

Bridging the Energy Gap: India's Strategy for Affordable and Clean Energy in the Pursuit of SDG 7

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Abstract: *According to the United Nations' Sustainable Development Goal 7 (SDG 7), having access to inexpensive, clean energy is essential to sustainable development. This research paper explores India's strategy for bridging the energy gap, emphasizing affordable and clean energy solutions, to align with the objectives of SDG 7. This research paper examines India's policy initiatives, renewable energy expansion, energy efficiency measures, and international collaborations as key components of its energy transition efforts. India, with its rapidly growing economy and population, faces significant challenges in meeting the energy demands of its citizens while simultaneously reducing carbon emissions. By analyzing India's progress and challenges in this context, this paper aims to provide insights into how India can achieve sustainable energy development while addressing environmental concerns. It underscores the importance of a holistic approach that balances economic growth with environmental sustainability to address the global energy challenge.*

Keywords: sustainable, development, energy, demand, renewable, solar

1. Introduction

1.1 Background on SDG 7 and its importance for sustainable development:

The United Nations' Sustainable Development Goals (SDGs) represent a global commitment to address some of humanity's most pressing challenges, from poverty and inequality to climate change and environmental degradation. Among these goals, SDG 7 stands out as an important pillar to achieve sustainable development. SDG 7 focuses on ensuring access to affordable, reliable, sustainable and modern energy for all and recognizes the central role of energy in promoting economic, social and environmental well - being. Development of SDG 7 has its roots in previous international agreements and initiatives aimed at promoting sustainable energy. One of the most important assumptions is the Millennium Development Goal (MDG) 7, which aimed to ensure environmental sustainability, although without special attention to energy. As the global community realized the central role of energy in achieving other development goals, the need for its own energy goal emerged. In 2012, the United Nations Conference on Sustainable Development (Rio 20) marked an important milestone by calling for the creation of Sustainable Development Goal 7, which set the stage for the adoption of the 2030 Agenda for Sustainable Development in 2015. The 7th goal of sustainable development was formulated having key dimensions of energy efficiency: availability, efficiency and renewable energy.

Sustainable Development Goal 7 plays a key role in **eradicating poverty** (SDG 1) as it provides the energy needed for economic growth and job creation. Access to modern energy services increases productivity in agriculture, industry and services, reduces income inequality and improves the standard of living of the most disadvantaged population groups.

Health facilities and schools run on reliable energy sources that enable quality health and education (SDG 3 and SDG 4). The availability of electricity makes it possible, for example, to freeze vaccines and extend school hours, especially in off-grid and rural areas where fuel poverty is most common.

SDG 7 intersects with SDG 5 (**Gender Equality**) by reducing the burden on women and girls, who often spend a lot of time collecting firewood or water, and providing opportunities for income - generating activities that promote gender equality and empowerment.

Transition to sustainable and renewable energy sources is essential for **climate change** (SDG 13). By reducing reliance on fossil fuels, SDG 7 contributes to greenhouse gas emissions reduction, aiding in the fight against global warming and its adverse impacts.

Access to reliable energy sources fuels **industrialization** (SDG 9) and economic growth (SDG 8). It fosters innovation, drives technological advancements, and attracts investment, all of which are essential for the development of prosperous and sustainable societies.

Sustainable energy practices help **conserve ecosystems** (SDG 15) by reducing habitat destruction and pollution associated with non - renewable energy sources. Clean energy technologies have a lower environmental footprint, helping to preserve biodiversity.

Achieving Goal 7 calls for global partnerships (SDG 17) that **facilitate technology transfer, capacity building** and financial support to developing countries. Cooperation between governments, the private sector and civil society is crucial to ensure universal access to sustainable energy.

SDG 7, which focuses on affordable, reliable, sustainable and modern energy for all, is central to the broader framework of

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sustainable development. It intersects with several other Sustainable Development Goals, promoting poverty eradication, improving health and education, gender equality, climate change mitigation, economic growth and ecosystem protection. To realize the vision of the 2030 Agenda, global action must prioritize the achievement of Sustainable Development Goal 7 and ensure that no one is left behind in the pursuit of a more sustainable and just future.

