is worth mentioning that, from an administrative point of view, the energy sector in Iran is governed by two separate ministries and one separate organization:

- Ministry of Petroleum, in charge of oil, gas, and petrochemical products
- Ministry of Energy (MOE), in charge of electricity and water
- Atomic Energy Organization of Iran (AEOI)

1.1 Energy production and consumption

Total energy supply in the fiscal year 2021-2022 exceeded 2121 Mboe, marking a 2.5% decline from the previous year. During the same period, final energy consumption amounted to 1,583.9 Mboe in 2021-2022, experiencing a decrease of approximately 2.7% compared to the previous year. This reduction was partly attributed to initiatives focused on energy conservation and efficiency improvements.

Due to ease of access to fossil energy, as is observed in Figure 1, a large amount of this energy is met using these energy carriers, and more specifically from natural gas.

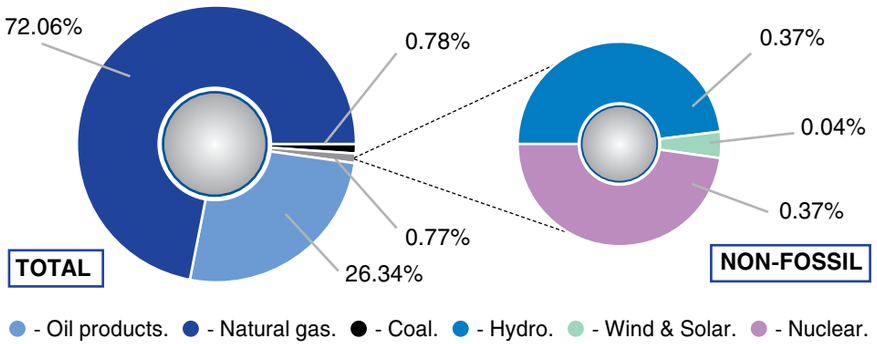


Figure 1: *Primary Energy Supply (Fiscal year: 2021-2022)*

As shown in Figure 2, over an 8-year period, total energy production rose from 1,663 Mboe in 2013 to 2,121 Mboe, reflecting a yearly increase of over 3%. Additionally, in the fiscal year 2021-2022, Iran's crude oil refinery capacity exceeded 791 million barrels.

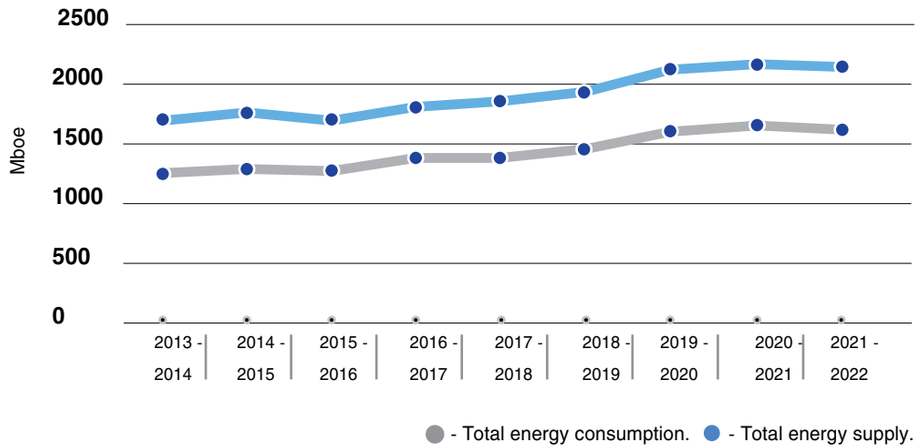


Figure 2: *Annual trend of energy supply and consumption*

As of the fiscal year 2021-2022, more than 29% of the total energy is consumed in the residential sector, with industrial sector and transportation accounting for 28% and 23% of annual energy consumption, respectively.

Due to its abundance of energy sources and minerals, Iran is home to a variety of large energy-intensive industries including steel production, automobile industry, aluminum complexes, copper industry, and more. Therefore, enhancing energy efficiency is recognized as a key strategy for energy transition, receiving greater attention in energy policies in recent years.

From an energy affordability perspective, Iran has been taking a path to using its vast energy sources as a means of social development, and from this point of view, energy affordability for the whole population, especially in the residential sector, has been highly valued. Real data demonstrate that energy costs for wealthy, and low income families account for 4.7% and 1.8% of the total family expenditure, which is not considerable. Nonetheless, it is contended that the heavily subsidized energy prices have encouraged excessive consumption, affecting their consumption behavior nega-

tively. During the past few years, energy authorities have taken steps towards subsidy reform, which contributed to economic progress in terms of energy conservation and efficiency enhancement.

1.2 Oil

There are multiple oil reservoirs within the Iranian boundaries, with some being shared with neighboring countries. As of 2021, the total production of crude oil, gas liquids, and condensates peaked at around 559 Mboe. Considering the pivotal role of revenue stream from oil export in the national budget, Iran is determined to increase its production volume and in recent years, some official regulations, such as 'The 6th National Development Plan' obliged the Ministry of Petroleum to take necessary measures for increasing oil production capacity, and consequently, around 16,000 square kilometer geological operations were performed in 2021 alone.

In the oil refining sector, during the fiscal year 2021-2022, more than 332 million barrels have been refined per day, with gasoil, petrol, and light fuel oil together accounting for 79.5% of total production. «National Energy Charter», issued by the government in 2017, gave a mandate to the Ministry of Petroleum to promote both quantity and quality of petrochemical products with the aim of gaining higher added value in the supply chain. Gasoil is a petrochemical product which is widely used in transportation as well as industrial activities and power generation. In 2021, gasoil consumption totaled 38 billion liters which was 3.1% higher than the previous year.

1.3 Natural gas

With reserves totaling 32.6 trillion cubic meters as of 2021, Iran holds a significant position in the global natural gas sector, ranking second after Russia. The country's daily natural gas injection amounted to 26.3 million cubic meters in 2021. The nominal capacity for dehydration and refining of natural gas stood at 1,052.8 million cubic meters per day. By the end of 2021, Iran had approximately 38 thousand kilometers of operational pipelines, with an additional 485 kilometers constructed during the year.

In terms of consumption, in 2021 Iran's total final natural gas consumption in the energy sector reached 241.5 billion cubic meters, with 61.1% allocated to final consumption and 38.9% to the energy sector. The breakdown of natural gas consumption among different sectors was as follows: 30.3% for power plants, 28.8% for residential, commercial, and public sectors, 16.2% for industry, 10.7% for petrochemical complexes. Other sectors such as oil refineries and transportation accounted for the remaining 14%. The per capita annual consumption was recorded at 2,783 cubic meters.

1.4 Coal

As for the coal sector, there are more than 200 coal mines, mostly owned by private entities. The country's coal reserve is estimated at around 1,190 million tonnes, predominantly coking coal (75.3%), followed by thermal coal (22.9%), with the remaining 1.7% unspecified.

During 2021, a total of 3,743.5 thousand tonnes of coal were extracted, with coking coal accounting for the largest share. Coal consumption stood at 2,892.5 thousand tonnes, including coking and steam coal, with coke production and consumption recorded at 1,516 and 2,077 thousand tonnes respectively. Additionally, significant volumes of gas coke and blast furnace gas were produced and consumed within the steel industry. To diversify its energy sources, Iran seeks to incorporate advanced technologies for using clean coal in electricity generation.

1.5 Electricity

In 2021, total nominal power generating capacity reached 86,910 MW, with a diverse mix of energy conversion technologies contributing to this figure. Combined cycle power plants accounted for 37.9%, steam power plants for 18.2%, gas turbine units for 27.1%, hydro for 14.0%, nuclear for 1.1%, and diesel generators and renewables for the remaining parts. Approximately 51% of the generation capacity was owned by IPPs, 7.2% by large industries, and the remainder by the state.

Due to new constructions and ceding existing plants to the private sector, the nominal capacity owned by the private sector increased from 42,032 MW in 2020 to 44,056 MW in 2021. Electricity generation in Iran reached 357.0 TWh in 2021, marking a growth of 4.2% from the previous year, with more than 62% contribution from the private owned power plants. As illustrated in Figure 3, the fuel mixture for thermal power generation is highly dominated by natural gas.

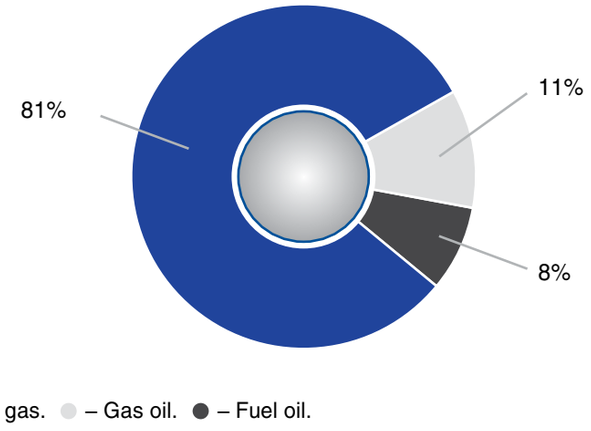


Figure 3: *Primary energy source of thermal electricity generation in 2021*

In 2021, domestic consumption of electricity exceeded 307,143 GWh. The breakdown of electricity in different sectors was as follows: industry 35.9%, residential 32.1%, agriculture 14.2%, public and commercial 8.6%, with the remaining portion allocated to other sectors such as transportation and street lighting. The number of electricity customers (excluding street lighting and illumination) grew from 37.6 million to over 38.6 million, reflecting an annual growth rate of about 2.7%.

The capacity factor for electricity generation increased to an impressive figure of 73.8%, indicating an increase of about 6.7% from the previous year. This index demonstrates the reliability and efficiency with which Iran's power plants are operating, contributing to the country's energy security and economic stability.

Iran, as the 14th largest electricity producer in the world, is currently implementing the 2040 plan for the development of its electricity system. This plan is based on different consumption growth scenarios and aims to increase the production of renewable energy to at least 30% of the electricity production portfolio, enhance the efficiency of thermal power plants from 35% to over 55%, and integrate these improvements into the electricity grid while reducing carbon emissions.

1.6 Nuclear energy

As reflected in the COP28, nuclear electricity sources have drawn great attention due to their environmentally friendly nature. Total nominal nuclear capacity in Iran stood at 1000 MW in 2022, with electricity generation exceeding 6,280 GWh, which rose to more than 6,620 in 2023 constituting around 2 percent of total annual generation. To increase the capacity of nuclear electricity, AEOI is conducting ongoing projects for construction of two nuclear power plants.

1.7 Renewable Energy

Although Iran is a major natural gas producer, it has been paying attention to renewable energy power plants since a long time ago. Since 2006, Iran has utilized off-grid PV systems for rural electrification, with over 360 hybrid systems installed by 2012. However, as the electricity grid expanded, this approach became outdated, though portable PV systems continued to serve extremely remote areas and nomadic communities. In 2013, Iran shifted to a Feed-in Premium strategy for small-scale PV systems to encourage renewable energy use. This, inter alia, led to rooftop PV installations on schools and government buildings via regional solar plant tenders. The current FiT mechanism allows small consumers to install PV systems up to twice of their allowed connection capacity, with a maximum capacity of 200 kW, and to feed the electricity directly into the grid. To manage the large volume of power plants and associated data, a cloud-based web platform was developed for streamlined management and monitoring of all related activities. So far, around 16,000 rooftop PV systems with a cumulative capacity of 180 MW have been installed nationwide. The long-term goal is to install 550 thousand systems with a total capacity of 2,750 MW.

In 2015, Iran's Ministry of Energy introduced a tax-free, long-term Feed in Tariff (FiT) scheme to boost renewable energy in the electricity sector. This initiative aimed to attract private and international investment by offering 20-year power purchase agreements. To fund this, an electricity consumption levy was set, reaching up to 10% for residential customers in the cities, as well as industrial customers. Investors were guaranteed a fixed price for all generated energy over a two decade period, with rates varying by technology and plant size, favoring small-scale PV systems. Additional incentives included higher tariffs for low voltage grid connections, and up to a 30% increase in purchase tariff for using locally

manufactured PV panels and inverters. A mandatory policy also required government buildings to source at least 20% of their energy from renewables, whereas non-compliant buildings face higher electricity costs.

In 2017, Iran established the Renewable Energy and Electricity Efficiency Organization (SATBA) at the deputy minister level to foster energy efficiency enhancement and renewable energy development. SATBA aims to build necessary infrastructure, enhance energy supply efficiency, minimize transmission losses, and encourage private sector involvement through policy-making, regulation, facilitation, and the management of relevant projects. It supports knowledge-based companies and industrial renewable energy users. SATBA's current mission is to increase renewable energy capacity to 30,000 MW and reduce energy losses equivalent to 15,000 MW by 2030, positioning it as the central authority for national energy efficiency.

SATBA's current initiatives focus on developing renewable power plants with private sector collaboration, enhancing energy consumption efficiency, localizing renewable technology, and exporting clean electricity. These efforts aim to ensure stable energy supply, generate industry income, and create jobs. To achieve these goals, various frameworks and mechanisms have been established in recent years as indicated in the table below.

Developing Plan (focus on Construction)	**Method** (MW)	**Capacity**
PV Power Plants (Special rapid construction process)	Auction Mechanism	4,500
PV Power Plants	Auction Mechanism	4,000
Wind Power Plants	Auction Mechanism	3,000
Renewable Power Plants in industries	Buyback Model	4,000
Renewable Power Plants (8GW PV + 2.5GW Wind)	Foreign Finance	10,500
Small-Scale and Rooftop PV Power Plant	Guaranteed Purchase Agreements	2,750
Renewable Power Plants[5]	Green Trading Board	1,000
Renewable Power Plants[6]	Guaranteed Power Purchase Agreements	250
Total		**30,000**

[5] - Iran's green trading board of the energy exchange market, supplying electricity for cryptocurrency mining centers, specialized solar parks, …
[6] - Guaranteed power purchase agreements (Small Hydro, Biomass, Turboexpander, Rooftop Solar Power Plants ,…)

In recent years, and especially after the establishment of 'the Green Trading Board' within the energy exchange in 2023, investing in renewable energy sources has become an appealing option in Iran. Moreover, to promote the development of renewable energy sources and ensure sustainable energy procurement, industries, cryptocurrency mining centers, and governmental entities that procure their electricity via this market have been exempted from obligatory demand side management programs.

Furthermore, based on another initiative promulgated in 2023, industries are now required to source 5% of their electricity from renewables within the next five years, while government administrative sectors must obtain 20% from such sources in the next four years.

By the end of 2023, renewable energy sources reached an installed capacity of 1,113 MW, generating 1,074 MWh of green electricity in 2023. Additionally, projects totaling 5,762 MW in various renewable energy forms are under construction.

1.8 Hydrogen

Iran possesses large oil and natural gas reserves, offering a great opportunity to exploit its energy resources for developing a comprehensive hydrogen strategy. Its large refining and petrochemical infrastructure offers a good potential for hydrogen production, well suited to its established energy sector. As well as improving energy security, this approach paves the way to a cleaner and sustainable future.

Technically, Iran can produce a high amount of hydrogen due to its abundant natural gas resources, primarily via steam methane reforming and gasification.

In the context of hydrogen generation, there should be a concentration on building up a renewable energy infrastructure (starting with solar and wind) for providing the required energy. This will help to lower the country's carbon footprint whilst offering more sustainable energy sources.

Since 1996, several projects have been developed in Iran to produce clean hydrogen through water electrolysis. Years later, production, storage, and consumption of hydrogen in fuel cells were also implemented in a demonstration site based on a national fuel cell strategy that was adopted in 2007. Moreover, pilot projects for hydrogen production, purification, and usage of Proton Exchange Membrane (PEM) or Solid Oxide Fuel Cells (SOFC) were implemented in different universities and research institutes.

Recently, National Hydrogen Value Chain Development Document has been developed to catalyze research projects and activities for integrating hydrogen technologies into the power sector, with a focus on the renewably energized hydrogen production and shaping the green hydrogen economy in the future. This is a step toward creating a clear plan for governmental policies to support businesses based on the development of the hydrogen sector in Iran. The use of hydrogen can, for example, ease the energy source diversification needed in power generation, transportation, and, to some extent, in the industrial sector. The formation of a strong hydrogen value chain in Iran is not only a chance for the state to reduce greenhouse gas emissions and transition to a clean fuel, but also a chance to create new lucrative industries and contribute to sustainable economic development.

National Hydrogen Value Chain Development Document is expected to be officially announced by the end of 2024, marking the beginning of a new era for the hydrogen sector in Iran. There is a positive outlook for the development of the sector since the document will present the needed funding mechanisms, policies, and legal frameworks that will foster the development of the sector. It will also determine primary areas for industrial research and development, along with international collaboration and partnerships.

2 POLICY, GOALS, OBJECTIVES AND INSTRUMENTS FOR IMPLEMENTATION OF JUST ENERGY TRANSITION IN IRAN

2.1 Energy economy indicators

Iran's per capita final energy consumption stands out significantly when compared to global averages. Breaking down the per capita final energy consumption by sectors reveals that agriculture, residential, public and commercial, transportation, and industry sectors in Iran consume 3.4, 2.1, 1.6, and 1.5 times more energy than the global average, respectively.

To address these challenges, Iran has implemented several policies aimed at improving energy efficiency across various sectors:

1. Energy efficiency in buildings: Iran has reviewed its policy frameworks impacting building efficiency. Efforts include revising building codes, product standards, and energy labels, as well as developing a supportive cross-sectoral energy efficiency strategy.

2. Emission reduction: In partnership with UNDP and Tehran Municipality, Iran aims to improve energy efficiency by 25% for existing buildings and by 60% for new buildings. This is part of the efforts to reduce carbon dioxide emissions, where residential and commercial buildings are significant contributors.

3. Renewable energy: The future perspective of renewable energy sources development in Iran to increase the share of renewables and clean power plants reflects Iran's commitment to the enhancement of energy efficiency and reducing its carbon footprint.

According to Iran's economic policies presented in the National Document on Energy Strategy, the main goals and objectives of the energy sector are stated as follows:

- Increasing the energy efficiency and reducing the energy intensity;
- Maximizing the oil and gas production from shared fields;
- Focusing on proper policymaking to develop Iran's energy sector, including oil, gas, electricity, renewable energies, nuclear, and coal;
- Improving the security, reliability, stability and quality of the energy supply;
- Waste recycling and reducing losses in energy production and consumption side with regards to account environmental issues and standards;
- Realizing the price of energy carriers for energy producers.

In this document, general strategies of Iran's energy sector are summarized as follows:

- Reducing waste and losses in production, transmission, distribution and consumption of energy to the national standard levels;
- Technological advancement in the energy supply chain;
- Effective use of Iran's regional and geographical location for buying, selling, exchanging, and swapping energy carriers in domestic and regional markets;
- Expanding the business opportunities of Energy Service Companies (ESCOs);
- Conversion and production of energy carriers with a higher added value;
- Commercialization of renewable and environmentally friendly energy technologies;
- Technical advancement within the energy sector;
- Reducing emissions of greenhouse gases and pollutants caused by production, transmission and consumption of energy carriers;
- Reducing electricity distribution losses to the average level of developed countries;
- Increasing the share of renewable energy in electricity generation capacity;
- Improving the energy efficiency of thermal power plants to the average level of developed countries;
- Optimal use of coal in energy supply and electricity generation along with environmentally friendly technologies;
- Supporting the domestic production of equipment used in renewable energy production;

2.2 Ensuring Access to Modern Energy Forms

Providing access to modern energy forms has been one of the oldest and most successful policies in Iran. Despite technical and economic challenges, Iran effectively managed to provide its citizens with firm access to natural gas, even in the most remote areas of the country. In the residential sector, 98.75% of the households in urban areas and 86.11% of the rural ones are connected to the national gas network, together covering 95.54% of the population in the country.

Moreover, aligned with the policies regarding social equity, Iran has pursued a robust policy of expanding its national power network and ensuring electricity access. While less than 6,000 villages had access to electricity in 1979, thanks to the significant and continuous investment in rural electrification, the number of villages with electricity access rose to 58,686 by the end of 2022. In case of residential sector by the end of 2022, 100% of the residents in urban areas and more than 99.97% of the rural population had access to electricity and there were more than 31.5 million residential grid connected customers nationwide.

