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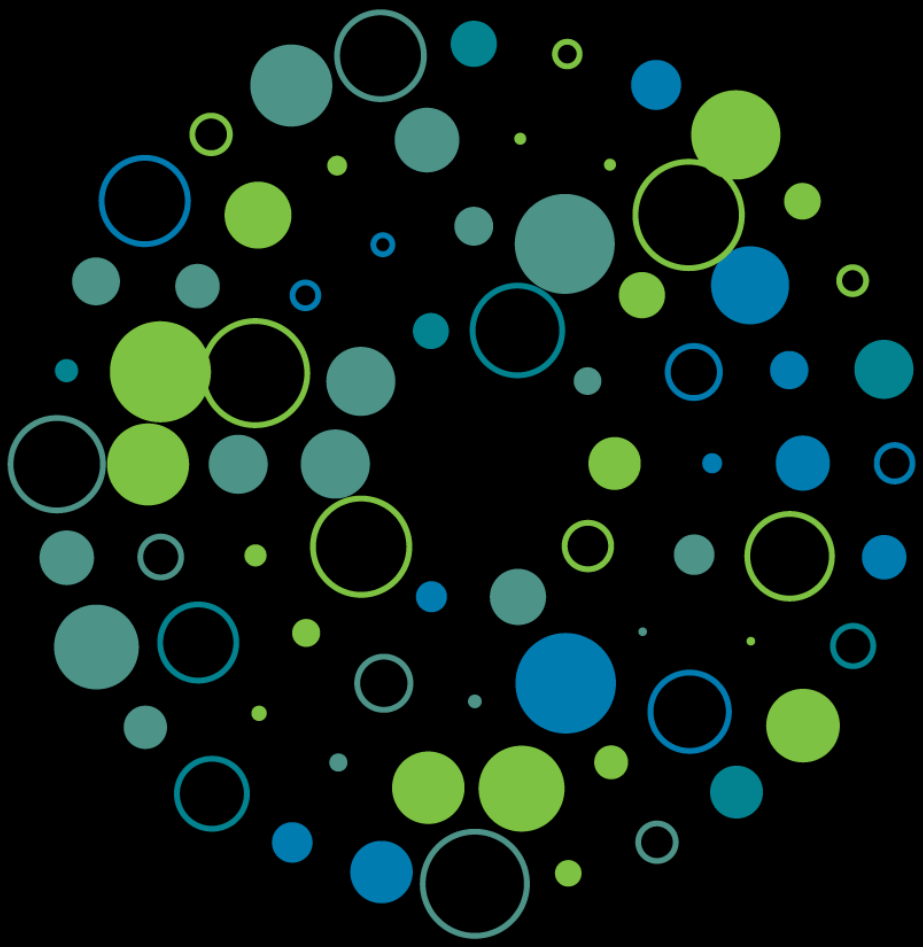


Economics of energy transition

September 2024

Decoding the economics behind the transition towards cleaner energy sources

Until the early last decade, the global shift towards greener alternatives was relatively modest. However, this trend changed. Demand-side factors (such as environmentally conscious consumer preferences) and supply-side dynamics (such as falling renewable energy costs, especially in solar and wind) resulted in a rapid transition towards clean energy usage due to technological advancement and economies of scale. Geopolitical uncertainties, energy security concerns and global pressure compelled governments to move towards renewable sources. Consequently, the world is now following a more cautious approach towards new investments in fossil fuels, with a clear focus on lower carbon investments. In addition, one can expect a shift in energy trade equations due to differences in renewable endowments, changing energy security dynamics and nations' capacity to scale up faster.

What are the possible implications of these shifting global dynamics in India?

Deloitte's energy experts estimate India needs an annual average investment of approximately US$300 billion between 2022 and 2070 to achieve clean energy transitions.[i] For a country with a population of 1.4 billion that aspires to be the third-largest economy in the next few years and a developed nation within the next 2.5 decades, committing to such a significant investment will come with pros and cons. While experts provided answers to "where" and "how", we have tried to answer the "why" from an economic lens, using a benefits and costs analysis.