2. Energy Gap in India

India, one of the fastest growing major economies in the world, is expected to grow its energy demand by around 35% by 2030. India has set a target of producing 175 gigawatts of energy from renewable sources by 2022. It contains 100 gigawatts of solar energy. Energy and an additional 75 gigawatts from wind, biomass and other sources. It plans to raise its renewable energy target to 450 GW by 2030. Mission programs on clean coal technologies, alternative fuels such as methanol and dimethyl ether (DME), energy storage materials, building energy efficiency and the hydrogen economy will help India achieve this. Its commitment to clean fuel. Such national mandates would help promote the long-term growth of technological innovation in those areas. India plays a major role in the global energy economy. Since 2000, the energy consumption of India has more than doubled. This is fueled by population growth - soon to be the largest in the world - and a period of rapid economic growth. Household electricity access was almost universal in 2019, meaning that more than 900 million citizens have been connected to electricity in less than two decades.

India's continued industrialization and urbanization is making enormous demands on the energy sector and its decision makers. Per capita energy consumption is well below half the world average, and there are large differences in energy use and service quality between countries and between rural and urban areas. Affordability and reliability of energy supply are major concerns of Indian consumers. The Covid - 19 pandemic has disrupted India's energy use; our updated estimate shows that the country's energy demand will decrease by about 5% in 2020 due to shutdowns and related restrictions, with coal and oil suffering the most. The pandemic has also affected investment in the power sector, which is estimated to fall by 15 percent in 2020, adding to overall financial pressures, particularly among India's power distribution companies. More than 80% of India's energy needs are met by three fuels: coal, oil and solid biomass. Coal supported the expansion of power generation and industry and remains the largest fuel among energy sources. Oil consumption and imports increased rapidly, as did vehicle ownership and the use of road transport. The share of biomass, especially firewood, in the energy segment is decreasing, but it is still widely used for cooking. Despite recent progress in expanding LPG coverage in rural areas, 660 million Indians have not fully transitioned to modern and clean cooking fuels or technologies. Natural gas and modern renewable energy sources began to spread and were least affected by the effects of the Covid - 19 pandemic in 2020. In particular, the growth of solar electricity was enormous; the resource potential is huge, the goals are high, and the political support and falling technology costs have quickly made it the cheapest option for new power generation. Total energy

consumption per capita is still around 0.7 fingers (2022), half the Asian average. Per capita electricity consumption in 2022 was 990 kWh, about one - third of the Asian average. Total energy consumption continued to grow very rapidly (7% in 2021 and 2022) and exceeded 1 Gtoe for the first time in 2022 (7.3%). It increased rapidly between 2010 and 2019 (3.7% per year). Coal was the country's largest energy source with a share of 46% in 2022, followed by oil (24%) and biomass (20%). Natural gas covers 5% and primary electricity (hydro, nuclear, solar and wind) 4%. Coal and lignite consumption peaked at 1.2 Gt (8.3%) in 2022. In the years 2015 - 2018, its development was significant (approx.5% per year). It decreased in 2019 and 2020 and increased in 2021. In 2021, the largest consumers of coal and lignite were power generation and industry, 76% and 19% respectively (only households and services 3%). Oil production has decreased since 2010 and was 33 Mt in 2022 (- 10% compared to 2019). India is the third largest importer of crude oil in the world, reaching a peak of 240 Mt in 2022 (9.6%). In 2021, oil imports accounted for 86 percent of the country's oil needs. The country is a net exporter of petroleum products (21 million tons in 2022), although its exports have decreased by 33% since 2018. Consumption of petroleum products decreased and recovered in 2021 after a sharp decline in 2020 (- 13%) and peaked in 2022 at 233 Mt (11%). It increased rapidly between 2010 and 2019 (4.4% per year). Of the total consumption in 2022, 44% was spent on transport, 29% on industry (including non - energy use) and 20% on the residential, service and agricultural sectors. The rest is consumed in power plants (1%) and the hydrocarbon industry (6%). Natural gas consumption fell by 2.7 percent to 61 billion cubic meters in 2022, or below the 2017 level. In 2021, it grew by 2.8%. Between 2014 and 2019, gas consumption grew by 4.8% per year. Industry will be the largest gas consumer in 2022 with 52% (mainly fertilizer factories). It is followed by electricity production (21%) and to a much lesser extent transport (5%) and the housing and service sector (6%). India is working to promote the use of CNG vehicles to reduce urban pollution; By April 2023, 5, 700 CNG stations were in use. Electricity consumption increased by 10% to 1, 390 TWh in 2022, after a 7% increase in 2021. It grew rapidly (7%/year) between 2010 and 2019 and decreased by 6.7% in 2020.