2.3 Ensuring Energy Security

Energy security has a fundamental strategic importance for Iran's economic prosperity and stability. The country is a world's key player in the production of oil and natural gas whereas its energy sector is an essential part of its economy. Country's energy infrastructures have been developed over the years and adequate provisions have been made to deal with energy breakdowns. Also, the Iranian energy sector has well-established bodies and regulations, which enable the country to utilize its energy resources in a way that would benefit the entire economy as well as the social welfare.

With its substantial energy reservoirs, Iran is well-positioned to maintain its energy security and ensure a stable energy future, showing a unique advantage in terms of energy security. As mentioned earlier, Iran's energy sector is a key driver of its economic growth, having a large share in its GDP. To further enhance its energy security, Iran has implemented several strategies. One key strategy is to diversify its energy mix via investment in renewable energy sources such as solar and wind power to reduce its reliance on fossil fuels and mitigate the impact on climate change. Furthermore, the country has implemented energy efficiency measures to reduce energy consumption and improve the efficiency of its energy infrastructure.

It is worth mentioning that despite vast energy reserves, there exists an imbalance between supply and consumption during peak load periods. Gas consumption reaches its peak load in winter, while electricity consumption peaks during summer. Iran, as a developing country, grapples with rising energy demand during these peak times. This trend has triggered energy authorities to emphasize the need of attracting both local and international investors, as well as take major steps towards energy efficiency advancement and demand side management to tackle this issue.

2.4 Ensuring Energy Efficiency and Energy Saving

Considering the structure of energy subsidies, low energy tariffs, and vast electricity and gas network in Iran, national energy authorities have put an emphasis on energy efficiency enhancement policies as well as energy conservation guidelines.

In this regard, Iranian Fuel Conservation Company (IFCO) was established in 2000 as a subsidiary of National Iranian Oil Company (NIOC), with a focus on different aspects of fuel consumption including:

- Implementing policies related to optimizing fuel consumption in various sectors of consumption;
- Applying demand management;
- Compilation of standards, criteria and guidelines related to the optimization of energy consumption.

A number of actions taken so far by IFCO are listed below:

- Developing general energy policies, and specific energy standards;
- Implementing a large-scale plan for substituting petrol with CNG in the transportation fleet;
- Compilation and revision of standards for energy consumption in industry, construction and transportation sectors;
- Improving public awareness and promotion of social attitude towards energy conservation;
- Conducting energy audits in industrial units and setting up a system for monitoring, measuring and validating energy saving plans;
- Optimizing energy consumption based on standard ISO50001;
- Providing appropriate mechanisms to support Energy Service Companies (ESCO);
- Establishment of energy efficiency and environment market.

Mid-Term MOE's energy efficiency developing plans are based on 3 main legal and financial mechanisms to reach 10 GW of equivalent power consumption reduction:

- Mandatory energy consumption standards and energy efficiency labels.

This mechanism is designed to revise energy efficiency labels in various devices including: air conditioning systems, lighting products, electromotors, refrigerators, and elevators. In addition, mandatory energy consumption standards for several industrial activities such as aluminum, tile and ceramic, iron and steel production, as well as casting industries are issued.

- Market mechanism to boost energy efficiency and climate change abatement.

This mechanism intends to establish a market structure to optimize energy consumption in all sectors.

- Fuel saving as a means for investment in efficiency advancement.

This mechanism aims to provide financial backing from fuel saving, to optimize energy consumption in home appliances, especially air conditioning and lighting systems.

2.5 Ensuring Environmental Friendliness and Reducing Climate Impact

As already mentioned, Iran is a home to various energy intensive industries and because of that, there is a considerable potential for climate change mitigation. This potential can be harnessed through proper support in terms of finance, technology transfer, and capacity building to reduce the carbon footprint of the energy industry. In line with international efforts to reduce greenhouse gas emissions, Iran has consistently adopted national policies and guidelines to fight climate change, adhering to the principle of «Common But Differentiated Responsibilities». Iran presents its «Intended Nationally Determined Contribution» in the areas of mitigation, vulnerability, and adaptation.

Iran aims to reduce its greenhouse gas emissions through the development of combined cycle power plants, renewable energy, and nuclear power, as well as reducing gas flare emissions, increase energy efficiency and substituting high-carbon fuels with natural gas. Also, to enhance public awareness and participation, there is an emphasis on developing effective market-based mechanisms to promote investment in energy conservation and emission reduction.

2.6 Scientific and Technological Base

Iran's scientific and technological base plays a crucial role in Just Energy Transition to shift from its heavy reliance on fossil fuels to more sustainable and RES-based energy systems. Iran's government has implemented some initiatives to promote RES and energy efficiency, such as development of solar and wind power projects, and integration of RES into the national grid. Technological innovation has a significant impact on renewable energy development in Iran. Transforming today's predominantly carbon-based energy system into one based on renewable or low-carbon sources requires technologies that facilitate Iran's energy transition. International cooperation in technology innovation is crucial to accelerate energy transitions globally. Cooperation among countries, companies, and research institutions can drive systematic change by aligning resources and supporting innovations. Key scientific and technological factors that are important for Iran's energy transition transition are as follows:

1. Renewable energy development: Iran has significant potential for renewable energy sources like solar, wind, and hydropower, but their utilization has been limited so far. Developing all technological capabilities and infrastructure as well as international collaboration and investments to harness these renewable resources is crucial for Iran's energy transition are as follows:

2. Energy efficiency improvements: Recent initiatives issued by energy authorities in Iran consider energy conservation and efficiency enhancement as one of the top priorities with considerable practical potential, aiming at reducing Energy Intensity Index. This unprecedented emphasis on implementing energy-saving measures in various sectors like industry, residential and commercial buildings, and transportation is a response to high growth rates of energy demand in Iran which can significantly reduce energy intensity and emissions.

3. Grid modernization and integration of renewables: In order to harness Iran's renewable potential at large scale, upgrading power system flexibility to accommodate high volume of intermittent renewable energy sources is an essential prerequisite. This includes technologies like smart grids, energy storage, and demand-side management.

4. Alternative fuel technologies: Transitioning from conventional fossil fuels towards alternative fuels such as biofuels and hydrogen, as well as electrification of rail and road transportation require technological advancements and infrastructural development.

5. Carbon Capture, Utilization and Storage (CCUS): Given Iran's reliance on fossil fuels, CCUS technologies could play a key role in reducing emissions by the oil and gas industry. However, further scientific investment and international collaboration with countries experienced in CCUS projects are needed to develop this technology in Iran.

6. Increased R&D investments and activities are vital for technological innovations in Iran's Just Energy Transition. From Iran's perspective, major benefits of international R&D collaboration include:

- Pooling financial resources, sharing risks, and setting common standards for large or risky research projects
- Networking to identify possibilities for collaborative efforts
- Supporting a diverse global portfolio of energy technologies
- Facilitating technology deployment

7. Public education and awareness of the importance of energy efficiency and benefits of a sustainable energy transition

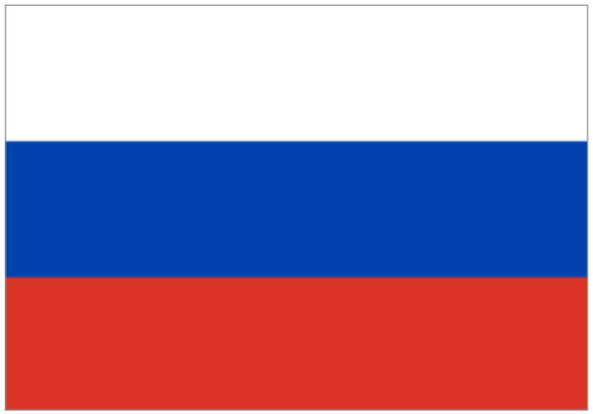
8. Innovation and knowledge-based economy for long-term economic growth and development in energy transition

9. Starting in 2017, the Renewable Energy and Energy Efficiency Organization (SATBA) has issued guidelines to encourage the use of locally produced renewable energy equipment. These guidelines facilitate the manufacturing of essential equipment for renewable power plants, either through localization or licensed production. As an incentive, this localization effort is taken into account in determining electricity purchase tariffs.

2.7 Instruments for Just Energy Transition

During past decades, there have been several high level initiatives and guidelines that can pave the way for Just Energy Transition in Iran. Some of the most important ones are as follows:

- Developing knowledge-based industries related to the renewable energy and market development for these industries as well as producing clean electricity, as mentioned in Knowledge-based Production Leap law (issued in 2022);
- Supplying large customers by constructing efficient thermal power plants and renewable energy-based ones, as referred to in a law entitled Development of the Electricity Industry (issued in 2022 by the parliament);
- Smartening of power distribution networks according to the Development of the Electricity Industry;
- Achieving energy conservation goals and reducing energy intensity through the implementation of Modification of the Energy Consumption Pattern (issued in 2010 by the parliament);
- Taking effective measures to reduce energy intensity according to the 7th National Development Plan of the Islamic Republic of Iran (issued in 2024 by the parliament);
- Energy loss reduction by implementing Penalizing Unauthorized Consumption of Water, Electricity, and Gas (issued in 2017 by the parliament);
- Mandating governmental entities to obtain 20% of their electricity consumption from renewable sources according to the Knowledge-based Production Leap law (issued in 2022). ■



RUSSIA

OVERVIEW OF THE ENERGY SECTOR

The Russian fuel and energy complex (hereinafter – FEC) is a multifaceted and intricate system, which includes oil, natural gas, petrochemical, coal, oil shale and peat industries, power sector and heating. It holds a significant place in the Russian economy, generating revenues for the budget system of the Russian Federation and serving as the largest consumer for related industries.

The share of the Russian FEC in fixed capital investments is about one third of the total volume, in the structure of federal budget revenues – about 45%, in the Russian exports (in value terms) – 65%. At the same time, the share of those directly employed in FEC industries is less than 4% of the total number of people employed in the economy.

The Russian energy infrastructure, which is based on the Unified Power System (hereinafter – UPS) of Russia, the Unified Gas Supply System, regional gas supply systems, trunk pipeline system for transportation of oil and petroleum products, trunk and distribution heat networks, is one of the longest in the world and operates in various natural and climatic conditions – from the Arctic to the subtropical zone.

Among other countries, the Russian Federation takes a unique position as a major producer, consumer and exporter of energy resources, being among the world leaders in hydrocarbon reserves, production and export of energy resources, as well as in the development, use and export of nuclear energy technologies. At the same time, among the world`s largest economies, the Russian fuel and energy balance

of the Russian Federation (hereinafter – FEB) is one of the most environmentally friendly (low-carbon).

All things considered, the Russian FEC performs key system-forming functions in the national economy and social sphere. At the same time, the industrial sectors included in the Russian FEC are characterized by a variety of production and technological functions. The nature of production and supply to consumers of certain types of fuel and energy resources (hereinafter – FER) that make up the products of the Russian FEC are determined by the general pace and regional specifics of the Russian economic development and the dynamics of external demand for Russian energy resources.

Further, to analyze the course of the energy transition, the change in the contribution of each energy source to the total energy balance over the 10-year period is considered.

1 ENERGY PRODUCTION, ENERGY CONSUMPTION, ENERGY TRADE

1.1 Energy Sectors

The total energy production in the Russian Federation has been growing from year-to-year. Since 2021, the figure has increased by 9.75% as compared to 2011 and reached 2,727 million tonnes of fuel equivalent. The level of energy consumption in the Russian Federation annually shows moderate positive growth. In 2022, the total consumption of FER in the country reached 1,027.9 million tonnes of fuel equivalent[8] .

Over the past decade, the share of natural gas, recognized as the most environmentally friendly fossil fuel, in Russia`s total energy consumption has grown from 33% to about 40%. Over this period, the share of oil in the structure of total energy production reached 35%, with coal accounting for about 15% and primary electricity production, including renewable energy sources (hereinafter – RES), and other fuels accounting for 10%.

Within the structure of primary energy consumption in the Russian Federation natural gas has the largest share – 54%. The share of crude oil is 18%, coal – 12%.

Thus, the Russian Federation has implemented a diversified approach to energy supply for the economy and the social sector.

Russia is recording an increase in electricity consumption per capita, which can be explained by the growth of national economy. By the end of 2022, the figure reached 1,153.6 MWh, which is 8.5% higher than in 2012.

1.2 Coal

In 2023, coal production reached 438.7 million tonnes which is more than 20% higher than in 2013 (98.7% of the 2022 level). In 2023, coal was produced in Russia by 179 enterprises, of which 127 were surface mines, and 52 were mines (shafts).

97.7 million tonnes of coal were produced through underground mining (3.6 million tonnes, or 3.5% less than in 2013). Coal production in 2023 by open-pit method reached 341 million tonnes (90.2 million tons, or 26.4% less than in 2013). The share of the open pit method in total production was 77.7%, while in 2013 the same indicator was at the level of 71.2%[9].

The processing facilities and plants processed 206.2 million tonnes of coal in 2023 (+32% as compared to 2013), including 109.0 million tonnes of steam coal (+46% as compared to 2013) and 97.2 million tonnes of coking coal (+19% as compared to 2013).

By the end of 2021, coal exports was 223.4 million tonnes (+95.3% as compared to 2011)[10]. By the end of 2022, coal exports reached 221.2 million tonnes (99.0% of the 2022 level). By the end of 2023, coal exports reached 212.5 million tonnes (96.1% of the 2022 level).

[8] - Hereinafter data are given in accordance with Rosstat data, unless otherwise specified. Tonne of coal equivalent or tce – fuel, combustion of 1 kg of which releases 29.31 x 106 J, or 7 000 kcal of energy (i.e. calorific value of 1 kg of conventional fuel is equal to 7 000 kcal/kg), – serves as a commonly accepted unit for measurement of conventional fuel in the Russian Federation.

[9] - According to the National Inventory of anthropogenic emissions by sources and removals by sinks of greenhouse gases unregulated by the Montreal Protocol for 1990-2021 period.

[10] - Data provided by the Federal Customs Service of Russia.

As for the regional aspect, in 2023, 83% of Russian coal exports were directed to the Asia-Pacific countries` markets. The total tonnage of coal loaded for this destination was 174 million tonnes, which is 32 million tonnes above the 2022 level.

Supply of coal products to the domestic market of the Russian Federation in 2023 was 181.2 million tonnes (+2% as compared to 2013), including 89.9 million tonnes (+2% as compared to 2013) for power generation, 39.6 million tonnes (+3.9% as compared to 2013) for coking, and 26.7 million tons (-1.1% as compared to 2013) for municipal and household needs[11].

The reduction of anthropogenic impact on the environment remains the focus of the government policy. Since 2013, the discharge of polluted wastewater has reduced 2-fold and reached 173 million cubic meters, while pollutant emissions have decreased by 5% and reached 1 074.4 thousand tons. These reductions were achieved amid a 20% growth of coal production.

In 2022, Russia launched the state scientific and technical program «CLEAN COAL - GREEN KUZBASS». The programme aims to develop technical solutions in various fields, including coal mining and processing, digital solutions and technologies, as well as ecology and health preservation.

The key instrument for reducing the anthropogenic impact on the environment caused by coal industry enterprises is a transition to the best available technologies.

1.3 Oil

Oil production and oil exports have been driven by the OPEC+ agreement on balancing the global market. Oil and gas condensate production in 2022 reached 535 million tonnes.

In 2021, the Russian Ministry of Energy approved the General Scheme of Oil Industry Development for the period until 2035, which is designed to detail the target vision of oil industry development set out in the Energy Strategy of the Russian Federation for the period until 2035.

[11] - Meshkov G.B., Petrenko I.E., Gubanov D.A. Russia's coal industry performance for 2023. Ugol', 2024, (3), pp. 18-29. (In Russ.). DOI: 10.18796/0041-5790-2024-3-18-29

The General Scheme outlines economically justified strategic directions for the development of the oil industry with the aim of improving the industry`s competitiveness, operational efficiency and technological equipment, as well as preserving its role as a driver of the Russian economy. The document outlines potential scenarios for the oil industry, illustrating how it could function based on key performance indicators and target levels. The target level of oil production by 2035 is 540 million tonnes per year.

The implementation of existing production projects is underway, including in the Arctic zone on the continental shelf of the Russian Federation.

The federal project «Technologies for the Development of Hard-to-Recover Hydrocarbons» was approved in 2021. Implementation of the project may provide Russia with up to 50 million tonnes of additional annual production by 2030 at existing and new fields in Western Siberia. The federal project provides for the development of Russian technologies for the unconventional resources exploitation, primarily the Bazhenov formation (shale), the world`s largest source of unconventional hydrocarbons.

In 2023, the domestic market of petroleum products in the Russian Federation was fully supplied with motor fuels of environmental class 5, meeting the requirements of the Technical Regulations of the Customs Union.

1.4 Natural Gas

The text of the Decision of the 28th Conference of the Parties to the UNFCCC notes the potential role of transitional fuels in facilitating energy system transition while ensuring energy security. The Russian Federation unconditionally considers natural gas as a transitional fuel.

The Russian Taxonomy of «Green» and Adaptation Projects, approved by Resolution of the Government of the Russian Federation No. 1587 dated September 21, 2021, positions natural gas-fired power and heat generation projects using the best available technologies as «green» projects.

The Russian Federation considers the use of natural gas as an effective way to mitigate climate change at the current stage of the energy transition process, which will contribute to energy security and sustainable development.

In 2022, the volume of natural and associated petroleum gas production decreased by 4.6% compared to the volume of 2013 and amounted to 636.9 billion cubic meters.

In 2021, the Russian Ministry of Energy approved the General Scheme for the Development of the Gas Industry of the Russian Federation until 2035, including the Eastern Gas Program and the Concept for the Development of the Domestic Gas Market.

The document details the target vision of the gas industry development laid down in the Energy Strategy of the Russian Federation for the period until 2035. It defines economically feasible strategic directions for the gas industry development aimed at ensuring reliable gas supply to existing and prospective Russian consumers, fulfilling obligations under intergovernmental agreements and concluded contracts for gas supply to foreign countries, and implementing new cost-effective projects for gas supply to foreign markets.

According to the document, the role of natural gas in Russia's energy balance will grow over the coming decades to reach 53-55% by 2035, depending on the scenario (52% in 2019).

In 2021, the Action Plan («Roadmap») was approved to introduce a socially oriented and economically efficient system of gasification and gas supply to the Russian regions. By 2030, the gasification rate is expected to increase by more than 10% and reach 82.9%.

In 2021, the Government of the Russian Federation approved the Long-term Programme for the Development of Liquefied Natural Gas Production in the Russian Federation and the Action Plan for its Implementation, which provide for the expansion and diversification of natural gas export destinations. In 2023, several federal laws that significantly simplify LNG supplies were adopted.

The adopted decisions will make it possible to expand opportunities for the supply of transitional fuel (natural gas) to global energy markets, including within the BRICS framework.

The expansion of natural gas consumption as an environmentally friendly motor fuel is being driven forward by the continued implementation of the Development of the Gas Engine Fuel Market Programme launched in 2020. One of the key mechanisms in this programme is the subsidizing of the conversion of existing motor vehicles to the use of natural gas as a fuel.

By 2023, the total volume of gas consumption used as a motor fuel reached 2.19 billion cubic meters (+211% over 5 years), and the total number of functioning natural gas vehicle refueling stations reached 1,080 units (+170% over 5 years).

The share of the oil and gas chemical industry in the consumption of hydrocarbon raw materials (LPG, ethane, naphtha) at the end of 2021 was 29.8% (+2.2% as compared to 2020) of the total use of hydrocarbon raw materials or 13.3 million tonnes.

1.5 Power Sector

In 2023, electricity generation by the Russian UPS power plants reached 1,134.0 billion kWh (+10.8% as compared to 2013). In 2023, electricity consumption reached 1 121.6 billion kWh (+11% as compared to 2013). As of 1 January 2024, the installed capacity of the Russian UPS power plants was 248,164.88 MW (+9.6% as compared to 2013), including thermal power stations accounting for 65.98%, hydropower plants – 20.24%, nuclear power plants – 11.90%, wind power plants – 1.01%, solar power plants – 0.8%[12].

