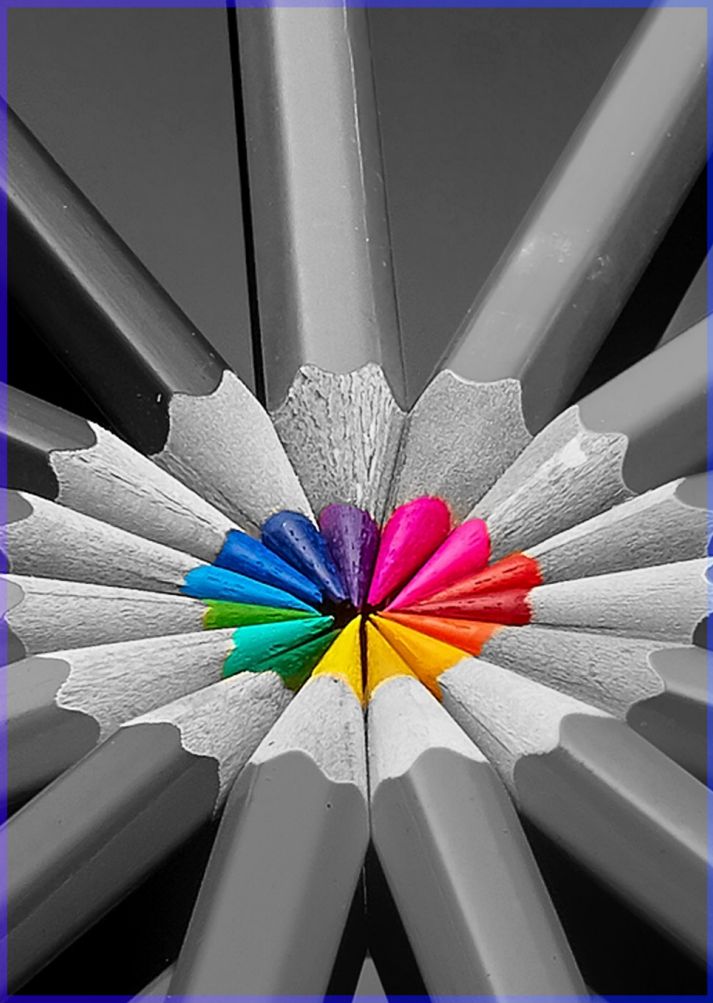
KPMG

Young Voices on the Energy and Resources Trilemma

ENRich 2022



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A message from Anish De

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This edition of Voices at ENRich 2022 puts forth the perspective of our sector's young and budding tribe, bringing together their point of views on the event theme of dealing with energy and resources trilemma.

The energy sector is riding wave of transition. We are witness to an intensifying energy crisis, record levels of greenhouse gas emissions, and a pronounced increase in extreme climate and weather events. Climate change can no longer be referred to as 'an invisible threat', since it has been showing its presence and intensity a lot lately. A large part of how it will play out in the future will depend on how nimble we remain with our actions

As the world reached the mark of 8 billion population, the need for finding a practical and sustainable solution for our expanding energy needs has never been of such importance. Future generations will carry the burden of present actions and inactions. Therefore, it's important that we hear their voices. The Young Voices on the Energy and Resources Trilemma carries opinion pieces from the next generation of sector professionals within and outside KPMG. I believe these articles will provide a well-rounded set of views on the sector and how we should look at our future priorities.

Contributors

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The energy trilemma: Lessons from Europe

As winter approaches this year in Europe, the trilemma of energy security, affordability, and sustainability is all set to take global centre-stage. Natural gas is key to Europe's energy basket, accounting for 20–25 per cent of its primary energy consumption. Russia, which used to supply ~40 per cent of Europe's gas requirements till 2021[1], has become an unreliable supplier due to the ongoing Ukraine war. There are rising concerns that Russia may use gas crisis to lobby for a better deal in Ukraine and this has the potential to become an achilles heel for Europe.

Currently, Europe is making up much of the Russian shortfall by purchasing expensive Liquefied Natural Gas (LNG) supplies from countries such as Norway, the U.S. and Qatar. Natural gas represents 1/5th of Europe's electricity and is also used for heating and cooking (~45 per cent). Due to costly LNG imports, electricity prices in most EU states have almost doubled in 2022. At one point, the situation was such that EU nations had to even announce heating limitations for swimming pools and building corridors. In short, in a bid to achieve energy security, Europe is being forced to give-up its energy affordability.

Europe's sustainability goals have also been hit as more coal power plants are coming online to compensate for the costly gas power-for e.g., in Germany alone, 20+ coal-fired power plants are being resurrected or extended past their closing dates to ensure energy supply this winter. The current European scenario presents clear lessons for nations that have an energy deficit. When planning their future energy supplies, nation-states must consider the interplay of the energy trilemma.

Had Europe developed large-scale LNG import infrastructure and invested in offshore oil and gas fields, current reliance on Russia would have been negated to a large extent. If we

The energy trilemma: Lessons from Europe

Kumar Abhishek

focus on another large energy importer, India, it currently imports ~75-80 per cent of its fossil fuel needs. However, India's fossil fuel sourcing strategy seems well-diversified between Saudi Arabia, UAE, U.S., Iran, Iraq, Nigeria, Russia etc. This strategy circumvents challenges to its energy security and also gives some leverage to its foreign policy.

However, for fossil fuel deficit countries, the best bet to solve the energy trilemma is to rapidly develop ingeniously available renewable energy sources. We may refer such fuels as energy elixirs. Generally speaking, achieving energy security by focusing on energy elixirs is a long-term process. Thus, in the short term, diversification of fossil fuel sourcing is the only way out to avoid situations similar to that of Europe.

In the long term, renewables especially solar, wind, bioenergy and their derivatives, i.e., green hydrogen/ammonia, have the potential to be energy elixirs. These are typically abundantly available (esp. solar and bioenergy), sustainable and becoming more affordable by the day. To solve their energy trilemma, nation states and political unions, including the EU and the UK, must invest in these energy elixirs.

With the changing European landscape, we are already witnessing increased traction for green hydrogen and bio-gas vis-a-vis natural gas. The road is long for Europe, but it is taking clear steps (by forming commissions to promote diversified and pooled gas sourcing, by subsidizing biogas and green H2) to help it wean itself from Russian gas well before 2030.

[1] EU imports of energy products - recent developments, Eurostat Statistics Explained, September 2022

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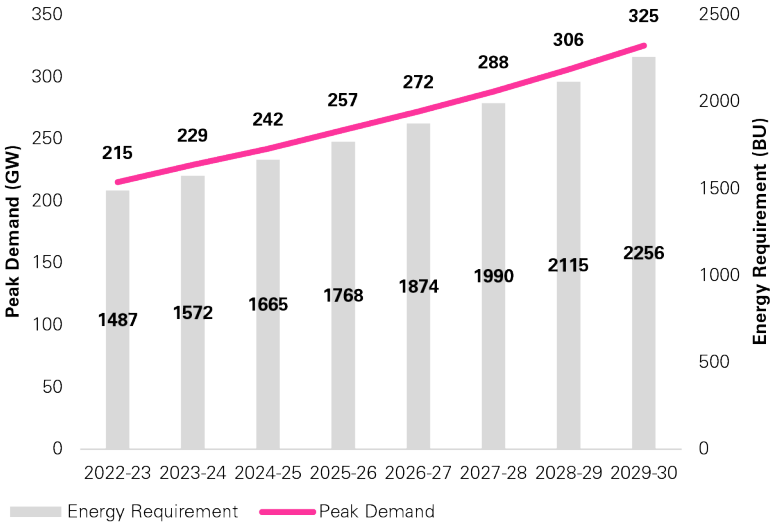
The emerging context of energy security in India

The Indian power sector has come a long way in the past decade, transforming the country from a power-deficit to a power-surplus nation. Electricity generation has increased at a CAGR of ~4 per cent, enabling India to reduce its energy and peak deficit from 4.2 per cent and 4.5 per cent in 2014 to 0.4 per cent and ~1 per cent in 2022 respectively[2]. This has enabled India to cater to its current electricity demand.

As the country emerges from the COVID-19 pandemic, it expects to see a dynamic period of growth in energy demand. Our peak power demand already reached its all-time high earlier this year. As per Central Electricity Authority's draft National Electricity Plan (NEP) 2022, the electricity demand is expected to grow at 6 per cent per annum for the next decade (against an annual growth of 4.1 per cent in the last decade)[3]. Against this backdrop, ensuring uninterrupted energy supply to all users will be one of the foremost priority for us as a country.