We believe India may see immense benefits from investments in greener technology reflected in GDP, employment, financing and supply chains over the medium term. We estimate that this new investment in green energy is expected to boost the GDP by 2030. India may see its GDP increase by an annual average of US$613 billion annually and increment GDP by 1.1 percent in 2030. Similarly, a significant additional net direct job growth of over 56.8 million by 2030 is expected since the renewable energy sector has a higher employment elasticity today than the fossil fuel sector per unit of money invested. In addition, higher credit growth and reduced supply chain disruptions are expected as India becomes more self-sufficient in energy.

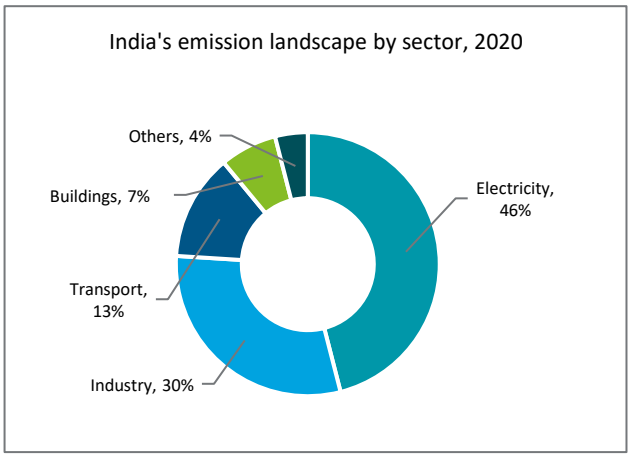
However, such a transition will come with costs. Higher investment in cleaner energy options may result in higher fiscal expenses (at least in the initial years) or require reallocating resources from other social sectors. There could be associated job losses (in non-renewable sectors), viability funding and risk exposure. On the other hand, inaction could lead to significant costs, including loss of wealth and assets due to frequent and unpredictable natural disasters, poor health conditions due to low air quality and possible investment downgrades. These will have implications on borrowing costs and the current account balance. The consequences of climate change are expected to be felt as early as 2030, and India could see a downgrade in credit ratings by one notch, according to a study by Cambridge.[ii]

The good news is India is already ahead in the game. Over the past 8.5 years, the country's installed non-fossil fuel capacity has increased by 396 percent.[iii] But is that enough? Not really! Certain challenges, such as the under-utilisation of resources (in terms of a lower generation mix of renewables), remain a concern. India will need to significantly increase renewable energy generation, requiring substantial upfront investments, to meet the energy needs of the world's largest population and ensure that cost concerns do not outweigh the benefits of the transition. It makes sense from an economic standpoint, and our experts have outlined a roadmap to achieve this. The speed at which India can get on the path to transition will be something to watch for.

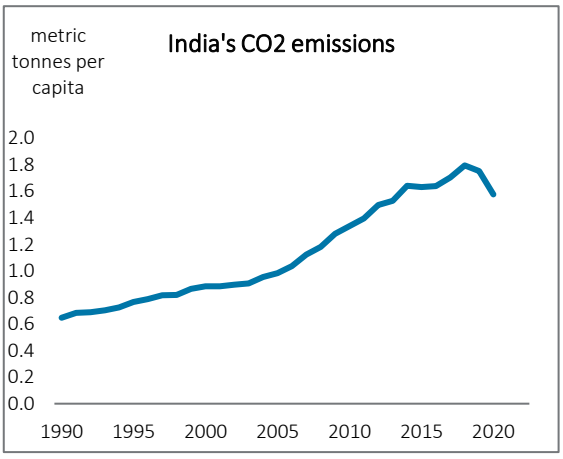
India's current energy consumption profile

India is behind major industrial nations on the economic development path, and its per capita energy consumption is much lower. Yet, it is the third largest nation in Greenhouse Gas (GHG) emissions in the world. This is due to its coal-dominated energy mix, leading to increased carbon dioxide emissions (Figure 1).[iv] In India, energy used for the power sector accounts for 40 percent of GHG emissions. Meanwhile, industry (specifically iron and steel, cement and chemicals sectors) accounts for 30 percent and transport accounts for about 15 percent.[v]

