Policy Brief

Why does India still need coal?

Putting India's use of coal in the right context

Vivekananda International Foundation

WHY DOES INDIA STILL NEED COAL?

PUTTING INDIA'S USE OF COAL IN THE RIGHT CONTEXT

ॐ द्यौः शान्तिरन्तरिक्षं शान्तिः
पृथिवी शान्तिरापः शान्तिरोषधयः शान्तिः।

"Om dyauh śāntir antariksam śāntih prithvi śāntih āpah śāntih osadhayah śāntih"

-- Yajur Veda 36.17

Unto Heaven be Peace, Unto the Sky and the Earth be Peace,
Peace be unto the Water, Unto the Herbs and Trees be Peace

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Photo courtesy (front and back cover): Dr Pinaki Sarkar, Chief Scientist, CSIR-CIMFR Digwadih Campus, PO-FRI, Dhanbad 828108

Cover: *Front*

A heap of coal.

Indian coal largely originates from the Gondwana supercontinent dating back to the Permian period. It is uniquely characterized by its slow-burning propensity, low heating value, and exceptionally high ash content. The latter is erosive and possesses high electrical resistivity when compared with the coals of other countries. Indian coals are generally classified, based on international standards, as bituminous, sub-bituminous and lignite. The nature of Indian coal poses significant challenges for the design of equipment over the full value chain from production to transportation to handling and utilization, particularly power generation. Decades of effort by the Indian industry were required for adapting largely imported technologies to suit Indian coal. Self-reliance was achieved through extensive customisation and innovation, enabling India to reduce dependence on foreign technologies. This not only strengthened the country's energy security but also fostered industrial growth, paving the way for indigenous advancements in power generation and coal-based industries.

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Foreword

This policy brief, '*Why Does India Still Need Coal?*', directly addresses the challenge posed by the global climate action developing around us, in the context of our pressing need for regular supplies of affordable primary energy for development. With a population of ~1.4 billion, limited domestic oil and gas reserves, and limitations of quick and cost-effective hydro and nuclear capacity expansion, India's continued reliance on coal is not a choice but a necessity. Yet, India is being seen and singled out as one of the world's most prominent coal guzzlers, second only to China. Amid the carbon anxieties engulfing the world, the government's push for solar PV and wind power is commendable. Nevertheless, it must be recognized that modern renewables have limitations of intermittency, requiring interventions like long-term energy storage, and grid augmentation, which are all cost-intensive.

This policy brief builds a data-driven case for coal as a critical least-cost endogenous resource for India's economic development, energy security and stability in the near and medium term. It places India's coal consumption in the proper context, flagging the case of developed countries, which all had coal as the workhorse till they hit gas super-abundance more recently. India's major energy source is coal, making up over 56% of the primary energy basket. Still, India's annual per capita coal consumption of about 890 kg is way lower than that of developed countries, generally in the 1500-3500 kg range, even though most of these countries use excessive amounts of gas and oil in addition to coal. Notably, it was only recently that India's absolute coal consumption crossed the 1 billion tonnes threshold, which was the USA's peak reached in 2007 while having a mere 1/4th population as compared to India.

The brief simultaneously emphasizes India's commitment to a low-carbon pathway, decoupling emissions from economic growth to reach net zero by 2070. In parallel, the policy brief reminds us of the principle of CBDR (common but differentiated responsibilities) embedded in the architecture of the Climate Convention. The commitment to reduce global emissions lies more with developed countries, which are the historic polluters. The Indian initiatives to reduce GHG emissions emerge as exemplary as these compare with countries like Germany, which are considered leaders in environmentalism. These voluntary initiatives give India a moral standing to choose its future energy path independently. The argument remains anchored to the fundamental Indian realities of energy affordability and security, the key determinants for the Indian energy strategy.

Climate change is one of the defining challenges of our time. Its root causes lie primarily in the production and consumption patterns of the developed world, where the Industrial Revolution, powered by coal and later petroleum, set off an era of unprecedented materialism. Geopolitical alliances surrounding fossil fuels intensified, particularly after the Second World War, while mounting scientific evidence of global warming, increasingly noted and well-understood by the 1960s, was largely ignored.

Global emissions have continued to rise even post-1992, the year of adoption of Climate Convention, with the IPCC's latest reports underscoring urgent action as the Earth's carbon budget dwindles, reminded more by the extreme weather events that are increasing and intensifying. The spreading anxiety in the developed world is explicably prompting them to throw stones at others while living in glass houses. The policy brief charts historic coal consumption and refers to the rise in emissions in developed countries since the Climate Convention, exposing their double standards.

Climate change, fundamentally a collective action challenge, demands multilateralism. It calls for metamorphosis of the design of energy systems and other societal organizations that evolved and optimized in the previous two centuries. The pace of change during three decades after the Climate Convention has been dismally slow, resulting in ~60% rise in carbon dioxide emissions instead of reduction as envisaged during the Climate Convention. Unfortunately, solar PV and coal have come to symbolize opposing ends of this energy debate. While the world acknowledges the realities of global warming, the climate discourse increasingly leans toward symbolic gestures of international climate action. The wartime like mobilization and urgency are missing, with affairs left to the market forces to find their course. At the same time, developed countries continue to appropriate the global carbon budget by continuing their excessive consumption patterns. Strangely, the restlessness and anxiety resulting from extreme weather events and prospects of missing the 1.5°C target are being directed towards the developing countries.

Authentic global climate action must be grounded in the principles of climate justice, where nations equitably share access to sustainable development. This is especially relevant for India, where the idea of a 'fair share' of the global carbon budget drives our national low-carbon pathway. India's Long-Term Low-Emission Development Strategy (LT-LEDS), submitted to the UNFCCC in 2022, reassures the world of India's commitment to this principle. However, while global cooperation is essential, it must also respect the sovereignty of each nation's strategies in addressing climate change while on its nation-building journey, with the economy being a critical dimension of the endeavour.

India's ambitious economic goals, especially its urge to address energy poverty, intersect with an increasingly complex global climate change narrative. It faces heightened scrutiny, particularly with developed countries calling for a coal phase-out—a stance with profound economic, trade, and diplomatic implications. The global narrative often fails to recognize India's national circumstances and unique legacy challenges. Even today, the Government is carrying out structural changes to come out of the long shadow left by the colonial rule. This policy brief explores the tension between India's substantial energy needs and the growing international demands for rapid decarbonization and energy transition within such a paradigm.

The Vivekananda International Foundation (VIF) recognizes the complex intersections of climate, energy, and national security. With 1/3rd of the global average and 1/6th of the OECD average, India's per capita energy usage is dismally low. For millions in India still grappling with energy poverty, increased energy access is not just about climate action but an economic imperative. India is highly dependent on oil and gas imports which introduces energy security risks. It also has a long technology import legacy and therefore policies must be formulated considering its implication on energy prices and accessibility. At VIF, we have launched several dialogues to unpack the critical issues surrounding the energy and climate conundrum, helping policymakers navigate the critical issues and rapid advancements.

The policy brief also tackles the geopolitical dynamics that shape today's climate-energy agenda, highlighting the inequities developing countries face when pressured to compromise growth for emission targets. The developed countries seem to have enthusiasm for all but themselves for addressing global climate change. They have almost shirked their responsibility of taking the lead in drastically reducing their emissions and have failed to provide new and additional climate finance and technology transfer to the developing countries. Recent COPs witnessed their newfound distracting tactics of calling for coal phase-out. COP29 was simply a replay of the approaches visible during most other COPs when developed countries dragged their feet on climate finance.

The author, Dr JR Bhatt, makes the case that, burdened by coal's stigma linked to an irrelevant legacy of excessive use by developed countries using primitive technology to amass wealth, India faces unjust calls for phase out of coal from countries with abundant access to oil and natural gas. Meanwhile, India's economic landscape is still significantly tied to coal's indigenous availability and affordability. The policy brief emphasizes that such calls overlook the historic energy access inequities from which industrialized nations have always benefited. The author cuts through prevalent myths around coal through a grounded, data-driven approach, highlighting a path forward that integrates India's developmental imperatives and positions the country as a responsible leader in the global climate arena.

The author brings evidence of coal's strategic role in India's energy mix and crucial input to the industry, suggesting that coal remains indispensable to India's path toward carbon neutrality by 2070. The brief also emphasizes the central importance of self-reliance and technology R&D in bolstering our energy strategy alongside renewables. This nuanced approach emphasizes energy security and economic resilience by reducing dependency on imported petroleum, natural gas, critical materials, and technology know-how for renewable technologies.

The policy brief proposes a balanced, 'dual track' approach for India: using coal as a near-term solution while investing in clean coal technologies, including liquids from coal. At the same time gradually tapering towards renewable capacity based on its own technology and investing in power grid resilience, enabling a smoother transition aligned with the sustainable development goals.

An essential resource for government bodies, negotiators, and other stakeholders, the policy brief enables a clear understanding of India's energy needs in a global context, flagging the nuanced realities of changing climatic regimes. The way it stands, it can also guide other developing countries facing similar challenges in balancing climate commitments with national priorities. By reinforcing the value of endogenous resources like coal, the present work aligns with the principles of the Climate Convention and its Paris Agreement and advocates both sustainable utilization of coal and fostering global technology collaboration in emerging areas. It advocates for technological self-reliance and pragmatic approach, challenging the oversimplified binary between coal and renewables while making energy affordability a central consideration. The author's vision suggests that by embracing this balanced approach, India can set an example, charting an energy future that is ambitious yet firmly grounded in its people's needs, economic circumstances, and sustainable aspirations. The policy brief covers a large landscape in its bid for a comprehensive and original subject treatment.

The VIF remains committed to supporting research and dialogue on energy, climate, and technology to promote India's growth and security.

We look forward to continued engagement in this crucial area and commend the author, Dr J R Bhatt, for providing valuable insights on this vital subject.

April 2025 | New Delhi

(**Arvind Gupta**)
Director VIF

Preface

In the context of global warming due to anthropogenic greenhouse gas emissions vis-a-vis the energy required for essential development, the importance of coal to the Indian economy was well understood even before the Earth Summit held in 1992. The current work, however, was primarily motivated by the COP26 held in Glasgow in 2021. From that event, the perception that coal was the primary impediment to global climate action has grown and spread like wildfire. This perception has been current for some time, yet, it was at COP26 that for the first time, developed countries, led by the United Kingdom, made a strong push to include coal phase-out in the COP decision language. As a member on several occasions of the Government of India's delegations to various Conference of Parties of the UNFCCC, though I can't say it was my most difficult phase as a long-time climate negotiator, yet the debate at COP26 in 2021 left a lasting imprint. In the following months, the scrutiny grew, and wealthy countries often officially targeted India's coal use. Lobbying efforts to stop India's investments in coal mines, power generation assets, and so on were palpable on a global scale. It was this buildup by certain countries which pursued their extravagant energy goals relentlessly but wanted India to stop in its track to meet the minimal needs of its citizens that motivated this undertaking. It was in 2022 that I systematically started to prepare a case to precipitate such unjust developments when the U.K. again pressed for the inclusion of coal phase-out in the language of the decision text at COP27 held at Sharm-el-Sheikh.

Environmentalists are privileged to have a box office view of the country's infrastructural development from various angles. As a long-time watcher of the energy sector from an environmental standpoint, I have seen Indian coal-based projects acquire 'industrial assembly line' status. India commissioned projects one after another, much like the way we see metro construction today. Coal's importance as India's least expensive and reliable energy source has never been underestimated. Simultaneously, in recent years, the government stepped up its efforts to build renewable energy capacity. It is gratifying to see that we have entered the modern renewable fray, as energy security has always been a concern for me as an Indian citizen. I also saw non-fossil energy as part of our NDC's remit. The government's efforts to auction coal mines, aversion to coal imports, announcements about coal gasification, and ultra-efficient power generation technology initiatives, also contributed to a favorable feeling on the energy front. With such a background, the rising international pressure to turn our back on coal-producing capability following the Paris Agreement was quite disconcerning.

Regardless of the implications of anti-coal ideas, it is clear that the global climate situation is extremely complicated due to the massive and multifaceted nature of global warming's anthropogenic origins. Globally, governance systems have never seen such complexity. The implications go beyond the earth's climatological system to various aspects of the economy and politics. The direct link to extreme weather events, agriculture, freshwater availability, disease profile and job losses, adds a delicate human dimension. The recent globalization of commodities, as well as the dramatic rise in energy trade, have complicated the geopolitical connection even more. Rising public awareness and grassroots movements in the Global North have added a new dimension. As a result, developed countries, failing to meet their commitments, have turned short-sighted, reducing the climate action to solar PV vs. coal symbolism. Instead of fostering diverse technologies for the varied needs of developing countries, they now fixate on coal bashing inflaming its legacy stigma.

However, the science of global warming, particularly the concept of the global carbon budget has provided the right anchor to reference all discussion on what the world needs to do and how the responsibilities are to be distributed across nations. The global carbon budget, which defines the limit on the quantum of carbon dioxide emissions that can be cumulatively emitted, if a global temperature increase is to be kept below a specified threshold, is naturally a global commons. Such a global commons, given that carbon dioxide is no pollutant in the traditional sense, must be equitably shared. Unfortunately, the developed countries have usurped a vastly disproportionate share of this budget, leaving the rest of the world, with little headroom even for essential development, let alone obtaining a fair share of this budget. In this perspective, the targeting of emissions from coal used by the developing world, without reducing the much larger scale of emissions from oil and gas, especially in the developed world, is a further appropriation of the little that remains of the carbon budget and is an egregious affront to the intelligence of the Global South, and India in particular.

As we continued this debate on climate forums, it became increasingly clear that the energy scenario and India's strategy needed clarity, especially for well-meaning Indians who were keen that India should be part of the solution, even if it was not responsible for creating the challenge of global warming. As we sped into adding solar PV and wind power capacity, the spectre of rising energy prices in India has also rankled. The subsidy-driven solar PV and wind power uptake were known to have more than doubled the domestic electricity prices in countries like Denmark, Germany, USA (especially California), etc. It was in this backdrop that, I continued developing a narrative that would enable us to understand the energy landscape more clearly. However, decades of experience cannot substitute precise data collation and analysis. I could never speed up writing the narrative that I started building post-COP27, as it was difficult to give that kind of time due to my engagements at the MOEFCC. Satisfactory reactivation of the energy narrative had to wait for the opportunity I received at Vivekananda International Foundation (VIF) last year. Several discussions with domain experts as well as internal discussions reinforced the previously developed ideas. Specifically, expert brainstorming sessions organized by the VIF on coal, renewable energy, and energy policy allowed for a more precise delineation of a structure within the narrative I was attempting to build.

The resulting policy brief on hand addresses the coal question directly, as suggested by the title. To provide a rational response to this layered and complex problem, the brief goes into the framework components of India's approach to energy, environment, and technology policies. The landscape's intricacy is unparalleled due to the very nature of the global warming crisis. It is a collective action challenge that necessitates international cooperation and belief in multilateralism. The intricacy of the policy setting is exacerbated by direct links to the country's economy, sociological fabric, and geopolitics, which eventually manifests in internal political ramifications. For India, the challenges become considerably more important as the monthly energy bills account for a large portion of most household budgets, as does the energy security factor due to very high oil and gas imports. Another overarching factor is that coal already accounts for more than half of the country's primary energy needs.

Deft handling of the situation is a paramount necessity as, more recently, international climate negotiations have become intricately mixed with negotiations and issues from other spheres, such as trade, international relations, and the country's image. The biggest threat to forming any worthwhile domestic energy strategy is, however, posed by the influence of the developed countries. These countries are bent upon setting the narrative for all based on their own perspective and, of course, self-interest. The policy research deluge emanating from these countries impacts Indian thinking and approaches. As it is, quite a bit of Indian work on these issues is based on a relatively weak research foundation and lacks hands-on experience. The complexity of the energy, climate, and technology landscape and the shadow of developed country narratives further affect much of this literature. Even many well-meaning works tend to lose track due to insufficient focus on picking the correct framework. For these reasons, this brief devotes substantial attention to upstream framework aspects while also discussing the detailed determining factors.

The narrative in the brief starts by examining the primary assumption that Indian coal consumption is high, as its gross consumption ranks as number two globally. The discussion is expanded to consider the other fossil energy sources, namely, petroleum and natural gas. Considering other energy sources as well, like hydro and nuclear, provides a balanced evaluation that points to the legitimacy of India's coal requirements. The narrative is rounded out by discussing the foremost importance of modern renewable energy sources to fulfil the country's energy security.

The canvas is expanded by addressing the usage of coal in industrial activities other than energy, as critical feedstock for diverse industrial products. The coal-to-chemical route has received special attention because of its relationship with energy security. It is observed that this pathway has completely lost its relevance to industrialized countries, where such coal usage was replaced by inexpensive gasoline. In recent years, natural gas abundance has further taken up that space.

The narrative emphasizes the importance of an appropriate climate policy stance in order to establish a comprehensive energy strategy. It acknowledges the likelihood of greater global opposition to coal, especially as the effects of climate change, particularly as extreme weather events, are felt around the world. It advocates for continuation and intensification of technological research and development to improve the cleaner use of coal. The meaning of energy security has been broadened to encompass technological competence and crucial material imports.