As of 1 January 2024, the installed capacity of power plants of the Russian UPS and united energy systems conforms to the following structure: thermal power stations – 163,711.96 MW (+5.9% as compared to 2013), hydropower plants – 50 222.58 MW (+7.6% as compared to 2013), nuclear power plants – 29 542.99 MW (+16.9% as compared to 2013), wind power plants – 2 517.75 MW (+1309% as compared to 2013), solar power plants – 2 169.60 MW (+716% versus 2013)[13].

Thermal generation prevails in the energy production structure and is dominated by power plants using transitional fuel (natural gas). Natural gas-fired generation accounts for about a half of Russia`s total electricity generation.

At the same time, about 40% of the total electricity generation is zero-carbon, represented by nuclear power plants, hydropower plants and RES, the latter, including large hydropower, comprising 20% of all zero-carbon generation.

In 2023, the Federal Law introducing generation attributes and certificates of origin, issued upon the fact of electricity generation from zero-carbon (low-carbon) energy sources, on the territory of the Russian Federation was adopted.

[12] - *Report on the functioning of UPS of Russia 2023. Available at: https://www.so-ups.ru/functioning/tech-disc/tech-disc2024/tech-disc2024ups/*
[13] - *Data provided by the RREDA*

The law provides for the owners of generation attributes and low-carbon certificates to confirm compliance with the international requirements for low-carbon electricity consumption and to disseminate information, including advertising, on the use of «green» energy sources in the manufacture of their products.

1.6 Nuclear Energy

Nuclear energy, as an efficient and safe source of energy, plays a crucial role in the power generation in Russia. As of 2023, the Russian nuclear industry comprises of 11 nuclear power plants, including FNHPPs[14] with 36 nuclear power units, including 2 reactor units of the floating nuclear heat and power plant. Among other things, nuclear power is an essential element of energy diversification that contributes to the achievement of the goals to mitigate the negative impact on the environment and climate. The leading role of nuclear power in the context of forming an energy balance and clear environmentally friendly energy production in the long term is premised on the stability of power supply, low cost of generated power, a wide range of power capacity options and a continuance of guaranteed operation of nuclear power plants with minimal carbon dioxide emissions, as well as the potential for hydrogen production at nuclear facilities.

The main areas of nuclear power development in Russia include:

1) Expanding capacity and modernization of pressurized water reactors (PWRs);
2) Development of nuclear power plants with fast fission reactors at the nuclear fuel cycle-closing;
3) Development of the system of small and medium nuclear power stations;
4) Nuclear heat supply
5) Integration of nuclear capacity into energy-intensive industries;
6) Provision of a full range of services for the nuclear fuel cycle.

The large-scale development of nuclear is possible only if new technological products of two-component nuclear power system are elaborated, which include thermal-neutron reactor, PWRs along with a commercial fast reactor that ensure closure of the nuclear fuel cycle and a new segment – small nuclear power plants to provide energy to remote and isolated areas as well as local consumers.

[14] - *Floating nuclear heat and power plant*

At the moment, the power units No. 1 and No. 2 of the Kursk II Nuclear Power Plant, equipped with the PWR-TOI (typical, optimized, with an enhanced information project of a two unit nuclear power station with pressurized water reactor) are currently under construction.

In 2021, the construction of the world`s first power unit with a hot lead metal reactor BREST-300 4.0 was started, which is part of a pilot demonstration energy complex that also includes a module of uranium-plutonium fuel production, a module of nuclear fuel reprocessing and its refabrication. This energy complex will demonstrate the potential of the closure of the nuclear fuel cycle in practice. In order to provide energy to remote and isolated areas of the Russian Federation, the work on the projects of small nuclear power plants is being carried out. Currently, the high-availability and referential technology is the RITM-200 reactor plant, which provides for the land-based and floating small nuclear power plant options.

A pilot project for the construction of an onshore small nuclear power plant with a 55 MW RITM-200N reactor is being implemented in the Republic of Sakha (Yakutia), in a district technologically isolated from the energy system, to provide energy to all consumers. The plans for the development of Russian nuclear industry are stipulated in the General Scheme for the Allocation of Electric Power Objects until 2035, updated in 2022 by the Decree of the Government of the Russian Federation. According to the General Scheme, 16 nuclear power plant units are planned to be constructed and commissioned by 2035.

The strategic goal of Russia`s nuclear generation development is the transition to two-component nuclear power with a closed fuel cycle, with a 25% target share in the country`s energy balance by 2045 and a significant contribution to the gradual approximation to carbon neutrality.

1.7 Renewable Energy

Since 2013, the Russian Federation has been implementing a programme to support RES in the wholesale electricity and capacity market. Taking into account the established targets, there is an annual competitive tendering of investment projects for the construction of generating facilities operating on the basis of RES for solar and wind, as well as hydrogenation with an installed capacity less than 25 MW.

The first investment cycle of the RES state support programme runs from 2013 to 2024. The competition resulting from the tendering process led to a drastic decrease of the average planned capital expenditure per 1 kW of installed capacity.

In 2021, the support programme of the RES use in the wholesale electricity and capacity market was extended for the period 2025-2035. It is based on the system of concluding contracts for the supply of capacity of RES generating facilities to the wholesale market, but with the establishment of additional requirements for potential participants of the programme, both in terms of compliance with the indicators for the localization of power equipment and the availability of a portfolio of export supplies. Implementation of these measures will allow to stop subsidizing RES facilities using the wholesale electricity and capacity market already starting from 2036 and, at the same time, help to make the Russian RES industry competitive in domestic and global markets.

In parallel with the RES support programme in the wholesale electricity and capacity market, there is also a programme to support RES generation projects in retail electricity markets through regional competitive selection of RES projects. The tender winners receive the right to supply electricity to grid managing companies (guaranteed suppliers in isolated energy systems) at a fixed tariff based on the results of the tender, for a 15-year period, thus allowing for the recoupment of their investments.

In 2023, 340 MW of new RES capacity were commissioned (within 10 years, installed RES capacity has increased by 371%)[15], including wind power stations – 251 MW, solar power stations – 44 MW, and micro hybrid energy systems – 44 MW.

1.8 Hydrogen

In 2020, the Government of the Russian Federation approved the Action Plan («Roadmap») for the Development of Hydrogen Energy in the Russian Federation until 2024, aimed at increasing hydrogen production and expanding the scope of using hydrogen as a clean energy carrier, as well as bringing Russia to the forefront as one of the global leaders in hydrogen production and export.

In order to implement the 2021 Roadmap, the Government of the Russian Federation adopted the Concept of Hydrogen Energy Development in the Russian Federation.

[15] - *Data provided by the RREDA*

The document defines the goals, objectives, strategic initiatives and key measures for the development of hydrogen energy in the Russian Federation for the medium (until 2024) and long (until 2035) term period, as well as the main future perspectives for the period until 2050.

Russia has significant competitive advantages for hydrogen production and export. These include possessing energy potential (low-carbon electricity, solar and wind potential), natural resources, underutilized generating capacity of the UPS, experience in industrial application of the methane steam conversion and electrolysis, well-developed scientific and technical base, as well as favorable geographical location. Given these advantages, Russia can provide competitive hydrogen pricing. At the same time, it should be noted that the problem of hydrogen transport is yet to be solved, which results in persisting high hydrogen final costs for consumers.

Further development of regulatory legal acts aimed at the development of hydrogen energy in the Russian Federation continues. In 2022, a roadmap for the development of Hydrogen Energy for the period until 2030 was developed and approved. The document is aimed at enhancing scientific and technical potential of the Russian Federation in the field of hydrogen energy for the development, improvement and commercialization of hydrogen technologies, ensuring industrial safety of their application, assessing and reducing the negative impact on the environment, as well as making industrial production of hydrogen and basic equipment cheaper.

Moreover, for large export-oriented projects a special mechanism to provide subsidies for partial compensation of the costs of projects in the field of hydrogen production, transport and storage technologies has also been developed[16].

An important direction of hydrogen energy development is the creation of domestic hydrogen energy technologies, including: hydrogen production technologies (by pyrolysis, carbon dioxide extraction, separation of methane-hydrogen mixtures, short-cycle adsorption, electrolysis, high-temperature electrolysis, coal gasification), as well as hydrogen storage and transportation (composite materials for high-pressure tanks, barrier coatings for pipelines, hydrogen transportation using organic compounds).

As part of the initiative to adapt the Russian economy to the global energy transition, a draft Action Plan for Hydrogen Energy and Carbon Capture and Storage (CCUS) Technologies has been prepared.

[16] - *Approved by the Decree of the Government of the Russian Federation No. 1679 dated 11.10.2023*

Just energy transition is implemented in accordance with the Sustainable Energy Development Goals of the 2030 Agenda for Sustainable Development, primarily in regards to ensuring access to affordable and clean energy under Sustainable Development Goal 7 (hereinafter – SDG 7), which are discussed in detail in Section 1. Accordingly, the objectives and implementation instruments are consistent with the goals, objectives and instruments of the implementation of the Sustainable Development Goals (hereinafter – SDGs).

2 POLICY, GOALS, OBJECTIVES AND INSTRUMENTS FOR IMPLEMENTATION OF JUST ENERGY TRANSITION IN THE RUSSIAN FEDERATION

This section reviews the national vision for the way forward and progress towards the goals, objectives and instruments for implementation of SDG 7 in the context of just energy transition.

2.1 Ensuring Accessibility of Energy

Russian and global energy outlooks developed by the Russian Academy of Science`s researchers[17] and the Russian Energy Agency`s experts[18] indicate the enduring validity and the crucial role of fossil hydrocarbons in the global FEB over the 2035-2040 time horizon and up until 2050, thus highlighting their importance in maintaining energy availability and security during energy transition. Maintaining the demand for fossil FER is important for the Russian Federation, whose economy also depends on revenues from fossil fuel extraction and production, as well as consumption of fossil fuels and related energy-intensive products.

[17] - *Makarova A.A., Kulagina V.A., Grushevenko D.A., Galkin A.A. World and Russian Energy Forecast 2024. The Energy Research Institute of the Russian Academy of Sciences, 2024, Moscow. 208 p. ISBN 978-5-91438-038-7*

[18] - *https://rosenergo.gov.ru/press-center/news/stsenarii-razvitiya-mirovoy-energetiki-do-2050-goda/*

Russia`s energy security is based on the priority of ensuring a stable supply of available energy resources to the domestic market.

In 2023, 100% of Russia's population had access to electricity. In parallel with the UPS, energy systems of Azerbaijan, Belarus, Georgia, Kazakhstan, and Mongolia operate simultaneously. The energy systems of Central Asia – Kyrgyzstan and Uzbekistan – operate simultaneously with the UPS of Russia through the energy system of Kazakhstan. Electricity is transmitted from the Russian power grids, including through direct current links, to the power system of China.

Since 2021, additional gasification measures have been implemented throughout the Russian Federation, providing the opportunity to supply gas free of charge to houses located in gasified settlements. Additional gasification of Russian regions is a large-scale socially significant project aimed at qualitatively improving living standards of the Russian citizens.

The accessibility of energy depends on its cost, as well as on the income of the population. In this regard, the use of objective price indicators will help to reduce non-transparency and risks in the financial system, simplify investment decisions and allow for the development of new financial products. At the end of 2022, the Russian Federation approved an action plan for the development of organized exchange trading in certain commodity markets for 2023-2025 and is working to identify a list of exchange-traded commodities for which it is necessary to form national price indicators based on exchange and OTC price indices to ensure economic independence.

There is a system of forming analytical materials (including forecast indicators) and price indices[19] in the Russian Federation reflecting fair assessments of the cost of energy resources, including natural gas, as a low-carbon energy source.

Russia`s objective is to ensure that energy is available to the population and businesses at affordable prices. Accordingly, in regards to ensuring energy affordability for the population and all sectors of the economy, the imperative for the Russian Federation is to provide an independent choice of the method and ways of conducting energy transition, with due consideration of national peculiarities of energy balance and energy development strategies, based on the priorities of sustainable and balanced socio-economic development.

[19]- *https://www.gazprombank.ru/corporate/page/cii/?ysclid=lvat59yno525327394*

2.2 Ensuring Energy Security

In order to ensure energy security of the Russian Federation, the Doctrine of the Energy Security of the Russian Federation was adopted in 2019 – and approved by the Decree of the President of the Russian Federation. The Doctrine identifies challenges, threats and risks of energy security, defines the purpose, directions and tasks of government activities aimed at ensuring energy security.

In the context of ensuring energy security, the Doctrine provides for a number of measures, such as promoting competition in the FEC, protecting energy facilities from external interference, technical re-equipment and modernization of energy facilities, ensuring technological independence in the energy sector, ensuring the reproduction of the mineral resource base, improving the environmental friendliness of the energy sector, developing energy based on RES and distributed generation, enhancing international cooperation in the energy sphere with countries of the Commonwealth of Independent States, BRICS, the Shanghai Cooperation Organization, OPEC countries, etc.

The Russian Federation pursues a balanced and economically sound energy policy based on the efficient use of all energy sources, including fossil fuels, renewable and new energy sources, with a focus on advanced environmentally friendly technologies and environmental protection.

The Russian Federation considers energy security as the most crucial component of national security.

Ensuring energy security of the Russian Federation is the prerogative of the state and is achieved through a system of legislative, regulatory and other measures adequate to the identified threats and destabilizing factors.

The system for ensuring energy security of the Russian Federation is determined by federal laws, acts of the President of the Russian Federation and the Government of the Russian Federation, as well as decisions of the Security Council of the Russian Federation.

Within the Action Plan for the implementation of the Energy Strategy of the Russian Federation for the period until 2035, approved in 2021, the issues of ensuring energy security of the Russian Federation to address the tasks of ensuring state, public and information security in the energy sector are placed in a separate section.

As one of the largest suppliers of energy resources to the global markets, Russia contributes to the sustainable and safe development of energy in other countries. Further development of cooperation in the diversification of energy sources and types of energy resources used, development and protection of critical energy infrastructure, as well as joint development and exchange of energy-efficient and cleaner energy technologies will help ensure energy security in the context of energy transition.

2.3 Ensuring Energy Efficiency and Energy Saving

The Russian Federation is characterized by a high level of energy intensity of GDP, which reflects the specifics of natural and climatic conditions of functioning of the Russian economy, and, at the same time, indicates a significant potential for improving energy efficiency by reducing the specific consumption of fuel, thermal and electricity energy and ensuring their rational use.

The dynamics of changes in the energy intensity of GDP serves as the main indicator for evaluating the energy efficiency in Russia. In 2022, the figure was 9.64 tonnes of fuel equivalent / million RUB in 2016 prices, which is 1.8% above the level of 2021, but almost 14% lower than the traditionally calculated energy intensity of GDP. The average annual rate of decrease in GDP energy intensity (without non-energy needs exclusive) was 0.53% per year in 2015-2022.

In 2023, the Comprehensive State Programme «Energy Saving and Energy Efficiency Enhancement», aimed at increasing energy efficiency in energy, industry, transport and housing and communal services. As a result of the Programme,

it is expected to reduce the energy intensity of GDP by 35% in 2035 as compared to 2019.

Increasing the energy efficiency of the Russian economy is an important aspect of State policy not only at the federal level but also at the regional level. In particular, as of 2022, 62 regions of the Russian Federation had adopted regional energy efficiency programmes, and their actual funding in 2022 had increased by 5.6% to RUB 170 billion.

Information and education activities are being carried out in the regions of the Russian Federation to promote energy saving. Fora, thematic exhibitions in the field of energy saving, educational lessons for schoolchildren are held, magazines, newspapers,

videos are produced, events are held within the framework of the All-Russian Festival #Together-Brighter (organized in 2016), the main goals of which are to form a careful attitude to energy resources in the younger generation and to popularize an energy-saving lifestyle among the adult population.

2.4 Ensuring Environmental Friendliness and Reducing Climate Impact

The Russian Federation fully supports and recognizes the need to ensure universal access to affordable, reliable, sustainable and modern energy, as identified by the SDG 7. The development of sustainable energy is among the priorities of the national energy policy. The Russian FEC provides a balance between energy security, economic development and environmental protection. Taking into account the high degree of diversification of FER used, as well as the significant share of sustainable and low-emission energy sources in the FEB, Russia adheres to the position that further forced phase-out of fossil fuels can lead to high socio-economic risks and negative impacts, such as reduced access to electricity because of its high prices, changes in employment and the high capital cost of re-equipment of the manufacturing facilities. Russia believes that the transition to low-carbon and zero-carbon energy systems should be gradual and implemented individually, taking into account national characteristics and priorities of sustainable socio-economic development, social needs and technological capabilities.

In 2023, the updated Climate Doctrine of the Russian Federation was approved.

In the Russian Federation, an important area in supporting the development of sustainable energy is promoting the use of zero-carbon energy – nuclear energy, hydropower and renewable energy. All these types of energy were included in the «green» taxonomy of the Russian Federation in 2021.

Moreover, in 2021 the Government of Russia adopted initiatives of social and economic development «New Nuclear Energy, Including Small Nuclear Power Plants for Remote Territories» and «Clean Energy (Hydrogen and RE)» and also extended until 2035 the State Programme for Support of RE in the Wholesale Market of Electric Energy and Capacity. In addition, a programme to support renewable energy in the retail electricity and power markets is being implemented, and the development of microgeneration capacity up to 15 kW is being stimulated.

Measures aimed at combating climate change, in compliance with the Paris Climate Agreement, should make a major contribution to the development of sustainable energy in the Russian Federation. In 2021, the Russian government adopted the Strategy of Socio-Economic Development of the Russian Federation with a Low Level of Greenhouse Gas Emissions until 2050, as well as criteria for sustainable (including «green») projects development in the Russian Federation along with verification requirements of sustainable development projects, containing the taxonomy of these projects.

2.5 Scientific and Technological Base

Russia supports the development and implementation of new technologies and energy practices to ensure the achievement of the SDGs. In formulating FEC transformation and development programmes, Russia is guided by the principle of technological neutrality, which recognizes equal opportunities in the use of all available technologies for the FER production and consumption, including natural gas as a transition fuel, introduction of low-emission solutions, including carbon capture and storage, in the management of fossil fuels, as well as hydropower, nuclear and hydrogen energy.

In 2024, the Strategy for the Scientific and Technological Development of the Russian Federation was adopted, which identified the transition to environmentally clean and resource-efficient energy, enhancement of hydrocarbon production and deep processing efficiency, development of new energy sources, methods of energy transmission and storage as the priority and prospects of scientific and technological development.

Within the framework of this Strategy, the accelerated development of import-independent technologies, the development and localization of known foreign technologies are planned for the period until 2030 and beyond in order to ensure the sustainable development of the main economy sectors, including energy, as well as replacement of outdated technologies and steady increase in exports of Russian science-intensive technologies and products.

A general list of promising energy technologies is presented in the Forecast of Scientific and Technological Development of the Energy and Fuel Complex of Russia for the Period up to 2035.

The policy in the field of technological development is implemented on the basis of the activity of sectoral centers of excellence in various areas, agreements between

the Government of the Russian Federation and companies on the development of cross-cutting technologies, and also on the basis of the community of technological companies and scientific teams, including within the framework of the National Technology Initiative «EnergyNet».

The Russian Federation considers it necessary to promote free and non-discriminatory access to technologies for the just energy transition in the technological sphere, including within the framework of BRICS, which, inter alia, can contribute to the climate agenda.

2.6 Instruments for Just Energy Transition

In identifying the principal instruments for a just energy transition, the Russian Federation adheres to the conviction that the use and equitable exchange of the most advanced best available technologies and financial mechanisms, including cross-border investments, enhanced energy and environmental efficiency in using fossil fuels are of paramount importance. Russia does not support artificial restrictions and barriers limiting access to environmentally friendly technologies, including nature-ecosystem solutions that contribute to the achievement of the environmental, climate and biodiversity conservation SDGs, as a co-benefit of implementing sustainable energy policies.

Since 2019, the Federal Law «On Limiting Greenhouse Gas Emissions» has introduced an explicit opportunity to implement climate projects and trade carbon units generated from such projects. The established system is aimed at the implementation of voluntary climate projects.