Projected growth in electricity demand



Traditionally, energy security risks pertain to fossil fuel supply shocks. With India importing 85 per cent of crude oil and ~50 per cent of natural gas, it is highly susceptible to global price volatility and supply disruptions. However, the energy landscape is dramatically changing, leading to an emergence of new challenges to energy security. Some of these

The emerging context of energy security in India

Ankit Anurag

emerging trends include:

- **Electrification of end-use sectors:** Electricity's share in final energy consumption is growing rapidly – for India, it is expected to grow from 17 per cent in 2019 to 23 per cent by 2030[4]. As electricity begins to play a major role, the need for robust electricity security measures will become paramount.
- **Clean energy transition:** Energy transition will bring a major structural change to electricity systems. As per the National Electricity Policy (NEP), the share of non-fossil generation capacity is expected to increase from 42 per cent today to 68 per cent by 2032. This will call for a robust grid and increased flexibility of power systems.
- **Climate change:** Energy systems are witnessing increased pressure from climate change. Extreme weather events increase the likelihood of climate-driven disruptions. For instance, unprecedented heatwave conditions this year caused a sudden surge in electricity demand, leading to power outages across the country. Similar events linked to climate extremes point towards the need to harden the energy infrastructure and build in climate resilience.
- **Digitalisation and cybersecurity:** Utilities in India are adopting new-age digital solutions for increased operational and financial benefits. But it also exposes power systems to the risk of cyberattacks, triggering outages and interruptions in supply – thus cyber resilience is becoming equally important.

It is clear that in light of these trends, the context of energy security is evolving, and the type of risks are broadening. Today, energy security is no longer about just import dependence. It is about ensuring reliable energy for all citizens in an economically viable and environmentally sustainable manner.

As we prepare for this new paradigm, actions will be needed on multiple fronts. First and foremost will be to harness more of indigenous resources in order to reduce our exposure to external supply options. This implies scaling up hydro and nuclear energy, and tapping into our vast solar and wind potential. As we make this transition towards a low carbon future, deployment of clean technologies will depend entirely on the unhindered availability of critical minerals. Therefore, it will be essential for India to ensure supply security and diversity for critical minerals as well.

Past practices on energy security were focused mostly on ensuring supply adequacy. However, today the demand-side is increasingly becoming a part of the solution. India has made good progress in this direction, having achieved significant reductions in energy intensity of its economy. There still remains vast potential to drive energy efficiency in the Micro, small and medium enterprises (MSME) and residential sectors. In this regard, the Perform, Achieve and Trade (PAT) scheme is already being expanded to other sectors, and the recently launched Mission LiFE aims to encourage people towards sustainable living. Successful implementation of these measures will have a positive bearing on India's energy security.

As the context of energy security evolves and type of risks broaden, energy systems will need to anticipate and manage both existing as well as the emerging challenges. A coordinated approach to creating robust supply chains for clean technologies, securing supply adequacy, and bolstering resilience will go a long way to ensure uninterrupted access to sustainable and affordable energy.

[2] Executive Summary Report 2014 – 2022, Central Electricity Authority
[3] Draft National Electricity Plan, Central Electricity Authority, 2022
[4] India Energy Outlook, International Energy Association, 2021

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Future of coal in India's power sector transition

Coal is currently the dominant energy source in the Indian power sector by virtue of its reliability and lower costs. However, Government of India has announced aggressive targets for renewable energy capacity wherein solar PV is expected to contribute significantly, considering ongoing projects and improving techno-commercial feasibility. Therefore, from the perspective of global decarbonisation efforts to mitigate climate change and long-term commercial viability, there is dire need to rethink the future of coal in the power sector.

In terms of cost, while solar has achieved grid parity, there is still no alternative to thermal power for ensuring round the clock power supply. Coal based power plants function as base-load power source with limited flexibility and higher time required for load transition as compared to gas or hydro units. Meanwhile power distribution companies are being compelled to move towards significantly shorter management cycle time (i.e., period between the demand for power being registered and the time of actual power supply) from current 15 minutes to two minutes in coming years. This will help improve the efficiency of operations and minimise transmission and distribution losses. It will also be a welcome move for the RE sector, as solar independent power producers (IPPs) can ensure steady power levels for shorter periods at a more economical rate. Nevertheless, this will have adverse impact on the coal power plants in terms of availing continuous power supply orders, as low-cost solar power will displace coal during the daytime due to the existing merit order dispatch (MOD) system. At the same time, from operations perspective, running the coal power plants at critically low power levels (less than 50 per cent of rated capacity) during daytime will be inefficient, resource intensive and expensive.

Future of coal in India's power sector transition

Vikrant Bhalerao

As part of their decarbonisation efforts, developed countries have retrofitted the coal-based power plants with natural gas, which comes along with marginal reduction in the profits but with the benefit of higher turn-down ratios. This may not be the solution for India considering the existing cross subsidised economic model of Indian power sector. In this context, smaller capacity modular power units (capacity below 300 MW) with efficient technologies can be a compelling solution in future to cope with flexible power demand and competing with solar PV for supply slots without sacrificing the commercial viability.

Another major issue faced by the Indian thermal plants is environmental compliance in terms of air emissions (CO_2, SO_2, NO_x and particulate matter), fly ash management and water conservation. Efforts to control SO_2 emissions from coal-based power plants are being planned since 2014 – the operational timelines for which have already been extended thrice (from 2018 to 2022 and now 2026). Expected capital investment for SO_2 mitigation across India ranges from INR60 to 70 thousand crores, which seems unwarranted considering Indian coal quality and existing data of ambient air quality in power station area for SO_2 and associated by-products. This will burden not only the debt-ridden power generating companies in terms of capital expenses (INR0.3 crores/MW) and operating expenses (INR0.22 per unit), but also the end-consumers, who are price-sensitive.

Expected technological pathway which is limestone based wet flue gas desulphurisation (FGD) is displacing SO_2 emissions into inferior quality gypsum with purity below 80 per cent. This results in land pollution similar to fly ash along with CO_2 emissions (0.7 ton/ton of SO_2) from additional process and auxiliary power consumption (up to 3 per cent). Therefore, policy initiatives with life cycle assessment for various available technologies should be promoted considering sustainability of measures. The best available technology for FGD may be ammonia based wet FGDs which has 42 per cent less lifecycle cost over conventional limestone technology and the product i.e., ammonium sulphate is fertiliser which is imported as of now. With commercial barter model between fertiliser industry and power industry for ammonia and ammonium sulphate can be a win-win sustainable solution.

The key solution to all these issues lies in the quality of coal being used by power plants. Till date, the coal ash content and its economics were only considered from the perspective of increase in transportation cost. But coal beneficiation should be assessed from the perspective of external costs in terms of increased CO_2, particulate matter and SO2 emissions, higher station heat rate, higher fly ash disposal efforts, higher plant maintenance requirement etc., which will result in significant reduction in carbon intensity along with better revenues.

While renewables will be in the limelight, coal thermal plants will continue to remain the reliable, affordable option for next 15 – 20 years and efforts towards its decarbonisation will make it sustainable and will drive the economic engine of India.

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Strengthening India's solar manufacturing ecosystem

India expects to witness a period of radical growth with aspirations to become a USD 40-trillion economy by 2047[5]. Economic development is intricately linked to the provision of reliable and affordable energy to all. Hence, India's energy sector will play a critical role in underpinning the envisaged scale of economic growth. It will also be imperative to ensure a balance between India's ambitions of economic growth and climate action.

As India strides towards its goal of becoming a net-zero economy by 2070, it has set ambitious targets for its renewable energy (RE) sector. By 2047, the country aims to achieve an installed RE capacity of 1,200 gigawatts (GW) and an indigenous RE manufacturing capacity of 60 GW[6]. To achieve India's formidable targets, it will be essential to strengthen the country's domestic solar manufacturing ecosystem.

Several important interventions have been announced and implemented, including the Safeguard Duty, Basic Customs Duty, and the INR 24,000-crore Production-linked Incentive (PLI) Scheme for solar cells and modules. However, India must eventually transition to a solar manufacturing sector that is market-driven in contrast to subsidy-driven. For this, there are certain challenges that need to be addressed.

The country's domestic manufacturing capacity – estimated at 20 GW for solar modules, and over 4 GW for solar cells[7]– is not able to meet its high domestic demand. This is compounded by the absence of upstream manufacturing capacity for polysilicon, ingots, and wafers. These factors have led to a significant import dependence not only on solar cells but also on the non-cell bill of materials (BOM) components such as glass, ribbons, backsheets, etc. These components further account for 30 to 35 per cent of the total cost of a solar module[8].