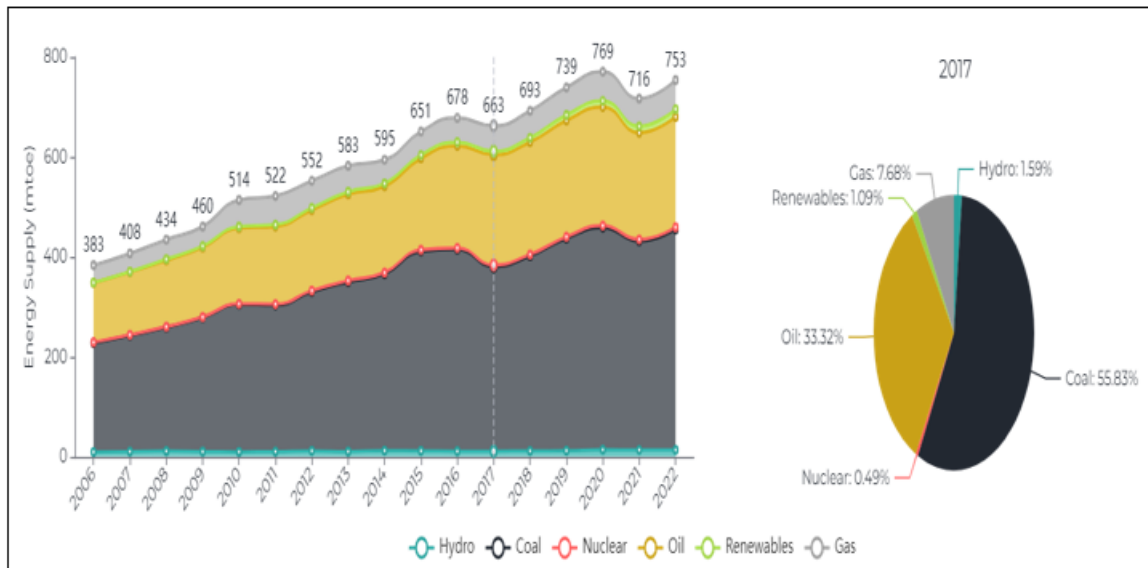
3. Policy Framework for Achieving SDG 7

Over the past 9 years, significant progress has been made in increasing power generation capacity, expanding access to electricity, promoting renewable energy and implementing innovative policies. India's journey towards a greener future has received global acclaim. The addition of more than 175 GW of generation capacity in the last nine years has transformed India from a deficit to a surplus country. The country's commitment to renewable energy sources has played a key role in this achievement. Significant growth in solar and wind capacity has strengthened India's position as a world leader in renewable energy deployment. India currently ranks fourth in the world in terms of installed renewable energy capacity, with 43 percent of its installed electricity capacity coming from non - fossil energy sources.