Coal fuelled Britain's Industrial Revolution, driving it along with other factors from a small rural kingdom to the world's most spectacular economic empire. Subsequently, similar coal-driven commercial successes were created for many more countries which all became developed countries. Most recently, China used this energy source to forge a much higher economic rise in an unprecedented short period. Today it alone consumes more than half of the world's coal. The Viksit Bharat 2047 vision brings India into a very similar situation to these countries, both in terms of the economic aspirations and inevitably the primary energy source. Explicably, coal will continue to remain India's main energy resource.

Therefore, before considering and debating the details of energy strategy for India, we must examine aspects like the state of endogenous sources of energy, affordability for the masses, energy security vis-à-vis a volatile geopolitical realm, the state of energy deprivation in the country, and issues of technology and dependence on various materials. A coal-based net-zero pathway will certainly appear radical to most, especially considering the anti-coal stance being propagated by the developed countries. The challenge will be no bigger than for countries harnessing oil and gas for sustaining the continued economic growth. However, India has the technological capabilities and moral standing earned based on its resolute domestic actions wherein it continues to separate emissions from its economic growth, as well as overwhelming international climate actions including the formation of the International Solar Alliance (ISA), Coalition for Disaster Resilient Infrastructure (CDRI) and Global Biofuels Alliance (GBA).

By the time this policy brief was made press-ready, President Trump had already ascended to office. His energy approach had been discussed in previous weeks, but it was the office order that confirmed his will to withdraw once again from the Paris Agreement. The USA has been entering and exiting the climate agreement at its own discretion. Even under the Trump administration's second innings, the USA would continue to participate in ongoing negotiations, potentially pressurising developing nations to increase their commitments or align with the EU on such terms as ever and before.

The US withdrawal makes an earlier covert dillydallying approach crystallize into an overt shunning of responsibility by the biggest historical polluter. The emerging new reality will further weaken the already feeble global climate action. It only emphasizes the approach suggested in this policy brief of using endogenous energy resources for the country's good with conviction while remaining committed to climate action and not getting deterred by any fresh pressures. The Global South, in response to the USA's withdrawal from the Paris Agreement, must continue pursuing its own climate commitments but should not fall prey to the illusion that it is obligated to compensate for the significant gap created by the USA. India, along with the broader Global South, should remain steadfast in fulfilling its climate commitments as outlined in their respective NDCs. However, it must also prioritize bridging the development deficit while placing far greater emphasis on adaptation as an overriding priority for climate resilience. India must continue pursuing economic growth that is people-centric and inclusive.

The evidence-based case studies details and discussion in this brief are intended to be of use to negotiators on climate platforms and other international forums. It should also provide a solid foundation for policymakers while pointing to the urgent need for additional research and studies in the relevant areas of energy-climate-technology trilemma.

All too often in the policy literature, the efforts to evaluate India's energy-climate-technology nexus begin with the conventional framework provided by the Global North, rather than evaluating India's necessities and the status of its industry, technology, and economy as a whole, including the dimension of energy security, access and affordability. We hope that this brief will convince all stakeholders to take a fresh and hard look along with a data-based re-examination of the relevant issues to develop the right pathways, avoiding the fruitless studies and pursuit of pathways that neither help the global climate cause nor shed light on India's potential and options to growth and development. A sense of need and purpose has to prevail, overriding any despondency arising out of a West-induced anxiety or embarrassment.

Jaivardhan R. Bhatt

April 2025 | New Delhi

Dr J R Bhatt

Abbreviations

A

AUSC	Advanced Ultra Supercritical

B

bcm	billion cubic metres
BESS	Battery Energy Storage Systems
BHAVINI	Bhartiya Nabhikiya Vidyut Nigam Limited
BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation

C

C_3H_8	Propane
C_4H_{10}	Butane
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CBDR	Common but Differentiated Responsibilities
CCS	Carbon Capture and Storage
CDRI	Coalition for Disaster Resilient Infrastructure
CH_4	Methane
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
COP	Conference of the Parties
CSH	Calcium Silicate Hydrate
CSIR-NEERI	Centre for Scientific and Industrial Research - National Environmental Engineering Research Institute
CTCN	Climate Technology Centre and Network
CTL	Coal to Liquid
CUF	Capacity Utilisation Factor

D

DLS	Decent Living Standards
DMF	District Mineral Foundation

E

EI Report	Energy Institute Report
EJ	Exa Joule
ESPs	Electrostatic Precipitators
EU	European Union
EV	Electric Vehicle

F

FFNPT	Fossil Fuel Non-Proliferation Treaty
FGD	Flue Gas Desulphurisation
FT Process	Fischer-Tropsch Process

G

GBA	Global Battery Alliance
GCV	Gross Calorific Value
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GJ	Giga Joule
GST	Goods and Services Tax
GW	Gigawatt

H

H_2	Hydrogen
HDI	Human Development Index
HVJ	Hazira-Vijaipur-Jagdishpur

I

IISD	International Institute for Sustainable Development
IGCC	Integrated Gasification Combined Cycle
IP	Intellectual Property
IPCC	Intergovernmental Panel on Climate Change
IPRs	Intellectual Property Rights
ISA	International Solar Alliance

K

Kg	Kilogram

L

LED	Light-Emitting Diode
Li-ion	Lithium-Ion
LNG	Liquefied Natural Gas
LT-LEDS	Long Term-Low Emission Development Strategy
LULUCF	Land Use, Land-Use Change and Forestry

M

METI	Ministry of Economy, Trade and Industry
MOEFCC	Ministry of Environment, Forest and Climate Change
$MtCO_2$	Million Metric Tonnes of Carbon Dioxide
MW	Megawatt

N

NAPCC	National Action Plan on Climate Change
NC3	Third National Communication
NCQG	New Collective Quantified Goal
NCV	Net Calorific Value
NDC	Nationally Determined Contributions
NGO	Non Governmental Organization
NMET	National Mineral Exploration Trust
NPT	Treaty on the Non Proliferation of Nuclear Weapons
NITI Aayog	National Institution for Transforming India

O

OEM	Original Equipment Manufacturer
OSOWOG	One Sun, One World, One Grid

P

PFBC	Pressurised Fluidised Bed Combustion
PFBR	Prototype Fast Breeder Reactor
PNG	Piped Natural Gas
PSUs	Public Sector Undertakings

R

ROM	Run-of-Mine

S

SASOL	South African Synthetic Oil Limited
SMR	Small Modular Reactors
SRM	Solar Radiation Modification

T

TPPs	Thermal Power Plants
TRIPS	Trade-Related Aspects of Intellectual Property Rights

U

UN	United Nations
UNDRR	United Nations Disaster Risk Reduction
UNEA-6	United Nations Environment Assembly (6th Session)
UNFCCC	United Nations Framework Convention on Climate Change
UNO	United Nations Organization
USDOE	United States Department of Energy
USGS	United States Geological Survey
USSR	Union of Soviet Socialist Republics

V

VIF	Vivekananda International Foundation

W

WG-III	Working Group III
WTO	World Trade Organization

Executive Summary

1. **Rich countries vilify coal with India as a specific target while expanding on their own oil and gas resources, ignoring realities that are shaping the world.**

At the UNFCCC and other forums, developed countries have in recent years been calling for the phase-out of coal while not doing the same for oil and gas. Influential lobbies and voices are appealing to India to stop all investments in the coal sector, including mining and power generation. The basis for this campaign is India's rise to the second position in the coal consumption ranking. Developed countries themselves are claiming to be phasing out coal as climate positive action/virtue even as their oil and gas consumption continues to increase. These voices can be expected to get more insistent and louder as the 1.5-degree target continues to be rapidly slipping out of reach.

Nations like the UK, the USA, and Germany that amassed all their wealth based on coal now push for its phase-out, even as their fossil fuel use rises every passing year. India, with meagre oil and gas reserves, faces unfair pressure to abandon coal, distorting the direction of its energy policies while confusing its coal industry. In this context, the recent declaration of national energy emergency in the US highlights the urgency of a realistic global climate strategy. Energy prices and their impact on its industry and jobs have been one of the key issues that prompted the US to drive deglobalisation. The indications from the EU are also similar.

Likewise, any pathway that raises energy costs and increases external dependence will also be quite untenable for India, creating energy policy instability, increasing energy vulnerabilities, disrupt the coal industry, and ultimately delaying real climate progress. It is essential for India to clearly articulate its energy needs and imperatives to counteract the anti-coal campaign directed at it and ensure that external pressures do not distort India's energy choices. This is particularly vital for regaining investor trust in India's coal and power sector, where private participation is foundational and depends on the perception of policy stability to sustain long-term resource planning, workforce expertise, and funding for infrastructure.

2. India's low per capita coal consumption must rise for ensuring its social and economic development, given the weak oil and gas reserves situation.

India's coal production today is pegged at ~1 billion tonnes per year which is nearly same as that of USA in 2008 with roughly 1/4th of India's population. India's coal consumption surpassed 1.28 billion tonnes in 2023, placing it globally after China, having overtaken the USA. Such ranking, of course, does not portray the full picture. With the same population as India, China consumed about 4.9 billion tonnes last year, or about the same as the rest of the world combined. China's annual per capita coal consumption is about 3500 kg compared to India's 900 kg, which is almost 1/4th of China's level. Such figures need tuning as Indian coals have high ash content and correspondingly lower heating values. The comparable value of Indian coal consumption annually is less than 700 kg per capita, which is about 1/5th of China and a little over half of the world's average. Several developed countries have a much higher per capita coal consumption than India. Australia's annual consumption is about 3500 kg per capita and Germany's figure is more than 1500 kg.

To get a genuine picture, we need to look at coal consumption over the long term. Any current snapshot of coal consumption, as reflected in the per capita values above, even with the heating value adjustments, requires additional information to provide an accurate picture, as most developed countries have increased their natural gas consumption in recent years rather than coal. The time-series data for coal use demonstrates India's significantly lower cumulative per capita coal production share. Between 1900 and 2022, India's coal production was only 3.04% of the world's total coal production. When the heating value is taken into account (which overstates values by approximately 25% due to the lower heating value of Indian coals), the value drops to ~2.28%. Such a discrepancy in coal use between developing and developed countries becomes even more pronounced when cumulative coal use is considered since the start of industrialisation, exposing important global energy equity concerns.

The 1:1 comparison on coal consumption with developed countries is not reasonable, as all countries use a larger basket of energy fuel sources. A realistic comparison requires looking beyond coal and evaluating India's total fossil fuel dependency relative to other economies. In 2023, the world's total primary energy consumption amounted to about 620 EJ (exajoule), of which about 31.6% came from oil, 26.5% from coal, 23.2% from natural gas, 6.5% from hydro, 4% from nuclear, and 8.2% from other renewables like solar PV, wind power and biofuels. Most of the countries follow this typical trend of fossil energy dependence. This is particularly true for countries of the Global North, which industrialised on coal mainly during the 19th and 20th centuries. This was supplemented by oil during the previous century. And in the last two decades, the developed countries saw a general trend of energy shifting away from coal towards natural gas.

The developed country bogey of high coal consumption by India can be countered by dissemination of accurate data and information. The bigger and real internal concern should be the low value of coal consumption. A value that is 1/5th of coal-rich countries like China and Australia gets further concerning when we consider that coal is our main energy provider. Coal provides 56.3% of India's primary energy while the world average remains at 26.5%. The root reason is very low energy consumption itself. India's annual per capita energy consumption is 27 GJ, which is ~1/3rd of the world average and ~1/10th of the USA. Accordingly, the annual per capita oil and gas consumption values are also very low. Indian annual per capita oil and gas values stand at 175.6 kg and 48.1 m^3. This is 1/3rd and 1/10th of world average oil and gas consumption, respectively, and 1/12th and 1/56th of consumption in the USA. Even such low consumptions are met largely by imports of oil and gas as the country has very weak reserves. Typical imports for oil in recent years have been around 85%, while that of natural gas is at 50%. Such high imports create an annual burden of nearly US$ 150 billion for oil and about US$ 15 billion for natural gas while creating a national security issue due to supply chain uncertainties and use of sea routes.

3. **Unlike the Indian situation, the developed countries transitioned from coal to oil and very recently to natural gas, all after first achieving coal-driven prosperity.**

A long view indicates that energy transitions have consistently been driven by cost economics, use convenience, and geopolitical environment. The next energy option is generally slower to penetrate the global market, largely due to the inertia of sunk costs: in 60 years, coal's share increased from 5% to 50% of the global primary energy supply (1840-1900). Over an equal period (1910-1970), the share of petroleum rose from 5% to 40%, while natural gas saw a rise from 5% to 20% only (1930-1990). The higher energy density of fossil fuels emerged as the main attraction over traditional biogenic fuels, which mainly energised the world till the 19th century. The popularity of natural gas had to await LNG till the late 1990s for its long-distance technological feasibility and supply infrastructure.

The geopolitical importance of energy rose, along with the above-described energy transitions, as a key determinant of industrial competence of a country in global trade. The USA, despite discovering coal many centuries after the UK, picked up quickly. The Pittsburgh industry soon rivalled Manchester in the 18th century. Oil got added to the energy basket in the early 20th century. With the rise of automobiles, it soon became the preferred fuel option. The US's activities in the Middle East, though followed many decades after the Sykes-Picot line which divided the Middle East between Great Britain and France, indicate the importance acquired by oil in the energy business. The Suez Canal emerged as the eye of the ensuing post-war energy storm. The EU had a similar energy trajectory. Coal and petroleum were its energy mainstays for most of the previous century. Commercial pressures, post-1990s liberalisation, took them to import coal, magnifying the diplomatic role of European energy. Gas consumption increased with gas field discoveries within Europe and the North Sea. Gas pipelines connecting the EU with the erstwhile USSR at the height of the Cold War reflect the importance and geopolitical linkages that energy had acquired by that time. With almost nil domestic energy reserves, Japan always depended on coal and oil imports.

It got into the thick of energy diplomacy before the World War II and remained so thereafter. Japan was also the original promoter that established the LNG trade.

The non-fossil energy sources always remained on the sidelines mainly due to the higher energy density and better cost-economics of the fossil fuels. Biomass, mainly wood, was still the main energy source till about 1900s, supplying half of the world's energy. The commercial non-fossil energy options have essentially been two: hydro and nuclear. Windmills have been around, but the modern wind turbines, along with solar, got introduced only in the 1970s. Hydro-energy was the first significant point source with the advent of the world's first power plants in the 1880s. However, in 1900s, hydro contributed less than 0.5% of the global primary energy, and even in 1950, it contributed only about 3%. As a result of higher costs, siting and permitting restrictions, its contribution in 2023 was still only 6.5%. Likewise, nuclear energy, once considered the energy panacea, peaked in the late 1990s at a little over 6%, while presently, its contribution remains at about 4%. Solar PV and wind power provide 2.3% electricity (about 6% input energy equivalent) but remain dependent upon dispatchable fossil sources for power grid stability and supply continuity. For these reasons, these options need to be attentively watched for their role in the bigger energy picture. The persistent marginality of non-fossil energy options, despite policy pushes to increase them, has not been able to alter the fossil-dominated energy landscape.

Natural gas is the current favourite globally among the energy options, consuming 4242 bcm annually and contributing 23.3% to the world's primary energy. The usage shows high regional disparities, with the Russian Federation consuming 52.2% and the USA 33.8% of their primary energy. India, on the other hand, despite over 50% imports, supports only about 6% of its primary energy basket through 69.28 bcm annual consumption.

The complete industrialisation of developed countries took place essentially on coal energy, as that was the only available option at scale. The post-World War II economic boom also rode on coal and oil. The shattering of the confidence of developed countries post-1973 oil shock and the aftermath brought them back to coal. Advanced carbon conversion technologies were again reactivated. The R&D funding of these projects followed an interesting correlation to the oil prices. Notably, the developed countries were all actively continuing to use coal even a decade after the United Nations Framework Convention on Climate Change (UNFCCC) held in 1992. The USA's coal consumption peaked at about 1 billion tonnes in 2007, a full 15 years after the UNFCCC was adopted. The R&D funding for clean coal technologies, activated due to the 1973 oil shock from the Arab-Israel war, continued to be on ascendance in the years after the Climate Convention. The 1990s witnessed a critical focus on increasing the efficiency of coal-based power plants, mainly due to commercial pressures of market liberalisation, which saw a large-scale shift to imported coals in many countries of the EU. Several technology demonstration plants were installed to establish advanced carbon conversion technologies (IGCC-integrated gasification combined cycle, PFBC-Pressurised Fluidised Bed Combustion and oxy-combustion.) in the EU, USA, and Japan. The motivation was higher energy efficiency, cost economics, low carbon emissions, and reduced level of other pollutants. These clean coal technology development programs were gradually shelved once cheap natural gas became available.