[5] Cities as Engines of Growth, Asian Development Bank and NITI Aayog, 2022
[6] Vision India @ 2047 for the Resources Sector, Sectoral Group of Secretaries – Group 3 (Resources), 2022
[7] Ministry of New and Renewable Energy, 2022
[8] Scaling Up Solar Manufacturing to Enhance India's Energy Security, Council on Energy, Environment and Water, 2020

Strengthening India's solar manufacturing ecosystem

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Indian manufacturers rely on imports from several countries such as China, Malaysia, Thailand, Vietnam, etc. for various components of the solar manufacturing value chain. In FY22, India's cumulative imports for solar cells and modules amounted to USD 4.5 billion. Of which, USD 4.145 billion worth of solar cells and modules were imported from China alone, constituting approximately 92 per cent of India's total solar cell imports for the year[9].

Significant levels of import dependence leave India extremely susceptible to supply chain vulnerabilities and pricing shocks that may be attributed to geopolitical tensions, trade disputes, raw material shortages, etc. In the recent past, a supply shortage for polysilicon, exacerbated by the COVID-19 pandemic, resulted in a sharp escalation in price from USD 7.68 per kilogram in January 2020 to USD 33.70 per kilogram in June 2022[10]. Instances such as this have underscored the need for a robust domestic manufacturing ecosystem underpinned by a diversified supply chain.

Therefore, it shall be essential to institute long-term policy and regulatory interventions and market-driven reforms to strengthen India's domestic manufacturing ecosystem with a sharp focus on enhanced self-reliance. As Indian manufacturers aim to leverage the PLI Scheme to create gigawatt-scale solar manufacturing capacities, they must prioritise vertical integration. There also needs to be enhanced investment in research and technology development, with a specific focus on efficiency improvement and utilisation of indigenous resources such as quartz.

While meeting India's domestic requirement is a massive challenge in itself, India must also endeavour to play a greater role in the rapidly growing global market for solar energy. Globally, the installed capacity of solar energy is expected to more than double from approximately 1 terawatt (TW) in 2022 to 2.3 TW in 2025[11]. In the next ten years, the world will witness a deployment of approximately 370 GW of solar capacity each year if nations are able to successfully deliver on their climate pledges[12]. Therefore, India must aim to attain global leadership in solar manufacturing with a strong focus on exports. This will allow for significantly enhanced economies of scale resulting in the manufacture of cost-competitive solar equipment in line with global standards.

Finally, with the ability to generate around 2.6 full-time equivalent (FTE) jobs per megawatt (MW) of output, integrated cell and module manufacturing has the potential to create a sizeable number of green jobs[13]. This must be leveraged by designing skilling and re-skilling programmes to rehabilitate the workforce affected by the transition away from legacy sectors such as coal, oil and gas, etc.

In conclusion, it is imperative that India positions its domestic solar manufacturing ecosystem to play a pivotal role in ensuring energy security, affordability, and sustainability. At the same time, the sector is also well-placed to play a meaningful role in minimising the negative socioeconomic impact of the transition towards clean energy, thereby serving as a key enabler for a just energy transition.

[9] Export Import Data Bank (Annual), Ministry of Commerce and Industry, 2022
[10] India RE Navigator, Bridge to India, 2022
[11] Global Market Outlook for Solar Power 2022-2026, SolarPower Europe, 2022
[12] World Energy Outlook, International Energy Agency, 2022
[13] Scaling Up Solar Manufacturing to Enhance India's Energy Security, Council on Energy, Environment and Water, 2020

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Dealing with the energy and resources trilemma: Security. Affordability. Sustainability

The energy trilemma, a fine balance between energy security, affordability, and sustainability does not remain constant – either over time or across regions. There is a constant change in equilibrium – depending on shifting priorities revolving mainly around geopolitics, economy, technology and, more recently, the climate.

India is amongst the fastest growing energy markets, with consumption of primary energy expected to more than double by 2050[14]. While renewables are expected to witness the fastest growth, hydrocarbons are likely to stay relevant over a longer period as compared to more developed economies. India has taken up the formidable challenge of becoming energy independent by 2047 and net zero by 2070. Very ambitious but do-able through a laser focus on integrated policies, planning and execution – involving a holistic basket of all renewable sources of energy, green hydrogen, offshore wind, and natural gas as a transition fuel.

The HOW (pathway to our goal)

As per a study[15] USD200 billion of investment is required for India to meet the solar and wind capacity targets of 2030. This is

[14] BP Energy Outlook 2022, British Petroleum, October 2022
[15] Financing India's 2030 Renewables Ambition, BNEF, Shantanu Jaiswal and Rohit Gadre, June 2022

Dealing with the energy and resources trilemma: Security. Affordability. Sustainability

Neha Jain

substantial and will require **societal** and **policy** support to attract capital through private, sovereign financing. Over the last decade, we have witnessed a steep increase in energy usage as well as increased scale/commercialisation of non-fossil energy sources. The ecosystem that helped India drive down the **cost** of renewables needs to be replicated for new energies to grow at scale.

Increased **technical** and **system efficiencies**, **innovative solutions**, and **simplification** of the energy value chain and end-use – all are going to play a role in ensuring an optimal balance of the factors contributing to the energy trilemma. Through incremental steps, we must rewire and overhaul the existing systems to the **changing ecosystem**. The energy transition is the next great engineering frontier calling for faster innovation, adaption and adoption, and a new mindset to optimise the way we use energy.

Think integration, think efficiency

As industries, utilities, local and national bodies progress in their decarbonisation journey, the energy sector can no longer offer up individual products but needs to come up with bespoke integrated solutions in power, mobility, and consumption. These could range from small tailored localised solutions to complex integrated decarbonisation solutions for heavy industries and transport. Integration allows developers to optimise resources – fuel, assets, finances and aim at optimal efficiencies and offer convenient solutions.

As we progress in the transition journey, we cannot lose sight of the third angle of the trilemma – energy security. For all countries and India especially, it is imperative to be self-reliant as much as possible in this area. We need to ramp up all available renewable resources – wind is not just cleaner, it is more secure, because it is local and more affordable because cost to convert to electricity is low once the turbines are in place. These things can contribute enormously to energy security and at the same time deliver on climate goals.

As an energy professional inspired to develop win-win solutions for climate, people, and businesses, I believe that to maintain the fine balance in the energy trilemma we must simplify, innovate, keep driving efficiencies and never lose sight of our goal to provide clean and affordable energy and make India energy independent in time for the 2047 centennial of India's independence.

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E-Mobility – Paving the way to balance energy security, energy affordability and environmental sustainability in India

The world is advancing towards carbon neutrality and with the ever-increasing levels of automobile emissions and strong demand for green and cost-efficient mobility, electric mobility (e-obility) through electric vehicles (EVs) presents a viable alternative to balance the energy security, affordability and environmental sustainability when combined with innovative pricing solutions, appropriate technology and support infrastructure.

EVs may be fully powered by electric batteries, fuel cell like hydrogen or hybrid having both engine and electric motors which results in zero or ultra-low emissions and much lower noise.

India has committed to an aspirational goal of having at least 30 per cent of private automobiles as EVs by 2030[16]. This will reduce the burden of oil imports which will in turn increase energy security and environment sustainability.

Some of key challenges to fulfil this commitment and faced by the Indian EV industry are battery technology, non-availability of adequate charging infrastructure, affordability and lack of educational awareness among people.

However, Indian government is taking various initiatives, providing incentives to overcome these challenges being faced by the EV industry. Some of the key initiatives are:

1. In February 2021, the Government of India launched the 'Go Electric' campaign to create awareness among masses about benefits of switching over to EVs, including various initiatives taken by centre and state governments to enhance acceptability of EVs and[17]
2. In November 2021, 'E-Amrit', a web portal as a one-stop destination for all information on EVs—busting myths around the adoption of EVs, their purchase, investment opportunities, policies, subsidies, etc.[18] was launched by the

[16] Aim to have 30% of 2030 car sales as EVs, The Hindu, 8th October 2021
[17] Annual Report 2021-22, Ministry of Power, Government of India
[18] National statement by Prime Minister Shri Narendra Modi at COP26 Summit in Glasgow, Press Information Bureau, 1st November 2021

E-Mobility – Paving the way to balance energy security, energy affordability and environmental sustainability in India

Harneet Kalra

Government of India.

The government (both national and state level) is providing various upfront subsidies and incentives to reduce the overall costs of EVs. Few of the key incentives are:

- **Demand incentives:** Faster adoption and manufacturing of (hybrid and) electric vehicles (FAME), is currently India's flagship scheme for promoting E-Mobility and other incentives such as reduction of GST rate on EVs
- **Supply incentives:** Production linked incentive (PLI) scheme for the manufacturing of advanced chemistry batteries for EVs, renewable energy and other applications. Other incentives such as removal of separate licence requirement for charging stations.