Climate projects have the potential to become one of the main instruments for decarburization in Russia. They hold vast potential for reducing emissions and increasing the absorption of greenhouse gases, as well as monetization opportunities for businesses. However, in order to launch the carbon units market in Russia, it is crucial to provide the necessary conditions to incentivize companies to invest in climate projects, as well as address a number of issues regarding regulation.

These tasks are currently being implemented in the Sakhalin Oblast, as part of an experiment to achieve carbon neutrality.

The Russian Federation is interested to participate in the international voluntary carbon market, within which the quality of carbon units is recognized as crucial in justifying the validity of emissions offsets as a tool, especially for natural solutions.

Methodologies adopted in the Russian Federation conform with SDGs in ensuring access to affordable, reliable, sustainable and modern energy for all (SDG 7). These methodologies establish eligibility requirements that may limit the ability to apply them to certain activities or technologies, or may contain specific requirements for the location of a climate project.

In this regard, in order to develop a common understanding of the principles of a just energy transition, it is advisable to develop common approaches and rules for the assessment of greenhouse gas emissions, methodologies for the implementation of climate projects, as well as common approaches to verification and carbon accounting systems, including those that exclude double counting, within the BRICS format.

A crucial prerequisite for investments in climate projects is the transparency of the information on the price of carbon units and zero-carbon or low-carbon products. The lack of such indicators constitutes a barrier to investment decisions by businesses, banks, as well as to the development of supportive measures by regulators. The Centre for Price Indices sees energy transition indicators as a priority for development and has already been publishing premium estimations for carbon-free electricity in the over-the-counter voluntary market.

The Russian Federation considers the national system for certification of the origin of electricity as one of the important mechanisms to support the energy transition. The system was established by a special Federal Law and started operating on the 1st of February this year. The main function of the system is to ensure that the rights associated with the positive environmental effects of renewable and low-carbon generation (generation attributes) are legally reflected and that the transfer and utilization of such rights by interested parties is accounted for. Legal entities and individuals acquiring such rights can associate (link) their electricity consumption with its production at specific generating facilities using specific energy sources in various forms, as well as using this information to quantify the amount of greenhouse gas emissions associated with the production of electricity from external sources.

All the necessary legal and organizational framework for the system`s operation and technological infrastructure have been established, and an authorized organization – The Energy Certification Centre – has been appointed to qualify generating facilities for participation in the system, maintain a registry of generation attributes and issue certificates of origin for electricity.

Participation in the system is voluntary for both electricity producers and consumers. Prices for generation attributes and certificates are determined by the free market and are not regulated by the government. Owners of generating facilities based on RES and nuclear power plants recognized as low-carbon generating facilities are allowed to participate in the system. The system operates under a single set of rules applicable throughout the country.

The system is based on the same principles as the majority of certification systems in the world. It has been designed with full consideration of the requirements and recommendations provided in international guidelines on the accounting of greenhouse gas emissions (GHG Protocol, CDP recommendations), existing standards (including the ISO 14064, European EN 16325:2013) as well as the recommendations of the RE100. The functioning experience and best practices used in such systems, mainly in European and North American groups, as well as in the I-REC system, have been studied and taken into account.

The technical side of the system is represented by a specifically designed information platform with which the participants interact via a web-interface. The information system enables the connection of software tools of electronic trading platforms (stock exchanges and others) and the execution of transactions in organized trading, accompanied by appropriate information exchange between the operators of such platforms and the system operator.

In the context of energy transition, the origin of a electricity certification system is considered as one of the elements of the information infrastructure that can ensure the realization of the growing demand for electricity generated from renewable and low-carbon energy sources and thus contribute to the growth of the respective electricity sectors.

It is planned to couple the system of certifying the origin of electricity with a mechanism of calculating the greenhouse gas emission factors, which considers the emissions of all power plants in the Russian energy system. Such emission factors can be used by electricity consumers in determining their indirect energy GHG emissions (Scope 2). The calculation is carried out for each price and non-price zone of the wholesale electricity and capacity market, as well as for each isolated energy system. The input data for the calculation are the data on actual electricity generation per category of generating facilities using various energy sources (fuels). The derived factors are published daily on the website of the commercial operator of the wholesale electricity and capacity market: https://www.atsenergo.ru/results/co2map.

In addition, with the development of the renewable energy industry in Russia, bilateral contracts for the purchase and sale of low-carbon electricity on the wholesale market between corporate entities and owners of solar, wind and hydro power plants are being actively pursued. The volume of supply under these contracts is growing every year. This enables companies to contribute to sustainable development and reduce the carbon footprint of their products. ■

SOUTH AFRICA

1 OVERVIEW OF SOUTH AFRICA'S ENERGY LANDSCAPE

South Africa is rich in a variety of mineral reserves all of which hold strategic significance to the global economy with recent studies estimating the mineral preliminary gross in-situ value of South Africa at 9.6 trillion USD, an almost 290% increase from the previous estimate of 2.5 trillion USD. Of these, about 43% are coal resources, followed by PGM's (31.5%) and Gold (11.7%). The mining sector continues to be one of the country's largest employers, providing the country with considerable export revenue while supporting the local labour force.

The South African energy sector is undergoing a profound shift driven by a combination of factors, including the imperative to diversify the energy mix, enhance energy security and mitigate environmental impacts. As the largest economy on the African continent, South Africa's current energy landscape of transformational changes not only provides the country with the opportunity of addressing and shaping its own prospects of development and growth, but also that of the broader regional and continental energy dynamics.

While the country has historically been heavily reliant on coal for its energy needs - a legacy which has been informed by its abundant coal reserves, the country has taken energy policy and regulatory review initiatives aimed at incorporating cleaner energy sources, including nuclear into its energy mix.

South Africa has had a myriad of diverse efforts and initiatives on Just Energy Transition (JET) with South African stakeholders like the Presidential Climate Commission (PCC), Labour, Environment, the Mineral Council of South Africa, Trade, and Industry and Competition), South African National Energy Development Institute (SANEDI), Eskom, Sasol, the Council for Scientific and Industrial Research (CSIR), the National Business Initiative (NBI), Business Unity South Africa (BUSA), and the private and public sectors to name a few, aimed at evaluating and charting a course and bridging gaps for a Just and Inclusive Energy Transition.

2 TOTAL PRIMARY ENERGY AND INDIVIDUAL INDICATORS OF SOUTH AFRICA'S MACROECONOMICS

The South African primary energy supply is dominated by coal, which made up 70% of the primary energy supply in 2023, followed by hydro at 12%, wind at 6%, photovoltaic (PV) at 4%, concentrating solar-thermal power (CSP) at 1%, imports at 3% and nuclear at 3% as depicted in Figure 1 below.

South Africa's Real GDP growth was 2.1% in the year 2022 and 0.6% in 2023 (after it was predicted to be 4.8%), while consumption (use of goods and services) was 6.5% in 2022. The World Bank's business ranking for South Africa in the year 2022 was 71 out of 190 countries. The low performance can be attributed to extensive power supply constraints during 2023.

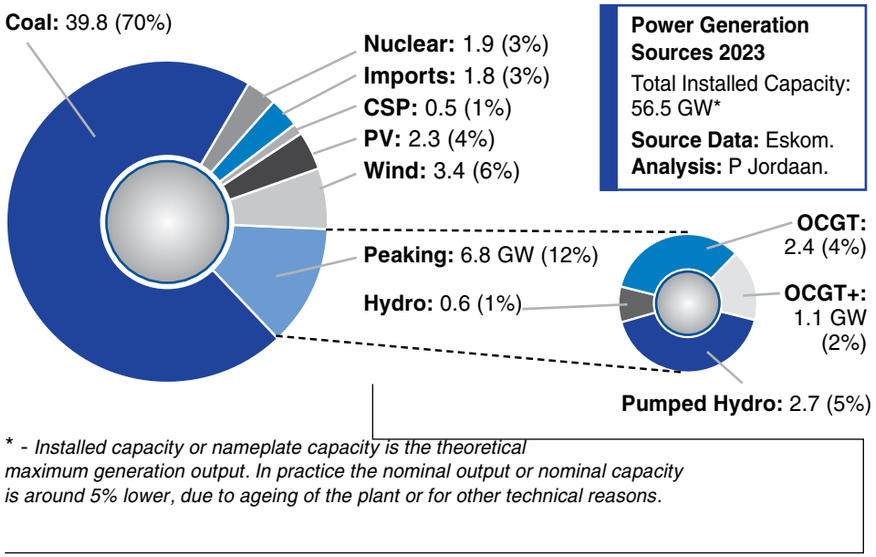


Figure 1: *Current Global trends on energy resource (Business Tech, 2023)*

2.1 Energy Sources

South Africa has a myriad of diverse energy sources however coal remains the prevalent energy source. Below is a summary of these energy sources

2.1.1 COAL

South Africa is globally ranked amongst the top ten (10) countries in respect of coal reserves, sitting at number six (6), while number seven (7) in terms of production and number five (5) in terms of export. A good portion of the produced coal is used to fuel power stations locally and internationally.

In addition, in 2022 coal was the third largest employer in the mining industry after precious metals and PGMs, directly employing 89 548 people, 20.48 percent of total mining industry employment of 437 288. These employees received over R30.71 billion in wages and salaries, which constituted 20.27 percent of the mining industry's total wage income (R 151.53 billion).

It is thus apparent that coal will remain the most crucial resource in the energy mix for a variety of strategic reasons.

For developing nations like South Africa, coal is a very affordable source of primary energy, and it is abundantly available. However, it faces several challenges not least among them, as one of the contributors to greenhouse gas (GHG) emissions, it is viewed as responsible for environmental degradation.

Domestically, the commodity will continue to play a critical role in the reconstruction and recovery of the economy. However, the country is mindful that at some point, coal use will eventually decline as nations and businesses strive to reduce their environmental impact and abide by climate policies.

2.1.2. CRUDE OIL AND PETROLEUM PRODUCTS

Though South Africa continued to import almost 100% of its primary crude oil requirements in 2021, the country has had a significant drop in Crude Oil imports in recent years and has become dependent on imports of finished Oil products (with 52% of imports, 41% locally produced and 7% exported) to meet and make-up for its domestic production shortfall. The imports of the finished petroleum products are predominantly from the Middle East at 50% with Asian regions including India,

Malaysia and Singapore in second and third place at 29%. Other regions of import include Europe at 15%, America at 3% and Africa at 1%.

The Department of Mineral Resources and Energy has introduced the Upstream Petroleum Bill which established the South African National Petroleum Company. The Bill seeks to separate petroleum provisions from the mineral provisions to address issues that are pertinent to the upstream petroleum sector. It also seeks to provide for State participation in the development of petroleum resources and create an enabling environment to attract investment in the upstream petroleum sector by contributing to the country's economic growth, creating employment, energy security and the development of the oil and gas industry.

Furthermore, the stated-owned enterprise Central Energy Fund (CEF), which manages South African energy assets, agreed to buy the 180 000-barrel-a-day Sapref plant. The acquiring of the Sapref plant is aligned with CEF's growth strategy following the decline of local refining capacity.

2.1.3. NATURAL GAS

South Africa is currently importing natural gas by Sasol Gas through an 865km pipeline running from Temane and Pande gas fields in Mozambique. Reserves in the Temane and Pande are estimated at around 2.6 trillion cubic feet (TCF). The pipeline has a capacity of 240 million gigajoules (GJ) per annum. Approximately 120 million GJ is used annually by Sasol in the GTL and chemicals plant, while the balance is distributed to commercial and industrial customers via a pipeline network covering more than 3,000 km across five provinces in the country.

In 2021, natural gas made up 3% of the total primary energy supply in South Africa with all its natural gas requirements imported with no local production or exports.

South Africa's reliance on international crude oil will be reduced through the electrification of the transportation sector, and an integrated approach to transport sector transition. Oil field exploration will be pursued, and a targeted source diversification strategy will be developed focusing on Africa, while both the Biofuels Framework and Strategic Stock Policy will be implemented.

2.1.4. ELECTRICITY

South Africa - equipped with a well-developed electricity network, has the largest power market in Sub-Saharan Africa with over 40% of the regional demand (246TWh versus 560 TWh in all sub-Saharan Africa) from varied utility-scale generation technologies, including coal, nuclear, hydro, solar photovoltaics (PV), onshore wind, concentrated solar power (CSP), pumped storage, and diesel-fuelled open-cycle gas turbines.

With respect to the energy mix, South Africa remains committed to achieving an energy mix that is consistent with its development goals and its climate change goals while ensuring the security of electricity supply. While coal remains the dominant energy source in the country, contributing 83% of the country's electricity generation, renewables are the third major player in SA's energy mix and is set to account for around a quarter of SA's overall energy supply in the next few years.

The recent investments towards cleaner energy technologies have seen South Africa increase in the contribution of its cleaner energy technologies, such as wind, solar PV, and CSP, from 2% in 2015 to 12% of electricity in 2023. This contribution remains below the global average of 13% but above the Africa's average of 6%. Nuclear and diesel energy contribute 4.6% and 1.6% respectively.

The dedication to diversifying the energy mix and promoting a more robust and sustainable economy is demonstrated by programs like the Renewable Energy Independent Power Producer Procurement Program (REIPPPP). The goal of South Africa's Renewable Energy Independent Power Producer Procurement Program (REIPPPP) is to promote the growth of renewable energy projects. The South African government introduced it in 2011 as part of its goal to lessen reliance on fossil fuels and increase the amount of renewable energy in the nation's energy mix.

The following are the principal functions and goals of the REIPPPP:

- **Encouraging the Development of Renewable Energy Projects:** The main objective of REIPPPP is to encourage the growth of renewable energy projects, such as small-scale hydroelectric, wind, solar, and biomass projects. South Africa hopes to accomplish these goals by diversifying its energy sources and lowering greenhouse gas emissions.
- **Private Sector Involvement:** Independent power producers (IPPs) are invited to submit proposals for renewable energy projects as part of the program's efforts to promote private sector involvement. This makes it possible for private businesses to finance and run renewable energy projects.

- **Competitive Bidding procedure:** REIPPPP uses a competitive bidding procedure in which prospective developers submit proposals. The bidders who offer the highest value in terms of cost, technical viability, and local economic development are chosen to carry out the projects.

  The program has a strong emphasis on the creation of jobs and economic development, especially in local communities. Implementing socio-economic development projects, including community infrastructure projects and skill development programs is often a requirement for successful bidders.
- **System Integration:** to provide a steady and dependable supply of electricity, REIPPPP seeks to integrate renewable energy projects into the country's electrical system. Coordination with the national utility and pertinent authorities is required to handle the technical and legal facets of grid integration.

In the last 2 years South Africa has experienced severe loadshedding which has since been drastically reduced in 2024. The existing power stations' technical performance has improved, and new generation capacity has been added. However, there is an urgent need to expand transmission capacity.

Eskom, one of the largest power utilities in the country, has embarked on a project to decommission some of its stations and repurpose them for supporting the energy transition. By repurposing power stations, the country aims to shift away from conventional fossil fuel-based energy generation and embrace cleaner energy sources. This transition is vital in reducing greenhouse gas emissions, mitigating climate change, and ensuring a cleaner and healthier environment for future generations.

This initiative highlights the commitment of the country to embrace cleaner energy sources and transition away from conventional power generation. It also demonstrates the recognition of the urgent need to address climate change and build a more sustainable future for all.

Depicted in Figure 2 below is the remaining life of the coal fired power stations in South Africa. The decommissioning plan for coal-fuelled power plants coincides favourably with the country's Just Energy Transition to alternative lower-carbon fuel sources.

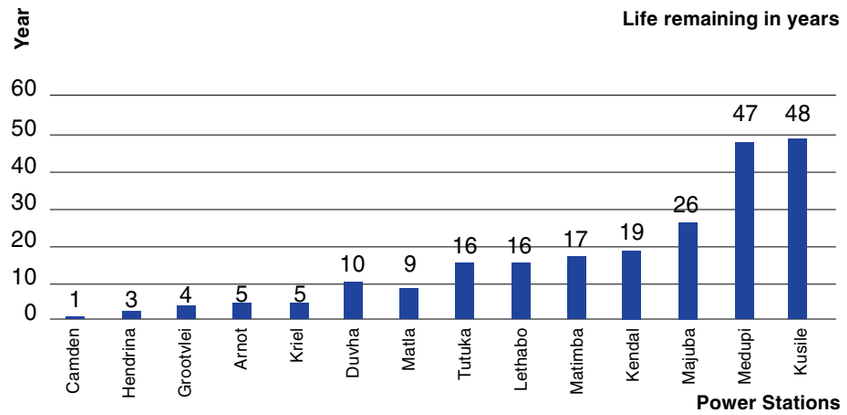


Figure 2: *Remaining Life of the Power Stations*

2.2 The Impacts and Challenges Affecting the Transition of the South African Energy System

South Africa is still in its early and evolving stages of Just Energy Transition implementation with several issues that still pose challenges, such as obtaining investment in and preparing for mitigation in the harder-to-mitigate sectors and addressing the economic and social consequences resulting from this transition in coal-producing areas.

Numerous studies done on the impact of the transition indicate that Education and skills development are the core catalysts and are at the centre of a Just Energy Transition. Hence, the Just Energy Transition Framework focuses on initiatives such as:

- Reskilling and upskilling individuals, both in the formal and informal sectors, to navigate the transition, create new career pathways, and overcome the barrier to skills development;
- The creation of green jobs and opportunities that align with the foundational skills development systems to accelerate the workforce.

In addition to this, South African Energy Risk Report conducted by the South African National Energy Association (SANEA) in 2023, found that the top trends impacting the transition of the South African Energy system are due to:

- **The widening energy cost gap:** energy is not only the driving force of the economy, but it is responsible for income distribution across the population. South Africa has high inequality rates, and therefore it is important to enhance the need for a more equitable, just and sustainable energy transition.

  Factors impacting South African energy prices include geopolitical shifts, operational and technological costs, and overall global energy prices. Both the government and public sector need to play a role in promoting energy efficiency, incentives and subsidies, and implementing alternative fuels.
- **Energy security:** challenges like electricity supply constraints, deteriorating and aging power stations, and lack of new generation capacity brought to the grid impact the country's energy security.
- **Adaptable and resilient energy systems:** the lack of resilience and adaptability of energy systems infrastructure results in social economics implications, energy security and access to resources.
- **Shifting towards sector coupling:** Sector coupling is the electrification of energy demand while reinforcing the interaction between electricity supply and end-use, driven ultimately by decarbonization efforts and climate change. Decarbonisation targets, carbon taxes, cost of energy, innovation and SMART technologies impact sector coupling. Actions such as the creation of adequate infrastructure, the reviewing of grid operations standards, and installing integrated policies are required.
- **Evolving energy markets:** as a result of global-driven technology and policy, the country must move away from large centrally controlled electricity systems to decentralised smaller systems. This affects the energy markets and other energy resources, the government policies, the size of the country's markets, and the investor confidence in the country. Actions such as constant policy updates are necessary to fully address this.

2.3 Policy, Goals, Objectives And Instruments For Implementation Of Just Energy Transition In South Africa

To transition towards a low-carbon economy, South Africa introduced a white paper in 2003, outlining a plan to generate 10 TWh of electricity from sources such as biomass, wind, solar, and small-scale hydro.

Subsequently, in May 2011, an Integrated Resource Plan (IRP) was enacted, setting a new goal of adding 17,800 MW of cleaner energy to the energy mix. The establishment of the Renewable Energy Independent Power Producer's Programme (REIPPP) in 2011 marked an ambitious initiative for promoting renewable energy generation in South Africa, focusing on three core objectives, namely, reducing CO2 emissions, enhancing generating capacity, and fostering economic development. The REIPPP program has successfully diversified energy generation by involving over 60 power producers, leading to a steady increase in South Africa's renewable energy capacity. Still, the country relies more on coal (about 80%), while the renewable energy mix provides the balance. South Africa is also home to Africa's only nuclear power plant.

The development of cleaner energy sources in South Africa holds the potential to significantly reduce the heavy reliance on unabated coal technologies. Furthermore, the growth of the cleaner energy sector in the country can create new job opportunities, thereby bolstering the South African economy.