4. **Energy security shaped the West's energy transitions, driven by oil shocks, geopolitical shifts and cheap natural gas while climate commitments often remained secondary considerations.**

Energy transitions have always been shaped by technology and market forces, rather than by deliberate incentivised shifts as in the case of renewable. The West's coal decline is driven not by climate action but by abundant, cheap natural gas. This shift is particularly visible in most EU countries and the USA, where coal sharply decreased to about 14% and 9% of the total energy needs respectively—well below the world average. The intense collaborative focus among the developed countries on gas turbines and LNG became key enablers for driving the coal to gas transition. The superior contemporary technology R&D ecosystem vis-à-vis what was available during coal technologies evolution a century ago, determined the shift. As a result, global gas-based (and also some oil) electricity capacity has reached 2100 GW, matching the total global coal-based capacity, despite natural gas being a far more recent entrant in the power sector. By comparison, the combined generation of solar PV and wind and its rise over the previous three decades remains lower than natural gas.

Energy security has always been assigned supremacy by industrialised countries in all governance affairs. Energy was at the heart of two great conflicts. Japanese invasions in Manchuria (1931 onwards) and the German Wehrmacht movement towards Azerbaijan in 1942 were linked to the primary goal of securing energy supplies. The well-known oil shocks of 1973 and 1979 altered the world forever. The first caused shortages, quadrupling oil prices following the Yom Kippur War. The second was the result of Khomeini's takeover of Iran. Oil prices rose to $12 to $13 per barrel in 1973 and crossed $38 in 1979. The Russia-Ukraine war is simply another repeat in which the energy politics demonstrated its centrality once more.

Clean technology research, including in clean coal, energy conservation, solar PV, wind, and so on, got triggered post the above-referred two oil shocks. These remained marginal as oil prices got controlled diplomatically in the following years. The eventual abandonment of clean coal initiatives was another sign of the decoupled energy transitions and climate action, as all this took place a full decade after the Climate Convention. Yet today, solar is promoted as the centrepiece of climate action, while coal is vilified as the chief villain masking broader failures, including unmet climate finance and technology commitments under the international agreements. The China-prompted rise of solar PV has conveniently taken attention away from other pressing mitigation responsibilities of the developed countries. Coal, with its dirty image from the bygone era, has become a sacrificial lamb.

The lacklustre response of the developed countries towards their climate commitments shows their apathy towards the cause. Global CO_2 emissions have increased by over 60% since the Climate Convention was signed in 1992. The rise of emissions appears predominantly in China but reflects consumption elsewhere as it has emerged as a central manufacturing hub for all developed countries. The inaction of developed countries to tackle climate change is resulting in nervous actions as public awareness in these countries is gaining political traction. Labelling natural gas as green and substituting coal with wood in European power plants seem like reactionary political manoeuvres.

5. **Learning from the last two centuries, India must secure its energy future by maximising coal, hydro, and nuclear while scaling renewables pragmatically, balancing affordability, self-reliance, and climate responsibility.**

India must take lessons from the last two energy centuries. Its energy strategy must navigate the triple imperatives: self-reliance, affordability, and sustainability. India's energy reserves and consumption profile make it unique. It has an annual primary energy supply of only 39 EJ, which is only 6% of the world's supply while having 17.8% of the population. Coal forms the mainstay, contributing 56.4% of the current primary energy requirement, while petroleum provides 27.1% and natural gas 5.8%. The non-fossil component of 10.8% comes from renewable (including solar photovoltaics and wind) 6.1%, hydro 3.6%, and nuclear 1.1%. Raising the annual per capita consumption of 27.1 GJ, which is only 1/3rd of the world average, and about 10% of that of the USA, remains the main challenge. India has coal deposits of more than 378 billion tonnes, which is its endogenous wealth. It also has ample WWS resources (wind, water, and sun) presently with 47 GW hydropower capacity, 102.6 GW solar PV, and 48.6 GW wind power. The country's nuclear capability is reflected in 24 operating reactors with 8180 MW capacity. However, its oil and gas reserves are highly constrained.

India's endogenous coal reserves are its overwhelmingly dominant fossil fuel asset, and the need to keep the energy costs down dictates that any increase in primary energy consumption ought to come mainly from coal. At the same time, all efforts must be made to maximise hydro and nuclear power. The higher costs, environmental impact difficulties, and project management issues must be settled to contain any project cost/time overruns. High imports of both petroleum and LNG expose the country to price volatility and sea-route risks in conflict situations. History provides ample examples, from World War II to the Russia-Ukraine conflict, that flag the need to arrest and dramatically reduce, wherever feasible, such energy imports.

Solar PV and wind power may eventually provide energy security; however, the enthusiastic capacity addition presently underway must take place under a keenly watchful eye on tariffs. It must be borne in mind that the cost of variable renewable at the generation point does not include the cost externalities associated with grid augmentation requirements, the adverse impact on conventional dispatchable power generation plants, and the necessity of energy storage plants. These costs become apparent only at their higher penetration in the power grid. It is crucial to account for the total costs, and not only the cost of the additional capacity, as the low-hanging fruits of the solar PV and wind power additions will soon get plucked. Though solar PV and wind are considered cheaper so long as the sun shines and the wind blows, these lose value as the generation contribution to the power grid rises. Therefore, the favoured approach of a 1:1 comparison of cost per MW can be very misleading in the context of large-scale solar PV or wind capacity additions. Fundamentally, a 1000 MW coal-based power plant intended to be replaced by modern renewables will require a solar PV or wind plant with a capacity of more than 3000 MW and a battery plant to store the excess generation. The energy storage duration will need to be far longer than the current practice of 4-5 hours. For reliability of the grid having any significant variable renewable, one needs to factor in extended cloudy and low wind days, certain seasonal insolation variations, and wind droughts. Further, such variable renewables additions will call for modernisation and augmentation of the power grid. These are all cost-intensive undertakings that do not show up at the generator end but must be passed on to the end customer. This is already evident in two-to-threefold increase in electricity prices across the EU, Australia, and the USA, despite most of these being in the early stages of renewable additions vis-à-vis their net-zero requirements. Solar PV and wind, by their very nature, require a parallel dispatchable system to absorb fluctuations and periods of low/no generation. Unlike developing countries, developed countries already have such capacity in place. Developing countries like India will require creating new dispatchable capacity in the coming decades. Such parallel capacity will be hydro/coal/nuclear or energy storage plants or a mix of these options and will have a cost. Early signs of these cost burdens are already visible. Indian power utilities have reported financial strains owing to the 'must-run policy' for solar PV and wind power plants. This issue will intensify with increasing renewable penetration.

Sharply reducing petroleum imports, of course, needs to be a national priority. Coal can strengthen weak internal supplies of oil and gas. This will avoid any supply infrastructure change linked to other energy options like ammonia, hydrogen, EV etc. In this context, Coal-to-liquid (CTL) technology merits deployment as it has been around for a long time. The gasoline and aviation fuel supplies for the German military during World War II were produced mainly from coal. South Africa used indigenous coal to reinforce about 25% of its petroleum shortfall during the embargo period. The baseline technology for the coal-to-chemical route remains coal gasification. It converts coal to synthetic gas (termed syngas, which is largely a mixture of carbon monoxide and hydrogen). It can also generate power through Integrated Gasification Combined Cycle (IGCC) plants. Fair amount of work has been done on this technology in

India in the last 3 to 4 decades. The coal gasification mission announced in 2021 by the government is a step in the right direction. It targets technology R&D to gasify 100 million tonnes of coal by 2030. The program needs to be expanded to include other technology components of syngas processing and chemical preparation. The R&D program needs to achieve cost parity in large part, with existing technologies - an often underestimated lever, as cost reduction is widely ascribed to production scale alone, sometime leading to frustrated scaling attempts and false starts. Strategic reinforcements on case-to-case basis depending on techno-economics can also come through ammonia, hydrogen and EVs while minimising the addition of fresh energy supply infrastructure. A pragmatic, coal-based but multi-resource approach is key to ensuring a secure and stable energy future.

6. **Intense indigenous R&D in advanced coal technologies while leveraging global collaboration to drive renewable energy innovation and reduce import dependencies.**

Domestic R&D should form a central part of India's clean energy strategy. It will provide next-generation, high-efficiency, and low-emission power plants and also open the coal-to-chemical route. The government has already taken the first steps in this direction in the form of a national project to indigenously develop the AUSC technology (Advanced Ultra-Supercritical) for coal-based power plants. The technology project was approved by the Cabinet Committee on Economic Affairs (CCEA) in 2016. The second phase of this project, i.e., the technology demonstration project, was announced during the Union Budget 2024-25. Likewise, the National Coal Gasification Mission is underway. Unlocking such capability will also enable India to develop technologies for hard-to-abate sectors and technology elements necessary for a full-fledged modern renewable system, including batteries and other options for long-term energy storage, power-2-X (P2X), electrolysers etc, and critical materials production. The R&D outcomes of developing coal gasification and other coal-to-chemical technologies indigenously should be transferrable to other advanced carbon conversion technologies.

The necessity of coal as the mainstay of the country's primary energy supply is straightforward. However, this will not be easy considering the anti-coal stance engulfing the world today, as developed countries seek to evade urgent emissions reduction from their oil and gas use. As part of India's responsible approach towards the climate, state-of-the-art technology for coal utilisation has been one critical aspect. Continued development of coal utilisation technologies will be a crucial tenet of India's climate policy stance. Such indigenous technology development programs will also benefit the country's industrial R&D ecosystem, whose development lags despite India's strengths in the nuclear and rocketry arena. The technologies for steel, petrochemicals, cement, fertilisers, and so on took the technical licensing route, through which technologies were purchased or acquired on bilateral terms from technology developers in developed countries. The habit of technology imports that started in the decades following independence seems to have taken root within the Indian industry. Even the supercritical technologies for coal-fired power plants, which were adopted in the early 2000s, had to be acquired through technical licensing, mainly from Germany and the USA. Latest examples perhaps are the series of such technology licensing arrangements made for FGDs (Flue Gas De-sulphurisation) plants subsequent to promulgation of SO_x emission standards by MOEFCC in 2015. The AUSC project is the only substantial indigenous attempt made in the power sector for any critical technology but does open a way for similar other products.

India must reinforce the necessary capabilities, institutional arrangements, industry backing, and linkages to develop such technologies independently. However, as such efforts and the required lab and field trials need time, these could benefit from international cooperation, especially in speeding up. As stated earlier, the developed countries worked on many advanced coal technologies before pivoting to natural gas but are holding IP/IPRs that are no longer useful to them. Seeking such IPRs would require completing the WTO/TRIPS amendments that developing countries have long been seeking. It would also require UNFCCC-led initiatives that foster technology IP sharing (additional to IPRs, as in unpatented know-how). The CTCN (Climate Technology Centre and Network), which is part of the technology mechanism of the UNFCCC, can significantly contribute to enabling such collaboration. Such initiatives are in excellent alignment with the principle of Common but Differentiated Responsibilities and Respective Capabilities (CBDR-RC) and the commitment of developed countries to providing the means of implementation, including technology transfer to developing countries. Such partnerships will also benefit other developing countries by rapidly creating and establishing clean technologies crucial to their national circumstances.

7. India's energy transition balances renewables, clean coal, and economic resilience while challenging prescriptive Western models with a pragmatic, self-driven path to sustainability.

The UNFCCC to which India is a party acknowledges that "the largest share of historical and current global emissions of greenhouse gases has originated in developed countries, that per capita emissions in developing countries are still relatively low and that the share of global emissions originating in developing countries will grow to meet their social and development needs". However, India has been taking climate initiatives as a responsible country driven by its value of 'Vasudhaiva Kutumbakam'. India took the lead role in the CDM (Clean Development Mechanism) projects of the Kyoto Protocol. It whole heartedly supported the creation of the Paris Agreement. It took initiative in committing to challenging NDCs (Nationally Determined Contributions). The targets for 2030 were achieved nine years before for the 40% non-fossil fuel target and 11 years ahead of the emission intensity reduction by 33-35% target. Also, these targets have now been ratcheted upwards. It has taken a holistic approach *ab initio* creating and nurturing a comprehensive program termed the National Action Plan on Climate Change (NAPCC).

India spearheaded modern renewable energy and other green initiatives despite the economic challenges faced by the country. It has attained over 151 GW of solar PV (102.6 GW) and wind power (48.6 GW), comparable to Germany which has over 176 GW, in solar PV (102.8 GW) and wind power (73.3 GW), while its per capita GDP is 20 times times higher than India's. Today, has 47 GW of hydroelectric capacity, i.e., over 10% of the total installed generating capacity. India has also taken steps to improve the efficiency of coal-fired power plants by upgrading from traditional subcritical technology to supercritical technologies (30% of the total coal-based capacity) and ultra-supercritical units. The AUSC technology is being indigenously developed. Other programs such as biomass firing, LED installation, cooking gas access, and so on, are accelerating the energy transition. For India, a meaningful transition strategy to net zero, as enshrined in its LT-LEDs, will depend on developing robust energy technologies and economic capacity.

India will continue to need access to coal as part of its developmental trajectory and shall need access to its fair share of global carbon budget for this purpose. Coal will continue to be an essential dimension of India's energy security as its foremost domestic fossil fuel resource. India is committed to optimal and responsible use of its carbon space through ensuring the deployment of clean coal technologies. Such responsible use includes the priority 'must run' status provided to renewable energy generation. This translates into a significant expenditure on the mitigation of emissions from coal-fired power plants. India has also implemented policies that incentivise clean coal technologies and effectively disallow less efficient but cheaper coal-based power plants even before the Paris Agreement was signed. Further all new coal plants in India are, and will continue to be, supercritical or ultra-supercritical. Given the constraints on the availability of natural gas and utilisation constraints on hydro sources, coal power plants are being run at lower loads currently and are being used to balance the high amount of renewable energy fed into the grid together with the 'must run' status of renewable energy generation. This further illustrates India's responsible use of coal.

India's achievements in renewable energy, adherence to Nationally Determined Contributions (NDCs), and success in various national and international sustainable initiatives provide it the moral standing to present a critique of the global climate action while advocating an original approach for itself. The time has come for India's climate leadership, as precious years have been lost waiting for developed countries to act on their commitments. The frameworks and approaches designed to suit the Global North's priorities are adopted as templates by developing countries in the absence of original approaches on their part. Such non-optimal approaches lead to serious difficulties during their growth and development. The developing countries must act on their own volition, as they will be the worst sufferers of climate change impacts. This is crucial as the developing world will shape the next phase of climate action, where many national circumstances mirror India's challenges. India has the potential to set a compelling example for emerging economies, demonstrating that economic growth and climate responsibility can be mutually reinforcing. Technology will form the keystone of this approach, guiding India toward net zero while offering a model for global climate leadership. By rejecting simplistic coal phase-out calls and investing in tailored, scalable solutions, India can lead the way for other nations. Based on a deep understanding of its energy needs and capacities, the country's strategy could transform it into a pillar of international climate action—promoting genuine sustainability while respecting developmental priorities.

8. India must devise a pragmatic roadmap for its energy future.

Coal shall continue to play a critical role in India's fuel and energy mix. Unlike the countries pretending to be proactive in planning to phase out coal, only to replace it with oil and gas, India must be transparent and forthright in projecting its need for coal for its energy security, in view of scarce domestic oil and gas resources. However, India ought to continue to use coal responsibly, as evidenced by the number of clean coal initiatives already undertaken, including retiring old and inefficient power units, adding ultra-supercritical thermal power plants, and pursuing development of clean coal technologies.

India must significantly reduce energy prices for domestic and industry use to boost with a view to raising its per capita energy consumption from 27 GJ to achieve Viksit Bharat by 2047. Outdated global prescriptions of poverty alleviation benchmarked energy targets are unsuited to its growth. A dynamic energy strategy must leverage coal, hydro, nuclear, solar, wind, and biomass while dramatically reducing reliance on imported hydrocarbons—currently covering far fewer days of strategic petroleum reserves compared to the international practice. Coal remains central to country's energy security, necessitating a clear long-term policy to attract investment and lower costs. Advanced coal technologies, including gasification, can curb emissions while maintaining affordability. A premature coal reduction without domestic technological readiness for alternative enegy options risks distortions and eventual economic instability. Europe's return to coal amid current geopolitical crises and Japan's increased dependence on coal in recent years highlights the need of developed countries for a stable energy mix.

An energy strategy based on coal will certainly raise pollution concerns. It must be reminded that coal's reputation for pollution largely stems from the industrial history of developed countries, where unchecked emissions scarred the environment. This is also true for the legendary pollution in Beijing and other major cities of China. However, these impressions overlook recent technological advances that dramatically curb coal's environmental impact. Modern emission controls like flue gas desulfurization, electrostatic precipitators, bag filters, NO_x reduction systems and benign ash utilisation by industry effectively mitigate pollutants.

Indian coal's low sulphur and chlorine content make it inherently less polluting, while its exceptionally high ash content binds many other pollutants. It will need to be clarified that the challenge today lies not in coal's inherent nature, but in deploying existing solutions more widely, backed by robust regulation and enforcement.