Figure 1. India's emission by sector and overall growth



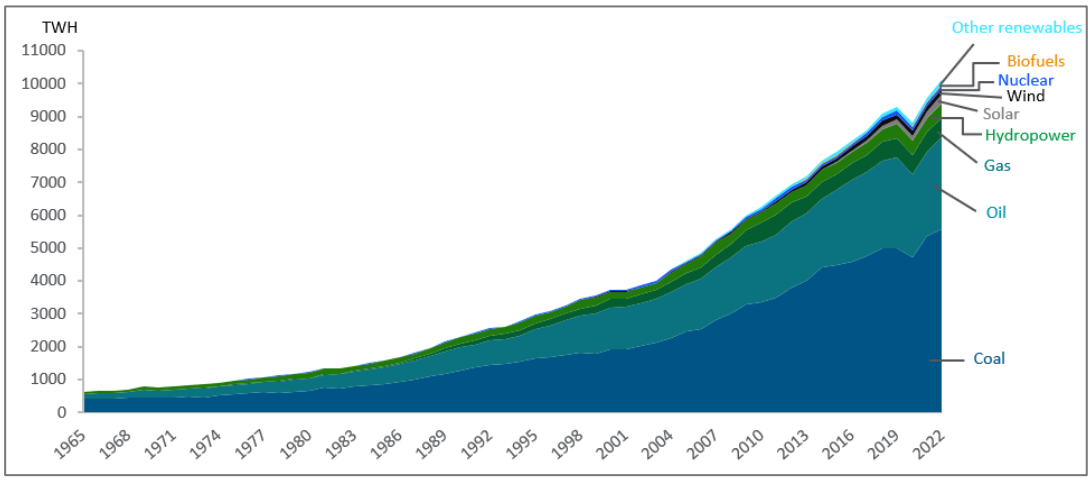
Source: IEA, Deloitte Report



Source: World Bank

Since dependence on coal plants is high for electricity and industrial sectors (in contrast to the world's consumption of various energy sources), India's share of coal in primary energy consumption is far higher (60 percent of total energy consumption as of 2022) (Figure 2). On the other hand, the share of renewables (10 percent) is lower than in the world (13 percent).

Figure 2: India's primary energy consumption



Source: Energy Institute - Statistical Review of World Energy (2023) – in collaboration with Our World in Data

Note: Energy consumption refers to the total consumption of different energy/fuel types across different sectors, such as power, manufacturing, transport and buildings.

If India is expected to be the fastest-growing major economy over the next decade, its energy consumption intensity is expected to rise only. Studies suggest that as economies become rich, their carbon footprint increases.[vi] With rising disposable income and the middle-income class population, India's consumption basket would tilt towards more energy-intensive goods (such as industrial goods with higher carbon content) and services (such as tourism and data).

The irony is that with increased environmental concerns and an emphasis on sustainability, India will have to meet its energy demand from alternative green energy sources. It is not a choice anymore!

In line with global trends (reference COP 27), India has committed to meeting the net-zero target by 2070. As an intermediate target, India aims to reach about 50 percent of its cumulative electric power installed capacity from non-fossil-fuel-based energy resources by 2030.[vii] In addition, it has committed to reducing the emissions intensity of its GDP to 35 percent by 2030.[viii]

The choices India has

Hard choices may lie ahead, but the economics of transitioning to renewable energy is rather favourable. Higher investments in renewable energy will lead to higher GDP, greater net employment, higher credit flows and improved balance of payments. At the same time, these investments will also come with associated costs. We have highlighted a benefit-cost analysis from the four perspectives:

GDP and employment[ix,x]

Benefit

Deloitte estimates India will require initially US$176 billion to US$204 billion investments every year until 2030 to transform the existing infrastructure, build new ones, transition technologies and facilitate and support the deployment of green energy across the country. Assuming that investment accounts for 32 percent of GDP, **such an investment will directly contribute to an average of US$613 billion annually and boost India's GDP by 1.1 percent by 2030**. Besides, the positive externality associated with building the infrastructure will trigger ripple effects throughout sectors, such as the social, private (via investments) and financial (for funding) and create employment opportunities.