The 2019 IRP, which remains South Africa's guiding policy framework for electricity, proposes a path that ensures that South Africa implements the proposed energy mix in a manner that also mitigates and manages the challenges and risks for a socially just transition that we will face, as the country moves to a low-carbon and climate-resilient growth trajectory. The draft 2023 IRP is under review and is expected to continue South Africa's commitment of a diversified energy mix whilst ensuring energy security.

The Bill of Rights, set out in Chapter 2 of the South African Constitution, enshrines first generation democratic and political rights, along with second-generation socio-economic rights (e.g., shelter, health care, food, water and social services) and third-generation collective development rights (e.g., environment and sustainable development, rights to collective organization and economic activities, rights of cultural and linguistic communities).

These rights are given further expression in Chapter 1 of the National Environment Management Act (Act 107 of 1998), which contains a justiciable set of principles, including putting human development concerns at the centre of decision-making, producer and polluter responsibility, equitable access to environmental resources, and equipping people to participate in decision making.

The just transition focus in South Africa aims to achieve a quality life for all South Africans in the context of climate change. In 2021, the Just Energy Transition framework by the Department of Mineral Resources and Energy (DMRE) identified the need for inclusive, people-centric interventions to deliver a just transition in the mineral and energy value chains. The DMRE framework notes the importance of managing the socioeconomic impacts of an energy transition for coal-dependent towns to minimise and mitigate against social risks and protect the vulnerable, while maximising the opportunities of structural transformation.

The Just Transition Framework supports the decarbonisation of the mining and energy sectors in a socially acceptable manner that contributes to the economic development of the country, focussing on the issues related to workers in the coal value chain and specifically coal miners, the economic development of coal-dependent regions, mitigating impacts on vulnerable groups such as youth and women associated with fossil fuel value chains, as well as access to modern energy services.

While the scope of defining a just transition varies internationally, the National Framework for a Just Transition provides a definition of a just transition that is appropriate to South Africa's context:

> ***"A just transition aims to achieve a quality life for all South Africans, in the context of increasing the ability to adapt to the adverse impacts of climate, fostering climate resilience, and reaching net-zero greenhouse gas emissions by 2050, in line with best available science".***

A just transition contributes to the goals of decent work for all, social inclusion, and the eradication of poverty. A just transition puts people at the centre of decision-making, especially those most impacted, the poor, women, people with disabilities, and the youth-empowering and equipping them for new opportunities of the future. A just transition builds the resilience of the economy and people through affordable, decentralised, diversely owned cleaner energy systems; conservation of natural resources; equitable access to water resources; an environment that is not harmful to one's health and well-being; and sustainable, equitable, inclusive land use for all, especially for the most vulnerable.

The National Development Plan sets the basis for South Africa's just transition policies in that it places people's livelihoods at the centre of the climate change response and envisions a low-carbon future as being integral to South Africa's development path.

2.4 JET Initiatives in South Africa

Gradual transitions within the South African energy sector have resulted in a multitude of Just Energy Transition (JET) initiatives, led by government institutions, the private sector, and civil society organisations.

As part of the strategic programmes/projects aimed at diversifying the generation energy mix, there has been several initiatives undertaken to this effect and are listed below:

- Eskom has rolled out the microgrids project in Swartkodam in 2023 and the Battery Energy Storage Systems (BESS) program as part of efforts in achieving universal access to electricity using clean and reliable technologies by pursuing a low-carbon future to reduce the impact on the environment.
- Clean cooking to address the greenhouse emissions related to the use of fossil fuels for cooking and domestic use has also been a theme being explored as a necessity for the transition with pilot projects and research studies done through the DMRE.
- The local mines also, such as Anglo-American have taken the initiative to build zero emission hydrogen production, storage and refuelling facilities for vehicles. ■

UNITED ARAB EMIRATES

OVERVIEW OF THE ENERGY SECTOR

The United Arab Emirates (UAE) has a highly developed and diversified energy sector that plays a critical role in the national economy. The country is one of the world's top producers of oil and gas, which has historically been the backbone of its energy sector. In recent decades, the UAE has been investing heavily in renewable energy sources to diversify its energy mix and ensure long-term sustainability. The country's electricity sector is integral to its economic growth, supported by a mix of natural gas, solar, and nuclear energy.

The UAE Energy Outlook 2050 is not prescriptive but attempts to suggest what the UAE's energy sector might look like under the country's ambitious policies aimed at achieving carbon neutrality. These scenarios and their accompanying technological options are not set guidelines or predictions; instead, they depict the potential evolution of the UAE's energy system based on certain techno-commercial assumptions and specific objectives.

The discussion contained herein is indicative and not restrictive, and therefore sensitive to change based on stakeholders' plans, energy providers and suppliers' business plans, technological advancements, energy costs, external market developments, and others.

The focus of this Outlook is therefore on identifying favourable and required set of enablers to support and facilitate the transition in a manner that is consistent with the

UAE's net zero ambitions. The findings of this document should be considered only as guidance for decision makers, and not as a prescriptive document. Energy system plans should remain flexible and preserve optionality.

Finally, this Outlook is subject to specific modelling constraints of the selected scenarios, which for the purposes of this document focus more on the power/utilities sector. All other sectors have also been considered at a level that justifies the adoption of technological pathways in which the UAE has a competitive advantage for meeting its net zero ambitions.

To uphold the integrity and precision of this document, and to ensure its effectiveness in providing comprehensive information to decision markets, this Outlook will undergo periodic updates. These updates will encompass technological advancements, the assessment of market developments, the alignment with evolving policy priorities, national net zero objectives, and insights gained from real-world experiences of energy transition both within the UAE and internationally. Additionally, the latest priorities of the UAE will be taken into consideration during these updates.

The UAE has adopted several climate and energy-related strategies, initiatives and plans to ensure its energy security all while reducing GHG emissions. Combined, these strategies and targets serve as pillars and enablers of the overarching UAE Centennial 2071 plan.

The UAE recognises the global shifts in the energy sector and their potential implications on the local energy landscape and, therefore, places great importance on updating its energy strategy to align, adjust, and expand its mission as the sector's outlook evolves.

The significance of locally accessible energy resources is paramount to safeguarding and fortifying the integrity and dependability of the power system. Given the prevailing geopolitical circumstances, the preservation of supply plays a pivotal role in sustaining the overall economy. Moreover, in view of the abundant solar radiation bestowed upon the UAE, it becomes strategically imperative to integrate this locally available and plentiful source of energy within its energy portfolio. By doing so, the UAE can effectively guarantee an uninterrupted supply of low-cost, clean power.

The path to net zero presents the UAE with three big opportunities: (1) make the domestic economy carbon-neutral to deliver on international commitments and preserve the local and global environment, (2) become a highly competitive centre for producing and exporting low-carbon materials and high-technology energy goods, (3) become a forefront country in clean energy utilisation, decreasing energy costs and saving on energy waste.

As countries commit to their climate change obligations, renewable energy's share in the global power generation mix is expected to increase, while the contribution of coal and gas-fired generation is anticipated to decline. Energy efficiency measures will drive down energy demand, particularly in advanced countries, leading to a substantial rise in the use of electricity for final energy consumption. Additionally, clean hydrogen is poised to emerge as a versatile solution for achieving decarbonization targets in various challenging sectors.

Taking part in the global efforts towards decarbonisation, the UAE has defined several strategic objectives and initiatives that shape its long-term, integrated strategic framework. The latter introduces six key enablers to guide the implementation of the strategy, including a (i) Decarbonisation-focussed Regulatory System, (ii) Research and Innovation, (iii) Global Collaboration, (iv) Financing the Transition, (v) Circular Economy, and (vi) Green Workforce Development.

To achieve decarbonization in a secure and reliable manner, while considering existing commercially available technologies, three scenarios were examined: the BAU/Base Case, characterized by high gas-based generation and lacking carbon neutrality; the Low-Carbon and Net-Zero cases, both aimed at deep decarbonization. These scenarios may be influenced by technological advancements and future cost dynamics, including fusion, low-cost batteries, low-speed wind, NET Power (CO2 power cycle with integrated CCUS), SMR nuclear technology, and waste-to-energy, among others. For modeling purposes, varying assumptions and levels of ambition were adopted to project the potential state of the UAE's energy sector in 2050, encompassing fundamental requirements and key policy elements.

OBJECTIVE OF THE ENERGY OUTLOOK 2050

The UAE Energy Outlook 2050 is a comprehensive document summarizing the updated UAE Energy Strategy prepared following extensive consultation with all relevant stakeholders of the UAE's energy sector. This Outlook analyses key global trends and their implications on the UAE's energy sector and demonstrating technological options that can inform scenarios to achieve the UAE's Net Zero 2050 Charter, with exclusive focus towards the electricity and water sector, delving into its intricate facets and aspects.

Three scenarios were chosen under the updated energy strategy to illustrate the broad potential routes for the UAE's energy system by 2050. Two of these scenarios aim to achieve net zero targets, with different assumptions about the technological pathways pursued. These specific scenarios have been developed by simulating numerous alternative scenarios based on a techno-commercial analysis of the available technology pathways in the UAE. The purpose of this analysis is to determine realistic and achievable short-term, medium-term, and long-term national goals that align with the strategic plans of all stakeholders in the UAE. These scenarios consider multiple technological, economic, geopolitical, and climatic developments and aim to meet the following objectives:

a) Achieving a prosperous future for all by delivering affordable energy system, which improves the UAE's economic competitiveness.

b) Possessing cutting-edge commercially available technologies in the power system, enabling it to accommodate a substantial proportion of variable renewable energy efficiently and proficiently, ensuring security and reliability of the grid.

c) Attaining environmental sustainability, by making substantial progress towards the 2050 net-zero carbon goal while concurrently enhancing other environmental indicators, including air and water quality, as well as biodiversity.

The Outlook aims to lay the foundation for the strategies, initiatives, and ambitions adopted by the Ministry of Energy and Infrastructure in its journey to ensure the country's energy security and environmental protection, as well as further strengthening and future-proofing them to achieve the net-zero 2050 target. These initiatives showcase the UAE's efforts in curbing the power and water sector's emissions by making use of a suite of technologies and adopting supportive policies at the national and emirate levels. The Ministry maintains a diligent focus on monitoring the dynamic shifts in global energy trends. Consequently, it assigns considerable significance to the revision and enhancement of the highlighted strategies. These strategies are aimed at fostering resilience in the midst of fluctuations and adopting nascent low-carbon solutions.

ENERGY EFFICIENCY

To ensure achieving the ambitious sustainability goals of the UAE Energy Strategy 2050 and the UAE Water Security Strategy 2036, the Ministry of Energy and Infrastructure (MoEI) is mandated to develop the UAE National Demand Side Management (DSM) Program. Throughout the project, MOEI collaborated with diverse municipalities, utilities, and relevant agencies across the seven emirates. The National DSM Program has been developed with the target of 40% reduction in energy demand and 50% reduction in water demand over business as usual by 2050.

The energy and power sector in the UAE is a crucial element of its economy, driven primarily by its vast reserves of oil and natural gas. Here's an overview:

1. **OIL AND GAS RESERVES:** The UAE possesses significant reserves of both oil and natural gas, making it one of the leading producers in the world. Abu Dhabi, the capital of the UAE, holds the majority of the country's proven oil reserves, while Dubai and Sharjah also contribute significantly to oil production. Additionally, the UAE has been investing in the exploration and development of natural gas reserves.

2. **OIL PRODUCTION AND EXPORT:** The UAE is a major player in the global oil market. The country is a member of the Organization of the Petroleum Exporting Countries (OPEC) and adheres to its production quotas. Abu Dhabi National Oil Company (ADNOC) is the primary state-owned entity responsible for oil exploration, production, and export.

3. **DIVERSIFICATION EFFORTS:** Despite its reliance on oil and gas, the UAE has been actively diversifying its energy mix to reduce dependence on hydrocarbons. Renewable energy sources, such as solar and wind, have been gaining traction in recent years. The UAE aims to increase the share of clean energy in its total energy mix significantly.

4. **NUCLEAR POWER:** The UAE has ventured into nuclear power to meet its growing energy demand while reducing reliance on fossil fuels. The Barakah Nuclear Power Plant, located in Abu Dhabi, is the country's first nuclear power plant and the first of its kind in the Arab world. It aims to provide a significant portion of the UAE's electricity needs in the coming years.

5. **RENEWABLE ENERGY:** The UAE has made substantial investments in renewable energy infrastructure, particularly solar power. The Mohammed bin Rashid Al Maktoum Solar Park in Dubai is one of the largest solar parks in the world and a flagship project in the country's renewable energy ambitions. Abu Dhabi has commissioned multi-Megawatts scale of IPP in Solar like Al Dafara 2GW, Swehan 1.17GW, and Al Ajban 1.5GW. Additionally, wind power projects are also being developed to harness the region's wind resources.

6. **ENERGY EFFICIENCY:** With a growing population and economy, energy efficiency has become a priority for the UAE. The government has implemented various initiatives and policies to promote energy conservation and reduce wastage.

7. **INFRASTRUCTURE DEVELOPMENT:** The UAE continues to invest in the expansion and modernization of its energy infrastructure to meet the growing demand for electricity and ensure reliable supply across the country. This includes investments in transmission and distribution networks, as well as the development of smart grid technologies.

Overall, the UAE's energy and power sector remains dynamic, with efforts underway to diversify the energy mix, enhance efficiency, and embrace sustainable practices for long-term economic and environmental sustainability.

1 ENERGY PRODUCTION, ENERGY CONSUMPTION, ENERGY TRADE

1.1 Energy Sectors

OIL AND GAS

The UAE's energy landscape is characterized by abundant reserves, substantial production capabilities, and active participation in global energy trade. Oil and gas exports continue to play a pivotal role in the nation's economy. The UAE has embarked on a series of policy initiatives aimed at curbing its own consumption of oil and gas.

Under the UAE Net Zero by 2050 Strategic Initiative, the nation has set ambitious goals for reducing its reliance on fossil fuels aiming to significantly limit the use of natural gas for power generation while decreasing gasoline and diesel fuel consumption within transportation the sector. This commitment is noteworthy, especially considering the significant economic and population growth.

On the production side, the UAE's Murban crude oil has a carbon intensity of less than half the global industry average. The UAE's oil and gas sector is committed to further emissions reductions. ADNOC stands out as a leader in lower-carbon intensity energy production. It achieves this through the utilization of zero-carbon grid power – a pledge to eliminate routine flaring of gas, and the implementation of a substantial carbon capture project – the region's first of its kind.

ADNOC has consistently maintained one of the world's lowest carbon emissions intensities and has set an additional target of reducing its greenhouse gas emissions intensity by 25% before 2030. To achieve this goal, ADNOC has allocated USD 15 billion for investments in low-carbon solutions, including carbon capture and storage, electrification, and ventures in hydrogen and renewables. Furthermore, ADNOC has publicly stated its ambition to achieve net-zero emissions by 2045.

SECTOR OVERVIEW

The UAE possesses substantial proven reserves within the energy sector, consolidating its position as a key player in the global energy landscape. Primarily concentrated in the emirate of Abu Dhabi, the UAE has an estimated 111,000 billion barrels of crude oil reserves, making it one of the world's leading holders of these valuable resources. Additionally, the country commands a significant presence in the natural gas market, with proved reserves amounting to 8.2 trillion cubic meters.

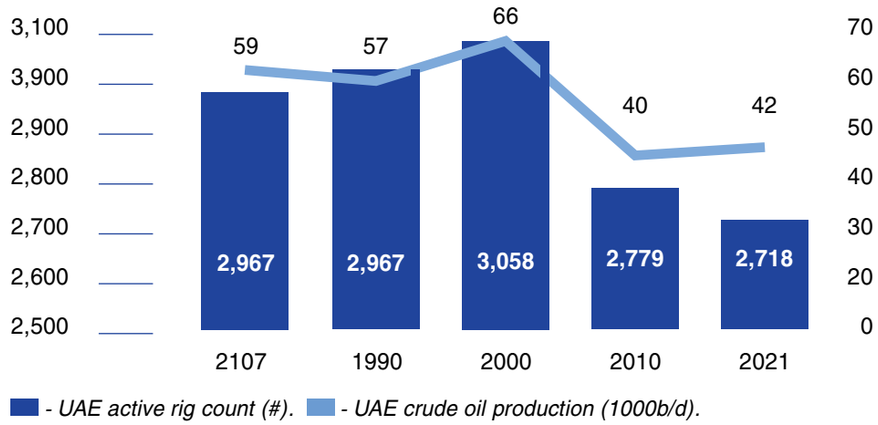


Figure 1: *UAE crude oil production (1000 b/d) and active rig count (#), 2017 - 2021*
Source: *Annual Statistical Bulletin 2022, OPEC*

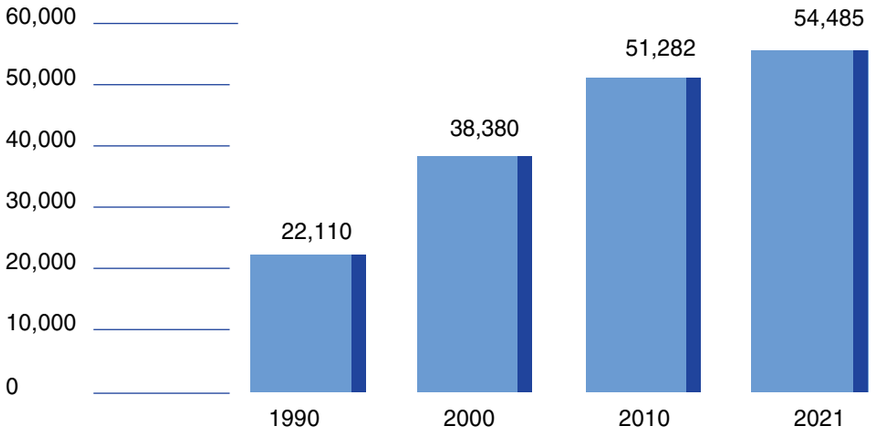


Figure 2: *UAE annual marketed natural gas production (billion cubic meters), 1990 - 2021*
Source: *Annual Statistical Bulletin 2022, OPEC*

On the domestic front, the UAE's energy consumption pattern is influenced by its dual role as both as producer and consumer of oil and gas. While the domestic consumption of oil fuel remains relatively low, accounting for only a small fraction of daily production, the majority of the country's crude oil production is directed towards international exports. Conversely, the consumption of dry natural gas domestically is substantial. This divergence underscores the UAE's reliance on natural gas to meet its domestic energy needs while leveraging its substantial oil reserves for export.

In terms of trade, the UAE plays a significant role on the global stage. It serves as a net exporter of crude oil, with a substantial portion of its oil exports directed towards the Asia Pacific region, particularly India and China. Conversely, all the UAE's natural gas production is exported as liquefied natural gas (LNG) to various nations, including India and Japan. However, the UAE concurrently operates as a net importer of natural gas with a significant portion sourced from Qatar through the Dolphin UAE-Qatar Natural Gas Pipeline. This dual role underscores regional energy cooperation and the UAE's strategy to fulfill its domestic energy requirements.

COAL

The revised UAE Energy Strategy took substantial strides in addressing climate change and the already ceased coal utilization for power generation since 2022, deviating from the initially projected target in the 2017 Energy Strategy which entailed approximately 12% capacity for clean coal. The Hassyan power plant sets a great example, as it was initially designed and commissioned for coal, but is now converted to run on natural gas and equipped with carbon capture and storage capabilities, furthering the UAE's commitment to emissions reduction.

In addition, the UAE is taking steps to lower emissions from baseload power generation, replacing it by a cleaner source of nuclear energy, which provides constant energy supply even during periods of low solar radiation complementing intermittent solar PV sources. As part of this effort, the UAE has shifted away from coal power generation totally.

The UAE does not possess domestic coal reserves, leading to a notable absence of coal production within its borders. As illustrated in the figure below, the UAE's coal consumption, which is mostly from industrial sector has maintained a relatively consistent pattern, averaging approximately 2.4 million short tonnes per year over the period spanning from 2013 to 2021. Importantly, the entirety of this coal is sourced through international imports.

ELECTRICITY

Electricity Production

Energy demand in the UAE is increasing, driven by rapid urbanization and industrial growth. This places a significant burden on energy resources and carbon emissions. To address this, the UAE has set ambitious goals to increase the share of clean energy sources and improve energy efficiency, as outlined in its first update of the Energy Strategy 2050.