The Global North's retreat from coal is often misrepresented and also hyped as a purely environmental victory, while in reality, it was driven by cheap natural gas finds. Otherwise developed countries were developing clean coal technologies with full vigour for about a decade after the Climate Convention. Without gas, coal would have been made cleaner, not abandoned. For India, where energy access underpins human development, the real challenge is not avoiding coal but increasing production productivity and using it better. With the right investments, India can ensure energy availability, access and security with cleaner technologies, when coal becomes a bridge to prosperity—clean, smart, and accountable.

The roadmap for the energy-climate-technology trilemma needs to be based on the following actionable steps:

1) Developing a long-term coal use trajectory as part of the overall energy strategy while clearly expressing our intent to the world and own industry that this would be part of India's net-zero pathway.

2) Dramatic reduction of petroleum and natural gas imports based on coal-to-chemical pathways, reinforced with the use of renewable energy sources (and other technologies such as ammonia, hydrogen, EVs etc.).

3) Hydroelectric, nuclear, and variable renewable sources are to be maximally ramped up while paying close attention to energy costs to ensure that energy access remains affordable for the general population.

4) An intense national focus on domestic R&D moving from advanced carbon conversion, which covers power generation and chemicals, to modern renewables and hard-to-abate sector technologies.

5) Pilot test for renewable-based power grid; appropriate area to be powered by incrementally increasing variable renewables to confirm the design, operating parameters, storage size, accurately detect costs, etc.

6) Reactivate the call for the WTO/TRIPS amendment for IPRs, reinforced by the UNFCCC's decisions to transfer technology IPs as in unpatented know-how available with OEMs.

7) Powerful advocacy on all international platforms of India's strategy and of India's need for energy from coal, with a firm pathway commitment towards net zero.

Hosting COP33, India can lead climate-tech diplomacy, offering a self-reliant energy model for the Global South by promoting efficient and clean utilisation of its endogenous, strategic national resource.

Coal often triggers a brouhaha, being labeled as the largest remaining source of unclean energy that exacerbates climate change. However, this framing is both misguided and unscientific. For India, coal is not merely a fuel—it is the foundation of our development, providing an abundant, reliable, and cost-effective domestic energy source. India's priority is not to abandon coal, but to continuously learn and adopt improved methods of utilizing it. It must be understood that the fossil energy challenge is fundamentally a collective action problem, where the aggregate outcome relies on the efforts of all actors. No single country can address it alone. The Climate Convention lays out the right pathway, acknowledging the unique circumstances and capabilities of each nation. For India, the responsible use of coal is our contribution to the broader global effort—an effort where the principles of equity, common but differentiated responsibilities, respective capabilities, and finance-technology-capacity-building support for developing countries must guide action.

Why does India still need coal?

Putting India's use of coal in the right context

1. Reality Check on the 'Coal phaseout call' for India

A significant lobby worldwide, led by the UN Secretary-General and with the discreet support of developed countries, the UN hierarchy, and some international NGOs, is clamouring for a shutdown of coal as part of the effort to fight global warming. A specific target of this lobbying effort is India, and several voices and spokespersons have called for India to, among other things, cease investment in coal-fired thermal power plants, cease coal mine auctions, and peak its coal consumption right away (Guterres, 2021). India is the second-largest consumer of coal in the world, primarily a result of the energy requirements of its people constituting 17.8% share of the global population. If we convert the total coal consumption into per capita consumption, India's share now looks much lower than many other countries, including those considered the 'green harbingers'.

Several factors must be considered to view Indian coal consumption from a proper perspective. Table 1 gives the population, coal reserves, coal production and consumption, and overall primary energy requirements of the top coal-consuming countries worldwide. India ranks relatively low in annual per capita coal consumption, which today stands at 891.5 kg. It is also evident that countries like Germany and Japan, which project themselves as leaders in environmentalism, consume 1561.2 kg and 1310.6 kg per capita annually. The annual per capita coal consumption in the USA currently stands at 1118 kg, which used to be the highest globally at 3400 kg in 2007, when the annual coal consumption in the USA peaked at about 1 billion ton. This is almost the same level of coal consumption as India has today. Around this time, an energy shift from coal to gas occurred in the USA, gradually reducing coal consumption. China alone consumes more than half of the world's total coal consumption, with 3509.8 kg per capita annually, almost four times the Indian coal consumption.

Looking a little closer, even per capita coal consumption is not an accurate

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Table 1: Coal production/consumption and energy profile for top coal-consuming countries worldwide

Country	Population (1)		Proved Coal Reserves (2)		Coal Production			Coal Consumption						Total Primary Energy (2)		
	Million	Share (%)	in BT	Share (%)	EJ (2)	in MT (3)	GCV (kcal/kg)	EJ (2)	in MT (3)	GCV (kcal/kg)	Share (%) of coal consumption (in MT)	Share (%) of coal to primary energy	Kg per capita	Total (EJ)	GJ per capita	Share (%) of global primary energy
China	1,422.6	17.6	143.20	13.3	93.10	4,705.0	4,733.8	91.94	4,993	4,405.1	56.8	53.8	3,509.8	170.74	120.0	27.6
India	1,438.1	17.8	111.05	10.3	16.75	1,045.0	3,834.6	21.98	1,282	4,101.9	14.6	56.3	891.5	39.02	27.1	6.3
United States	343.5	4.2	248.94	23.2	11.84	528.0	5,364.7	8.20	384	5,106.6	4.4	8.7	1,118.0	94.28	274.5	15.2
Germany	84.5	1.0	35.9	3.3	0.92	102.0	2,157.8	1.83	132	3,309.4	1.5	16.0	1,561.2	11.41	135.0	1.8
Russia	145.4	1.8	162.17	15.1	9.21	429.0	5,136.0	3.83	258	3,555.0	2.9	12.3	1,773.9	31.29	215.1	5.0
South Africa	63.2	0.8	9.89	0.9	5.41	222.0	5,830.0	3.33	160	4,972.0	1.8	68.5	2,531.1	4.85	76.8	0.8
Indonesia	281.2	3.5	34.87	3.2	15.73	752.0	5,004.2	4.32	221	4,676.1	2.5	42.7	785.9	10.11	35.9	1.6
Japan	124.4	1.5	0.35	0.0	0.017	0.68	5,943.2	4.54	163	6,658.1	1.9	26.1	1,310.6	17.40	139.9	2.8
Turkey	87.3	1.1	11.53	1.1	0.58	66.0	2,104.7	1.65	107	3,687.2	1.2	23.5	1,226.1	7.00	80.2	1.1
Poland	38.8	0.5	28.40	2.6	1.48	88.7	3,991.8	1.51	91	3,960.8	1.0	36.6	2,346.6	4.12	106.2	0.7
Australia	26.5	0.3	150.2	14.0	11.66	439.0	6,354.2	1.51	92	3,922.5	1.0	25.1	3,478.1	6.02	227.6	1.0
Sub-total	4,055.4	50.1	936.5	87.2	166.70	8,377.4	4,760.4	144.62	7,883	4,389.0	89.8	36.5	1,943.8	396.24	97.7	63.9
EU 27	745.6	9.2	137.2	12.8	3.31	410.0	1,929.7	5.48	544	2,411.4	6.2	9.7	729.6	56.38	107.0	13.1
Rest of world	4,036.4	49.9	137.6	12.8	12.54	623.3	4,814.4	19.41	900	5,160.5	10.2	8.7	223.0	223.39	55.3	36.1
Total World	**8,091.7**	**100**	**1074.1**	**100**	**179.24**	**9,000.6**	**4,764.2**	**164.03**	**8,783**	**4,468.1**	**100**	**26.5**	**1,085.4**	**619.63**	**76.6**	**100**

Sources: (1) UN PROSPECTS 2024 (United Nations, 2024), (2) Energy Institute Yearbook – 2024 (Energy Institute, 2024), (3) ENERDATA – 2024 (ENERDATA, 2024)

Notes to Table 1:

- Rows indicating proved coal reserves 'Sub Total' for countries and for the 'Rest of World' provide importance of selected countries vis-à-vis the overall world.
- The EU (EU27) data is additionally presented for the clarity and is also covered in listed countries and 'Rest of World'. The coal production and consumption data has been drawn from the EUROSTAT tutorial, which aligns with other coal reports of the EU parliament. The data included in the WEO 2023 (World Energy Outlook) report is much lower and, therefore, ignored.
- The EU-27 energy contribution is worked out based on the typical GCV for brown coals (300 million tonnes having 2300 kcal/kg) and hard coals (50 million tonnes having 6200 kcal/kg) found in EU countries. GCV for coals has been worked out using production and consumption data with energy data. Minor variation may be seen with average coal GCVs for the country due to differences in energy and mass data, which may have differing assumption elements used for projections. Also, consumption includes imported coals, which generally have higher GCV values than brown coals, predominantly used in the EU27.
- Indian coal reserves stand at 378.21 billion tonnes, as the Ministry of Coal website indicates. The data in Table 1 is based on. International databases, including ENERDATA, which report lower coal reserve values. However, the value reported internationally has been maintained for data evenness.

representation, as it does not account for the relatively lower heating value of Indian coal. Much of the Indian coal is inert material, i.e., coal ash. To account for the impact of heating value, the tabulation in Table 2 presents the average heating values of coal from major coal-producing countries. As shown in Table 1 earlier, these countries represent ~83% of global coal production. It is pertinent to mention that these are average values, as the heating value of coals generally varies quite a bit between coal seams, mines, regions, and countries linked to their origin. The heating value of coal is given in Table 2 as NCV (Net Calorific Value), which is generally the reporting practice worldwide. The same has been converted to GCV (Gross Calorific Value) to match Indian practice for reporting heating values, using conversion factors calculated for each country listed in the Table.

Table 2: Coal heating values and production in different coal centric countries worldwide

Country	AVERAGE NCV (net calorific value)		Conversion Factor (NCV to GCV)	GCV (gross calorific value)	Production
	GJ/ton	kcal/kg		kcal/kg	MT/year
Australia	27.0	6448.8	1.038	6693.9	439
China	20.4	4872.5	1.05	5116.1	4705
South Africa	23.7	5660.6	1.046	5921.0	222
Indonesia	25.8	6162.2	1.054	6495.0	752
USA	26.9	6425.0	1.06	6810.5	528
India	16.7	3988.7	1.057	4216.1	1045

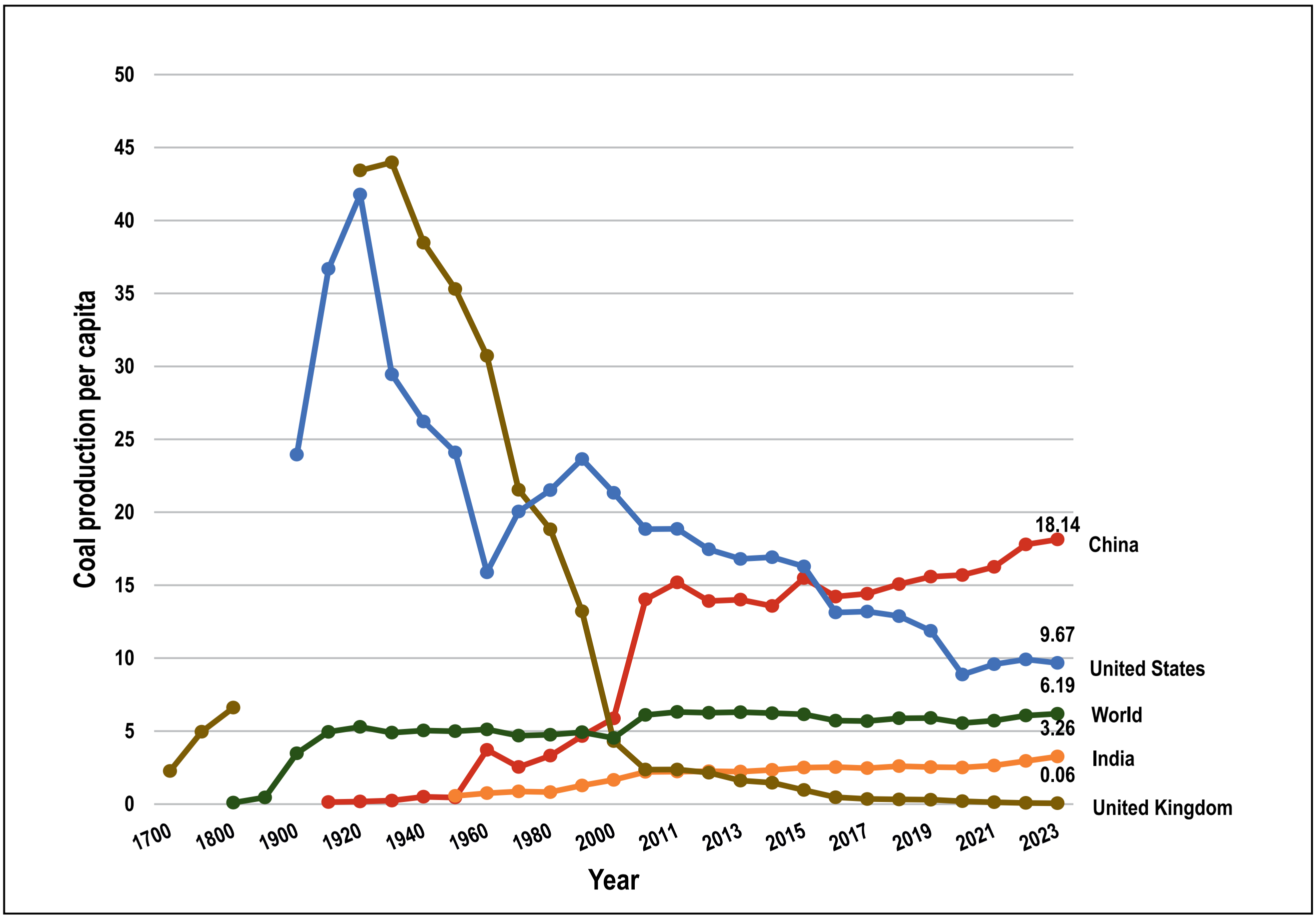
Source: (ENERDATA, 2024), (Energy Institute, 2024), (UN STATISTICS DIVISION, 2015)

The weighted mean of productions from major coal-producing countries shows the Indian coal heating value to be about 25% lower. Specifically, this would mean that the Indian coal production of 1045 million tonnes needs to be reduced by at least 25% for an accurate global perspective. This works out to be only 783.75 million tonnes per annum. Therefore, the consumption in India gets revised to 961.5 million tonnes, giving an annual per capita consumption figure of ~669 kg. This signifies that on a per-capita basis, India consumes only about one-fourth of the top six coal-consuming countries, including even Germany, which is often viewed as one of the global climate leaders. It is clarified that the coal imported by India has been pegged at 237 million tonnes per year, and GCV correction was not applied to it.

The appeal of per-capita numbers on coal consumption notwithstanding, the current snapshot presented above, even when corrected for lower heating values, is far from representing the true picture of historical responsibility. Cumulative per capita coal consumption must be weighed, considering equal per capita entitlements, which is vital to global participation. Figure 1 indicates the per capita coal consumption (without heating value correction) of India and major coal-consuming countries since the beginning of the Industrial Revolution.