India's commitment to power generation and universal electrification was the driving force behind this transformation. The Pradhan Mantri Sahaj Bijli Har Ghar

Yojana (SAUBHAGYA) initiative is a symbol of success in achieving universal household electrification covering all the villages and districts of the country. This ambitious program has provided electricity connections to 2.86 million unelectrified households in both rural and urban areas as of September 25, 2017. The International Energy Agency (IEA)

called it the fastest access expansion in electricity history anywhere in the world. The availability of electricity has increased significantly both in the countryside and in cities. In rural areas, the availability of electricity has increased from about 12 hours a day in 2014 to the current 22.5 hours and in the city to almost 24 hours.



Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) was launched in 2014 to improve the quality and reliability of electricity supply in rural areas. The DDUGJY program achieved 100% village electrification on April 28, 2018 electrifying 18, 374 unelectrified villages. distribution network and ensure electricity access to every corner of rural India.

efficiency, India has set an inspiring example to the world. The commitment of the Government of India along with stakeholder engagement has led the nation to a sustainable, affordable and reliable energy future. As the journey continues, continued investment, innovation and collaboration will be key to strengthening India's energy sector and ensuring a brighter and more prosperous tomorrow for all its citizens.

The government's investments in promoting energy efficiency have also yielded significant results. In the Unnat Jyoti by Affordable LEDs for All (UJALA) program, the purchase price of LED lamps decreased from 2014 to 2019 by almost 90 euros. So far, more than 36.86 billion LED bulbs have been distributed under this scheme. This initiative not only reduced household electricity costs but also encouraged the production of LED lamps in the country by supporting the 'Make in India' campaign. As a result, energy - efficient lighting solutions have been widely adopted in India, contributing to reduced energy consumption and a greener environment.

The Ujwal Discom Assurance Yojana (UDAY) was launched by Ministry of Power in November 2015 to improve the financial health and operational efficiency of state - owned distribution companies (discoms) across the country. The major benefits for UDAY participating states are: (i) rationalization of coal price, (ii) addition of coal at notified prices and (iii) faster completion of inter - state transmission lines. 27 states and five union territories participated in the scheme. States had to achieve certain UDAY targets. In addition, UDAY has defined certain operational targets like achieving 15% AT and C losses by 2018 - 19 at the national level.

To improve power distribution, the government implemented initiatives such as the Restructured Distribution Sector Scheme (RDSS). RDSS has significantly reduced transmission losses of DISCOMs from 21.5 percent in FY 2020 - 21 to 16.5 percent in 2021 - 22. These initiatives focus on reducing technical and commercial losses, improving metering and billing systems, and promoting energy efficiency. The integration of smart grids, advanced metering infrastructure and demand response mechanisms have improved grid stability and enabled consumers to actively manage their energy consumption.

National Solar Mission is a major initiative of the Government of India in which aims to make India a global leader in solar energy by creating the political conditions for the spread of solar technology across the country as soon as possible. This is in line with India's proposed Intended Nationally Determined Contribution (INDC) target of around 40 percent cumulative electricity generation capacity from non - fossil fuel sources. To achieve the above objective, Government of India has launched several schemes to promote solar energy production in the country such as Solar Park Scheme, VGF Scheme, CPSU Scheme, Conservation Scheme, Canal Bank and Canal Top Scheme, Bundling Scheme, Grid Connected Solar Roof Scheme etc. Several of the policy initiatives implemented included the development of the Renewable Energy Purchase Obligation (RPO),

The transformation of India's energy sector since 2014 is a remarkable story of progress and resilience. With achievements like universal electrification, rapid expansion of renewable energy, better distribution and improved energy

including solar energy, abandonment of the interstate transmission system; fees and losses on interstate sales of solar and wind energy in projects commissioned until March 2022, mandatory status, guidelines for procurement of solar energy through rate - based bidding, commissioning standards for solar energy systems and equipment, rooftop solar and solar supply. The installed capacity of solar energy reached approximately 61.97 GW as of November 30, 2022.