In 2022, the UAE produced approximately 130 terawatt-hours (TWh) of electricity, up from around 120 TWh in 2020. This growth is largely due to increased demand from all sectors.

Energy Consumption

Total Consumption: The UAE's electricity consumption reached around 125 TWh in 2022, showing an upward trend from previous years.

Sectoral Consumption: The residential sector consumed about 62.5 TWh (50% of total consumption), the commercial sector consumed 37.5 TWh (30%), and the industrial sector consumed 25 TWh (20%).

Per Capita Consumption: The UAE's per capita electricity consumption is among the highest globally, reflecting the high standard of living and extensive use of air conditioning.

Energy Trade

Net Exporter: While the UAE is a net exporter of energy in the form of crude oil and natural gas, it focuses on self-sufficiency in electricity. The UAE is part of the GCC Interconnection Authority (GCCIA), facilitating electricity trade within the Gulf Cooperation Council (GCC) countries

1.2 Coal

Nil

1.3 Oil

Oil Production (2023) = 2.944 million B/D
Oil Refining Capacity (2023) = 1.227 million B/D
Oil Trade Exports (2023) = 2.651 million B/D Crude / Products 1.143 million B/D.

1.4 Power Sector

ELECTRICITY

Market Structure

The UAE will continue its dependence on the single buyer approach, where the energy mix is centrally decided, and Power Purchase Agreements (PPAs) are created to encourage private investment in the industry. This encompasses agreements for renewable energy capacity, storage, and other necessary technologies. Furthermore, the UAE's electricity market operates with a decentralized regulatory structure, with each emirate following its regulatory authority. This decentralized approach allows individual emirates to tailor their regulations and policies to meet their specific energy needs and priorities. Here is an in-depth look at the market structure and key regulatory authorities:

Federal Level Regulation

The federal Ministry of Energy and Infrastructure plays a central role in governing the electricity sector at the federal level. It establishes overarching policies and standards that guide the entire nation in ensuring a reliable, affordable, and sustainable electricity supply.

Emirate-Level Regulation

Emirate-level regulatory authorities oversee and manage the electricity markets within their respective regions. Each emirate has its regulatory body responsible for regulating and supervising electricity production, distribution, and pricing. Key emirates and their regulatory entities include:

- **ABU DHABI:** TThe Department of Energy (DoE) is the regulatory authority responsible for overseeing the electricity sector in Abu Dhabi, which includes setting regulations, ensuring compliance, and promoting sustainable practices. The Emirates Water and Electricity Company (EWEC) plays a significant role in electricity production and supply. EWEC was formed in November 2018, succeeding the Abu Dhabi Water and Electricity Company (ADWEC).

- **DUBAI:** The Dubai Electricity and Water Authority (DEWA), a self-regulated entity, and the Dubai Supreme Council of Energy (DSCE), jointly oversee the electricity sector in Dubai. DEWA is responsible for electricity generation, distribution, and retail, while DSCE sets policies and strategic directions to ensure energy security and sustainability.

- **SHARJAH:** The Sharjah Electricity, Water, and Gas Authority (SEWA) is the regulatory body governing the electricity sector in Sharjah. SEWA plays a crucial role in managing electricity supply, infrastructure development, and pricing in Sharjah.

- **ETIHAD WATER & ELECTRICITY:** EtihadWE, regulated by the Ministry of Energy and Infrastructure, is entrusted with the responsibility of catering to the electricity and desalinated water requirements of the northern

emirates namely, Ajman, Umm Al Quwain, Ras Al Khaimah, and Fujairah. Federal Electricity and Water Authority (FEWA) was transformed into EtihadWE to enhance the efficiency and upgrade the services provided by the authority, as stated in the Federal Decree-Law No. (31) of 2020. FEWA was transferred to the ownership of the UAE's sovereign wealth fund, the Emirates Investment Authority.

This multifaceted regulatory framework reflects the UAE's commitment to local governance and ensures that each emirate can independently manage its electricity sector while adhering to overarching federal policies and standards. It allows for flexibility in addressing unique challenges and opportunities within each emirate's energy landscape.

ADVANCEMENTS IN CLEAN ENERGY CAPACITY TRANSITION

The UAE has taken significant strides towards mitigating climate change and transitioning to a more sustainable energy landscape with comprehensive efforts and notable projects underscoring the UAE's commitment to diversifying its energy mix while securing a sustainable energy future:

Pioneering Projects in Clean Energy

- **BARAKAH POWER PLANT:** The Barakah Power Plant is a ground-breaking achievement, marking the UAE's entrance into commercial nuclear power generation. With a planned capacity of 5.6 GW, it is poised to fulfill approximately 25% of the UAE's energy needs. This nuclear facility plays a pivotal role in reducing carbon emissions and advancing sustainability goals preventing the release of 21 million tonnes of carbon emissions each year after completion of all four units in 2024.

- **MOHAMMED BIN RASHID AL MAKTOUM SOLAR PARK:** Positioned as the world's largest single-site solar park, the Mohammed bin Rashid Al Maktoum Solar Park is a flagship project for solar energy. With substantial investments totaling AED 50 billion, it makes a significant contribution to clean energy generation and carbon emissions reduction.

- **ABU DHABI SOLAR PROJECTS:** Multiple projects in the emirate of Abu Dhabi such as the Al Dafra, Noor PV, Sweihan, are offering some of the world's lowest solar tariffs. These projects contribute to renewable energy capacity in the emirate of Abu Dhabi.

Collectively, other projects for reverse osmosis, hydropower, and molten salt thermal energy storage system showcase the UAE's comprehensive strategy for addressing climate change, nurturing sustainability, and diversifying its energy portfolio. The nation's commitment to fostering a balanced energy mix, coupled with substantial investments in renewable energy, plays a pivotal role in realizing its ambitious environmental and energy objectives.

Electricity Consumption

In the year 2022, the UAE witnessed a substantial surge in its domestic electricity consumption, reaching a total of 134,605.7gigawatt-hours (GWh). This marked a notable increase compared to the previous year, 2021, when electricity consumption stood at 129,028GWh. The data reveals a consistent and upward trend in electricity demand spanning the nine-year period from 2014 to 2022, with an average annual consumption of approximately 116,617.7GWh. This robust growth in electricity consumption highlights the UAE's expanding requirements for electrical power, primarily driven by factors such as increasing electrification in the nation, growing industrial demand, economic development, and the continued process of urbanization.

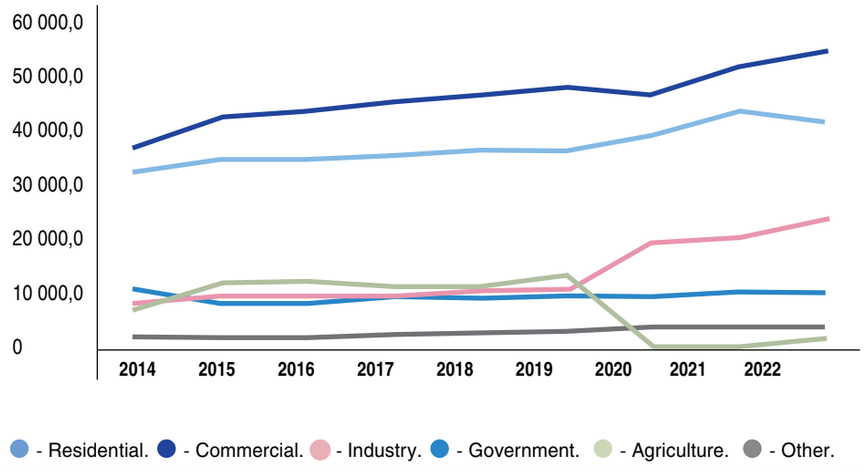


Figure 4: *Total domestic electricity consumption (GWh) in the UAE, 2014 – 2022.*
Source: *Ministry of Energy and Infrastructure; Federal Competitiveness and Statistics Centre, UAE*

Detailed Sectoral Breakdown of Electricity Consumption

The year 2021 witnessed a multifaceted landscape in the sectoral breakdown of domestic electricity consumption within the UAE. The distribution of electricity consumption across various sectors is as follows:

- **RESIDENTIAL SECTOR:** Accounting for 33.3% of the total electricity consumption, the residential sector represents a significant portion of domestic power usage. This segment includes households and residential properties, reflecting the electricity needs of the UAE's population.
- **COMMERCIAL SECTOR (OFFICES):** The commercial sector, consisting of offices and businesses, accounted for 39.7% of the overall electricity consumption. This sector's substantial share underscores the thriving business and commercial activities that are integral to the UAE's economy.
- **INDUSTRIAL SECTOR:** The industrial sector accounted for 15.8% of the total electricity consumption. This category includes various industrial processes and manufacturing activities that rely on electricity to power machinery and operations.
- **GOVERNMENT SECTOR:** Electricity consumption within government facilities and institutions represented 8% of the total. This sector encompasses government offices and administrative buildings.
- **AGRICULTURAL SECTOR:** The agricultural sector, which includes farming and agricultural activities, represented 3.1% of the electricity consumption. Electricity plays a role in irrigation, lighting, and other agricultural processes.
- **OTHER SECTORS:** Miscellaneous sectors, collectively comprising 0.2% of the total electricity consumption, encompass a range of activities not classified in the primary sectors mentioned above.

This sectoral breakdown highlights the diversified nature of electricity demand within the UAE. While residential consumption reflects the needs of the population, the significant share of the commercial sector underscores the importance of business and commercial enterprises in the country's energy landscape.

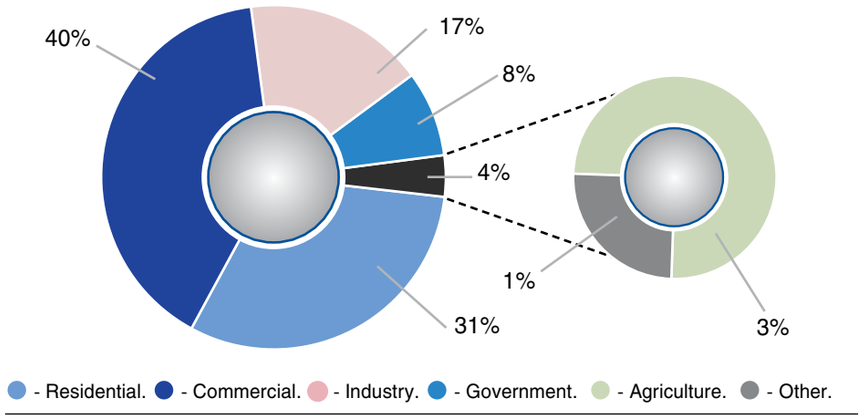


Figure 5: Sectoral breakdown of domestic electricity consumption in 2022.
Source: *Ministry of Energy and Infrastructure; Federal Competitiveness and Statistics Centre, UAE*

Total Generating Capacity (as of 2022)

The UAE maintained a robust total cumulative installed generating capacity of 38,488.0 megawatts (MW) in 2022. This capacity is distributed across various technological sources:

- **GAS TURBINES:** Gas turbines accounted for 20.1% of the total generating capacity. These turbines are commonly used for electricity generation due to their efficiency and reliability.
- **STEAM TURBINES:** Steam turbines contributed 3.7% to the total generating capacity. Steam turbines are known for their versatility and are used in both fossil fuel and nuclear power plants.
- **COMBINED CYCLE TURBINES:** Combined cycle turbines held the largest share, constituting 60.9 % of the total generating capacity. Combined cycle power plants are highly efficient, utilizing both gas and steam turbines to generate electricity.
- **SOLAR:** Solar power made up 8% of the total generating capacity. The UAE has been investing in solar energy projects to harness its abundant sunlight for electricity generation.
- **NUCLEAR:** Nuclear technology contributed 7.2 % to the total generating capacity. The emergence of nuclear power in the UAE reflects a commitment to diversifying energy sources and ensuring a reliable power supply.

This diverse mix of technologies underscores the UAE's commitment to a secure and sustainable energy landscape, with a significant emphasis on combined cycle turbines and growing contributions from solar and nuclear sources.

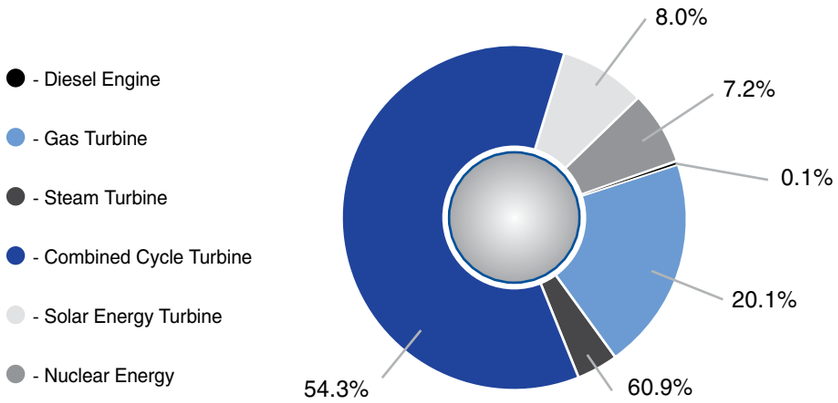


Figure 6: Percentage Distribution of Installed Capacity of Electricity Generation Plants by Type of Generator, 2022

Source: *Ministry of Energy and Infrastructure; Federal Competitiveness and Statistics Centre, UAE*

In 2022, the UAE achieved a remarkable total electricity generation of 155,438.4 gigawatt-hours (GWh). The breakdown of electricity generation by major entities is as follows:

- **EWEC (EMIRATES WATER AND ELECTRICITY COMPANY):** EWEC was the leading contributor to electricity generation, accounting for 60.8% of the total. EWEC supplies power and water in the emirate of Abu Dhabi as well as exports them to some other emirates.
- **DEWA (DUBAI ELECTRICITY AND WATER AUTHORITY):** DEWA closely followed, contributing 34.02 % to the total electricity generation. DEWA serves the emirate of Dubai and plays a vital role in meeting the city's electricity needs.
- **SEWA (SHARJAH ELECTRICITY AND WATER AUTHORITY):** SEWA made a smaller yet significant contribution, representing 5.17 % of the total electricity generation. SEWA serves the emirate of Sharjah

This distribution of electricity generation highlights the pivotal role of key entities, such as EWEC and DEWA, in ensuring a stable and efficient power supply for the UAE.

- **STATE-OWNED AND IPPS:** The UAE's power sector is predominantly managed by state-owned entities, with independent power producers (IPPs) playing a growing role.
- **CLEAN ENERGY PROJECTS:** Key projects include the Mohammed bin Rashid Al Maktoum Solar Park, set to reach a capacity of 5,000 megawatts (MW) by 2030, and the Barakah Nuclear Power Plant, which began operations in 2020 and will have a total capacity of 5,600 MW upon completion.

1.6 Nuclear Energy

Since the discovery of oil and gas reserves over half a century ago, the UAE has undergone a remarkable economic transformation. In just a few decades, the country has transitioned from a small fishing and pearl trading economy to a global hub for tourism, trade, business and finance. With a view to sustaining this economic progress while reducing its carbon emissions, the UAE is diversifying its energy mix, including through the introduction of nuclear energy.

The Barakah nuclear power plant (NPP), the first in the UAE and the Arab world, began operating in 2020. Three reactors are currently in operation, and the final one is close to construction completion. The NPP is expected to provide up to 25% of the country's electricity – with the capacity to power more than half a million Emirati households – when it becomes fully operational in the coming years. However, as with any other NPP, it will have to be disassembled at the end of its useful life, in around 60-80 years. Today, every country embarking on a nuclear program is required, when designing a nuclear facility, to develop preliminary plans for decommissioning the facility so that the site can be repurposed. Some of key highlights:

- The UAE has embarked upon a nuclear power program in close consultation with the International Atomic Energy Agency, and with huge public support.
- It accepted a $20 billion bid from a South Korean consortium to build four commercial nuclear power reactors, total capacity of 5.6 GW, by 2024 at Barakah.
- Unit 1 of the country's first nuclear power plant was connected to the grid in August 2020, followed by unit 2 in September 2021, unit 3 in October 2022, and unit 4 by the end of 2024.

The Barakah NPP will play a key role in the UAE's 2050 net zero strategy, which aims to drastically increase the country's production of clean energy. It will prevent the release of over 22 million tonnes of greenhouse gases per year — equivalent to the emissions of nearly five million cars — constituting a quarter of the UAE's emission reduction commitments under the Paris Agreement, the international treaty on climate change to that effect. The Barakah NPP is already the largest single generator of electricity and the largest source of clean electricity in the region.

1.7 Hydrogen

The National Hydrogen Strategy 2050 aims to support low-carbon local industries, contribute to achieving climate neutrality and strengthen the UAE's position as a reliable producer and supplier of low-emission hydrogen by 2031. The UAE will achieve this through the development of supply chains and the establishment of hydrogen oases and a dedicated national research and development centre for hydrogen technologies.

The strategy focuses on 10 enablers and outlines the key steps that the UAE will take to accelerate the growth of the hydrogen economy and reduce emissions in highly emission-intensive sectors.

The strategy contributes to:

- fostering the domestic market
- developing a regulatory framework and policies that support hydrogen as a sustainable fuel for the future
- strengthening regional collaboration to establish a regional hydrogen market, and
- bolstering investments in research and development to improve the cost effectiveness of hydrogen production, transport, and utilisation.

The strategy enhances the investor confidence and helps companies develop robust supply chains. It supports the country's approach to fully utilise its abundant solar energy and natural gas resources, its ability to capture and store carbon, and its strategic location to unlock local hydrogen production capabilities while accelerating the global hydrogen economy.

PRODUCTION MILESTONES

The strategy will help accelerate the global hydrogen economy and scale up local hydrogen production to:

- 1.4 million tonnes per annum (mtpa) by 2031 (consisting of 1 mtpa of green hydrogen and 0.4 mtpa of blue hydrogen)
- 7.5 mtpa by 2040, and
- 15 mtpa by 2050.

Following a thorough study of hydrogen demand, the National Hydrogen Strategy forecasts local demand of low-carbon hydrogen to reach 2.7 mtpa by 2031.

An overview of the targets and predictions for hydrogen production was considered while preparing short-, medium-, and long-term scenarios for the future generation of blue, green, and pink hydrogen until 2050.

KEY ENABLERS

To enhance the UAE's position as a supplier of low-emission hydrogen and achieve the country's objectives, 10 enablers have been identified. They are:

10 enablers have been identified within three main stages in the National Hydrogen Strategy to reach the targets set by 2031

Global Collaboration

Building international partnerships and creating investment opportunities to drive the global transition to a hydrogen economy.

Resources and Assets

Leveraging natural resources and existing assets to competitively lead future energy markets.

Climate, Safety and Social Driver

Guiding society to embrace hydrogen and unlocking the common good as a results of global carbon mitigation.

Enabling Infrastructure

Creating the infrastructure necessary to link production with demand, accelerating hydrogen availability and utilization.

Research and Innovation

Incubating and accelerating next generation hydrogen technology developments across the value chain.

Policy, Regulation and Standards

Establishing the legislative mechanisms to support the low carbon hydrogen transition, including hydrogen certification and guarantees of origin.

Finance and Investments

Creating an attractive investment environment to support the hydrogen transition, as well as developing green finance mechanisms domestically.

Industry Development and Demand Activation

Providing the certainty, predictability and confidence the industry needs to transition to hydrogen.

Sustainable Commercial and Economic Models

Achieving and maintaining globally competitive hydrogen pricing through a long-term market driven support mechanism.

Skills and Education

Nurturing and growing a highly skilled workforce to drive forward the transition to hydrogen.

EXPECTED OUTCOME OF THE STRATEGY

The National Hydrogen Strategy drives the country's investments in clean energy and its contribution to the global efforts towards environmental sustainability, in line with its role as the host of the 28th UN Climate Change Conference (COP28).

It is a crucial tool to meet the country's commitment to net zero by 2050 and the Paris Agreement.

It will also help reduce emissions in hard-to-abate sectors, such as land, sea, and air transport, chemicals and fertilizers, as well as metals, including aluminum, iron, and steel, by 25 per cent before 2031 and 100 per cent by 2050.