Given, we are at the cusp of energy trilemma and increasing use of EVs in India comes with various challenges, but we should not be intimidated by these challenges and rather focus on solutions that help meet future demand while keeping down costs such as:

- Investments in battery innovation and storage technologies and development of potentially world-leading capabilities
- Establishing additional charging stations and related infrastructure in key cities and along important routes
- Providing easy and beneficial financing options to the industry players as well as consumers
- Spreading awareness among the millennials of the coming age who anyways are more cautious of their choices and its impact on the environment.

To summarise, our approach to achieve India's carbon neutrality commitments needs to be focused on cutting costs, carbon emissions, and maintain security of supplies – and drive towards a future where the three corners of the energy trilemma work in concert and not opposition.

Saarthak Khurana
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Climate Policy Initiative

India's climate change commitments and futureproofing of public sector entities

India is currently the third largest carbon emitting country in the world. With the economic growth over the next decade projected at a significant rate, the country is likely to witness a persistent growth in emissions in the near future as well. The inextricable linkage of emissions with climate change presents a significant challenge to the country, since three-fourths of its districts – home to 80 per cent of the nation's population – are vulnerable to extreme climate-linked disasters such as floods, droughts, and cyclones.

Considering the potentially pervasive impact of emissions-induced climate change on the country's populace; as well as the country's leadership position on the global stage, India has committed itself to ambitious targets for mitigating climate change. These commitments present significant opportunities and challenges for existing businesses, especially in the key core sectors.

In India, public sector entities have a strategic presence across sectors like oil and gas, electricity, minerals, and infrastructure. Their dominance is even stronger in the Indian energy sector, with sizeable contribution to India's gross domestic product (GDP). They have also been catalysts for enabling the country's high growth and vehicles for purveying social justice and equity.

As carbon emissions are inherent to the very nature of the current business operations in the energy sectors, these entities are likely to face pressure not only due to India's climate change commitments but also from unprecedented competition from cleaner and more cost-effective technologies. The financial risk exposure of these public sector enterprises in the energy business has been documented in published literature. Some of the potential transition risks that these public sector entities are likely to confront are:

- **NPTC –** (i) Increasing competitiveness of RE and storage solutions; (ii) Carbon pricing and impending development of carbon market could make thermal power even more uncompetitive.
- **CIL –** (i) Decline in business with reduction in coal demand; (ii) Increase in competition from higher quality imported coal.
- **Oil PSUs –** (i) Growing cost competitiveness of EVs; (ii) High volatility and geopolitical uncertainties raising costs; (iii) Possible resistance in export markets (like EU) to accept petrochemical products manufactured from unmitigated processes.
- **Gas PSUs –** (i) Increasing competitiveness of batteries, displacing gas-based peakers; (ii) Electrification of activities such as heating and cooking.

India's climate change commitments and futureproofing of public sector entities

Saarthak Khurana

- **Indian Railways –** (i) Reduced demand for coal transport; (ii) Financial stress due to lower freight revenue which subsidises passenger traffic.

Considering the dominant position of public sector entities in India's energy sector, their active participation would be imperative to meet India's international commitments. The current position of these entities in their respective sectors affords them a unique opportunity where they can become the drivers of India's energy transition. To do so, they would need to reformulate their existing business models and delve into areas aligned to the country's climate commitment, to not only de-risk their long-term financial position, particularly their cashflows, but also to retain their pole position in the new economic order. These entities have therefore started taking some early steps for diversifying their businesses which are highlighted below:

Public Sector Entities	Pilots/Partnerships/MoUs/Investment Plans					
	RE	Energy Storage	E-Mobility	Fossils to Chemical	Manufacturing	Others
NTPC	✓	✓	✓			✓
CIL	✓			✓	✓	✓
BPCL	✓		✓		✓	✓
IOCL	✓	✓	✓		✓	✓
HPCL	✓	✓	✓		✓	✓
ONGC	✓	✓	✓		✓	✓
GAIL	✓	✓			✓	✓
Indian Railways	✓				✓	✓

While the process of diversification has been initiated by these entities, a further decarbonisation focused re-evaluation of business strategies may be undertaken factoring the following:

1. **Investment evaluation:** Evaluate current and planned investments in high-carbon businesses to identify potential risks while prioritizing decarbonised diversification
2. **Develop climate resilient infrastructure:** Identify critical infrastructure vulnerable to climate change-related disruptions and invest in making it climate resilient
3. **Leverage strong financial situation:** Leverage the current cashflows and balance sheet strengths to accelerate investment in decarbonised diversification
4. **Focus on dominance:** Prioritise investments in low-carbon technologies at early adoption stages to gain market dominance not just domestically but globally

Indian public sector entities play the role of nation-builders and therefore enjoy a prime position in decision-making circles as well as in investment portfolios. This makes them lucrative candidates for acting as agents of change in leading the nation toward decarbonisation while retaining high economic growth. The strategic actions and investment decisions of these entities towards diversification and decarbonisation will have a significant impact on not just futureproofing their businesses but also setting the pace of India's transition to a low-carbon economy.

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Tabreed

Inclusive and efficient energy use for sustainable economic growth

In the last five centuries or so, the human race has made significant economic progress as measured by the 1000-fold increase in size of global GDP. In large parts, this extraordinary growth was catalysed in the mid-19th century through discovery of fossil hydrocarbons and human ability to extract this surplus energy at a commercial scale. Access to easy and cheap debt further allowed us to borrow growth from the future by consuming resources today. However, this economic growth has come at a cost. Significant income inequalities aside, the period witnessed extinction of at least 60 per cent of animal species and destruction of life-sustaining ecosystems; according to many experts, the battle to keep temperatures below 1.5°C is already lost. To compound the problem, we now realise that supply of fossil fuels is no longer unlimited or unrestrained, raising questions of energy security and affordability, worsened by the geo-political state of the world. This is particularly true for India, which is heavily reliant on imports (70-90 per cent) for fulfilling demand of its expanding population with growing per capita incomes, undergoing rapid urbanisation - all of which will add to India's energy requirements.

As India seeks to levelise its economic, political and cultural standing in the world, it is presented with a unique opportunity to charter a distinct course for economic growth which is both inclusive and sustainable. It is imperative we focus our efforts on not only technologies that can support sustainable and efficient energy use but also revisit the idea of economic growth to include socio-ecological costs and externalities in our macro-economic models of growth (beyond consumption, savings and investments as captured through GDP).

In the arena of urban energy use, a key driver for the country's rapidly growing energy consumption, significant potential lies

Inclusive and efficient energy use for sustainable economic growth

Archa Modi

in adopting integrated urban energy planning approaches where circular, more optimal and inclusive resource use can form the foundation for the way forward. Here, district cooling (DC) can be the missing link that forms a cohesive thread across the siloed and rather fragmented energy plan and use approaches that are currently adopted in the country. Already widely adopted in the Middle East, Europe and North America, DC systems supply chilled water produced in a central plant to buildings through a network of insulated pipes. The technology leverages economies of scale and eliminates the need for independent AC units for buildings by aggregating demand and blunting the peak power requirement.

Currently, a fifth of India's peak energy demand is attributable to air-conditioning, forecasted to go as high as 45 per cent by 2050. When cooling is approached as a utility, demand across all buildings can be centralised in a district cooling system (DCS) reducing aggregate energy demand by up to 50 per cent. DC systems take advantage of time of day (ToD) tariffs and enable peak shaving/shifting through integration with thermal energy storage. DCS can provide significant anchor demand to city gas distribution companies enhancing their viability and uptake. More space on building rooftops through elimination of cooling towers or other equipment offers opportunity for availability of a larger footprint for roof-top solar. Within the building itself, sewage treatment can be aggregated for better water use through production of treated sewage effluent. Water bodies like seas, rivers or lakes can be considered where suitable for heat rejection to provide 'natural cooling'. Conducive regulation can ensure application for municipal solid waste to energy (for cooling), providing economic viability even without pricing in externalities. Integrated operations minimise refrigerant leaks/ use and urban heat island effects. With far more optimal resource use, a net zero vision then becomes closer to reality.

Although district energy is only one such example, it is critical to focus on technologies that support energy efficiency gains and circularity of resource use while we transition towards cleaner fuel sources to secure India's future prosperity that axes on affordable, clean, inclusive, reliable and sustainable use of energy.

Solar pumps: A climate smart way of irrigation

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Almost 55 per cent of India's population is dependent on the agriculture sector[19] and the sector remains a significant emitter of GHGs, currently accounting for 14 per cent of India's total emissions[20]. For long, the sector has remained at the forefront of India's policy, economic as well as social reforms agenda. Many policies and schemes have been introduced to increase farmer's income or to make agriculture affordable for the farmers. Despite some visible progress, the monthly income of agriculture household remains only at around INR10,000; almost 40 per cent of which comes from wages[21]. The farming income has remained stagnant, and the primary reason has been the increased dependency on conventional fuels for powering agriculture, especially pumps. Out of the 30 million pumps, almost 69 per cent are run on grid electricity, 30 per cent on diesel and only 1 per cent on solar[22].