Pradhan Mantri Ujjwala Yojana is launched on May 1, 2016 from Ballia, Uttar Pradesh, the central government's ambitious social welfare program aims to replace the dirty cooking fuels mostly used in rural India with clean and more efficient liquefied petroleum gas (LPG) with five million LPG – connections on names of rural women living below poverty line (PBL) across the country. This scheme is now implemented in 35 states and all union territories. Some of the objectives of the scheme include women empowerment, health protection and safety in relation to deaths in India due to impure cooking fuel to prevent a significant number of acute respiratory illnesses in young children due to indoor air pollution from burning fossil fuels. This flagship program of the central government is to provide free LPG connections and has been running for two years, providing more than 3.5 million free LPG connections to poor women. This much - needed scheme is an important step to reduce indoor air pollution and stress experienced by women and promises to expand LPG availability.

4. Advancements and innovations in renewable energy technologies

India had adopted floating solar panels. The term "floating solar panels" refers to panels mounted on platforms that float in bodies of water such as lakes, reservoirs or the sea. The solar panels are mounted on platforms whose anchor extends to the bottom of the lake or seabed. The electricity produced by the solar panels is then transmitted to shore via underwater cables. One of the main advantages of floating solar panels is that, unlike traditional solar panels, they take up less space on land. Another advantage of water - based solar energy is the reduction of water evaporation from tanks. The motivation is to use renewable energy and avoid waste. Water - cooled panels can be more efficient than traditional solar panels because cooler temperatures can increase their efficiency.

Another innovative solar energy technology is the perovskite solar cell. These are a type of solar cell that uses perovskite, a mineral with a unique crystal structure. One of the main advantages of perovskite solar cells is their high efficiency. Perovskite thin film solar cells have already achieved efficiencies of up to 25 degrees and have the potential to go much higher - a huge leap considering their efficiency was only around 3 degrees in 2009. They are already comparable or even higher than that of conventional silicon solar cells. In addition, perovskite solar cells can be made using simple and inexpensive processes, which can lead to lower production costs and more widespread use of solar energy. Perovskite solar cells are also light and flexible, making them ideal for wearable and portable devices. They can also be made translucent by using them in windows and other building materials. In addition, perovskite solar cells can be made using simple and inexpensive processes, which can lead to

lower production costs and more widespread use of solar energy. Perovskite solar cells are also light and flexible, making them ideal for wearable and portable devices. They can also be made translucent by using them in windows and other building materials.

Photovoltaic windows integrate solar cells into the window glass that convert sunlight into electricity. Photovoltaic cells can be either transparent or translucent, allowing sunlight to pass through and generate electricity.

Vertical axis wind turbines (VAWT) have a unique design that allows them to capture wind energy from any direction. The VAWT blades are positioned vertically and rotate around a central axis, making them ideal for use in urban areas and other places where wind direction is unpredictable. Due to their compact design, VAWTs can be installed in a variety of spaces, including residential and commercial buildings, making them a viable option for distributed energy generation. In addition, VAWTs tend to be quieter than their horizontal - axis counterparts, making them better in noise - sensitive environments.

Another innovation in the field of renewable energy is offshore wind turbines. These turbines are located in bodies of water, such as oceans or large lakes, where steady winds can be used to generate electricity. Researchers recently found that large offshore turbine and power plant projects can reduce average life - cycle costs per megawatt - hour by more than 23 percent compared to the average fixed - base offshore wind farm. One of the main advantages of offshore wind turbines is that they can take advantage of the stronger and more consistent winds that blow near the coast. In addition, offshore turbines can be located far enough from shore to minimize visual and noise impacts on local communities (although there may be environmental impacts). The most important feature is that they also have the potential to generate significant amounts of energy. A single offshore turbine can generate enough electricity to power thousands of homes, and entire wind farms can generate enough energy to power entire cities.