In India, the renewable energy sector generated 9,88,000 direct and indirect jobs in 2022, up from 8,63,000 in 2021. Most of the jobs were created in the hydropower sector, followed by the solar PV sector. Research suggests that a green energy programme (including renewable energy sources, public transport and improved efficiencies in industries efficiencies) has an employment-generating capacity of 151.7 direct and indirect jobs per million US$ invested. This is 107.7 jobs more than those created from fossil fuel programmes. We foresee a net direct job growth of 56.8 million jobs by 2030.

Increased employment and **lower energy prices will increase the real income of households and improve their purchasing power leading to a higher GDP.**

Cost

The energy transition is highly capital-intensive with high requirements of frontloaded investments, high gestational lags and delayed return on investments. Until the unit economics kicks in, private participation is expected to be limited. The government will have to bear the initial expense of building the infrastructure (transmission and storage) and provide subsidies to the producers and consumers for wider adoption. **For a resource-constrained nation, such as India, it may reflect in the form of higher fiscal expense, or reallocation of resources away from other social sectors.**

In the next couple of decades, the coal industry is expected to shed jobs. According to a study by Global Energy Monitor, closing coal mines is expected to cost a large potential layoff in India by 2040s, even without climate commitments and coal phase-out policies. India's climate commitments to phase out of coal power generation may accelerate these trends in the future, although the quest to shift away from fossil fuels is marginal at present. The shift towards renewables is expected to help absorb these employees. However, the government will have to step up to adequately to compensate and upskill these workers for reemployment and resettlement.

Financing [xi]

Benefit

Rising investments are expected to increase the need for credit and boost credit growth. The appetite to borrow from banks will increase and boost innovative finance methods. For example, **the outstanding bank loans to the renewable sector more than doubled to INR4.2 billion by the end of 21 October 2022**, compared with INR2.1 billion (a year ago). In this sector, banks can expect an increase in demand for credit without worrying about the economic state or consumption levels. It could also lead to new collaborations to offer solutions, boosting the BFSI space.

Cost

As the upfront investment in building infrastructure is huge, it will entail finding viable funding solutions, including collaborating with multilateral development banks. Some of these investments are financed through bank lending, potentially competing with lending to other productive sectors. While the financing structure for solar and wind projects is becoming well established, credit risk exposure remains a concern to certain kinds of projects (such as green hydrogen and Carbon Capture, Utilisation and Storage [CCUS]). Implementation delays will involve government guarantees and costs of insurance.

Supply chain[xii]

Benefit

India is heavily dependent on imported oil, hence the rising share of renewable energy is expected to reduce dependence on certain economies for fossil fuel imports as well as its exposure to supply chain disruptions (due to geopolitical uncertainties). According to a study by IRENA, **the trade balance can improve by over 1 percent due to higher electrification of energy.** Furthermore, pursuing energy self-sufficiency increases energy security.

Cost

Any change in energy sources is expected to disrupt various existing supply chains across industries and geographies. These disruptions, until recently, have led to inertia among consumers, businesses, investors and policymakers to change the status quo. India relies heavily on imports of cells, modules, glass, encapsulant film, backsheets and aluminium framing. These are sourced from different nations adding supply chain vulnerabilities and price fluctuations. Besides, shifting towards renewables will require massive policy intervention and coordination across nations.

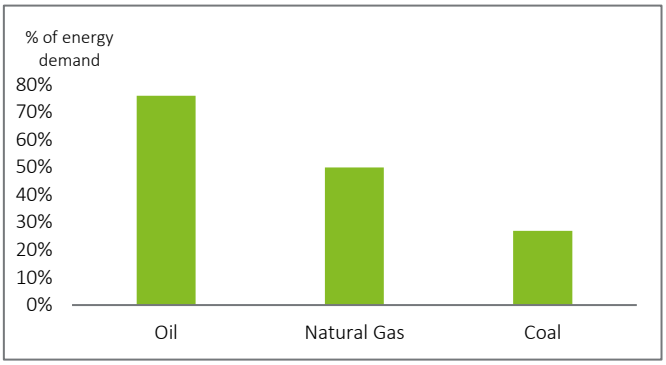
The costs of inaction

Significant costs associated with inaction also exist. According to a Deloitte study, no significant reduction in emissions could lead to a global average temperature increase of more than three degrees Celsius by 2070. This could lead to an economic loss of US$6 trillion in Present Value Terms (PVT)—equivalent to 6 percent of the GDP—by 2050. By 2070, this loss will escalate to US$35 trillion in PVT, which will be 12 percent of GDP in 2070 alone.[xiii]