Food and Agriculture Organisation (FAO) of the United Nations, the World Bank and other agencies have stressed on the need of climate smart agriculture (CSA) for reducing emissions and for sustainably enhancing agriculture productivity. CSA is an approach that helps guide actions to transform agri-food systems towards green and climate resilient practices. It focuses on three key pillars: 1) sustainably increasing agriculture productivity and incomes; 2) adapting and building resilience to climate change 3) reducing and/or removing GHG emissions[23]. Within this approach, the solar pump technology can be an ideal solution for increasing energy access and bringing self-sufficiency. Solar pumps can help improve energy security, bring energy independence and make irrigation affordable and sustainable. Solar pumps by their very nature are sustainable, in the sense that they utilise the energy from the sun for electricity generation, thereby reducing the dependence on electricity grids, which are often not available or are not reliable. Additionally, they also help reduce the dependence on government for water delivery projects, since now a farmer will effectively become a prosumer. On both these fronts, solar pumps help drive an element of self-sustainability in irrigation and agriculture, which is much required in the current context of climate change. Apart from promoting self-sustainability, pumps also help in bringing a change in the existing agricultural practices. This

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[20] India aims for better practices to cut agri emissions, experts call for clear goals, Hindustan Times, Zia Haq, 16th November 2021

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Solar pumps: A climate smart way of irrigation

Paritosh Moghe

includes change not only in the cropping pattern but also in the way farmers organise themselves for better utilisation of solar pump technology. In many places, owing to the greater availability of water and overall increased control over irrigation, farmers have organised themselves as groups or cooperatives to reduce the financial burden and also to target growth of horticulture/cash crops for better revenue realisation. The community/group business models can enable the optimal utilisation of solar pumps as well as ground water. They have also brought in a sense of joint responsibility for maintaining the solar pumps throughout their realisable project life.

Solar pumps have seen rapid scale up in many developing countries, especially in India where the installed base has increased from 11,626 in 2014 to 3.65 lakhs in 2022[24], a 30-times increase in just eight years. This has also led to increased visibility of technology on the ground thereby increasing awareness of farmers, government officials and financiers. The business case for the technology is fairly established and farmers now recognise the need for switching to solar pumps from their fossil fuel and grid-based alternatives. This is a result of both sustainability of technology as well as for commercial and operational reasons. The grid connected pumps although cheaper due to free electricity provision in many states are often unreliable due to frequent load shedding and poor supply provisioning. As compared to diesel pumps, the operational cost for solar pumps is 50 per cent less, with farmers selling the excess water at INR60/hour for solar pumps compared to INR120/hour for diesel pumps[25] (field study and primary research during project). This also has other socio-economic benefits which are often not quantified. The farmers in many cases had to travel long distances for procuring diesel for running the pumps, thereby reducing their time spent on other productive activities. Further, most of these pumps were either of poor quality bought in from local markets and thus faced frequent breakdowns.

The current approach on deployment of solar pumps has been on increasing supply and availability through state run tenders and Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM scheme)[26]. While this has certainly opened up the market significantly, it has not addressed other issues related to operations, financing, business models etc. At the same time, innovative models such as portable solar pumps have come up, which increases the viability of pump operations and reduces financial burden on farmers. On the financing front, innovative mechanisms such as first loss guarantee fund has been introduced through partnerships between bank and foundations. However, these measures are currently being operationalised in silos and there is a need to institute measures for their scale up.

Seen from the climate change perspective, the solar pumps need to quickly evolve from a technology novelty to an agricultural necessity. Then only, we can truly realise our agriculture potential, albeit at the same time providing new avenues of income generation for the farmers. In many places farmers have completely transformed their agriculture practices, owing to affordable costs and easy availability of water. In India, rainfed agriculture accounts for 51 per cent of the net-sown area[27] and this clearly shows that the current options are not sufficient to meet the crop water requirements of farms which is driven by both science as well as regional factors. Solar pumps provide that flexibility and truly provide energy independence to farmers compared to conventional options, which are not only costly (diesel pumps) but also less reliable (grid-connected pumps).

[22] International Energy Agency, Author's analysis

[23] Climate-smart agriculture, FAO

[24] Brief on off-grid solar energy programme, Ministry of New and Renewable Energy (MNRE), Government of India

[25] Author's analysis – Field study and primary research during project

[26] PM-KUSUM scheme was launched by MNRE in 2019 with the following key objectives - 1) increase the income of farmers, 2) provide sources for irrigation and 3) de-dieselisation of agricultural sector. The scheme plans to set up 30.8 GW of solar capacity by December 31, 2022, through the financial assistance of INR340.35 billion

[27] Overview of rainfed farming system, Department of Agriculture, Cooperation and Farmers' Welfare, Government of India

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Electric vehicle charging infrastructure: A roadmap for the future

India is emerging as one of the most important markets for electric vehicles. By 2030, India is expected to have 30 per cent of private cars, 70 per cent of commercial vehicles, and 80 per cent of two- and three-wheelers sold as electric vehicles. To meet this goal, governments, businesses, entrepreneurs, and investors in India have banded together to show their commitment to a future marked by electric mobility. However, while sales of conventional cars and light commercial vehicles have increased significantly in the nation over the past ten years, the adoption of EVs has lagged, partly because of a lack of charging infrastructure.

As the EV charging sector in India evolves, it is important that we understand what needs to happen for this space to become viable. Currently, EV charge point installers are hesitant to build charging stations until there is significant customer demand, at the same time, buyers are hesitant to purchase EVs unless there is a wide distribution of professionally run and well-maintained charging stations.

To overcome this impasse, the Government of India has taken several steps towards establishing standards for electric vehicles. The Faster Adoption and Manufacturing of Hybrid and Electric Vehicle (FAME)-II scheme is being amended to offer subsidies for the construction of charging points. Moreover, EV charging stations do not require a separate license and any individual/ entity is free to set up charging stations provided such stations meet the performance standards and protocols laid down by Ministry of Power, Bureau of Energy Efficiency (BEE) and Central Electricity Authority (CEA). It has also been acknowledged that PSUs like Convergence Energy Services Limited (CESL) are playing a crucial role in accelerating the EV adoption process by partnering with private players to set up the necessary charging infrastructure and even aggregating the government's demand for electric vehicle purchases. Keeping up with the times, CESL has also developed an intuitive smartphone app that enables consumers to take

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advantage of the government subsidy while buying EVs from the convenience of their homes.

Currently, a network of associated stakeholders, including automakers, government agencies, power companies, and oil and gas businesses, are funding various high-value components of the EV ecosystem, such as charging infrastructure, through public-private partnerships. Blending public and private sources of capital has been recognised by the World Economic Forum (WEF) as one of the six key strategies to accelerate innovation in the energy sector and can prove highly effective in building a robust, nationwide network of public EV charging stations to serve as a backbone for future growth. Competitive bidding makes it feasible to lowest-possible prices, and a revenue-sharing model for public-private ownership supports the sector's overall growth.

In conclusion, the Indian government's announcement of its intention to make electric vehicles an important part of India's future signals the importance of EVs in India and their potential as a solution for pollution, however, it does not mean that the charging sector will develop without challenges. The potential to develop novel products, services, and solutions to address these challenges is enormous for established businesses and start-ups. With the joint efforts of the government, the private sector, and business owners of various scales, India is certain to make great strides toward a future of sustainable transportation and become a global leader in electric vehicle sales.

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Sensing the vulnerability of India's built environment to the ongoing energy crisis

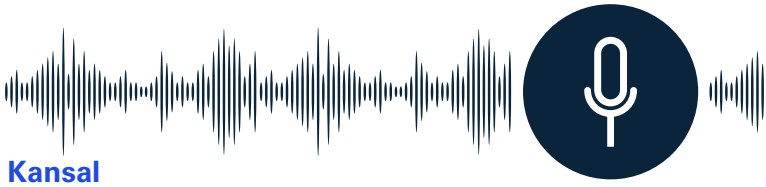
India's urban population grew from 290 million in 2001 to 378 million in 2011 and is projected to reach 590 million by 2030[28]. On the other hand, in 2012, the Technical Action Group on housing estimated the housing shortage of 18.78 million in urban India[29]. Population growth is also the primary cause behind the enormous disparity between energy supply and demand in the country. Moreover, India is susceptible to the externalities around rising crude prices and a looming recession. Based on the global urban GDP growth through the year 2035, India would be home to 17 of the world's 20 fastest-growing cities[30].