National Context, including but not limited to:

- Fuel and energy balance structure, fuel and energy resource availability and accessibility etc.
- UAE reserves of crude oil = 113 billion barrels, with natural gas reserves = 8.21 trillion cubic metres.
- Nuclear energy capacity reached 5 GW, and solar energy capacity can supply up to 5 GW by 2030.

TASKS, OBJECTIVES AND CHALLENGES IN THE NATIONAL ENERGY SECTOR

- Integrating the policies of all the emirates utilities to inform the federal government
- Coordination of all the strategic projects in the energy sector
- Coordination in the implementation of the approved strategies
- Data collection of all the energy sector
- Expansion planning of the sector
- Grid stability and reliability of the energy sector
- Energy transition implementation in the most economical and sustainable way
- Aligning between all stakeholders relating to policy, security, and future investments.

NATIONAL ENERGY POLICY IN THE CONTEXT OF JUST ENERGY TRANSITION (THE COUNTRY'S PERSPECTIVE), INCLUDING BUT NOT LIMITED TO:

- National targets for reducing the impact of energy enterprises on the environment and climate
- Policies, measures, and initiatives to achieve SDG 7
- Modern technology availability and access

DSM:

- Artificial Intelligence (AI) and Machine Learning (ML) to predict energy consumption trends and optimize energy distribution.
- Smart platform to analyse consumption data and take informed decisions.
- Electric Vehicles (EVs) and charging infrastructure
- Renewable energy integration
- Priorities for technology development in the energy sector, taking into account national features and capabilities

2 POLICY, GOALS, OBJECTIVES AND INSTRUMENTS FOR IMPLEMENTATION OF JUST ENERGY TRANSITION IN THE UNITED ARAB EMIRATES

NATIONAL STRATEGIES AND PROGRAMS THAT LEAD TO JUST TRANSITION

The UAE has carried out actions and plans in pursuit of economic diversification that will also help reduce its GHG emissions and support the country in its adaptation to the impacts of climate change. The UAE is actively implementing a comprehensive set of strategies and initiatives, both at the national and at emirates level such as,

- **UAE Net Zero 2050:** The UAE Net Zero by 2050 Strategic Initiative is a national effort aimed at achieving net-zero emissions by 2050, positioning the Emirates as the first MENA[1] nation to commit to this ambitious goal. This initiative is closely aligned with the Principles of the 50, the UAE's economic development roadmap, marking the nation's golden jubilee and signalling a new cycle of growth. Pursuing net-zero emissions aligns with the vision to make the UAE the world's most dynamic economy. Moreover, the UAE Net Zero by 2050 Strategic Initiative is in accordance with the Paris Agreement, which urges countries to formulate long-term strategies for reducing greenhouse gas emissions and limiting global temperature increases to 1.5°C compared to pre-industrial levels.
- **National Hydrogen Strategy:** The primary goal of the National Hydrogen Strategy is to bolster environmentally friendly local industries, actively contribute to the pursuit of net-zero emissions, and further solidify the UAE's standing as a major hydrogen producer by 2031. This strategy places emphasis on ten key facilitators and delineates the critical measures that the UAE plans to implement in order to expedite the expansion of the hydrogen economy and curtail emissions in sectors with high emission intensity. The UAE aims to achieve these objectives through activities like building robust supply chains, setting up hydrogen hubs, and establishing a specialized national research and development center focused on hydrogen technologies.
- **The National Strategy to Combat Desertification:** The National Strategy to Combat Desertification 2030, introduced to counteract land degradation, drought, and desertification, has set ambitious goals for the UAE. By 2030, the strategy aims to enhance land productivity, restore degraded lands, and safeguard water resources. The UAE government's objectives include a 40% improvement in production system efficiency, restoring at least 80% of degraded land, and achieving a 60% increase in the use of treated water while optimizing water consumption.
- **UAE Wind Program:** The UAE Wind Program is a 103.5-megawatt clean energy project designed to seamlessly incorporate cost-effective, large-scale wind power into the UAE's electricity grid. This initiative serves the purpose of diversifying the country's energy sources and accelerating the shift towards cleaner, more sustainable energy. It strongly underscores the UAE's dedication to decarbonization and its ambitious goal of achieving net-zero emissions by 2050. The project is planned to annually provide energy for over 23,000 UAE households and reduce carbon dioxide emissions by 120,000 tonnes.
- **UAE Energy Strategy 2050:** The updated UAE Energy Strategy 2050 focuses on advancing renewable and nuclear energy adoption, improving energy efficiency, fostering energy technology research and innovation, bolstering local clean energy capacity, and attracting investments in the clean energy sector. With a goal to triple the contribution of renewable energy, the strategy also includes substantial investments of AED 150 to AED 200 billion by 2030 to meet the growing energy demand resulting from the country's rapidly expanding economy.

- **The National Framework for Sustainable Development:** The National Framework for Sustainable Development in the UAE seeks to elevate the country's overall quality of life, stimulate economic diversification and prosperity, safeguard its ecosystems, maintain ecological resources, and contribute to the realization of the UN Sustainable Development Goals for 2030. The framework is structured around five primary pillars, addressing nature, environmental health, climate change, living organisms, and biosecurity to drive sustainable development in the nation.
- **The UAE's Green Agenda – 2030:** The UAE's Green Agenda 2030 is a comprehensive, long-term strategy aimed at advancing sustainable development and fostering an environmentally friendly economy. It encompasses strategic objectives that revolve around fostering a competitive knowledge economy, enhancing social development and quality of life, promoting environmental sustainability, preserving natural resources, advancing clean energy and climate action, and encouraging a green lifestyle and sustainable resource utilization. By 2030, the UAE's Green Agenda strives to increase the country's GDP by 4 to 5 percent, boost exports by approximately AED 24 to 25 billion, and reduce emissions to below 100 kilowatt-hours, aligning with sustainable development and environmental preservation.
- **The National Air Quality Agenda 2031:** The National Air Quality Agenda 2031 serves as a comprehensive framework to guide and coordinate federal and local government bodies and the private sector in their efforts to monitor and effectively manage air quality, reducing pollution for a healthier and safer environment. The agenda encompasses initiatives and projects targeting outdoor and indoor air quality, ambient odours, and noise levels. To achieve its objectives, the plan emphasizes essential enablers like establishing clear policies and institutional frameworks, enhancing technical and human resources, promoting research, utilizing advanced technology, and ensuring access to financial resources.
- **National Water and Energy Demand Management Programme:** The National Water and Energy Demand Management Programme is committed to achieving 40% efficiency in the UAE's most energy-intensive sectors: transport, industry, and construction. This program encompasses three core pillars: energy, water, and consumption rationalization. It aims to significantly reduce energy demand by 40%, increase the share of renewable energy to in the energy mix to ensure reaching Net Zero in the electricity and water sector by 2050, and expand water reuse by 95% before 2050. By uniting all stakeholders, the program aligns with the objectives of the UAE Energy Strategy 2050 and the UAE Water Security Strategy 2036, contributing to a sustainable and energy-efficient future.
- **National Climate Change Plan of the UAE 2017–2050:** The National Climate Change Plan of the UAE (2017-2050) serves as a comprehensive framework to addressing climate change causes and impacts, with the aim of transitioning to a climate-resilient green economy and improving overall quality of life. It has three primary objectives. Firstly, it focuses on managing greenhouse gas emissions while sustaining economic growth, intending to align climate action with economic goals. Secondly, the plan aims to mitigate climate-related risks and enhance adaptation capacity, safeguarding the UAE's economy, infrastructure, people, and ecosystems from climate impacts. Lastly, it seeks to support economic diversification by promoting innovative solutions that generate added value for emerging sectors and create jobs in green industries, ultimately fostering a strong growth momentum in non-oil sectors.
- **The UAE Water Security Strategy 2036:** The UAE Water Security Strategy 2036 is designed to secure sustainable water access in both regular and emergency situations. Its objectives include reducing water demand by 21%, enhancing water productivity, lowering water scarcity, increasing treated water reuse to 95%, and expanding national water storage capacity to two days. The strategy is structured around three main programs: Water Demand Management, Water Supply Management, and Emergency Production and Distribution. It also encompasses policy development, legislative measures, awareness campaigns for water conservation, advanced technology utilization, innovation, and capacity-building efforts to ensure water security in the UAE.
- **Environment Vision 2030 (Abu Dhabi):** Abu Dhabi's Environment Vision 2030 is a strategic plan developed to promote integration among the three dimensions of sustainability: environmental, economic, and social well-being. It seeks to preserve and enhance the emirate's natural heritage while efficiently using resources and improving the quality of life for its residents. The vision prioritizes five key areas: addressing climate change impacts, ensuring clean air and reducing noise pollution for safe and healthy living, managing water resources efficiently, conserving biodiversity, habitats, and cultural heritage for current and future generations, and optimizing waste management to create value through improved material flows and

waste handling. Under this program, Abu Dhabi has already set a target to introduce 60% of clean energy by 2035 and developed related policies, plan, and grid code.

- **Dubai Integrated Waste Management Strategy 2021-2041:** The Integrated Waste Management Strategy 2021-2041 is geared toward fostering innovation in waste management, recycling, and energy conversion. It envisions a 20-year timeline for implementing long-term projects aimed at offering practical solutions to environmental challenges, aligning with the government's environmental objectives. The strategy also seeks to enhance various vital areas and sectors. It complements other projects endorsed by The Executive Council of Dubai, focusing on sustainability, environmental preservation, quality of life enhancement, and building a sustainable future. To execute this strategy, a budget of AED 74.5 billion is allocated, with AED 70.5 billion contributed directly by the private sector.
- **RAK Energy Efficiency** and **Renewable Energy Strategy 2040:** The Ras Al Khaimah Energy Efficiency and Renewables Strategy 2040 (EE&R Strategy) outlines the long-term plan for Ras Al Khaimah's energy efficiency and renewable energy initiatives. This comprehensive strategy encompasses nine distinct programs, including green building regulations, energy management, efficient appliances, and solar programs. The primary goals are to achieve a minimum of 30% electricity consumption savings, a 20% reduction in water consumption, and a 20% contribution from renewable energy sources in the energy supply mix compared to business-as-usual scenarios. These targets are consistent with the RAK Vision 2030 objectives, aiming for 10% electricity savings and 5% of electricity demand to be met through solar power by 2030.
- **Dubai Clean Energy Strategy:** The Dubai Clean Energy Strategy is geared towards generating 75% of the emirate's energy needs from clean sources by 2050, while also positioning Dubai as a global hub for clean energy and the green economy. This strategy is founded on five key pillars: infrastructure, legislation, funding, capacity building, and an eco-friendly energy mix. Infrastructure initiatives include the impressive Mohammed Bin Rashid Al Maktoum Solar Park, set to be the world's largest solar energy generator with a capacity of 5,000 MW by 2030. The legislation pillar focuses on a legislative framework to support clean energy policies. The funding pillar involves the Dubai Green Fund, a substantial AED 100 billion resource offering affordable loans for clean energy investors. The fourth pillar aims to enhance human resources through global training programs, collaborating with international organizations and institutes. Lastly, the fifth pillar centers on an eco-friendly energy mix, with plans to increase clean energy sources to 75% by 2050, thereby positioning Dubai as the city with the world's lowest carbon footprint.

Diversification of Energy Sources

- **Investment in Solar:** The Mohammed bin Rashid Al Maktoum Solar Park is a key initiative, expected to reduce CO2 emissions by over 6.5 million tonnes annually.

Energy Efficiency

- **Building Standards:** Implementation of energy-efficient building standards and regulations.
- **Smart Grids:** Development of smart grid technologies to optimize energy distribution and consumption.

Carbon Emissions Reduction

- **Target:** Reduce carbon footprint of power generation to align with the net zero by 2050 goal.
- **Nuclear Energy:** The Barakah Nuclear Power Plant is expected to prevent the emission of 21 million tonnes of CO2 annually.

Innovation and Technology

- **R&D Funding:** Substantial funding allocated for research and development in clean energy technologies.
- **Innovation Hubs:** Establishment of innovation hubs like Masdar City, focusing on sustainable urban development and renewable energy research.

2.1 Ensuring Energy Security

While the energy transition is underway and must accelerate, the UAE is aware of its responsibility as a reliable, low-emissions energy provider and a driver of global energy security, particularly amidst the current energy crisis. The UAE is driving this transition in three ways:

1. Implementing policy measures to reduce its own oil and gas demand, for example through increasing energy efficiency across economic sectors, or through electrification in industry and transport.
2. Continuing production of Murban crude oil, which already has a comparatively low carbon intensity as a product of its advantageous geology, decades of advanced reservoir management practices, and continued investments in the decarbonisation of its operations and portfolio.
3. Heavily investing in renewable energy overseas. The nation has invested more than US$50 billion in renewable energy projects across 70 countries, including 27 island nations, and plans to invest an additional $50 billion over the next decade.

- **Diversified Energy Mix:** The UAE's strategy includes a mix of natural gas, solar, and nuclear energy to ensure a stable and reliable electricity supply.
- **Infrastructure:** Investments in infrastructure, such as grid enhancements and energy storage, to improve reliability.
- **Strategic Reserves:** Maintenance of strategic fuel reserves to safeguard against supply disruptions.

2.2 Ensuring Energy Efficiency and Energy Saving

National Energy and Water Demand Side Management Programme 2050 has been developed to target the most energy consuming sectors in the country: built environment, transport, agriculture, and industry, aiming to reduce energy demand by 40% and water demand by 50% before 2050, which will support cost reduction, investment, and sustainability.

The program consists of three main parts:

- **Energy:** It includes initiatives to reduce energy consumption for the three largest energy-consuming sectors in the country, namely industry, transport, and built environment, to reduce energy demand by 40% in 2050.
- **Water:** It includes initiatives to reduce water consumption for the largest water consumption sectors, agriculture and buildings sector, to raise the efficiency of water consumption, which contributes to improving the domestic product and enhancing the country's competitiveness in the field of environmental and economic sustainability.
- **Consumption rationalization:** It is a plan for an integrated awareness campaign for consumers within the target groups: families, students, employees, workers, and tourists.

The program has four pillars:

- **Built environment:** Optimizing energy and water efficiency within the urban environment through increased phasing in of green building, retrofitting existing building stock, replacing fixtures and equipment, and improving public and private irrigation practices.
- **Transport:** Reducing energy demand in transport across emirates through the Avoid, Shift and Improve Framework by using smart city planning, public transport, and green technology.
- **Agriculture:** Paradigm shift from unsustainable abstraction of groundwater to sustainable management of groundwater, by balancing water and food security requirements, promoting efficient irrigation, and using alternative water sources.
- **Industry:** Fostering responsibility and accountability within industry through regulatory and transparency requirements to promote efficiency, sustainability, and best practice to drive energy efficiency.

2.3 Scientific and Technological Base

The UAE holds a prominent position as a hub for innovation and technology in the Middle East, and its commitment to climate action further solidifies this role. The UAE views climate action as an opportunity and recognizes the necessity of investing in crucial tools, including technology, research and development (R&D), to attain its ambitious objectives. To ensure that essential technologies are available at the right level of maturity and scalability, the UAE has outlined a comprehensive strategy for technology and R&D, demonstrating the credibility of its implementation plan.

Key technologies of focus within the UAE include Carbon Capture and Storage (CCS), Direct Air Capture (DAC), hydrogen production and distribution, green standards for cement and concrete products, and the use of recycled materials. Additionally, the country is engaged in discussions concerning the potential adoption of Small Modular Reactors (SMRs). Implementing this technology and R&D strategy necessitates the mobilization of essential resources, including funding and human capital development.

As part of this mobilization effort, the Emirates Research and Development Council was established in 2021, with the goal of fostering a national environment conducive to research and innovation. The council aims to not only elevate the UAE's global standing in science and technology but also to unify efforts in achieving national R&D priorities, particularly in sustainability, for the development of a knowledge-based, post-oil economy. The UAE has also launched the Virtual R&D Hub, supporting applied research for economic growth.

The UAE consistently conducts research on climate, energy innovations, sustainable technologies, and practices through established scientific research centers and programs. For example, the Dubai Electricity and Water Authority operates a Research and Development Center dedicated to innovative solutions in areas such as solar power, water, smart grid integration, and energy efficiency, supported by enablers such as the Fourth Industrial Revolution technologies. Other institutions like Khalifa University of Science and Technology and UAE University offer research programs addressing a wide range of strategic, scientific, and industrial challenges associated with the UAE's transition to a knowledge-based economy, including clean and renewable energy, water, and the environment.

The UAE Space Agency plays a pivotal role in leveraging space data and technologies to address global sustainability challenges. The Space Data Centre, a digital platform, provides access to space data for various stakeholders, enabling the development of solutions for national and global challenges. The Space Agency's Space Analytics and Solutions (SAS) project focuses on enhancing waste and water quality monitoring, GHG and air quality inventory collection, emissions management systems, and food security through vegetation health monitoring and soil moisture mapping.

In 2021, the UAE launched the Hydrogen Leadership Roadmap to establish the nation as a global leader in low-carbon hydrogen, contributing to net zero by 2050 and creating economic opportunities. Multiple green hydrogen projects are already underway in the UAE.

The UAE is also attentive to emerging technologies crucial for advancing its climate agenda, including CCS, blended cement, and recycled materials. Programs supporting local and international entrepreneurs and innovators include the Mohammed Bin Rashid Innovation Fund (MBRIF), Climate Innovations Exchange (CLIX), and Solar Decathlon Middle East (SDME). These initiatives provide funding, mentorship, and networking opportunities for businesses and start-ups focused on climate-related solutions.

International universities and technological institutes present in the UAE, such as NYU, American University Dubai, and the Sorbonne, offer education to local students. The UAE actively seeks collaborative partnerships with leading international institutions to empower its youth in addressing climate challenges through innovation and research.

CAPABILITY BUILDING REQUIREMENTS

To achieve its goals in both climate mitigation and adaptation, the UAE is committed to enhancing its human resources and capabilities, empowering its citizens to address climate change. Under the UAE's Net Zero 2050 Strategy, it plans to generate an average of 160,000 jobs annually between 2025 and 2050 and aims to future-proof an additional 40,000 jobs. Effective upskilling and capacity building are essential to maximize local employment opportunities and harness the job creation potential offered by the transition to a green economy. The plan involves preparing the UAE's workforce to leverage the opportunities arising from the emerging green economy, mobilizing relevant stakeholders in climate action, enhancing their capabilities, and fostering greater awareness of climate change.

The UAE is making significant efforts to strengthen its capabilities in designing, implementing, enforcing, and monitoring effective policies and regulations to successfully achieve the objectives outlined in its Nationally Determined Contributions (NDC). The UAE is self-reliant in capability building for its climate agenda and has already initiated various initiatives in this regard.

CAPACITY BUILDING FOR GOVERNMENT AND PRIVATE SECTOR

In 2021, the UAE introduced the UAE Climate Change Research Network (CCRN), which serves as a collaborative platform for scientists and researchers to enhance the collection of climate-related information and conduct policy research on the effects of climate change and adaptation strategies. This initiative aims to bridge the gap between government and academia, fostering knowledge-sharing and guiding a science-based climate agenda for the country.

Launched in 2022, the Jahiz initiative focuses on upskilling government employees by offering programs that develop critical future skills, including digital literacy, data analysis, and AI, as well as expertise in areas such as net-zero concepts, climate change, the circular economy, and sustainability. The Jahiz digital platform provides

government employees with training opportunities, enhancing the competitiveness and future readiness of the UAE government.

Recognizing the significant role of educators in shaping the future workforce and preparing students to address the challenges of a changing economy, numerous capacity-building programs target educators. The UAE government, in collaboration with UNICEF, plans to train approximately 3,000 master trainers and 1,500 principals across the country. This training will facilitate the integration of climate education into teacher training, covering cross-curriculum and extra-curriculum activities. The TeachersCOP event aims to give primary and secondary teachers as well as school directors a voice in global climate discussions.

At the emirate level, Abu Dhabi has introduced the Integrated Energy Model (IEM), known as the Energy Cube, to provide policymakers, business leaders, and investors with a comprehensive view of the energy sector value chain. The IEM serves as a collaborative platform, offering insights for policy and decision-making in the increasingly complex energy landscape. In Ras Al Khaimah, the Environmental Sustainability Award recognizes institutions for their efforts in reducing environmental footprints and fostering environmental responsibility. The Upskill program, launched in 2021, provides training and certifications on energy efficiency and renewables for various professionals.