The losses will incur due to the rising pollution caused by using fossil fuel energy sources. This will lead to the following:

- High energy import dependence affects energy security, inflation and the current account balance (Figure 3).
- Perpetuated inequities in energy access and climate injustice occur when those who contribute the least are the ones who suffer the most from the adverse effects of climate change.[ivx]
- Impact on food supply and prices is driven by the salinisation of farmlands and degradation of freshwater supplies.
- Frequent and unpredictable natural disasters cause loss of assets and wealth of households and businesses.
- Loss of productivity due to poor health conditions and a rising number of diseases are emanating from environmental pollution.
- Possible investment downgrades could raise borrowing costs and lead to higher interest payments.[vx] This could cost treasuries billions of dollars and make corporate debts expensive. According to S&P, the consequences of climate change are going to be felt as early as 2030, and India could face a downgrade of two notches.

Figure 3: India's import dependence



Source: IEA

The demand-supply side dynamics

The economics of transition indicate that India may benefit from shifting towards cleaner energy alternatives, and a few demand-supply dynamics are at play as well (in addition to the assurance that energy is sourced domestically). Once considered too costly beyond niche markets, large renewable projects now beat the conventional energy sources on price and performance in India, accelerating the transition towards cleaner alternative energy sources.

On the demand side, Indian consumers, particularly in large cities, are becoming more environmentally conscious leading to changing preferences. A perceivable shift in energy demand that is reliable, affordable and environmentally friendly is noticed across sectors (including electricity, transport, urban and industrial). Besides, there is a demand to democratise the benefits through universal access. This is because renewable energy sources are more widely present and can be deployed in local, small-scale installations in a dispersed and distributed way.[xvi]

Globally, the intersection of trade policies and climate impact is gaining traction as lawmakers look to address emissions embedded in globally traded goods that are subject to different jurisdictions' climate regulations. For example, the European Union (EU) implemented the world's first Carbon Border Adjustment Mechanism (CBAM) to levy carbon tax on imported goods that are carbon intensive. In the U.S., the recently introduced Clean Competition Act and Foreign Pollution Fee Act aim to address climate and trade challenges.

In the medium term, a majority of the domestic energy demand in India is expected to continue to be met by non-renewable sources. However, the factors mentioned above are intensifying the demand for alternative cleaner energy counterparts such as electric vehicles, solar and wind, among others in India.

Sidebar 1

"In 2010, the global weighted average LCOE of onshore wind was 95 percent higher than the lowest fossil fuel-fired cost. In 2022, the global weighted average LCOE of new onshore wind projects was 52 percent lower than the cheapest fossil fuel-fired solutions. The most competitive weighted average LCOEs in onshore wind projects worldwide remained below US$ 0.050/kWh in 2022. India remained one of the key markets with low LCOE of US$ 0.037/kWh in 2022, which is a 61 percent decline from 2010 levels.

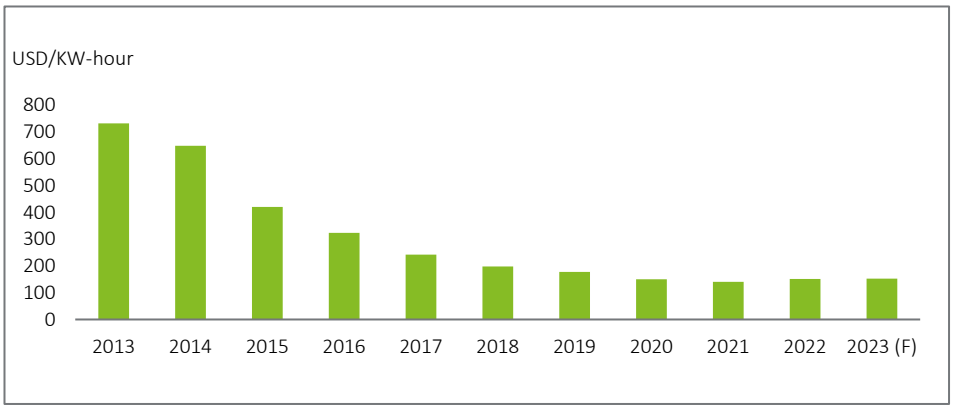
However, this improvement was surpassed by that of solar PV. This renewable power source was 710 percent more expensive than the cheapest fossil fuel-fired solution in 2010 but cost 29 percent less than the cheapest fossil fuel-fired solution in 2022. The lowest weighted average LCOE in utility-scale solar PV projects was observed in China and India in 2022. Between 2010 and 2022, costs in India declined by 90 percent, followed by China at 89 percent to reach US$0.037/kWh in both markets, which is 24 percent lower than the global weighted average."