Buildings in India consume more than 40 per cent of the nation's total energy, 20 per cent raw material, 20 per cent water, and 20 per cent land in urban areas, generating 30 per cent of solid waste, 40 per cent overall carbon emissions, and 20 per cent water effluents[31]. It is only justified hence that the sector's emissions must dramatically decrease to help India reach its country-level Net Zero goal of 2070. The reduction is also crucial to India's efforts to manage climate threats and realise the goals of sustainable development (SDGs) and Nationally Determined Contributions (NDCs). According to estimates from the Bureau of Energy Efficiency (BEE), existing buildings have the potential to save 30–50 per cent of their energy through retrofits such as efficient building envelope, technology advancement as well as switching to low-carbon cooling options.

Ironically, limited market penetration of sustainable building materials and the associated costs remain two main barriers to large scale adoption of sustainable construction.

Construction companies today strive to increase the cost-effectiveness of buildings through the adoption of the concept of green building by using innovative technology, products, and techniques. Buildings must be sustainable—that is, long-lasting—to be truly affordable. The gains, according to the life cycle assessment theory, will pay off over a few years in lower maintenance costs and higher energy efficiency, even if the cost of sustainable structure is higher than that of

Sensing the vulnerability of India's built environment to the ongoing energy crisis



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conventional ones.

Many real estate firms have been actively working on implementing top-notch ecologically friendly practices and wellness initiatives, pledging to reduce emissions and move towards a negative carbon trajectory. Another manifestation is the impact of ESG on real estate and infrastructure where it is designed to support a more reliable and environment friendly built environment with strong communication networks, optimised energy and water consumption, and solid waste management. In addition, several rating systems, including but not limited to Green Rating for Integrated Habitat Assessment (GRIHA), Indian Green Building Council (IGBC) and Leadership in Energy and Environmental Design (LEED), are also available to aid in evaluating and managing resource and energy efficiency at the building level.

The mass movement by people into urban agglomerations is a topic of growing concern behind the energy crisis. According to a recent study conducted by TERI, India, if all buildings in urban areas were required to use green building practices, the nation could save about 8,400 megawatts of energy annually, enough to light 550,000 houses[32].

India will be hosting the Clean Energy Ministerial (CEM)-14 in 2023 along with its Presidency of G-20 Summit of participating nations. Recognising that lifestyle has a big role in climate change, the Hon'ble Prime Minister of India, at Conference of the Parties (COP26), proposed a 'One-Word Movement', to the global community. This one word is LIFE…L, I, F, E, i.e., Lifestyle for Environment. The relevant government authorities need to push hard for the enforcement procedure. Efforts will require extensive stakeholder consultation, development of technical tools, administrative systems, and capacity building among several building industry practitioners.

Moving forward, India will need to adopt a series of measures to change its buildings landscape at scale and speed. The following avenues can be explored to ride the shift:

1. It becomes imperative that the Government should shift focus on to reducing absolute emissions and not just focus on emissions,
2. Information related to embodied carbon, construction material energy performance, etc. to be openly and widely shared to enable collaboration and transparent decision-making,
3. Awareness generation should be mainstreamed on not only the benefits of a more sustainable built environment, but also on pathways to achieve the goals, the financing avenues and the benefits accrued in the long run.
4. Development of financial instruments based on sustainable performance (such as green building ratings systems and other financial mechanisms) to promote coordination on monetary transition among stakeholders for developing a sustainably built environment

Therefore, the need of hour is to strengthen knowledge about the usage/adoption and relationships about green building concepts as it supports meeting the global agenda. India's energy choices matter. They have direct and far-reaching effect on the lives of a growing population, and a major indirect effect on the rest of the world.

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[30] Infographic: India: Home to the World's Fastest Growing Cities, Keelery, S., 2019.

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Sustainability of urban spaces

The emergence of the modern capitalistic mode of production was closely followed by rapid urbanisation as witnessed over the course of past 200 years. This trend of extensive urbanisation today can be seen in full flow in the emerging and developing economies across the globe in the form of sweeping built spaces being planned and constructed, making cities and urban spaces the centre of all economic activity. Due to improving lifestyles, social mobility, and presence of better employment opportunities; there has been expansive urbanisation, and the concomitant rise of massive built environment. The sustainability of this built environment, primarily buildings have huge ramifications for climate change mitigation and adaptation, as well as for ensuring the sustainable growth of human civilisation.

Buildings sector accounts for almost 33 per cent of the current global total final energy consumption[33] amounting for 15 per cent of end-use sector direct CO2 emissions. The share of CO2 emissions rises to 30 per cent if the indirect emissions resulting from catering to electricity and heat requirements of the buildings is included. Huge construction of built space would occur in the emerging market and developed economies, as 80 per cent of the growth in residential floor areas is slated to happen in these countries[34]. These countries would also be on the receiving end of huge space cooling challenge. The use of energy for space cooling, which amounts for nearly fifth of all electricity consumed in buildings, is growing faster than for any other end use in buildings, more than tripling between 1990 and 2016[35]. Hence, the need to tackle the emerging global space cooling challenge due to climate change, rapid urbanisation, and improved standards of living would be paramount.

While technological innovation solutions like use of automation, building management

Sustainability of urban spaces

Vyom Narad

systems, digitisation, internet of things (IoTs) for transforming designing, construction and operation of buildings are needed, the environmental impact of consumption behavior also needs to be ascertained.

Our lifestyle choices have a major impact on the environment. Despite the discourse on sustainable development, which has transpired over recent decades, the extensive global resource use and associated environmental impacts continue to rise on account of ever-increasing consumption. Moreover, there has been an unprecedented rise in the global consumer class, particularly in developing nations wherein consumers make use of their improved purchasing power to emulate the consumption patterns and lifestyles of economically developed countries[36]. This has led to an increase in environmental impacts from consumption arising from lifestyle choices, thereby making it imperative to explore the possibility of sustainable lifestyle, putting forth ways for everyone to live harmoniously, to mitigate the pressures, and impacts caused by consumption.

The adoption of responsible consumerism, by invoking the principles of environmentally conscious, mindful, and deliberate utilisation of resources can lead to better outcomes for planetary and human health. Responsible consumerism by enhanced consumer awareness and engagement leading to behavioral change can result in significant reduction of emissions emanating from the buildings sector[37]. Interventions like setting the air-conditioning temperature at 24 °C can bring a sizeable emissions reduction from space cooling in buildings in both advanced, as well as emerging and developing economies. According to International Energy Agency (IEA), behavioral change has the potential for contribution of one-quarter of the additional direct emissions reductions in the buildings sector by 2030[38].

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Energy transition – Painting the energy sector green while keeping it reliable too!

Year 2010 – India, a batch of 60 students were elated as all of them secured placements post their post-graduation in thermal power plant engineering, one amongst them was me. We all were happy to be associated with the most promising fuel resource in India's capacity mix.

A decade later, a lot changed. Coal, once the dominating fuel in the generation mix was facing tough challenge from multiple other generating sources who over time not only evolved as cleaner alternatives but also generate electricity at a lower cost than coal. Though coal remains the dominant fuel, accounting for 54 per cent[39] of installed capacity, (exactly what its percentage was in the fuel mix back in 2010) the overarching entire eco system had changed, the sector was going through its own cycle of energy transition. Renewables which accounted for only 10 per cent in 2010 had exponentially increased to 24 per cent[40] by the end of the decade with 51 GW of capacity addition taking place in just 5 years. So, once considered irreplaceable, coal was facing an existential crisis, something similar to what gas started to face a decade back. While on one hand production costs were increasing for coal (lower utilisation, environmental norms becoming more stricter (flue gas desulphurization installation), transportation), on the other hand renewables kept becoming more and more competitive. With technological improvements and focus from governments through policy measures, mandates, etc. renewables witnessed significant decrease in production costs. In fact, 2020 was the first year when renewable installation across the world overtook that of thermal and the levelised cost of electricity (LCOE) of renewables dropped below coal. A special mention should be made of solar which became the lowest cost fuel in the generation mix[41].

The energy sector is witnessing one of the biggest transformation ever in its history. Never has the sector experienced this level of dynamics before. But increasing renewable penetration, comes with its own share of challenges too. Grid operators across the world are faced with a new challenge, the challenge of being reliable while being green. Many countries have discouraged building any further new coal plants with some also planning of retiring the existing thermal fleet before its PPA life. But this comes at a risk. A reliable fuel source is being

Energy transition – Painting the energy sector green while keeping it reliable too!

Debmalya Sen

replaced by a fuel source which is variable. In such a scenario the question thus arises, "how can grid inertia and reliability be met in a renewable dominant grid?"