Figure 1 (Energy Institute, 2024; The Shift Data Portal, 2019; Our World in Data) clarifies that the UK and the USA have historically usurped all the coal production/consumption entitlements. Infact use of coal started in the UK much before the Industrial Revolution as a substitute to dwindling wood supplies. Establishment of coal as the main energy source during the 14th-15th century got deferred only due to the outbreaks of plague

Figure 1: Coal production per capita 1700-2023 (in MWh equivalents per person per year)

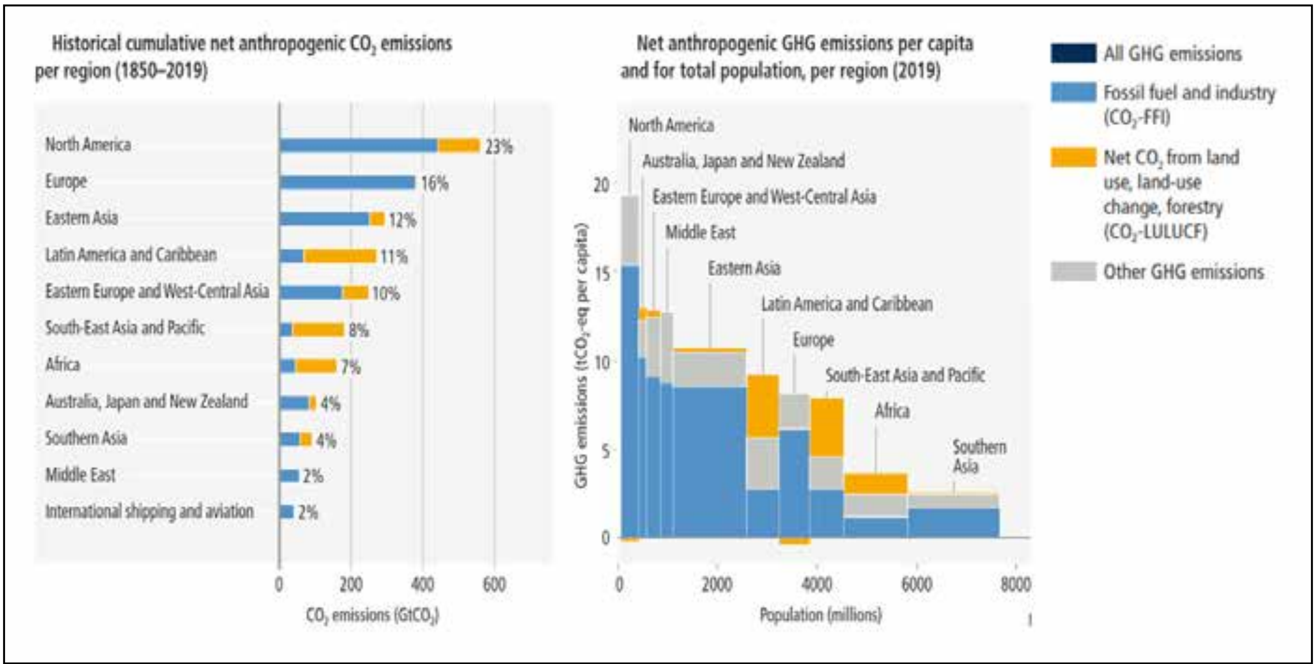


Source: Energy Institute, 2024; The Shift Data Portal, 2019; Our World in Data

and other diseases from time to time. Over time coal established as the primary energy source for U.K. which got concretised with the advent of steam engine towards the end of 18th century. The primacy thus gained continued in the 19th century with other countries joining in gradually. Figure 1 shows that even China, which has consumed an unparalleled quantum of coal for the last few years, is nowhere near these two countries. India understandably does not even merit a comparison. It is ironic that a country with a 17.8% share of the global human population, which on a per-capita basis does not even deserve comparison with the historic polluters, is being seen as part of the problem of global warming precipitated mainly by the developed countries. Looking further at the larger energy usage patterns of the world, the developed world's entire storyline emerges as one of such disproportionate value judgements.

We must also consider the relatively longer-term coal consumption for a realistic picture. Any contemporary snapshot of coal consumption, as reflected in the per capita values above, even with the heating value adjustments, needs to add additional information to provide an accurate picture,

Figure 2: Cumulative (1800-2019) and per-capita emissions from South Asia in global perspective



Source: https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_SummaryFor Policymakers.pdf

as most developed countries have increased their natural gas consumption instead of coal in recent years. The time-series data for coal production shows India's much lower share. India's cumulative coal production is only 3.04% of the world's total production between 1900 and 2022. This value further reduces to ~2.28% when corrected for the heating value (which overstates values by about ~25%, as indicated earlier). It is inconceivable that a country with a 17.8% share of the global population, which has just been contributing ~2.28% of the world's coal production, is being seen as part of the problem by the developed countries.

The low share of coal consumption is well reflected in the share of cumulative emissions from South Asia in the global emissions which is also minuscule. Figure 2 depicts how greenhouse gas emissions were distributed unequally throughout different parts of the world from 1850 to 2019 (IPCC, 2022). It illustrates that Southern Asia (including India) contributed only about 4% of historical cumulative CO_2 emissions between 1850 and 2019 despite being home to almost 24% of the global population. The annual per capita net greenhouse gas emissions ranged from 2.6 to 19 tCO_2eq, with the worldwide average being 7.8 tCO_2eq. The crucial point is that India's annual and cumulative emissions in absolute and per capita terms have been significantly low and far less than its equitable share. India, relative to its responsibility and what equity demands, is doing far more than its fair share in addressing climate change (Bhatt, 2024).

2. All economies are dependent on 'available' fossil energy.

Table 3 further contextualises India's coal consumption in terms of its contribution to the country's primary energy supply. For India, coal accounts for a much higher share (56.3% of Indian primary energy) than most other countries listed. Different countries use less coal because they use a lot of 'something else,' especially oil and gas. A complete fossil energy scenario for the countries listed in Table 1, covering coal, oil, and gas, is presented in Table 3. South Korea has been added owing to its appreciable coal consumption. The tabulation puts coal use by different countries into a better context. The tabulation provides a holistic view of the relative contribution of the fossil energy resources towards the economies of these coal-centric countries. It indicates that countries covered in 'Rest of World' i.e. some 180 countries are oil and gas dependent. The per capita consumption is close to world average.

Table 4 depicts all the primary energy supply sources used by the same set of 11 countries. The table includes nuclear, hydro and other renewables but the extent of dependence of countries on fossil energy sources is quite evident. It is seen from the Table that presently 81.5% of the world's primary energy consumption is met by fossil sources, i.e., petroleum 31.7%, natural gas 23.3% and coal 26.5%. These average numbers reflect the typical state of many countries with specific variations depending upon legacy and specific national circumstances. The listed countries have relatively higher coal energy dependence. The numbers reflect the global energy evolution. Most countries developed much later than the developed countries did, using oil and gas, which were more accessible than coal. Developed countries have traditionally depended more on coal than petroleum and gas. The same remains the case for India owing to its state of endogenous reserves. The contribution of different sources also changes with time. For instance, most countries picked up petroleum usage in the previous century. Natural gas has emerged as an essential energy source during the last 3–4 decades, mainly as imports through sea transportation became feasible for large gas quantities in the form of LNG (Liquefied Natural Gas). Until the start of the previous century, it was primarily coal (about 50% of global primary energy contribution) that had displaced traditional biomass. Hydro and oil also contributed but in minimal amounts till that time.

Clearly, it is not appropriate to single out India for its dependence on coal because all countries still rely on one fossil fuel energy source or the other.

Table 4 indicates the total quantity of the resources used. The energy content of the resource is one dimension, and it may also be used in process-based industries. For instance, coal acts as a reductant in steelmaking. Likewise, coal for cement furnishes heat, reduces the atmosphere inside the kiln, and provides mineral additives (coal ash). The tabulation also explicitly depicts electricity production, specifically based on solar and wind, for these countries. The numbers indicate that electricity is only a part of the energy used

Table 3: Reserves and consumptions of coal, natural gas and petroleum in major coal-centric countries

Country	Population (1)	Coal				Petroleum				Natural Gas				Energy emissions (2)		
		Proved Reserves (2)		Annual consumption (3)	Per capita consumption	Proved Reserves (2)		Annual consumption (3)	Per capita consumption	Proved Reserves (2)		Annual consumption (3)	Per capita consumption			
	Million	in BT	Share (%)	in MT	Tonnes per capita	in MT	Share (%)	in MT	Kg per capita	bcm	Share (%)	bcm	m^3 per capita	in MT	Share (%)	Tonnes per capita
China	1,422.6	143.20	13.33	4,993	3.51	3,500	1.43	712.74	501.01	8,400	4.47	435.76	306.31	12669.98	31.35	8.91
India	1,438.1	111.05	10.34	1,282	0.89	600	0.25	252.59	175.64	1,300	0.69	69.28	48.17	3121.55	7.72	2.17
United States	343.5	248.94	23.18	384	1.12	8,200	3.35	744.71	2,168.14	12,500	6.65	936.85	2727.55	5130.15	12.69	14.94
Germany	84.5	35.90	3.34	132	1.56	23	0.0094	81.51	964.03	24	0.013	86.16	1019.09	589.40	1.46	6.97
Russia	145.4	162.17	15.10	258	1.77	14,200	5.81	161.06	1,107.38	37,000	19.67	525.96	3616.34	2176.08	5.38	14.96
South Africa	63.2	9.89	0.92	160	2.53	1.8	0.00074	24.98	395.10	0.30	0.00016	4.60	72.79	478.10	1.18	7.56
Indonesia	281.2	34.87	3.25	221	0.79	300	0.12	67.85	241.30	1,552	0.83	45.63	162.29	861.46	2.13	3.06
Japan	124.4	0.35	0.03	163	1.31	5.2	0.0021	135.35	1,088.27	21	0.011	98.44	791.47	1038.55	2.57	8.35
Turkey	87.3	11.53	1.07	107	1.23	71	0.029	45.33	519.37	3.7	0.00197	51.53	590.46	457.13	1.13	5.24
Poland	38.8	28.40	2.64	91	2.35	16.2	0.0066	30.48	786.26	100	0.053	20.40	526.26	299.06	0.74	7.72
South Korea	51.7	0.33	0.03	110	2.13	11	0.0045	95.20	1,839.71	7.07	0.0038	61.53	1189.01	594.17	1.47	11.48
Australia	26.5	150.23	13.99	92	3.48	300	0.12	48.51	1,834.01	2,400	1.28	40.76	1540.85	440.43	1.09	16.65
Rest of world	3,984.6	137.27	12.78	790	0.20	2,17,193.3	88.86	1,838.60	461.43	1,24,766.16	66.34	1,864.79	468.00	12561.84	31.08	3.15
Total World	8,091.7	1074.11	100	8,783	1.09	2,44,421.5	100	4,238.89	523.85	1,88,074.23	100	4,242	524.20	40417.89	100	4.99

Source: (1) UN PROSPECTS 2024 (United Nations, 2024), (2) Energy Institute Yearbook – 2024 (Energy Institute, 2024), (3) ENERDATA – 2024 (ENERDATA, 2024)

Table 4: Global primary energy contribution for major sources highlighting coal centric economies along with portion converted to electricity

Country	Petroleum		Natural Gas		Coal		Fossil Sources		Nuclear		Hydro		Renew-ables		Non- Fossil		Total		Solar + Wind		Electricity	
	EJ	%	EJ	%	EJ	%	EJ	%	EJ	%	EJ	%	EJ	%	EJ	%	EJ	%	EJ	%	EJ	%
China	32.7	19.2	14.6	8.5	91.9	53.9	139.2	81.6	3.9	2.3	11.5	6.7	16.1	9.4	31.5	18.4	170.7	100	5.3	3.1	34.0	49.4
India	10.6	27.1	2.3	5.8	22.0	56.4	34.8	89.2	0.4	1.1	1.4	3.6	2.4	6.1	4.2	10.8	39.0	100	0.7	1.8	7.0	44.7
United States	35.9	38.0	31.9	33.8	8.2	8.7	76.0	80.6	7.3	7.8	2.2	2.3	8.8	9.3	18.3	19.4	94.3	100	2.4	2.6	16.2	42.5
Germany	4.0	35.2	2.7	23.9	1.8	16.1	8.6	75.1	0.1	0.5	0.2	1.6	2.6	22.8	2.8	24.9	11.4	100	0.7	6.4	1.8	40.2
Russia	7.2	23.0	16.3	52.2	3.8	12.2	27.4	87.4	2.0	6.2	1.9	6.0	0.1	0.3	3.9	12.6	31.3	100	0.0	0.1	4.2	33.6
South Africa	1.1	22.4	0.2	3.5	3.3	68.4	4.6	94.3	0.1	1.6	0.0	0.4	0.2	3.7	0.3	5.7	4.9	100	0.1	1.3	0.8	41.1
Indonesia	3.1	30.6	1.6	16.2	4.3	42.7	9.1	89.5	0.0	0.0	0.2	2.3	0.8	8.2	1.1	10.5	10.1	100	0.0	0.0	1.3	30.9
Japan	6.7	38.2	3.3	19.1	4.5	26.1	14.5	83.4	0.7	4.0	0.7	4.0	1.5	8.6	2.9	16.6	17.4	100	0.4	2.2	3.6	51.9
Turkey	2.3	32.9	1.7	24.9	1.7	23.6	5.7	81.3	0.0	0.0	0.6	8.6	0.7	10.1	1.3	18.7	7.0	100	0.2	2.8	1.2	41.8
Poland	1.4	34.2	0.7	17.0	1.5	36.7	3.6	87.9	0.0	0.0	0.0	0.5	0.5	11.7	0.5	12.1	4.1	100	0.1	3.1	0.6	36.1
Australia	2.2	36.0	1.4	23.9	1.5	25.1	5.1	85.0	0.0	0.0	0.1	2.3	0.8	12.6	0.9	15.0	6.0	100	0.3	4.6	1.0	40.4
Sub-total	107.1	27.0	76.8	19.4	144.6	36.5	328.5	82.9	14.4	3.6	18.8	4.8	34.4	8.7	67.7	17.1	396.2	100	10.2	2.6	71.8	44.9
Rest of world	89.3	40.0	67.6	30.3	19.4	8.7	176.3	78.9	10.1	4.5	20.8	9.3	16.1	7.2	47.1	21.1	223.4	100	4.1	1.8	35.9	39.8
Total World	**196.4**	**31.7**	**144.4**	**23.3**	**164.0**	**26.5**	**504.8**	**81.5**	**24.6**	**4.0**	**39.7**	**6.4**	**50.6**	**8.2**	**114.8**	**18.5**	**619.6**	**100**	**14.3**	**2.3**	**107.7**	**42.7**

Source: Energy Institute "Statistical Review of World Energy" 2024

NOTE:

- The % in 9 columns depicting the energy sources (petroleum, natural gas, coal, nuclear, hydro, renewable) indicate contribution to the candidate country's primary energy.
- Renewables includes electricity generated from solar, wind, geothermal, biomass and other sources of renewable energy not already itemised.
- The % in the last column is the total energy converted to electricity. Electricity presented in EJ is the typical first-class energy. In contrast, the energy on the left portion of the table is a lower form (heat), which necessarily requires a loss in energy when converted to electricity.
- The two sub-columns of the last column show the electricity generation (in EJ) and the portion of total primary energy (in %) which is converted to electricity. This is calculated by working out equivalent input energy using efficiency conversion factors (overall 40.7% as used by EI report) based on an order-of-magnitude analysis; as such efficiencies vary over a range.

in these sources. Table 4 shows that about 43% of the total primary energy supply in the world, i.e., 619.6 EJ, is used to produce electricity, i.e., 266.6 EJ. As electricity production means a significant energy loss, only 107.73 EJ of electricity gets produced. This includes all forms of sources listed in Table 4. In general, coal finds maximum conversion to electricity. Petroleum is generally used directly (automobiles)while natural gas is only partially used for electricity. The evaluation is based on certain efficiency factors (conversion efficiencies), which have been back-calculated using the data in the EI (Energy Institute) Report to maintain integrity as the Table-4 data is sourced from the EI Report.

Natural gas, primarily methane (CH_4), has been the predominant energy source among the fuel gases generally used. Other gas forms, like petroleum gas (mainly propane, C_3H_8 and butane, C_4H_{10}), are formed during the refining of petroleum. Biogas is another form, though it is used on a much smaller scale. The heating values of natural gas and petroleum gas are similar, though natural gas, depending on the source, has a lower heating value while biogas is still weaker in heat content. LNG is natural gas that has been cooled down to form a liquid to reduce volumes, which enables economical sea transportation. Hydrogen is now being developed as an energy source. It has a much higher heating value, more than double that of the natural gas.

Table 4 also shows that India's oil and gas consumption remains insignificant compared to most developed countries. The USA and South Korea's annual per capita oil consumption is almost 13 times that of India. Gas consumption in some of these countries is incomparably higher than that of India. The USA and Russian Federation's annual per capita gas consumption is 62 times and 85 times that of India, respectively. It is notable that despite such low consumption, India heavily depends on oil and gas imports due to its sparse endogenous reserves (0.25% of petroleum and 0.69% of natural gas of the total global reserves, while the population is 17.8% of the world population). India imports over ~85% of petroleum oil and ~50% of its natural gas requirements.

Table 3 indicates that India's annual per capita energy emissions were only 2.17 tonnes in 2023, less than half the world average of 4.99 tonnes. The USA, Australia, the Russian Federation, and South Korea's energy emissions for the same year, respectively at 14.94, 16.65, 14.96, and 11.48 tonnes per capita annually, provide a representative position of India vis-à-vis these countries. India's low emissions are well reflected in its low cumulative emission values. It is estimated that India ranked 129th based on cumulative per capita CO_2 emissions from 1960-2018, 7th based on cumulative historical CO_2 emissions from 1850-2020, 6th based on cumulative emissions (excluding LULUCF) from 1850-2019, 5th based on cumulative emissions (excluding LULUCF) from 1990-2018, and 4th, only if the ranking is based on current annual emissions. The chasm between India and the next countries i.e. China, EU and USA, clarifies only when absolute emission values are examined. (Bhatt, 2023).

Reflecting on the three energy tables

The three energy tables included in this policy brief, i.e. Table-1, 3 and 4, tabulate data which require dedicated reflection for deeper appreciation of the imbedded ideas and information. Table 1 includes 11 countries for which population, primary energy and data on coal-like reserves, production and consumption have been collated. Similar data for these 11 countries for petroleum and natural gas is presented in Table 3, wherein 12th country, South Korea has been added due its high coal consumption despite weak reserves. Further primary energy data for all commercial energy sources, viz. coal, oil, gas, nuclear, hydro, solar PV and wind power, is collated for these same 11 countries in Table 4. These three tables provide the core support to the storyline detailed in this policy brief. It may be pertinent to discuss the backstory for selecting these countries out of 193 countries worldwide, along with other relevant messages embedded in the tables.