– IRENA's global renewable power generation costs study, 2023

On the supply side, falling costs play an important role in ramping up investments and production of renewables. For instance, solar and wind can now beat conventional sources on price (especially when the latter remains highly volatile due to geopolitical factors). According to the Irena global research, in 2022, the global weighted average Levelised Cost of Electricity (LCOE) from newly commissioned utility-scale solar Photovoltaics (PV), onshore wind, Concentrating Solar Power (CSP), bioenergy and geothermal energy fell despite the rising material and equipment costs.

India was one of the major countries that witnessed a dramatic decline in weight average LCOEs in utility-scale solar and onshore wind projects between 2010 and 2022. (Refer to the sidebar 1).[xvii]

Figure 4: Lithium-ion battery pack price



According to Bloomberg NEF, lithium-ion battery pack prices fell from US$732 per kilowatt-hour in 2010 to US$151 per kilowatt-hour in 2022 (Figure 4).[xviii] The falling prices of batteries are enabling the electrification of transportation and electricity generation.

Source: Bloomberg

Two factors are driving down costs of renewables and alternative cleaner energy sources—technology and economies of scale.

Sidebar 2

- Automated drones and robots are used to reduce the inspection time of the internal structure and materials in solar panels and wind turbines, reducing maintenance costs.
- Artificial intelligence and machine learning systems can process satellite images, weather station measurements and historical data patterns from wind turbine and solar panel sensors. These systems can accurately predict the availability of wind and solar to map them with demand.
- Perovskite and additive manufacturing are increasing efficiency gains in solar panels and significantly reducing prototyping costs and time in building wind panels.

a. Technology: Innovation and digitisation are aiding in price and performance parity, cost-effectiveness and reliability in renewable production and usage (Examples of different technologies affecting costs are mentioned in sidebar 2). Renewable energy technologies become more efficient with incremental investment. Doubling the cumulative installed capacity causes prices to decline by the same fraction.[xix] **This is not true for energy from fossil fuel sources, suggesting that the cost differential is narrowing exponentially with technology advancements**. Prices of renewable energy sources such as solar and wind have decreased drastically and are comparable to non-renewable sources.

In India, rapid technological advancements in the solar sector have led to the establishment of the world's largest floating solar power plant in Kerala, where solar panels are installed on floating structures in water bodies. Floating solar plants have the potential for higher energy efficiency and yield than ground-mounted solar systems, resulting in lower LCOE. For instance, according to several recent studies, floating solar systems can produce 0.6–4.4 percent more energy and offer efficiency improvements ranging from 0.1 percent to 4.45 percent, reducing LCOE by more than 20 percent compared with land-based systems.[xx]

b. Economies of scale: In the case of renewables, especially in wind and solar, the economies of scale are greater at the equipment manufacturing stage than at the electricity-generating site.[xxi] For instance, solar energy has different economies of scale because it generates the bulk of overall output through many smaller and cheaper units instead of fewer but bigger and more expensive fossil fuel-based plants. Therefore, solar projects are driven more by the economics of panel production.