Efforts are also underway to build capacity within the private sector. Collaborating with Emirates Nature-WWF (EN-WWF), the UAE has conducted workshops to increase the private sector's capabilities in climate action, with a focus on carbon footprint estimation and emissions reduction strategies. The Leaders of Change mission by EN-WWF supports corporations and government employees in upskilling to promote sustainable development, the Net Zero pathway, and organizational transformation.

- Research and Development: Investment in R&D for advancements in renewable energy technologies, smart grids, and energy storage.
- **Innovation Centers:** Establishment of centers like the Masdar Institute to foster innovation and technological development.
- **Global Partnerships:** Collaborations with international institutions to leverage global expertise and best practices in energy technologies.

The UAE's proactive approach in evolving its electricity sector through diversified energy sources, efficiency improvements, and robust policy frameworks underscores the country's commitment to a sustainable and secure energy future.

2.4 Instruments for Just Energy Transition

The UAE has been actively working towards a just energy transition, balancing economic growth, environmental sustainability, and social equity. The UAE has implemented various instruments to achieve this transition, focusing on policy frameworks, investment in renewable energy, technological innovation, and public engagement. Here are some key instruments and initiatives:

1. Policy Frameworks and Strategies

- **UAE Energy Strategy 2050:** The strategy aims to increase the share of clean energy in the total energy mix to 30% by 2030, reduce the carbon footprint of power generation by 100%, and improve energy efficiency upto 45%.
- **The UAE's Net Zero 2050 Strategy:** which builds upon the UAE Net Zero by 2050 Strategic Initiative which outlines the UAE's ambitious journey towards net zero, and the National Net Zero by 2050 Pathway, which sets out the timeline and mechanisms for this transition. This strategy is designed to act as a stimulus for economic and societal advancement by leading the transition to net zero emissions. It has over 25 programmes across the following 6 key sectors: power, industry, transport, buildings, waste, and agriculture.

2. Investment in Renewable Energy

- **Masdar Initiative:** Abu Dhabi's renewable energy company, Masdar, has been a pioneer in driving renewable energy projects both domestically and internationally, focusing on solar and wind energy.
- **Solar Projects:** The UAE has launched several large-scale solar projects, such as the Mohammed bin Rashid Al Maktoum Solar Park in Dubai, which is one of the largest solar parks in the world.

3. Technological Innovation and R&D

- **Research and Development (R&D):** Investment in R&D for new energy technologies, including carbon capture and storage (CCS), hydrogen fuel, and energy storage solutions.
- **Smart Grids:** Development and implementation of smart grid technologies to improve energy efficiency and integrate renewable energy sources.

4. Regulatory and Market Instruments

- The UAE considers the renewable energy industry a crucial part of the country's energy strategy for the upcoming years. It has experienced significant growth and development, driven by the country's ambitious clean energy targets, favourable market conditions, and strong government support. According to the UAE Federal Decree-Law No. 17 of 2022, which regulates the connection of distributed renewable energy production units to the electricity grid, renewable energy is defined as "energy produced from natural resources and renewed at a rate that exceeds its consumption."
- **Green Building Regulations:** Implementation of regulations such as the Estidama Pearl Rating System in Abu Dhabi and the Dubai Green Building Regulations to ensure new buildings meet sustainability criteria.

5. Public-Private Partnerships

- **Private Sector Engagement:** Encouraging investment from the private sector in renewable energy projects through incentives and favorable policies.
- **Collaboration with International Organizations:** Working with organizations such as the International Renewable Energy Agency (IRENA), headquartered in Abu Dhabi, to promote global renewable energy initiatives.

6. Capacity Building and Education

- **Education and Training Programs:** Developing programs to build local expertise in renewable energy technologies and sustainability practices.
- **Public Awareness Campaigns:** Initiatives to raise awareness about energy conservation and the benefits of renewable energy.

7. Social and Economic Policies

- **Job Creation:** Ensuring the creation of new job opportunities in the renewable energy sector to support economic growth and provide employment.
- **Social Equity Measures:** Policies aimed at ensuring that the benefits of the energy transition are shared across different segments of society, including marginalized communities.

8. Financial Instruments

- **Green Bonds:** Issuing green bonds to finance renewable energy and sustainability projects.
- **Subsidies and Incentives:** Providing financial incentives and subsidies for the adoption of clean energy technologies by households and businesses.

9. International Cooperation

- **Global Partnerships:** Collaborating with other countries and international organizations to share best practices and technologies for sustainable energy development.
- **Hosting International Events:** Hosting events such as the World Future Energy Summit to foster dialogue and cooperation on renewable energy and sustainability.

By leveraging these instruments, the UAE aims to transition to a more sustainable energy system while ensuring economic growth, social equity, and environmental protection. ■

CONCLUSIONS AND RECOMMENDATIONS

The energy sector is one of the driving forces of socio-economic development and implementation of the UN Agenda for Sustainable Development 2030. Almost all of the 17 UN Sustainable Development Goals are in one way or another related to the growing demand for energy.

In 2015, the international community set an ambitious goal of ensuring universal access to affordable, reliable, sustainable and modern energy for all (SDG 7) with the aspiration to reach it by 2030. However, considering the existing approaches and the progress achieved so far, not all countries will be able to reach this goal within the timeline set due to the challenges of energy transition. In addition, there are differences between the internationally proclaimed SDG 7 target indicators and the approaches to socio-economic development, energy transition and climate mitigation options.

With this, the achievement of the SDG 7 in parallel with upholding just energy transition track makes it crucial to undertake the best possible efforts to harmonize and align the sustainable, balanced socio-economic development and mitigation of the negative impact on the environment and climate.

The BRICS countries have differences in energy self-sufficiency, fuel and energy balance structure, energy infrastructure, and domestic energy market operation models. Special consideration should be given to specific circumstances of the countries whose economies are heavily dependent on revenue from production or consumption of fossil fuels and related energy-intensive products and some BRICS countries where the majority of their population still lack modern energy access.

The BRICS countries today jointly represent 45 per cent of the global population and 37 per cent of the global GDP based on purchasing power parity. The BRICS countries are both the largest producers and the largest consumers of fossil fuels and energy resources. These countries account for 74 per cent of world coal consumption and 70 per cent of its global production. As of 2021, the BRICS countries produced 37 per cent and consumed 36 per cent of global natural gas. The BRICS countries account for 37 per cent of global consumption of petroleum products and 42 per cent of world oil production.

All BRICS countries have committed themselves to achieving carbon neutrality goal. Brazil, Ethiopia, South Africa and the UAE plan to achieve it by 2050, China, Russia and Saudi Arabia – by 2060, and India – by 2070. Egypt has not yet legally endorsed the goal, but the country has joined the Paris Agreement, which envisions net zero greenhouse gas emission target by the end of this century. Despite unilateral coercive measures against Iran's economy, Iran intends to diversify its energy portfolio and reduce carbon emission via investment in low carbon energy sources as well as renewable ones and produce at least 30% of its annual electricity from these sources until 2040.

All countries diligently invest enormous efforts towards the energy transition.

Brazil has a high share of electricity generation from renewable energy sources, primarily hydropower, but is seeking to diversify its energy mix to reduce dependence on hydropower plants, the output of which drops significantly during dry periods. Brazil's 10-year Energy Expansion Plan (MME 2022) envisions construction of an additional of nuclear power plants (Angra 3). As part of using its resources in a timely manner, Brazil also sees the relevance of its potential in other energy vectors, other than those strictly renewable. In this case, it is worth mentioning that the opening of the natural gas sector to the private market began in 2019, culminating in the replacement of Law No. 11,909/2009 by Law No. 14,134/2021, regulated by Decree No. 10,712/2021, which was updated by Decree No. 12,153/2024, as the first result of the discussions of the Working Group of the Gas to Employ Program (GT-GE), led by the Ministry of Mines and Energy.

China intends to diversify its energy balance. By the end of 2023, the cumulative installed capacity in China was about 2900 GW, an increase of 14 per cent year on year. In 2023, the total energy output was nearly 9,500 TWh, an increase of 7 per cent compared with 2022, cumulative installed capacity of renewables reached 1500 GW, including hydropower, wind power and solar power, accounting for more than 50 per cent of the total installed capacity, consisting of: solar power about 610 GW, an increase of 55.2 per cent year on year; wind power 440 GW, an increase of 20.7 per cent year on year. In 2023, the share of coal consumption in total energy consumption in China decreased by 0.7 per cent, while clean energy consumption increased by 0.4 per cent.

Egypt intends to develop low-carbon energy, looking to increase the supply of electricity generated from renewable sources, more diverse energy mix and direct investment to provide a range of fossil fuels, renewable and nuclear technologies.

There are more than 40 thousand's square kilometer has been identified and allocated for implementing renewable energy projects to generate approximately up to 150 GW from solar and 120 GW from wind farms. Renewable energy capacity should contribute to 20 per cent of power supply capacity (maximum peak load) by 2020 and 42 per cent by 2035.

Ethiopia in the 10 Year Perspective Plan (2021-2030) has set the following energy transition by 2030: Planned to diversify and increase the power generation capacity to more than 17 GW from different renewable energy sources where the hydropower generation share will reduce to 80% from 92% in 2021. Ensure the availability of grid electricity access for 96 per cent of population and 4% from off-grid technology; reduce the transmission and distribution losses from 21.5% to 12.5 per cent. Ethiopia will also promote cross-border and inter-regional power interconnection and will ensure reliable and sustainable renewable energy for regional development and integration.

With the aim of minimizing the carbon and pollutants emissions, the energy sector in Iran is largely empowered by the transitional fuel (natural gas). Currently more than 80% of annual electricity production in Iran is either from low carbon or carbon free sources. Iran intends to optimize its balance of fuel resources in power generation and export, to develop renewable energy sources, including construction of 30 GW of renewable power plants by 2030, implementation of a program for modernization of the existing HPPs, and construction of HPPs of low and medium capacity.

India plans to diversify its energy mix through addition of various non fossil-fuel based sources including renewables, biomass, nuclear and hydro. In the last one decade, the proportion of thermal sources in the total installed electricity capacity has decreased from 68.9% in 2014-15 to 53.4% in October 2024. As of October 2024, India's total installed electricity capacity stood at 454 GW, comprising 243 GW of thermal, 8 GW of nuclear and 203 GW of renewables including hydro (51.9 GW), solar (89.4 GW) and bio energy (11 GW). India aims to reach an installed capacity of 900 GW by 2032, with non-fossil fuel-based capacity projected to reach 615 GW, comprising 68% of the total capacity. India is also looking at accelerated deployment of energy storage technologies such as battery storage, pumped hydro storage and thermal energy storage to bolster grid stability, manage renewable source intermittency and improve energy access in remote areas.

Russia, although its energy sector is already one of the cleanest (more than 85 per cent of electricity is generated from low-carbon or carbon-free energy sources), has plans to pursue low-carbon energy further. Its development initiatives include building generating capacity based on renewable energy sources (solar, wind and hydro power), electrification of the Arctic zone and the Far East, which will help to find the most optimal locations for energy infrastructure in the regions where new mineral resource centers and petrochemical facilities will be constructed.

South Africa has plans to diversify its energy generation through a mix of renewable and none renewable sources including abatement technologies. South Africa is equipped with a well-developed electricity network from varied generation technologies including coal, nuclear, hydro, solar photovoltaics (PV), onshore wind, concentrated solar power (CSP), pumped storage, and diesel-fuelled open-cycle gas turbines. While coal remains the dominant energy source in the country contributing 83 per cent of the country's electricity generation, renewables are the third major player in of South Africa's energy mix and is set to account for for a substantial amount of SA's overall energy supply in the next few years. There are also plans to diversify natural gas supplies for the energy sector and industrial use.

The UAE aims to diversify its energy balance by using natural gas, solar, and nuclear energy. These targets are consistent with the We UAE Vision 2031 objectives, aiming to triple the contribution of the renewable energy and invest AED 150 to AED 200 billion by 2030 to meet the country's increasing demand for energy as a result of a rapidly growing economy. The UAE has ventured into nuclear power to meet its growing energy demand while reducing reliance on fossil fuels. The Barakah Nuclear Power Plant, located in Abu Dhabi, is the country's first nuclear power plant, The Mohammed bin Rashid Al Maktoum Solar Park in Dubai is one of the largest solar parks in the world. Abu Dhabi has commissioned multi-Megawatts scale of IPP in Solar like Al Dhafra 2 GW, Noor Abu Dhabi in Sweihan1.17GW, and Al Ajban 1.5GW.

It is obvious that the BRICS countries pay great attention to energy balance diversification and increase the share of low- and zero-carbon energy sources. At the same time there is no universal option for energy transition that could suit all countries. Countries independently choose their unique pathways and pace to implement energy transition with due regard to their domestic circumstances, factors and critical risks, including those related to the renewable energy enhancement.

Therefore, it seems that the most efficient strategy for just energy transition should be based on national interests and the principle of free choice of appropriate means of implementation with ensuring energy sustainability, security, self-sufficiency and balanced socio-economic development and the account for national climatic, natural and other circumstances.

Undoubtedly, the just energy transition relies on advanced technology solutions for energy delivery to consumers while complying with environmental standards and minimizing the impact on the climate.

The previous studies within the BRICS Energy Research Cooperation Platform (ERCP) provided for an insight on advanced technology solutions used by the BRICS countries in their energy sectors (BRICS Energy Technology Report2020, BRICS Energy Technology Report 2021, BRICS Renewable Energy Report 2022 and BRICS Smart Grids Report 2022).

The BRICS ERCP experts are of a view that the energy sector transition to a new technology basis could be facilitated by energy efficiency, biofuel and hybrid (multi-fuel) technologies, renewables and energy storage, digital, robotic and unmanned technics, grid, including active-adaptive grid technologies, distributed generation, hydrogen produced on the basis of zero and low emission technologies and processes, carbon capture, utilization and storage technologies.

The above technology options do not represent an exhaustive list and presently are at various stages of development and dissemination in the countries. On one hand, their adoption is stimulated by policy and measures (including subsidies), but on the other hand it is limited by economic affordability and access.

The development and dissemination of clean energy technologies that *inter alia* contribute to greenhouse gas emission reduction, would enable the BRICS countries to efficiently use all energy resources within their just energy transition pathways.

Climate change mitigation has become an important aspect of energy transition. In this context affordable transition fuels, primarily natural gas, are of a high demand given the present level of technology. It is due to the fact that the use of the natural gas results in 40 to 60 per cent less greenhouse gas emissions per unit of energy produced compared with other fossil fuels.

Rising demand for natural gas is also associated with its new applications, primarily in the transport sector, and also in production of low-emission hydrogen and new gaseous products (methane-hydrogen mixture (hythane), synthetic gas). In addition, the market has gained greater flexibility and mobility for this transition fuel owing to the growth of liquefied natural gas (LNG) industry.

With this, the natural gas may become the «fuel of choice» in achieving the SDG 7 targets for some countries.

BRICS countries support a bigger role of renewable energy, including solar, wind, hydro, biofuels, biomass, geothermal in energy transition, protecting the environment and mitigation climate change. According to some experts forecast by 2050 BRICS will account for 45% of renewable energy world consumption, compared to 39% in 2021. According to the national Chapters of the Report BRICS countries adopted policies to support the steady advancement of renewable energy according to their respective resource endowments.

The pace of development of solar and wind energy in the BRICS countries is significantly ahead of the global average. Solar and wind power are taking an increasing share of the energy mix in the BRICS. The growth in the share of these renewable energy sources in the future will be associated not only with improvements to wind turbines and solar panels but also with the development of energy storage and others technologies.

The biomass could be of an equal importance in energy transition. It is one of the most promising sources of renewable energy that may be used either independently or blended in various proportions with fossil fuels. Biofuels have huge energy potential given the relatively easy recovery in natural conditions or over artificial plantations (where the biomass growth is usually faster).

Based on the above, we may summarize that the BRICS countries use all available fuels and technology options to reduce greenhouse gas emissions within the framework of just energy transition. This constitutes a technology-neutral approach to the energy strategy development that will enable the BRICS countries to undertake the transition to more affordable, flexible, sustainable and stable energy systems in the most efficient, rapid and just way with the aim to achieve the SDG 7.

The pace of energy transition is contingent upon economic factors, including provision of financial and other necessary resources for technology development and deployment. However, limited or restricted access to funds and technologies in high GHG-emitting energy sectors may in some cases lead to increase rather than the decrease of the emissions, since:

- The energy producers tend to relocate to countries with more flexible GHG emission regulation;
- The stochastic nature and uncertainty in renewable energy operation requires reliable balancing and backup capacities (including conventional fuel-fired generation) and accompanying development of utility networks;

- The accelerated large-scale abandonment of fossil fuels may result in severe socio-economic consequences in some parts of the world.

Free and non-discriminatory access to energy technologies and funding may advance climate policies and becomes an essential circumstance for the just energy transition.

In particular, in line with expanding of green funding on the national level, some BRICS countries are also investing in projects and technologies that do not meet international green standards but are effective in complying with national environmental regulations and mitigating climate impacts.

It is expedient to create common approaches and rules for evaluating transitional and climatic projects, particularly with regard to greenhouse emission reduction, implementation methodologies, verification approaches and carbon units accounting systems. These will enable for dissemination of best practices and ensuring access to funding in the BRICS countries.

In order to enhance efforts on projects in the area of just energy transition, the BRICS countries may use common approaches, rules and compatible compensation instruments (including carbon units, credits and offsets, generation attributes and green certificates) that will contribute to the reduction and/or prevention of greenhouse gas emissions, provided that such instruments are aligned with the Sustainable Development Goals, in particular SDG 7.

Development of cooperation on harmonization of regulatory framework for certification of electricity from renewable and low-carbon sources, as well as mutual recognition of national certification systems is extremely important for the BRICS countries, who are the closest trade partners, especially in a view of a possible introduction of cross-border carbon regulation that is currently under discussion.

The analysis has shown that the BRICS countries consider progressive and sustained development of the energy sector as a priority to ensure energy security, sustainable, affordable energy supply with a minimum negative impact on the environment, while the deployment of new capacities is keeping pace with the needs of growing economies and the population.

Special emphasis should be paid on the important and proactive role of the state in mitigating potential adverse socio-economic consequences of energy transition, including, but not limited to, the following aspects: planning of measures to create

balancing and backup (reserve) capacities, power grid construction, switching focus on regions, industries and employees to new core economic activities.

Particular attention should be paid to energy personnel training in the context of energy transition. According to one of conclusions of the BRICS Skills for Energy Transition Report conducted by the experts from the BRICS ERCP in 2023, the BRICS countries are currently suffering from a shortage of professional human resources related to so-called energy of the future.

Thus, the just energy transition is a complex political, economic and social challenge for the BRICS countries that may be resolved based on the following principles:

- The transition to low- and zero-carbon energy systems should be gradual and prioritized with the national circumstances, conditions and objectives, while contributing to achievement of sustainable development goals;
- The use of all available fuels and technological solutions that reduce greenhouse gas emissions is advisable;
- Transitional fuels, including but not limited to natural gas, hybrid fuels (including biofuels) and other low-carbon fuels, may be used to ensure the just energy transition without compromising with energy security and access to energy;
- Equitable and sufficient access to technology and funding for energy transition should be ensured;
- It is acceptable to use additional instruments (including carbon units, credits and offsets, generation attributes, green certificates, etc.) aimed at reducing or avoiding greenhouse gas emissions, provided that such instruments contribute to achieving SDG 7;
- Implementing the just energy transition should contribute to stable employment, livelihood and social security for workers, as well as to reinforce sustainability of national economies;
- International cooperation based on equity, common benefit, mutual assistance and respect is paramount on the track towards the just energy transition.

In view of the above, we can conclude that mutually expedient cooperation in just energy transition on the basis of common principles, best policies and practices will contribute to faster achievement of sustainable energy development goals and will facilitate the implementation of rational, flexible and more ambitious socioeconomic strategies with low greenhouse gas emissions that will secure the welfare and prosperity of the BRICS countries. ■

DISCLAIMER

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