Let's talk about India. By 2030, India has declared to achieve an ambitious target of 500 GW[42] of renewables, in energy terms this will account for 40 per cent of grid energy requirements. The question that arises therefore is, "Can renewable energy alone be entrusted with the responsibility to reliably to meet this requirement on its own?", the response being, "No". Renewables alone cannot be entrusted to meet this requirement, renewables being variable by nature, require the presence of a buffer, which can act as a bank every time renewable generates more or less than the demand and smoothen out the variability which renewables brings into the grid. This buffer is energy storage, a necessary enabler to continue growing renewables in a sustainable manner. Central Electricity Authority (CEA) projects that India will require 108 GWh[43] of Battery energy storage system (BESS) by 2030 to reliably integrate 500 GW of renewables in the grid along with 10 GW of Pumped hydro storage plants.

In all this transition, did coal lose out its relevance? In our opinion, it's too early to write off coal – coal is there to stay in the grid for a long time. As per National Electricity Plan (NEP) 2021, India will require to add 17-28 GW of more coal capacity by 2031 over and above to 25 GW which at present is under construction. But with 10 times more addition in capacity, solar is projected to beat coal in becoming the dominant fuel in the Indian power mix by 2030.

Energy storage will play a very critical role for the world to achieve its decarbonisation ambitions. Storage, especially batteries has risen to this responsibility with great promise. Over the last 10 years the cost of batteries has seen an exponential drop of 90 per cent[44]. The price drop has been a result of continuous technological improvements and innovations in battery technologies and its accelerated deployments in electric vehicles. As on date, batteries are already cheaper than gas peakers and new built coal plants. But batteries have their bit of challenges too. Supply chain of batteries, especially lithium ion has been a challenge. The world at present is dealing with supply challenges for key raw metals (lithium, manganese, nickel, cobalt) all of which are essential ingredients to developing Li-Ion batteries. The dominance of China which controls over 70 per cent[45] of the battery value chain also has risen questions on energy security. This has pushed the world to think beyond lithium ion as a technology option. While there are many promising technologies that the world today talks about, none has been able to challenge lithium ion as on date, but yes going ahead when the requirement of storage increases from hours to days increasing to months the attractiveness of lithium ion will slowly decrease for grid storage and that is where technological competence increases for technologies like vanadium flow, sodium sulfur, aluminium air, pumped hydro, gravity storage, to name a few. Also, there is a new entrant here, if Gen Y of the power sector is batteries, Gen Z is Hydrogen!

Overall, it's a great time to be in this sector and be witness to all the dynamics the sector is going through. While the transition is to happen, it is important to prepare a sustainable roadway for the transition to take place. Else we may end up building many more expensive underutilised coal plants to keep addressing the reliability concerns. To avoid this, long-term holistic planning is required, with the objective of better utilising the existing fleet and keep growing renewables with the assistance of storage rather than building many more under-utilised assets which eventually will only lead to an increase in power costs rather than the noble intention of reducing the same and making it green.

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World is reexamining strategies to provide people with a mix of affordable, reliable, and sustainable energy - hydrogen has a key role to play

Energy is at the centre of the climate dilemma, and energy is crucial to finding a solution to the same. One of the objectives that nations all around the world have set for 2050 is decarbonising the planet. The generation of an element like hydrogen, which produces green hydrogen, is one of the keys to achieving this goal because it now accounts for more than 2 per cent of all worldwide CO2 emissions[46]. While there are several ways to manufacture hydrogen, green hydrogen will end up being the most economical due to India's inherent edge in cheap renewable electricity. According to the analysis, India's demand for hydrogen might more than quadruple by 2050, accounting for up to 10 per cent of the world's consumption.[47] Given that green hydrogen might eventually satisfy the majority of this need, the market for green hydrogen in India could grow to be worth USD8 billion by 2030.[48]

A record number of laws, projects and policies are being implemented globally for green hydrogen, which is currently experiencing unparalleled political and commercial momentum. It is becoming more and more important to use it as an energy source to decarbonise difficult-to-reduce sectors. Carbon-free hydrogen will be essential for enabling substantial decarbonisation in several industries, including those that produce iron ore and steel, fertilisers, petroleum refining, methanol, and marine shipping, which all generate significant volumes of CO2.

Hydrogen is one of the key solutions being investigated for other high-emitting industries having the potential to be the preferable solution in several applications, such as heavy-duty transportation and aircraft. As a result, there is increasing global momentum for hydrogen in general and green hydrogen, which is produced by electrolysing water with power derived from renewable sources.

World is reexamining strategies to provide people with a mix of affordable, reliable, and sustainable energy - hydrogen has a key role to play

Bhishm Sharma

The biggest impact comes from hydrogen fuel cells, which help create zero-emission heavy-duty vehicles, which are now a source of GHG emissions. Sustainable hydrogen generation is made possible by the scalability and affordability of renewable energy systems as well as technological developments in electrolysers. The utility of hydrogen as an energy carrier is further increased by technologies that use it to create intermediates. Hydrogen fuel cells provide instantaneous power generation and aid in demand response. The second is particularly important since hydrogen fills the gap between a grid supplied entirely by renewable energy sources (RES) and RES's power generation variations.

The main benefit of the development of improved electrolysis methods is the increased scalability of hydrogen production facilities. Proton exchange membrane (PEM) electrolysers is used for both industrial and domestic purposes and are becoming more and more popular due to the decrease in capital and operational costs. Since hydrogen has a respectable energy-to-density ratio in liquid form, using it as a fuel for space propulsion looks intriguing. Liquid oxygen-hydrogen propulsion systems are used to propel rockets, aircraft, and jets directly using hydrogen fuel. The blending of hydrogen with other fuels to power turbines and propellants to produce green propulsion is a recent discovery in space technology.

India has a substantial edge in the production of green hydrogen thanks to its favourable geographic location and the presence of a wealth of natural resources. India also gains from cheap renewable energy sources and fast-falling electrolyser prices. In India, green hydrogen production can be made affordable by increasing the country's capacity for the generation, storage, and transmission of renewable energy. This will provide energy security while steadily increasing India's self-sufficiency. Green hydrogen adoption will aid in reducing the predicted 1.5 billion tons of carbon emissions that will rise in 2021. Green hydrogen can help India reduce its CO2 emissions by 3.6 gigatons till 2050.[49] This might be a crucial instrument for the nation to advance its recently revealed climate aims and meet its 2070 net-zero targets.

It is predicted that investments of USD1 billion can be expected in hydrogen research and development to enable game-changing breakthroughs for the entire world if India's hydrogen adoption strategy proceeds as planned[50]. Green hydrogen, supported by proactive collaboration between innovators, entrepreneurs, and the government, can considerably aid India in combating climate change. Additionally, it can assist India in exporting high-value green goods, turning it into one of the first worldwide big economies to industrialise without 'carbonising.'

The global demand for hydrogen might increase by approximately 400 per cent by 2050, driven by industry and transportation, as the necessity for decarbonisation grows and hydrogen prices fall. There is a new growth trend developing across different countries.[51] Forty-three nations have already developed roadmaps or policies for a hydrogen economy, along with financial incentives to hasten the transition.[52] This current push for the hydrogen transition in India is in line with the country's bigger goals for economic development, energy security, and a low-carbon economy.

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Just transition in thermal power plants

The world is making steady strides towards addressing the impacts of accelerated climate change. At COP26 in Glasgow, India committed to achieving net-zero emissions by 2070. A key lever to achieving this is through decarbonising the power sector. At present, electricity generation in India is heavily reliant on coal. India has an installed coal-based electricity generation capacity of over 200 GW, accounting for about 50 per cent of its total installed electricity generation capacity. Given that coal-based electricity generation accounts for approximately 70 per cent of India's GHG emissions[53], with the falling costs of renewables and availability of cleaner production technologies meticulously planned coal phase-down has a high mitigation potential.

However, it is estimated that approximately 8,50,000 to 9,70,000 formal and informal workers are employed in India's thermal power sector, without considering ancillary jobs. Hence, the loss of employment and livelihoods is one of the key challenges that need to be addressed while transitioning to a low-carbon economy. It is important to note that coal-based power plants are labour-intensive and generate significant formal as well as informal employment. The number of informal and contractual workers in thermal power plants is usually between three to four times the number of formal workers[54]. In contrast, renewable energy is significantly less labour-intensive than its coal-based counterpart[55], thereby raising concerns about whether the renewable energy sector, which may not even be geographically co-located, would be able to adequately absorb those rendered unemployed by the decommissioning of thermal power plants.

Further complexities present themselves in the form of inadequate systemic

Just transition in thermal power plants

Adritha Subbiah

provisions to enable a just transition. At present, there are no policies, regulations, or laws in India to minimise the adverse socioeconomic impacts of the largescale decommissioning of thermal power plants on both formal and informal workers as well as dependent communities. This has the potential to exacerbate pre-existing socioeconomic asymmetries.