The Energy Institute Statistical Review of World Energy 2024, the main reference source for the energy data, presents data for 66 out of 196 countries in its report. These countries have been categorised into 7 regions in the report. The regions along with number of countries in each for which data is provided in the Energy Institute report are as follows: North America (3 out of 3 countries), South & Central America (8 out of 32 countries), Europe (20 out of 44 countries), the Middle East (8 out of 14 countries), Africa (4 out of 54), Asia Pacific (17 out of 38 countries) and the CIS (6 out of 11 countries).

The primary energy supply values for the 66 countries, as given in the Energy Institute data, vary over a significant range. All counties consume 620 EJ primary energy annually. China represents the highest consumer with 170 EJ. Sri Lanka defines the other end as having a primary energy supply of only 0.36 EJ. A closer look at the energy profile of these 66 countries indicates that most countries with very low primary energy supply typically indicate dependence on oil and gas along with traditional minor usage of hydro and coal. On the other hand, relatively larger economies generally indicate unique energy-sourcing patterns prompted by their past economic growth and energy-sourcing prospects. These 11 countries produce 93% of annual world coal production of 9 billion tonnes. The pattern of energy evolution since the Industrial Revolution starting with coal explains the complexion of different countries' energy mix.

Coal was the first energy source that displaced traditional biomass, wood, and muscle power in the early 19th century. Coal was used primarily in the U.K., followed by other countries like USA, Germany etc. that started industrialising. Hydropower plants emerged towards the end of the 19th century, followed by oil as automobiles picked up. Gas and nuclear emerged in the 1960s, while solar PV and wind began appearing in the 1980s. Fossil sources, such as coal, oil, and gas, are equally used for energy, like heat and electricity, and directly for producing steel, cement, fertilisers, etc.

It is assessed that economies with a primary energy consumption higher than 1% of the total world's primary energy supply provides an appropriate set for analysing global energy patterns. Considering the above stated threshold of 1% i.e. 6 EJ as the world's primary energy supply is 619.63 EJ, it provides a country listing with only 19 countries. These countries comprise 11 in Table-1 and 8 other countries, viz. South Korea, Iran, Saudi Arabia, Brazil, France, U.K., Canada and Mexico. It may be mentioned that though these 19 countries represent less than 10% of the number of UNO member states i.e., 193 countries, they represent 78.2% of the world's primary energy supply. Of these 19 countries, 11 mentioned in the three subject tables are coal-centric economies. These represent 90% of the world's coal consumption, 93% of the world's coal production, and 87% of the coal reserves in all countries while representing 50% of the world's population.

The sharp unevenness of population, energy resources, production and consumption across countries is glaring. Among these, India's annual per capita energy consumption of 27 GJ is 1/10th that of the USA. The gap still looks starker when other developing countries are considered. The unevenness of coal reserves is also notable in these 11 countries. These countries, representing less than 10% of all countries in numbers, hold 90% of the world's total reserves. Of the 11 countries, 7 are listed as Annex I to the Climate Convention, the 'Developed Country Parties'. The annual per capita energy consumption of all these developed countries is explicably much higher than the world average of 76.6 GJ.

The tabulation indicates that other than Japan, these 11 countries have more coal reserves than their population share. For instance, the USA, the Russian Federation, and Australia have 23.2%, 15.1%, and 14%, respectively, corresponding to a global population share of 4.2%, 1.8% and 0.3%. The USA has the largest proven coal reserves, with 249 billion tonnes, with the Russian Federation (162 billion tonnes), China (143 billion tonnes), and India (111 billion tonnes) close on its toes. These countries also have a disproportionately higher combined share of oil and natural gas vis-à-vis population share, viz. 5%,12.74% and 0.7%. The combined reserves have been worked out by adding individual % as oil and gas values. This is admissible as heating values of million-ton oil and billion cubic meters (bcm) of natural gas have almost the same.

The coal production share of these 11 countries is also higher vis-à-vis their global population share. All these countries use much higher annual per capita coal than the world's average value of 1085 kg. Among these, India remains an exception, with 669 kilograms of annual per capita coal consumption (corrected for low heating value). Among these 11 countries, China surpassed all benchmarks with its 4.7 billion tonnes per annum production. India also crossed 1 billion tonnes last year. Among the 19 countries with primary energy higher than 1% of world consumption, some migrated to other energy sources in the latter part of the 20th century. For example, France having very low coal reserves initially moved to hydro and oil. Subsequent to the oil shock, it significantly added nuclear capacity. Similar has been the case for Spain, Italy, etc., which presently have low coal consumption. Middle Eastern countries, which do not get included in the list of 19 countries due to low total energy usage, have incredibly high per capita energy supplies. These countries picked up economically in the latter part of the 20th century and depend on endogenous oil and gas.

The energy contribution from different energy sources for a candidate country varies globally. Legacy national circumstances and endogenous energy reserves generally determine the energy complexion of a nation. However, in the decades after the Industrial Revolution, it was essentially coal energy for all newly upcoming economies. In 1900, about half the world's primary energy came from traditional non-commercial energy sources, while the balance came from coal. Hydro and oil had barely started emerging. The shadows of this inception stage energy complexion of industrial countries, though gradually changed with time, continues till date. The contribution of coal remains high for most of these 11 countries, as each has a coal-centric economy. Recently, many developed countries have shed some coal in preference for natural gas.

The 68% contribution of coal to South Africa's energy profile is the highest of any country globally. Such an amplified role of coal is linked to its high coal reserves and legacy dependence due to oil embargo during the apartheid period. Next to South Africa is India at 56.3% and China at 53.8%, followed closely by Indonesia at 42.7%. The contributions of coal in the USA, Russian Federation, Germany and Japan are relatively lower in present times. Traditionally, these values were much higher than those of any other coal-centric countries. Coal was an essential part of the economic activities of these countries till the end of the previous century. Countries in the EU, and the USA have been decreasing coal consumption, replacing it mainly with natural gas recently. On the other hand, Japan has increased its coal contribution in recent years, as discussed in this brief.

The GCV (Gross Calorific Value) for coals in Table- 1 indicates the heating values of coals from different countries. Such heating values vary from mine to mine and with seams, representing large averages. The world average value of 4764 kcal/kg indicates typical values found in many countries, which puts Indian coals, having typically less than 4000 kcal/ kg (the average value given in Table-1 indicates 3834 kcal/kg), on a lower pedestal. The heating values for coals found in developed countries are generally higher. On the other hand, the value for Germany, 2158 kcal/kg is very low as most of the coal mined is lignite with very high moisture content. The bituminous coal (hard coals) found in the EU/Germany has a higher heating value.

The difference in production and consumption in Table 1 broadly represents the trade volume. Indonesia and Australia are the biggest coal-exporting countries. Both these countries export much more coal than they consume within the country. Indonesia exports 531 tonnes per annum out of 752 tonnes per annum production. Australia exports 347 tonnes per annum out of 439 tonnes per annum production. The USA, Russian Federation and South Africa are also seen as coal-exporting countries. China and India, while having substantial reserves, notably are coal-importing countries. India imports coking coal (required for steel making) and also thermal coal.

Presently, fossil fuels are responsible for meeting the world's primary energy needs. Coal, oil and natural gas presently contribute 81.5% of the total energy supply. Tables 1 & 3 indicate total coal reserves worldwide as 1074 billion tonnes, which will suffice for 100 years of global supplies. The international oil reserves are 244.4 billion tonnes, which should suffice for the 60-year requirement of all countries. Natural gas reserves in all countries are 188,074 bcm (billion cubic meters), which should suffice for 44 years for global requirements. For a further perspective on world fossil energy reserves, total world coal reserves represent about 21,000 EJ energy. In contrast, total world oil reserves represent 50% of coal reserves, i.e., about 1100 EJ, and gas availability is about 30% of coal reserves, i.e., 7000 EJ. From a global perspective regarding fossil energy reserves, coal remains the energy mainstay, while oil and gas are close fractions of it.

The main message from Table 4 is the continuing prominence of fossil fuels despite the excitement around solar PV and wind power. Fossil fuels still provide 81.4% of the world's primary energy supplies. The contribution in the case of 11 countries is still higher at 82.91%, while swings to 94% for South Africa is notable. India is at 89.23%, while China is at 81.56%. Oil is presently the primary energy source, while gas subordinates coal, although it is fast gaining prominence. Hydro contribution at 6.4% continues steadily despite its century-long evolution. Nuclear is at 4% while its peak was at 6% in 2001. Modern renewable provides 2.3% of electricity after three decades of the Climate Convention, which can be read as a 6% equivalent energy contribution. The pace of solar PV and wind power addition will require a paradigm shift to be counted as an alternative to fossil energy. Table 4 shows that less than half, i.e., about 43%, of the total primary energy of 620 EJ is converted into electricity. As a balance, fossil contributions are used directly, prompting a focus on non-electricity areas if emissions are to be reduced. A large part of these are termed as hard-to-abate sectors.

The state of global climate action in the three decades after the Convention is reflected in the ever-rising emission trajectory. It has shown continuous build-up during these three decades. Notably, today's global carbon dioxide emissions are about 60% higher than that at the time of the Climate Convention (Tiseo, 2024). On the other hand, the responsibility for mitigation commitment of the Kyoto Protocol rests on the developed countries to reduce their emissions by 5.2% below 1990 levels.

As mentioned earlier, Table 1 indicates that India's per-capita energy consumption is meagre. It is less than 15% of countries like the USA and the Russian Federation. India uses only ~6.3% of the world's primary energy while having a population share of 17.8%. India's primary energy is mainly supplied (more than half) from coal. India's petroleum consumption at 27% is typical of other countries (which generally hovers around 30%), while its natural gas consumption is low at 6%. Its weak petroleum and natural gas reserves determine India's energy choices. Table 3 indicates that India has only 0.69% and 0.25% of the world's natural gas and oil reserves, respectively. Table 3 also clarifies that the developed countries have substantial reserves of oil and gas. Due to access to cheap oil, their dependence increased beyond coal during the early decades of the 20th century. Similarly, more recent access to abundant, inexpensive natural gas has made it an energy source of preference for the developed countries.

For the context of fossil energy reserves, Table 5 provides a quick view of the Indian fossil fuel deposits, coal, oil, and natural

Table 5: Indian fossil energy reserves and production in key states

Fossil Energy Source	Top 5 Indian States/deposits	Reserves (proven)		Production (annual)	
Coal		billion tonnes	% (total)	Million tonnes	% (total)
	Odisha	52.1	26.0	219.0	23.4
	Jharkhand	55.8	27.9	156.5	16.7
	Chhattisgarh	37.2	18.6	184.9	19.7
	M.P.	15.3	7.6	146.0	15.6
	West Bengal	17.5	8.7	32.8	3.5
	Sub-total	**177.8**	**88.9**	**739.2**	**78.9**
	India	**199.9**	**100.0**	**937.2**	**100.0**
Oil		million tonnes	% (total)	million tonnes	% (total)
	Rajasthan	116.7	17.4	5.1	17.4
	Gujarat	120.3	18.0	4.9	16.6
	Assam	148.1	22.1	4.2	14.3
	Western offshore	218.4	32.6	13.9	47.7
	Eastern offshore	40.5	6.0	0.6	1.9
	Sub-total	**644.0**	**96.2**	**28.6**	**97.9**
	India	**669.5**	**100.0**	**29.2**	**100.0**
Natural Gas		bcm	% (total)	bcm	% (total)
	Assam	165.7	14.5	3.6	10.3
	West Bengal	79.3	6.9	0.4	1.2
	Rajasthan	64	5.6	2.3	6.8
	Western offshore	346.8	30.4	15.4	44.7
	Eastern offshore	262.4	23.0	8.0	23.2
	Sub-total	**918.2**	**80.4**	**29.7**	**86.2**
	India	**1141.7**	**100.0**	**34.5**	**100.0**

Source: 1. Coal data sourced from Ministry of Coal; 2. Oil and Gas reserves data source: Ministry of Petroleum and Natural Gas; 3. Oil and Gas state-wise production data source is www.energyportal.in

Note: The cited data in Table 5 (Ministry website) is a little different than that cited in Table 3 (international database). The difference has been retained for the integrity of the data in Table 3, and it does not interfere with the context presented.

Table 6: GHG emissions ($MtCO_2$ equivalent) and Growth (in %) in the period 1990-2019

Country	1990	2019	Growth (in %)
United States	6,487.33	6,617.92	2.01
Canada	588.60	723.68	22.95
Australia	425.62	546.61	28.42
Norway	50.71	50.96	0.48
Cyprus	5.57	8.502	55.64
Iceland	3.69	4.52	22.49
China	4057.62	13035.00	221.25

Source: GHG Inventory Database, UNFCCC

Note: China's earliest official GHG emission data was recorded in 1994, as per the GHG inventory database, UNFCCC. GHG emissions for 2018 were taken from China's Biennial Update Report 3.

gas, along with the production potentials of the key contributing states. Among other things, it depicts the uneven geographical disposition of hydrocarbons in India. Almost 90% of the coal deposits, 96.2% oil and 80.4% gas is concentrated in just five states. The production is likewise concentrated in these states only.

Table 6 indicates a steep growth in GHG emissions in five of the countries mentioned above. The growth is calculated for 1990-2019, with 1990 as the base year. All countries with a very high base value for GHG emissions in 1990 continued to contribute to the rise of GHG emissions in this period. The increase in GHG emissions is at the back of the oil, gas and coal production increase from their reserves in these countries. The rise goes against the spirit of the Climate Convention, which targeted reducing emissions below the 1990 level, and the Kyoto Protocol, which targeted emissions 5.2% below the 1990s levels. The above recorded rise in emission values needs to be read in the context of China emerging as a manufacturing hub for developed countries which started outsourcing downstream activities like manufacturing to developing countries. An assessment of the contribution of any country to emissions by way of consumption will attribute a significant chunk of the overall rise of over 60% carbon dioxide to the developed countries. This otherwise on national emission accounting, overlooks the globalisation trend of the last 2-3 decades accounting emissions mainly to China.

The ever-rising emissions notwithstanding, the last two decades saw a general trend of energy shift away from coal in the developed countries. This is quite visible in most EU countries and the USA. Currently, coal provides about 9% and 14% of energy for the USA and the EU, respectively. For the USA, this is down from 33% at its peak more than two decades after the Climate Convention in 1992. In the EU, it peaked in the 1990s, when coal's contribution was 42%. As would be noted, many years after the Climate Convention, an energy source shift occurred in these countries from coal to gas for completely unrelated and unanticipated reasons. Understandably, the key events were the breakdown of the Soviet Union, the rise of Asian economies, and the subsequent successes of shale gas drilling. The vast gas transportation and distribution grids available in the developed countries, historically laid for town gas distribution, also enabled the changes. Such ready availability of cheap natural gas worldwide was nothing short of a revolution (Maize, 2013). The availability of cheaper gas and simpler end-use technology viz. gas turbines, which has higher efficiency than coal assets, explicably prompted these countries to drop coal. Unlike coal, natural gas can also be used directly in automobiles. It is also used to produce fertilisers and for industrial or home heating. All these positive attributes led to the rise of natural gas as a preferred fossil fuel.

Japan increased its dependence on natural gas through LNG imports. However, the case is a little vexing, as Japan's energy mix profile indicates a rise in coal dependence from 18% in 1988 to 27.4% presently. It may be mentioned that Japan has been a key promoter of the dramatic increase of the global LNG trade in the last 2-3 decades. Its gas imports have steadily increased since the first LNG import in 1969 (Nikhalat-Jahromi, 2015). However, Japan's focus on coal continues due to its unique energy situation, which is characterised by a low energy self-sufficiency rate of only 12.1% (METI, 2022). Gas imports primarily compensated for the aggravation of the energy situation due to the sudden nuclear withdrawal in 2011 post-Fukushima. However, in recent years, coal has remained the focus instead of gas. Coal is considered necessary to maintain its power grid's base load as nuclear power is much reduced while existing power plants come in handy. (JERA, 2022). Also, coal is considered better than imported gas in terms of price volatility and cost-effectiveness. Unsurprisingly, 2023 saw the commissioning of two coal-fired power units of 650 MW each in Japan, while almost in parallel, ironically, the G7 committed to the phaseout of unabated coal by 2035 (JERA, 2023). Japan has also been developing technology to fire ammonia in coal-fired power plants instead of coal for the last 5 years. Long-distance transportation of energy makes ammonia more attractive than other options like hydrogen. Test firing was started in April 2024 at the Hekinan power plant (JERA, 2024).

China is a unique case from an energy and climate emissions perspective. Today, China alone consumes more than half the world's annual coal production of 9 billion tonnes. Notably, the increase was mainly in the years much after the Climate Convention. In 1992, China consumed only 0.6 billion tonnes of coal annually, compared to today, when it consumes ~4.9 billion tonnes annually (Cheng, 2021). Today, China has about 1200 GW of coal-based generating capacity, adding more yearly (IEA, 2023). In 2024, new construction reached a 10 year high with addition of 94.5 GW which earlier hovered between 32 GW and 84 GW (Carbon Brief, 2025). Its per capita energy emissions are, understandably, ~78% higher than the world average.