Another recent innovation is Airborne Wind Energy is a renewable energy technology that uses wind turbines mounted on flying devices to generate electricity. The technology exploits the stronger and more consistent winds found at higher altitudes where traditional wind turbines cannot reach. AWE systems use aerial devices such as kites, drones or booms to capture wind energy in higher and stronger and more consistent winds. One of the main advantages of AWE is that it can be used in places where conventional wind turbines are not possible, such as in places with low wind speeds or limited land availability. This makes AWE a promising solution for distributed energy generation, especially in remote or off - grid areas. Another potential advantage of AWE is that it has a lower environmental impact than conventional wind turbines. Because AWE systems use less material and their footprint on the earth, they can reduce the impact on local ecosystems and wildlife.

5. International Collaborations

The International Solar Alliance (ISA) was created as a joint effort between India and France to combat climate change through solar energy solutions. The ISA is a cross - border cooperation platform that aims to increase the adoption of solar energy technologies as a means to increase energy availability, improve energy security and promote the clean energy transition in its member states. Currently 101 countries have signed the ISA Framework Agreement. ISA is guided by its "To 1000" strategy, which aims to mobilize 1 trillion dollars in investment in solar solutions by 2030, while ensuring energy access for 1 billion people using clean energy solutions, resulting in the installation of 1, 000 GW of solar capacity. This would help reduce global solar radiation by 1, 000 million tons of carbon dioxide per year.

India was one of the three countries that took the initiative to plant the seed of "Mission Innovation". This term was coined by our honorable Prime Minister Shri Narendra Modi. Its member countries pledged to double government funding for clean energy R&D over five years and increase international commitment to clean energy R and D programs. The Mission Innovation initiative reflects the shared desire of countries to work together to solve common challenges to produce affordable and reliable clean energy. India has taken the lead in developing a framework for advancing clean energy technologies with the active participation of scientists, researchers, universities, industry, institutions and private organizations across the globe through the Mission Innovation platform.

India had also signed many bilateral and multilateral agreements with other countries like U. S., Denmark and European Union in the field of clean energy.

6. Challenges and Barriers

One of the primary challenges in India is ensuring access to modern energy services for all, especially in rural and remote areas. Millions of people still lack access to electricity, and many rely on traditional and polluting energy sources like biomass for cooking and heating. A significant portion of the population in India lives in energy poverty, meaning they lack access to reliable and affordable energy services. This hampers economic development and quality of life. Due to large population, there is great demand of power supply. India's power grid faces challenges related to intermittent power supply and frequent blackouts. This affects industrial productivity and the overall reliability of energy services. Many people in India find it challenging to afford modern energy services. Rural areas often face greater challenges in electrification compared to urban areas. Building the necessary infrastructure to extend power supply to these regions can be expensive and logistically complex. High energy costs relative to income can act as a barrier to accessing clean and sustainable energy sources.

India has a significant energy efficiency gap, with many industries and sectors still using outdated and inefficient technologies. Improving energy efficiency across various sectors is crucial to achieving SDG 7. Most of the energy demand of India is fulfilled by coal. India's reliance on coal

for energy production poses environmental challenges, including air pollution and greenhouse gas emissions.

India has made progress in developing policies and regulations to promote renewable energy and energy access, but there is a need for more comprehensive and stable frameworks to attract investments and ensure long - term sustainability as large - scale investments required to transition to cleaner energy sources and improve energy infrastructure can be a barrier. Securing financing and attracting private sector investment is crucial for achieving SDG 7. Building the necessary infrastructure for renewable energy generation, transmission, and distribution is a significant challenge. It requires substantial investments and coordinated efforts across the government and private sector.

Advancements in technology, such as energy storage solutions and smart grid systems, are essential to overcoming some of the challenges in achieving SDG 7. India needs to invest in research and development in these areas and encouraging sustainable energy practices and changing consumer behavior is a long - term challenge. Public awareness and education campaigns are essential to promoting energy conservation and efficiency.

7. Recommendations

To overcome these challenges and barriers, India must continue to work towards diversifying its energy mix, improving energy efficiency, expanding access to clean energy, and creating an enabling policy environment for sustainable energy development. International cooperation and partnerships can also play a crucial role in supporting India's efforts to achieve SDG 7.