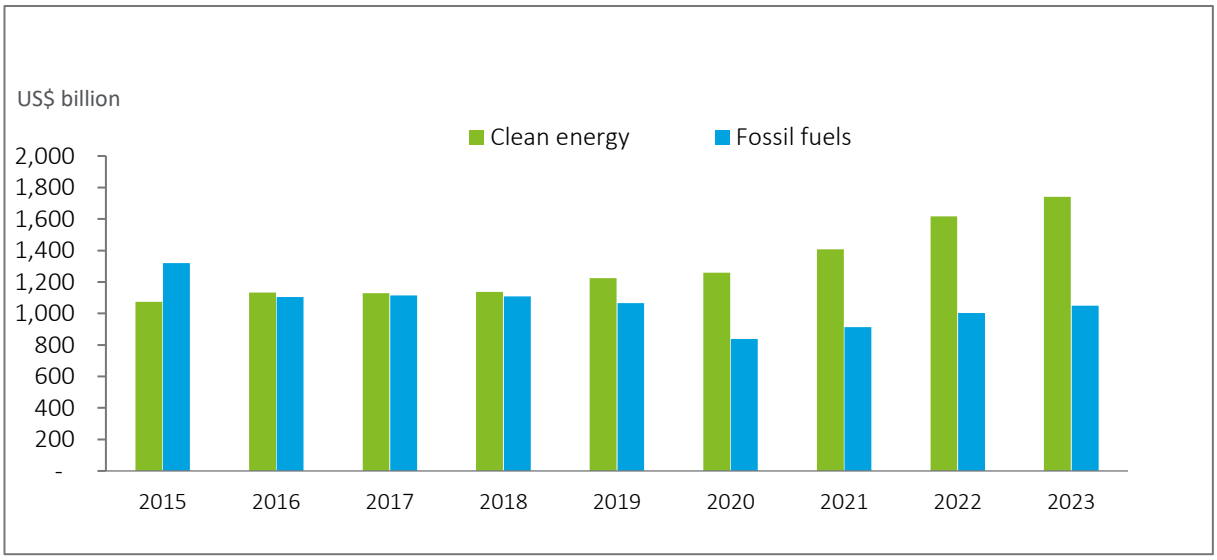
In India, the abundance of sunlight throughout the year and the government initiatives to promote solar adoption have led to a rising demand for solar energy in recent years. This increased production to meet the rising demand and cheaper financing options are resulting in scale economies, bringing down manufacturing costs of solar panels and components and boosting investment in supporting infrastructure. Reduced costs of setting up solar projects, manufacturing equipment and deploying products are further boosting demand, resulting in a virtuous cycle in action (Figure 5).

Figure 5. Virtuous circle of economies of scale

Source: Deloitte Research

The implications of demand-supply dynamics and the race towards energy security are visible globally. In 2023, global investment in clean energy technologies touched US$1.7 trillion, with an increase of 7.6 percent year-over-year, while investment in conventional fuels has moderated (Figure 6).

Figure 6: Global energy investment



Source: IEA

India is also making significant strides in clean energy investment. In 2023, the country spent about US$9 billion to add 13.5 GW of renewable energy capacity. It is further expected to add 25 GW of capacity in 2024 at an investment of US$16.5 billion, according to estimates from the power ministry. Moreover, the government has set an ambiguous target of achieving 500 GW of renewable installed capacity by 2030, with a plan to add 25 GW annually.[xxii]

In addition to solar and wind energy, the government is pushing the domestic production of green hydrogen, given the country's abundance of renewable energy sources (solar, wind and tidal). Measures include launching the National Hydrogen Mission in 2021, establishing separate manufacturing zones, incentivising production and raising the budget allocated for the mission by 102 percent to INR600 crore from the initial allocation. This is expected to provide a strong push for the development of a supporting green hydrogen ecosystem.[xxiii, xxiv]