On the other hand, India is decades behind China in terms of per capita CO_2 emissions, though both countries have almost the same population numbers. Also, the energy reserves scenario, rich in coal while weak in other hydrocarbons, is similar. Thus, China might be ready to peak its coal use, India isn't. China's existing coal based power generation capacity is more than 1171 GW. The coal based power generation capacity under construction is more than 204 GW while more than 216 GW is in various stages of active planning. This has to be gauged against India's total coal based power generation capacity of about 219 GW built over nearly 7 decades since independence. India needs to continue using coal in the coming decades until it finds other techno-economically feasible energy options that can be progressively increased while coal use can be tapered.

Over the past decade, new oil and gas licenses were issued by the US, UK, Canada, Australia, and Norway estimated to have contributed five times more greenhouse gas emissions between 2014 and 2023 than all other oil and gas producing countries combined. Despite their reputation as climate leaders, these five nations have issued over two-thirds of new oil and gas licenses globally since 2020, with a record-breaking 825 new licenses alone in 2023 (Milman et al., 2024). To quote IISD's global oil and gas expansion analysis, "Experts see these countries as the "other petro states" due to their financial and technological resources, potentially making the energy transition less equitable. Their 11.9 billion tonnes of GHG emissions, roughly the same as China's annual carbon emissions, from all current and upcoming oil and gas fields forecast to be licensed by the end of 2024, would be greater than the past four years combined. Under the Biden administration, the US has handed out 1,453 new oil and gas licences, accounting for half of the global total and 83% of all licences by wealthy nations. This is 20% more than during the previous Trump administration" (Milman et al., 2024).

The above patterns of specific substitution of coal by natural gas notwithstanding, the impression of withdrawal of coal capacity by developed countries needs to be carefully revisited. Table 7 indicates

Table 7: Oil and Gas plants country-wise in terms of installed capacity of the unit (in MW)

Country/Area	Oil & Gas based Plants			Coal based plants		
	Under Development	**Operating**	**Retired**	**Under Development**	**Operating**	**Retired**
United States	34,731	5,56,728	15,035	800	1,96,215	1,63,469
China	1,58,061	1,39,382	150	4,20,691	11,47,231	1,24,395
Russia	13,215	1,11,539	4,606	5080	37,811	9,960
Japan	8,436	95,571	20,383	500	54,751	3,202
South Korea	19,072	48,236	0	1,050	41,184	3,480
Germany	14,733	33,567	582	0	32,406	31,047
India	0	28,378	220	97,320	2,39,645	16,311
Türkiye	890	26,065	0	4753	20,473	0
Indonesia	12,719	23,349	0	15,055	52,317	0
Australia	4,096	16,277	480	945	22,403	8,641
South Africa	10,670	3,705	0	3755	44,224	1,180
Poland	7,771	3,465	0	100	28,457	7,756
United Kingdom	16,100	36,207	189	0	2,172	33,685
Rest of the World	4,50,318	9,85,536	14,805	54,025	2,06,238	82,456
Total World	7,50,812	21,08,005	56,450	6,04,074	21,25,527	4,85,582

Sources: Global Oil and Gas Plant Tracker, Global Energy Monitor, August 2024; Global Coal Plant Tracker, Global Energy Monitor, July 2024.

the present operating power-generating capacity with oil, gas and coal in the same countries as in Table 1. The tabulation also includes generating capacity in these countries' pipelines (announced, planned and under construction). The tabulation clarifies that most of the coal capacity (over 90%) is concentrated in these eleven countries plus South Korea and UK, as cited in the tabulation. In comparison, gas-based capacity in these countries is only around 50% of global capacity, indicating natural gas's worldwide reach and popularity as a preferred energy source.

The tabulation also shows that gas-based generation is becoming more popular as it now equals coal-based capacity globally which took over a century to build. Gas turbines for power generation emerged roughly in the 1970s, and any tangible ramp-up in power generation capacity took place only during the last 2-3 decades with the advent of LNG. The gas turbine units worldwide used to be small sets, generally around 100 MW, till around the Climate Convention. With the whiff of hitting natural gas abundance, the developed countries worked with a singular focus and increased the size to over 500 MW in the next two decades. This is a significant example of accelerated need-based technology development by the developed countries for themselves. In blatant denial of the Climate Convention provisions, the developing countries' technology needs were never taken up by the developed countries for development and transfer in any meaningful manner. The climate cause has suffered foundationally in an almost irreversible manner as a consequence. Table 7 indicates that Germany has also ramped up its gas capacity, reaching the level of its present capacity of coal-based plants. The added gas capacity is also similar to retired coal capacity reflecting on their energy strategy. Half of its installed capacity is in the pipeline, indicating intention to continue dependence on fossil fuels, i.e., natural gas, if not coal. The importance of natural gas for Germany can be gauged by the fact that due to Russia's recent regulation of natural gas in Europe, the industries in the eastern part of Germany are facing a severe downturn. It is important to note that the EU is still building coal-based plants (all countries not in the above tabulation) to the tune of 4840 MW. So are Russia, Australia, South Korea, and Japan, despite Japan's commitment at the G7 in 2023. Of course, China has ramped up its coal and gas-based capacity to unprecedented levels: 1171 GW and 153 GW, respectively, with another 420 GW and 158 GW in the pipeline as per Global Energy Monitor, 2025. Even if no new capacity gets into the pipeline, this will eventually mean 1865 GW of fossil-based capacity. This would provide a fair level of dispatchable power, even considering further significant improvements in per-capita electricity consumption, which can come from other non-fossil sources including variable sources.

The U.K., as per Table 7, has retired 33,685 MW of coal capacity while only 2172 MW is in operation. This capacity has also been taken out of service with the retirement of the Ratcliffe-on-Soar coal-fired power plant in September 2024. It needs to be read that the U.K. has converted some of its coal-fired plants into biomass (reportedly mainly forest wood) fed plants. These are considered emission-neutral plants, which is being debated as the wood chips are allegedly produced largely from healthy trees. This puts decades of sequestered emissions back into the atmosphere and takes away living sequestering capacity (Rajan Parajuli, 2025). The strategy of coal replacement with other fuels, like in the U.K. and some other EU countries with biomass, also envisaged by Japan with ammonia, enables them to keep the coal-generating assets alive and in working condition. Such off-line living assets enabled Germany to tide over the natural gas crisis due to the Russia-Ukraine war, providing them with a coal-based generating capacity reserve.

3. India has a legitimate case for coal use, albeit clean.

The correct question for comparing India with other countries in the context of global climate action should be: "Why do countries still need fossil fuels?" One could ask this question of all countries, including India, and then the priority immediately becomes clear — those who emit the most must answer first. Global warming occurs due to the combustion of ALL fossil fuels, NOT just coal. The UNFCCC (United Nations Framework Convention on Climate Change) is a treaty to reduce ALL greenhouse gas emissions from ALL emission sources, not ONLY coal-based emissions. The difficulties faced by many EU countries and Japan for coal phase-out despite their advanced economies is already known to the world.

Similarly, India's position on the growth trajectory is also well known. Why is there an eagerness to focus on coal and not ALL fossil fuels in India? For its ~1.4 billion people, India's energy needs are high, and the main primary energy source available to it domestically is just coal! Only a few other countries have this peculiar constraint. So, focusing on coal and excluding other fossil fuels from the discussion forces India to make early and expensive mitigation decisions by phasing out coal. Linked to direct and indirect employment and energy affordability, any such approach can have serious governance fallouts while adversely impacting India's economic growth.

Future energy infrastructure in India must be targeted to increase multi-fold. A vision of large leaps ought to guide the energy strategy. India's annual per capita energy consumption, presently at 27.1 GJ, has to rise to values beyond popular imagination. The role of coal as the main primary energy source, along with all other competing energy options, is justified when we consider such developmental horizons.

In the above context, detailed projection modelling provides little value given the uncertainties and promise of transformative future technology development. Further traditional energy projection approaches remain highly inadequate. These generally focus on basic needs or poverty alleviation. For instance, WG-III of the sixth assessment cycle of IPCC cited the Decent Living Standards (DLS) framework, which "defines a set of minimum material requirements essential for achieving human well-being and includes nutrition, shelter, basic living conditions, clothing, health care, education, and mobility". It specifies minimum energy use requirements consistent with enabling well-being for all between 20 and 50 GJ per person per year, depending on the context. Other studies provide higher numbers but still far less than developed countries (IPCC, 2022).

The energy studies designed for developing countries do not consider the energy thresholds necessary to fulfill the developmental aspirations of the Global South. Though delivering better services with less energy and resource input has technical potential, the current energy levels of the developed nations do provide guideposts. Without a doubt, certain sections of the Indian population need to be elevated first to meet the minimum HDI requirements. Indian aspirations for housing, education, personal transportation, food, healthcare, clothing, IT & communication, amenities, entertainment, tourism, infrastructure, defence, space exploration and a progressive national identity are no different. Annual per capita energy consumption in developed countries like the USA and many petrostates, which generally qualify as profligate, is in the range of 300 GJ. At the same time, other developed countries are in the range of 150-200 GJ which is also still much higher than the commonly projected or DLS values.

India has a legitimate case for using its endogenous coal reserves, not because it claims unrestricted rights to emit carbon but because the alternatives still need to be techno-economically established on a global scale to substitute or reduce the use of coal.

Importing larger quantities of petroleum and natural gas is not a viable solution as it burdens the nation's budget while compromising energy security. These already consume about US$ 150 billion for oil and ~US$ 15 billion US$ for gas annually, directly reducing resources for many other priority areas of the economy. The prices of both oil and gas in the international market remain volatile.

Over and above, India also imports about 20% of its coal requirements annually. For a country with coal reserves of the order of over 378 billion tonnes, it is only an irony that coal imports are continuing almost as a regular activity. In addition to being a drain on the foreign exchange reserves, such coal imports come with significant challenges. The characteristics of imported coals being different from Indian coal, the usage becomes a challenging undertaking for the end users, like power plants. The base design of Indian power plants is explicably tuned for using Indian coals and not imported coals. Further, the pitfalls of high dependence on imported coals have been exemplified in the large power plants planned/designed solely on imported coal over a decade ago (Jayakumar, 2013). For instance, the experience at Tata Mundra power plant of 4000 MW (5 x 800 MW), originally designed for imported coals, represents the gravity of such issues. The unanticipated hike in coal pricing policy by Indonesian Regulator had put the complete project in jeopardy (CERC, 2016). Firing Indian coals in power plants which are designed for imported coals requires significant modification to the design of the key equipment. Such undertakings are costly and time taking. These get complicated in respect of settling the commercial responsibilities which are difficult to manage once the project has taken-off. Further, the changes to tariffs, also complicate matters. Change of coal generally alters the power plant efficiency. The coal sourcing change would alter the pricing. All these call for changes in the basic commercial terms on which the power plants have been set-up creating undesirable precedence in a market economy. The volatility of price for the internationally traded coals, owing to Russia-Ukraine war, in any case exemplified the vulnerabilities of importing primary energy itself, by a country.

Such high imports of coal, oil and gas pose a significant energy security threat for the country. Additionally, it stretches the resources of the Indian Navy to guard the sea supply lanes (Bhattacharjee, 2017). Any significant LNG imports increase energy security risks, while also requiring the establishment of a gas transportation/distribution grid. Any increase in natural gas use by importing more LNG will also aggravate emissions compared to the domestic coal option, the rationale for which is discussed later in this policy brief. The country must reduce/stop coal imports to the extent possible and also reduce petroleum and natural gas imports dramatically to lower its economic burden and other associated vulnerabilities.

Hydro energy remains one potent emission-free option. These were the first electric power plants set up in the country. Hydroelectric power has always played a significant role in the country's energy landscape, providing essential balancing/ peaking support to the electricity grid, thus enhancing the reliability and resilience of the power system. Till the 1980s, the capacity mix of the country had ample presence of hydroelectric power. The development of hydropower projects has been marred by various issues, such as natural calamities, geological surprises and contractual disputes, which have resulted in slower hydro capacity addition thereafter.

Nevertheless, aligning with the ambitious targets set forth by India in the Nationally Determined Contributions (NDC), the government has adopted a proactive stance towards hydropower development, striving for accelerated progress. Hydroelectric power projects with an aggregate capacity of 15 GW are under construction in the country. The hydro capacity is likely to increase from 47 GW to 67 GW by 2031-32, marking an increase of almost half of the present capacity (MOP, 2024).

Similarly, nuclear energy is another promising option for the country. Nuclear power presently supplies about 10% of the world's electricity. It has a total installed capacity of 413 gigawatts (GW) in 440 reactors operating in 32 countries. However, it is much higher in countries with nuclear capabilities. It supplied 20% of the electricity requirements in Europe, and as much as 65% in France. Initially concentrated in G7 countries, it has spread to other countries, notably China, which has installed 56 reactors with a 54.3 GW capacity in the last two decades. Presently, 27 reactors with a 28.9 GW capacity are under construction in China (World Nuclear Association, 2024). The pathway is worth serious consideration, given India's nuclear legacy. India was an early starter, having commissioned the first atomic power plant in 1969. It operates 24 reactors with a 8180 MW capacity, contributing almost 2.5% to the country's electricity generation. However, India's nuclear energy development has faced obstacles due to international pressure, making the route more complex and uncertain. Still, efforts are being made by the government to increase the peaceful use of nuclear energy in India.

The government plans to more than triple the present capacity of nuclear power to ~22,480 MW by 2031. The additional capacity is scheduled with 10 new reactors (500 MW and 1000 MW rating), taking the total to 32 from the present 24 numbers (operating as of March 2025). Nuclear power plants to generate additional 7,000 MW have been considered during 2022-27. Additionally, a capacity of 8700 MW of nuclear power plants in various stages of construction (or in advanced stages of development) will likely accrue during 2027-32. The government has also given in-principle sanctions to increase the number of reactors to 50. The SMR (Small Modular Reactors) are also being planned (with a rating of less than 300 MW) in parallel (Singh, 2023). In pursuing this, the Indian government envisages a partnership with the private sector focusing on R&D, as announced in the Union Budget 2023. The report of the VIF Task Force published in 2022, 'India's Energy Transition in a Carbon-Constrained World', provides further perspective on nuclear energy options.

Indigenous nuclear projects, like BHAVINI (Bhartiya Nabhikiya Vidyut Nigam Limited) have been undertaken. The 500 MW PFBR (Prototype Fast Breeder Reactor) project began in 2004 and saw the first core loading in March 2024 (Bhavini, 2024). The prototype's success will open the way for a full-scale rollout of such power plants in the country.

Both hydro and nuclear options remain promising for the country to serve the gigantic energy needs of the future. However, project time delays and cost overruns are crucial questions for any infrastructure project, making it financially unsustainable due to the burden of the payable interest during the extended construction phase. Hydro and nuclear options need to be pursued in the long term. The project schedules/costs must be contained to make them dependable options in the country's energy planning. As it is, these have higher life-cycle costs than coal-based power projects.

India should make coal use as clean and efficient as possible. As seen from its track record of utilising state-of-the-art power plant designs, it is already doing so. Technology usage has been significantly improved since the Climate Convention came into vogue. Regular coal-fired power plant technology has been enhanced over the last three decades. The power sector used sub-critical technology until the 1990s, which has been upgraded to supercritical and ultra-supercritical for the latest projects. More clean coal technology programs (like advanced ultra-supercritical technology demonstrations, national coal gasification mission, and biomass mission) are underway. The government is actively promoting these. The AUSC (advanced ultra-supercritical technology) demonstration plant has been announced to be established by NTPC-BHEL JV in the Union Budget 2024. Once commissioned, this will be the first AUSC power plant in the world (PIB, 2024) as the AUSC programs initiated by EU, USA and

Japan all got dropped midcourse. EU's program progressed to advanced stages but never entered the demonstration phase.

These programs on advanced carbon conversion technologies can be hastened if the technology IP learnings of several technology demonstration plants that were set up in the 1990s (like IGCC, PFBC, AUSC, oxy-combustion, coal beneficiation, CCS etc) in the EU, USA, and Japan could be made handy for Indian programs (Kuchta, 2022). Many clean coal technology development programs were initiated after the 1973 oil shock, though the baseline technologies were developed during the World War II. The idea was to reduce the energy cost to match the price and convenience of oil. These developmental efforts continued post-Climate Convention, as all developed countries focused solely on coal until the sudden bonanza of cheap natural gas. The advent of LNG has gradually shelved all the clean coal technology programs in recent years. The advanced carbon conversion technologies like IGCC, PFBC and CTL progressed into the demonstration stage, and several full-scale plants were set up in the EU, USA and Japan. China has also actively developed clean coal technologies in the last two decades. India needs to actively pursue these options for technological self-reliance, energy security and simultaneously address GHG emissions.