Ending fossil fuel subsidies must be pursued in a socially responsible manner. If necessary, introduce new support to achieve clean energy targets and ensure a just transition. An agency will be created to coordinate energy subsidies, tax and pricing activities with relevant ministries, departments and expert institutions.

Government should establish a National Electricity Council as a forum for power sector issues and empower it to lead the dialogue between the Center and the states on reforming electricity subsidies, including targeting subsidies to poor consumers and shifting subsidies to sustainable agricultural practices. Ensure that LPG support is targeted and combined with the incubation of non - fossil cooking technologies. Develop a strategy and timetable for responsible reform of carbon subsidies - for example by shifting subsidies from an input (coal) to a service (cheap electricity). Identify and provide support for clean energy goals, particularly for new and emerging technologies.

Ministries should demand the diversification of energy sources into clean energy and adapt CSR regulations to encourage clear support for sustainability and a just transition. Energy sources should increase investment in clean energy while creating near - zero agendas to reduce fossil fuel.

Ministries should expand clean energy loan targets in line with the set policy goals. India's PFI should act quickly to end

new mainstream public financing of coal - fired thermal power or mining, excluding decommissioning and a just transition, to minimize the already high exposure to fossil fuels. In addition, the PFI should provide a vision and action plan on how to phase out public financing of fossil fuels and manage potential waste assets.

High revenues from fossil fuels during price increases should be reserved for better social security and public services to lower the cost of living; and public support for clean energy, including a just transition, to reduce volatility and improve security in the medium term. As the government develops a more detailed policy framework for net zero, it should clearly articulate the role of taxation in creating accurate and consistent carbon pricing and the social protection needed to channel revenue to the poor and vulnerable. Ministries, departments, energy agencies and energy agencies should improve energy subsidy reporting to enable better joint decision - making.

8. Conclusion

India's concerted efforts to achieve Sustainable Development Goal 7 (SDG 7) are not only significant for its own development but also hold great importance on the global stage. SDG 7, which aims to ensure access to affordable, reliable, sustainable, and modern energy for all, is pivotal in addressing various socio - economic and environmental challenges. India's journey towards achieving this goal underscores the nation's commitment to fostering sustainable development and bridging the energy gap, which has far - reaching implications for both its citizens and the world at large.

India's initiatives to expand access to clean and reliable energy sources have been commendable. The ambitious expansion of renewable energy capacity, particularly solar and wind power, has not only reduced greenhouse gas emissions but also improved energy access in remote and underserved areas. The Saubhagya scheme, which aims to electrify every household in India, has made significant strides in providing electricity to millions, thereby enhancing their quality of life, education, and economic opportunities. Furthermore, initiatives like Ujala, which promotes energy - efficient lighting, contribute to reducing energy consumption and minimizing environmental impacts.

India's experience in addressing energy challenges is highly relevant for other countries facing similar issues. Many developing nations encounter obstacles related to energy access, affordability, and sustainability. India's strategies and policies can serve as a valuable blueprint for such countries, demonstrating the effectiveness of a multi - faceted approach that combines renewable energy expansion, electrification programs, and energy efficiency measures. The Indian government's commitment to collaboration through international partnerships, such as the International Solar Alliance, also highlights the importance of global cooperation in achieving SDG 7.

Moreover, India's efforts align with the broader agenda of sustainable global development. Bridging the energy gap is not only crucial for meeting the energy needs of a growing

population but also for addressing climate change, reducing air pollution, and promoting inclusive growth. India's progress in this regard contributes to achieving not only SDG 7 but also other Sustainable Development Goals, including those related to poverty alleviation, health, education, and environmental sustainability.

In conclusion, India's steadfast commitment to achieving SDG 7 by bridging the energy gap serves as an inspiring example of how a developing nation can make significant strides toward sustainable development. The lessons learned from India's experience are invaluable for countries facing similar energy challenges, and the global community should continue to support and collaborate with India in its journey toward a more sustainable and equitable energy future. By doing so, we can move closer to the shared goal of a more sustainable and prosperous world for all.

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