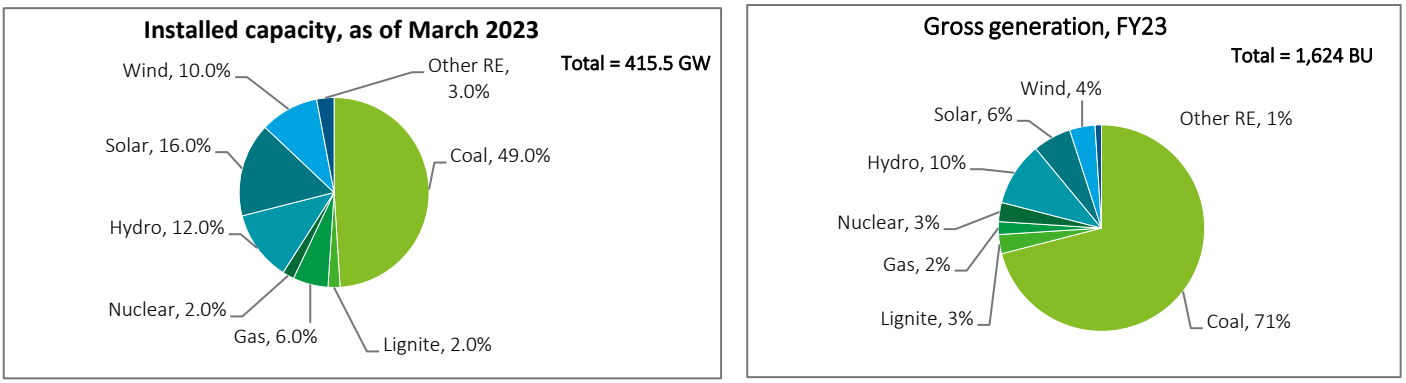
Time to double down on our efforts

India's commitment to energy transition is everyone's responsibility, and it is therefore important to understand the underlying economics of the transition. The benefits are immense and cannot be overlooked in the long run. India can accomplish the adoption of clean energy by:

Better utilisation of capacity through more generation: India's efforts towards the growth of renewables have been impressive. Over the past 8.5 years, the installed non-fossil fuel capacity has increased by 396 percent (at fourth position globally). As of March 2023, it accounts for more than 40 percent of the country's total capacity at more than 170 GW (including large hydro, solar and wind). In 2022, India recorded the highest year-on-year growth in renewable energy additions of 9.83 percent. The installed solar energy capacity has increased by 30 times in the past nine years and stands at 70.10 GW as of July 2023 (in third position globally).[xxv]

However, a disconnect remains between the installed capacity mix and the generation mix (Figure 7). Using renewable energy can potentially conflict with the legacy infrastructure and require changes in regulations and contract agreements among stakeholders. In addition, there are external or opportunity costs associated with renewables, such as the potential alternative land uses and altering ecosystems (for example, biofuel production from sugarcane is depleting water levels and windmills are harming birds).[xxvi]

Figure 7. India's installed energy capacity mix and generation mix



Source: CEA

Continuous government support and regulatory consistencies:[xxvii] According to Deloitte, India's final energy demand is expected to double by 2070, driven by rapid urbanisation and industrialisation. A targeted set of initiatives, including policy and regulatory, investment and R&D, will help contain the increase in final energy demand.[xxviii] The focus should be on reducing GHG emissions across key energy demand sectors—grid decarbonisation, industrial decarbonisation and transport transition. These areas are expected to have the most consequential effects, attracting policymaker attention. Moreover, the government's ability to design policies and implement regulations will be essential to steer the energy transition through the difficulties. The government must emphasise on R&D to hasten the adoption of renewable energy technologies, introduce new business models to facilitate supply and energy storage or enhance discoms' state of health to persuade them to invest in alternative energy sources and update their outdated infrastructure. In addition, a continuous need to align policy needs and regulatory consistency to encourage investors, markets and other stakeholders to engage in the transition with greater confidence is required.

Encouraging businesses to invest in new business models, sourcing strategies and operations: Industries and businesses will need to adopt changes throughout the entire value chain, from sourcing raw materials to distributing finished products. This transition may involve changes in supply chains, production processes and distribution networks to ensure a seamless transition. For instance, investing in renewable energy infrastructure within manufacturing facilities, such as installing solar panels or wind turbines, can help power operations sustainably and achieve cleaner manufacturing processes. In addition, it is necessary to closely monitor and adapt to evolving regulatory requirements and industry standards related to environmental sustainability and clean energy usage. Compliance with regulations on carbon emissions targets, energy efficiency standards and waste management regulations is critical to avoid penalties and maintain a good reputation.

Contributors

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