Urgent action is the need of the hour, given that India's thermal fleet is rapidly ageing with 50-60 GW of India's coal-based capacity expected to retire in the coming decade[56]. This necessitates integrated and inclusive planning, and concerted action across the spectrum to ensure a transition that is fair and just. For this, there is a significant need to strengthen discourse and action around addressing the social impact of the clean energy transition alongside the environmental and economic impacts.

At the outset, a comprehensive mapping of all affected stakeholders, followed by an assessment of the direct and indirect impact of the transition on the identified stakeholders, is essential. Thereafter, the impacted stakeholders, including the vulnerable and marginalised sections of society, must be involved in designing, planning, and implementing the transition. Moreover, there needs to be a detailed policy and regulatory framework in addition to national-level and state-level programmes around skilling, re-skilling, and re-employment of the impacted workforce towards emerging opportunities in alternate sectors such as renewable energy, manufacturing, and others. This may further be underpinned by the establishment of a just transition fund with local, foreign, and philanthropic capital to support impacted workers and communities through the transition including through social safety nets. Ensuring distributive justice for all impacted is critical to successfully navigate the generational transition away from coal and towards clean energy.

[53] Facilitating a transition away from coal in India, CUTS International, February 2022

[54] Just transition of coal-based power plants in India, Sustainability Innovation and Advisories Pvt. Ltd., Chandra Bhushan, Mandvi Singh and Yukti Chaudhari, October 2022

[55] Enabling a just transition in India's power generation sector, CUTS International

[56] India needs legal framework for closing mines and power plants, Mongabay, Kundan Pandey, 25th October 2022

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Europe's energy trilemma in a 'VUCA' world

The brief but intense period of the past couple of years served as stark reminder to most of the policymakers, industry, and the wider population that we live in a world prone to volatility, uncertainty, complexity, and ambiguity (VUCA).

2021 and 2022 wreaked havoc on Europe's energy landscape, featuring inflationary pressures, driven by post-covid supply chain disruptions and pent-up demand, followed by an acute energy crunch which was then aggravated by the war in Ukraine and compounded by hydroclimatic extremes that rattled nuclear, hydro and coal generators.

The common denominator of these events was how they caught most observers off guard, despite insinuating weak signals and long-emerging trends of VUCA.

Ranging from overstretched supply chains through climate-destructive business models to shifting global balance of power, trends have been pointing to a volatile, uncertain, complex, and ambiguous future which render reconciling the trade-offs between Europe's energy security, affordability, and sustainability a challenging endeavour.

Europe, and the rest of the world, should regard today's disruptive events as a critical policy juncture to readjust and enhance our balancing act between constituent elements of the energy trilemma in the future.

Sustainability

From the trilemma perspective, Europe perhaps achieved the most in the area of sustainability which reflects in, for instance, the World Energy Council (WEC) regional energy trilemma scores.

EU has considerably reduced its energy intensity and decreased its carbon intensity, although this occurred in context of the economic crises that curtailed production.

In recent years, criticism has been levelled at EU's energy and climate packages for failing to deliver on expectations and for having

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had numerous unforeseen impacts on the energy markets and industry. Taking a closer look at the power generation sector, some outcomes of the energy policies in this sector were unintended (e.g., the development of renewables has been driven by policy support and incentives, rather than by supply and demand adequacy and market signals, or new installations resulted in significant overcapacity on European level).

Security

EU's concept of 'Strategic Autonomy' (SA), the capacity to act autonomously in strategically important policy areas such as energy security, gained traction only in the near past as attention on EU's co-dependency with its largest hydrocarbon supplier, Russia, has been propelled to the top of the legislative and popular agenda.

Leading up to 2022, the speed of EU policy-cycle did not heed the warnings of unfolding geopolitical escalation as cogs tended to turn notoriously slow in the domains of security policy, which enjoyed limited electoral support.

However, inter-institutional negotiations among EU's co-legislature (the three main institutions) demonstrated relative unity which reflected in unprecedently swift measures compared to the usual dynamics of ordinary legislative procedures.

EU should leverage the momentum to reinforce the EU-SA, and consequently, Europe's energy security of supply.

Affordability

The extremely volatile price environment puts European cost regimes to the test. In 'normal' conditions, EU performed relatively well in the equitable provision of energy.

However, EU's low level of wholesale prices leading up to 2021 did not make consumers better off on the long term, as end-user real prices for electricity increased over the last decade.

EU needs to find alternative ways to improve financing smart grids, energy efficiency, and renewables while integrating them fully into a competitive market without leaving the burden on households and small and medium-sized enterprises (SMEs).

EU as one of the largest economic powers has positioned itself as a climate-leader by prioritising sustainable investments, technologies, and R&D, and by transitioning to a new economic model that is less carbon-intensive and more renewables-oriented.

Strategic considerations, including energy security and the quest for diversification, enjoyed less political support in the past. Therefore, new measures should leverage the current momentum and should not be temporary but long-lasting.

There is no silver bullet for operating in a VUCA world, however, the energy trilemma can be best addressed by agility and adaptability to ensure secure, affordable, and sustainable future energy.

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Carbon market: Institutionalizing market-based mechanism for fixing the climate crisis and supporting sustainable development

The threat of climate change has been duly recognised the world over, and nations have declared their targeted emission reduction goals (i.e., Nationally Determined Contributions) post the historic Paris Climate accord in 2015. Even though the nations have declared their NDCs, according to the recently released emission gap report 2021 by United Nations Environment Programme (UNEP), to get on track to limit global warming to 1.5°C, the world needs to take an additional 28 GtCO2eq reduction in the annual emissions by 2030, over and above what is promised in updated unconditional NDCs. Although India's per capita greenhouse gas (GHG) emission is around 2 tCO2eq which is around one-third of the global average, the NDC target has been further revised upwards which now aims to reduce carbon intensity by 45 per cent by 2030 (w.r.t 2005 levels) and to become a net zero nation by 2070.

In order to accelerate the efforts against climate change, there is an urgent requirement to channelise climate finance and funding towards sustainable projects. Robust carbon markets can play an enabling role by sending market signals of carbon price and help investors and corporates to plan their capex allocation towards energy transition in an optimal manner. Currently, through compliance carbon markets, carbon pricing instruments such as carbon tax and emission trading systems (ETS) act as a driver for energy intensive industries (including hard to abate sectors) to invest in low carbon technologies in the production value chain and in various offset projects. Globally the size of the compliance carbon market has reached USD851 billion with a trade of more than 10.2 billion allowances in 2021. Further, it is interesting to note that the number of companies with net zero target by 2050 increased from 500 in 2019 to 1000 in 2020. Further, the voluntary carbon markets are expected to play an important role to

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help corporates, airlines (CORSIA) etc. to achieve their net zero targets. The size of the global voluntary carbon markets has already increased to USD 2 billion with a traded volume of more than 500 million credits. The voluntary carbon markets can play an important role in supporting large scale adoption of low carbon technologies, climate change adaptation and supporting sustainable development goals.

To accelerate energy transition in India, early implementation of carbon market instruments shall be crucial. It is expected that going forward the existing PAT scheme in India shall be transformed to a national compliance market under ETS which shall cover energy intensive sectors involving more than 60-70 per cent of India's total emissions. Further, India is already playing a role of key credit supplier in the voluntary carbon markets and the same is expected to grow further. One of the recent successes of COP26 was the finalisation of the Paris rulebook through agreement on Article 6 that calls for cooperative approaches among all signatories to Paris Agreement. As per recent discussion paper floated by International Emission Trading Association (IETA), the potential cost reductions that may be achieved through Article 6 cooperation are estimated to exceed USD300 billion per year when compared with the independent implementation of NDCs by countries. As a way forward, institutionalisation and putting in place a detailed framework for implementation of global carbon market mechanism such as Art 6.2 and Art 6.4 carbon markets could help expedite climate finance in an effective manner.

Further, the robustness and transparency of the carbon ecosystem shall be crucial which can be supported by globally common principle and adoption of technology-based Measurement, Reporting and Verification (MRV) in the carbon credit value chain. Also, for carbon markets to flourish, the policy clarity on corresponding adjustments, additionality principles and use of carbon credits by corporate's offsetting requirements need to be unambiguously defined and accepted by all stakeholders. Thus, the role of efficient and transparent market-based instruments is crucial to help us meet climate goals:

1. By accelerating climate finance to sustainable projects through a transparent market-based route
2. Sending robust market signals to help corporates/industries decide when and how to allocate capex optimally in internal abatements by technology upgradation or sustainable practices
3. Giving directional inputs to industries and corporates to plan their business decisions or future expansion by factoring in cost of carbon.

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