Coal energy has remained India's mainstay for economic development for over five decades. Coal usage sharply increased from the 1980s with the advent of large multi-state coal-based power plants. While power was always on the concurrent list, the proactive focus of the country shifted the energy mix from hydro towards coal. Also, coal usage in other sectors of the economy, like steel and cement, grew in tandem with the economic expansion. Today, coal provides over 56% of the country's total primary energy requirement. The moot point to be noted is that India is no exception. Since the Industrial Revolution, all developed countries like the U.K., Germany, the USA and Japan accumulated economic wealth mainly based on coal energy.

Currently, coal is India's most dependable energy source. Coal-based power plants provide ~74% of total electric power, which is dispatchable and at the lowest/steady prices, resulting in stability for the power grid and the market. Coal is also a critical process ingredient for hard-to-abate sectors like steel and cement, aluminium, and many other industrial products. The intellectual property (IP) for the required technologies for all these coal uses, though initially imported, is now, by and large, indigenised. The power plant or industry technologies were explicably developed around the specific design conditions prevailing in OEM (Original Equipment Manufacturer) countries. These came to India through the technology licensing route or bilateral cooperations. All the initial plants, whether power plants, fertiliser, or steel, had significant issues. There were also questions like establishing sources for equipment spares, which are required for the lifetime, and services for project construction and maintenance-repair-overhaul. These are essential elements impacting the operating costs and plant utilisation factors. After all these decades, these technology inputs have been well internalised within the Indian industry, and continuing with this ecosystem entails minimal import dependence and high plant utilisation factors.

Any energy transition policy based on frameworks created by developed countries suitable to their domestic situations could reduce India's coal production/ consumption expansion rates. It is crucial first to weigh the potential adverse impacts, as the economic development of at least six coal producing states heavily rely on coal and its business value chains. These states directly benefit from GST compensation, royalties and levies linked to coal production, sale and use. The most immediate concern is the potential loss of jobs. This risk could materialise in the short term if we blindly follow the false narrative propagated by the developed countries. Further, the disparity between coal and solar/wind-rich states could have significant equity and political implications, even in the long term (Malik & Bertram, 2022).

Akin to the carbon tax, there is a coal cess of Rs 400 per ton in India. In addition, other charges are added that hike the coal price over and above what is worked out by the coal companies, which essentially represent the costs. The cess and these additional charges go to the central and state governments. Over Rs. 60,000 crores is collected annually through royalty, other levies and cess on coal production. Further, the current annual contributions of royalty (14% ad valorem, other than for West Bengal, which still charges cess) and other levies (DMF and NMET) to state governments stand (Bharadwaj, 2024). Coal also plays a significant role in cross-subsidising passenger services for railways (about 50% of the current freight revenue) with a pan-India impact. It must be flagged that coal's energy cost remains the lowest competing option despite these cost burdens meant to support central and state exchequers, GST compensation for states, and subsidising rail travel costs. In this context, it may be pertinent to refer to the book "Future of Coal in India: Smooth Transition or Bumpy Road Ahead" by Rahul Tongia, Anurag Sehgal, and Puneet Kamboj, which, among other things, provides good data.

Such ambitious use of coal to provide the primary energy necessary to support Viksitbharat@2047 economy will require, among other things, streamlined and incrementally increasing production of domestic coals. The unfortunate developments in the coal mining sector when coal mining was opened to the private sector about two decades back after the nationalization of the 1970s resulted in deep controversies due to the discretionary nature of mine allocations. The nature of the issues impacted the whole Indian coal sector, eventually leading to the cancellation of 204 coal mines allotment by the Hon'ble Supreme Court in 2014. The period will have a long shadow, though the present government seem quick in policy and legislative actions. The Coal Mines (Special Provisions) Act of 2015 was enacted to auction coal blocks to the private sector and allot these to public sector undertakings (PSUs) for specific end-use plants. Several rounds of mine auctions have occurred since then, with many such mines having restarted coal production. The new approach opens up a channel for market forces to establish themselves. The systemic correction will require persistence on the part of the Government as contracting practices and associated nuances of executing agencies take time to evolve and internalise, which is, however, a must if India has to look at 1.5 billion tonnes and to cross 2 billion tonnes annual coal production soon.

4. Dependence of Industrial Products on Coal

The importance of coal is generally seen in terms of electricity generation, though it provides many products of the industrial sector. The intricate dependence has evolved gradually over the last two centuries. The matter was never examined for alternatives until 'hard-to-abate' sectors were identified recently in the context of global climate action. This discussion also remained somewhat restricted to steel, cement, and fertiliser production. Many other products like activated carbon, coal tar, carbon black, amorphous graphite, synthetic fuels, ferroalloys, methanol, synthetic natural gas and so forth depend on the coal industry. However, the discussion on alternatives to coal has only been getting attention in recent years and remains oversimplified. Coal has entrenched in the industry over decades of technical, economic, and sectoral evolutionary optimisation. It is, therefore, essential to unpack the entire landscape to appreciate the nuanced reality, which, for India, also has a knowledge dimension commonality to the renewable technology development paradigm (IRENA, 2024).

Coal has been used to smelt iron ores for ages. From a hole in the ground with a yield of a few cubic centimetres to present-day blast furnaces of thousands of cubic meters, coal serves two functions. One, it provides heat for melting the iron ore, generally iron oxides. Second, the carbon in coal reduces the oxygen in iron ores to free the iron. Lifewise, in cement production, coal heats up the calcium carbonate charge inside the kiln. Moreover, the carbon creates a reducing atmosphere, which separates oxygen which is emitted as carbon dioxide, leaving behind calcium silicate molecules. Cement is a combination with CSH as the primary binding phase. Coal also produces syngas, a mixture of carbon monoxide (CO) and hydrogen (H_2). This is generally realised through gasification route using restricted air while feeding some steam. The resulting syngas is used as a primary feed for many chemical products like ammonia, methanol, urea etc.

Coal utility goes far beyond electricity generation and other primary uses like steel and cement production. Until the availability of cheap natural gas, coal was widely used for fertiliser production, though it is still used in many places. Activated carbon is another crucial industrial coal product. Due to its high absorption area and absorption properties, activated carbon is used for water purification and medical applications. As mentioned above, syngas is a primary feed for other products. Germany used it to produce gasoline during the World War II, while South Africa utilised it to make a quarter of its oil to compensate for the embargo restrictions. Like syngas, coal tar, a by-product of the coke oven process, gives an array of products, including wood preservatives, roofing materials, and chemicals for synthetic dyes and plastics. Amorphous graphite has applications in lubricants, batteries and brake linings, complementing mined and synthetic graphite sources.

The recent focus on hard-to-abate sectors has prompted the industry to look for alternatives to coal. The industry has been using biomass and waste fuels strategically for some time. Green hydrogen and electrolysis are the two new concepts being actively developed. Hydrogen acts as a reducing agent, forming a natural ingredient for steel. Electrolysis is being tried as a general concept for many products, including steel and cement. However, all these remain in the early stages of development. The difficulty is not the pace of development of these technologies but the optimisation and internalisation stages. All the coal-based technologies have taken decades of evolutionary stretches during which cost improvements, customisation to local conditions, supply chain establishment, human resource development, market detection of prices and services industry development have taken root. These are essential for the effective utilisation and bankability of these capital-intensive industry segments. The critical question on the alternative energy options remains open due to the time required for its optimisation and internalisation.

Economies of scale and scope have played a significant role in such optimisation. For each of the products, the equipment scale has grown to render cost economics. The industries have, in parallel, established the supply chains and downstream markets. Similarly, scope economies have affected the size and organisation of companies. The size of companies grew huge, as result of mergers and acquisitons especially in the steel sector, to exercise better business control on input materials. Steel production companies started owning mines for iron ore and coal. They would tend to have power plants for electric power supply reliability. After all this development and experience of two centuries, transitioning to new alternatives would disrupt these established, highly integrated systemic elements. The industry and funding agencies have also gradually understood the risks and returns of making such investments bankable. Like any other product in the market, the alternatives must go through these processes to achieve business process optimisations and the economies of scope and scales.

Sunk-in capital becomes another significant cause of inertia. The capital expenditure for any new factory generally recovers in the initial years, which becomes a significant barrier for a shift to a new process requiring a new factory or even changes in the existing set-up. The risk associated with new asset designs and operational processes would require investors to seek higher returns and debt to be financed at different interest rates compared to established processes. The low cost of coal, again determined by established mining and transportation mechanisms, is a significant factor. The new feed, like green hydrogen, depends on solar PV, an all-new capex, even if we consider the reduction of hard costs experienced in the last decade. The costs of alternative routes are further amplified due to low early-stage efficiencies. All these factors indicate that, while technically feasible, transitioning to alternatives would disrupt the traditional systems, requiring costly reconfigurations and new cycles of optimisation, which would take decades under the average market realm.

Transitioning away from coal in these industries may be feasible. However, the new processes will need time after these have been technically established through the developmental push. The development would require considerable R&D enablement by the government, as the private players will need incentive and the funding bandwidth to undertake such capital-intensive development. These new technologies must go through the same supply-and-demand-side developments and optimisation cycle. Without careful planning, hasty shifts could disrupt economies, strain supply chains, and jeopardise energy security, underscoring the need for a pragmatic, well-coordinated energy transition (Wyman, 2024).

5. The curious case of EU's 'green' fossil energy

Focusing on coal alone and not all fossil fuels helps developed countries, especially the EU, look much more proactive in climate mitigation than they actually are. Coal has been stigmatised for centuries, specifically since 1960s and was one key determinant of the wave of environmentalism that engulfed Europe. Hate for coal developed out of excessive use through primitive technology, and of course, nuclear energy and chemical pesticides as well, was a major factor in propelling the green movement. The developed countries are currently assuaging the public mood and grassroots climate movements, which have sprung up sensing years of insufficient action since the Climate Convention. Coal is a good lever as it is considered dispensable now, natural gas being handy. The nervous actions are also seen in the controversial replacement of coal with wood in power plants, the subsidies for which have given rise to a spurt in the wood chips industry. One needs to look more attentively at what developed countries are doing. They are not moving from coal to renewables but only from coal to natural gas. Some others, like many Scandinavian countries and France, rely on coal only in a minor way as they have legacy energy options based on nuclear and hydro. Explicably, the Climate Convention commitment and the specific country-wise emission reduction commitments made by the developed countries were never intended to be realised.

In a surprise move, in mid-2022, the European Parliament backed EU rules labelling investments in gas and nuclear power plants as climate-friendly (Abnet, 2022). The approach needs to be more scientific, especially considering the dismal record of developed countries' delivery of the commitments made in the Climate Convention. Emissions from natural gas combustion are indeed half that of coal for the same energy output. However, this is only a partial picture of the whole reality. The entire value chain, from extraction to transmission/transportation to distribution and end-use, must be considered when assessing the emissions from natural gas usage. Such overall consideration brings natural gas, specifically when used as LNG, on par with domestic coal, as revealed by recent studies (Howarth, 2024). This lopsided political decision points to nervous actions in the wake of rising public sentiments on climate change in these countries.

Natural gas handling, transmission and distribution entail leaks. Natural gas is methane, irrespective of its usable form: CNG (Compressed Natural Gas), PNG (Piped Natural Gas) or LNG (Liquefied Natural Gas). Methane absorbs much more sunlight than carbon dioxide but disintegrates faster (like in a decade essentially, while carbon dioxide remains for more than a thousand years). The net effect is represented by the GWP (global warming potential) of methane, which is 80 when calculated for 20 years. Recent work indicates that the impact of inevitable leakage and energy consumption in the LNG gasification process and ship transportation makes the total emissions higher than domestic coals. Such findings create a big question about portraying natural gas as climate benign. Notwithstanding, natural gas as a 'Green' or 'bridge' fuel is being aggressively championed by the developed countries in the decisions of COPs and the G7 and G20. The IEA-reported value of 3.042 million tonnes of methane emissions annually from coal mining activities in India was found to be exaggerated (Bhatt, 2025). The adverse impact of LNG has also been flagged by the USDOE report released on 20th December 2024. This broad-based study, which examines the impact of LNG exports on the US economy, has indicated that unfettered exports will increase emissions due to the displacement of energy sources, including renewables (USDOE, 2024).

Coal production in the EU has decreased since the 1980s, with gas-based electricity generating around 20% of the electricity in recent years, while coal and lignite provided 13-15%. Such new gas sources, like those from the Russian Federation, the USA, Norway and North Africa, include substantial transportation infrastructure investment. The Russia-Ukraine war significantly increased imports from the USA, requiring investments in LNG terminals. Earlier, the Nordstream 2 pipeline was constructed with enormous investment to supply gas from Russia to France and Germany for decades! (Russell, 2021). Together, fossil fuel-based energy in the power sector supplies around 35% of the electricity needs of the EU. The gas supply disruption to the EU due to the Russia-Ukraine war, and the aftermath of organising alternative gas arrangements from the USA and Middle Eastern countries in a rush, flagged its deep fossil energy dependence (Elliot, 2023). These developments have only escalated public sentiments on matters of energy, its pricing and climate action, including also the rising extreme weather events. The EU's politically charged situation exhibits their need for resorting to symbolism rather than taking tangible action. Solar PV and coal seem to fit the space on either side of this climate divide. Coal also provides a lever to shift the responsibility of rising emissions to developing countries. Further, the adverse impact of the hindered natural gas supply on the industry due to the Russia-Ukraine war, especially in eastern Germany, reminds us of the importance of such primary energy supply reliability for any country. Thus, the developed countries are still stuck in the coal-gas transition and will remain so for some time rather than taking the lead in the fossil fuel to renewable transition.

The EU has no target for the final phasing out of coal from power generation. Germany, individually one of the largest coal producers, will do so only by 2038, i.e., 13 years from now. The EU's coal production until last year was over 450 million tonnes. It was used mainly for operating 166 coal power plants with 112 GW of capacity. Ninety mines employ 76% of the total 200,000 workforce in the coal sector, spread in coal-rich regions of Germany, Poland, Czech, Slovakia, Hungary, Romania, and Bulgaria. These European coal-producing countries are yet to provide any coal-phase-out plans. Germany had initially fixed 2030 as a phase-out year but subsequently self-retracted it. In the ongoing Russia-Ukraine war, many power plants slated to be taken out of service were brought back on standby to supply the power grid. It's recent experience with energy shortages will explicably make the phase-out even longer. Clearly, the EU seems to be finding it extremely difficult to come out of the arms of coal and other fossil energy (European Commission, 2022). However, they seem to continue with their false narratives and symbolism of coal phaseout as manifested during the successive COPs and subsequent calls.

In addressing climate change, developed countries show enthusiasm for all but themselves. Among the most visible and touted climate actions and policies of the EU, are the over-ambitious coal phase-out targets, the burning of wood in power plants in large magnitudes, and significant green subsidies resulting in the doubling of energy prices. The most crucial manifestation of policy confusion is the creeping de-industrialisation of the EU, mainly due to high energy costs. The offshoring of industrial goods that commenced in the 1990s as a short-term measure purposed for cost reduction has become a long-term, unguided pursuit with China as the primary beneficiary. Today, China commands a leadership position in almost all major products and materials required for a modern economy. It produces over 50% of steel consumed globally (Statista, 2020), 80% of solar panels while over 90% of critical components like wafers and cells (IEA, 2022), 65% of the world's wind turbines (Wood Mackenzie, 2024), over 68% of rare earth minerals used globally (Statista, 2024), 60% of aluminium (voronoiapp, 2024), over 85% of magnesium (European Aluminium, 2021), which is crucial feed for many industries, 79% of the world's Li-ion batteries, to name just a few sectors (Statista, 2024). Low energy prices in China are one key reason for such dominance. Coal is the workhorse for its energy system, providing 53.6% of primary energy, mainly to its ~1200 GW installed power capacity, which is still rising at a higher rate than in any other country. As a result, China guzzles over half the world's coal production. Such a business monopoly by its immediate neighbour has two lessons for India. The first is to develop own capacities in all these crucial areas of the economy. China's monopoly in essential business areas can be risky as supply lines inevitably have embedded trade and diplomatic policy elements. Second is the importance of coal in supporting the energy system, especially as China's energy reserves resemble India's in terms of coal abundance and weak petroleum base. China's rise and all-around success can also be attributed among other things to its continued utilisation of coal as its primary energy source.

6. Coal-to-chemical route and coal gasification

Present-day use of coal is primarily based on its use in power plant furnaces wherein coal in powder form is burned with air. A fraction goes to industries as process enablers and heat providers. Small granules, like those used in cement and steel production, are used, as discussed earlier in this policy brief. However, early coal usage, i.e. over two centuries ago, developed almost equally on two routes: combustion of coal granules in steam engines and secondly, as town gas prepared by heating coal without air. The latter, coal gasification process was developed in the U.K. around the 1800s. Little known today, but town gas was popular in industrial countries until the 1950s, when it was gradually displaced by natural gas, which was much cleaner and progressively cheaper. The extensive network of pipelines in almost all the major cities of the developed countries, which we discuss today in the context of hydrogen, was laid for town gas only. These were subsequently extended for natural gas and now form one important basis behind the hydrogen focus.

Coal is burnt in the air to release heat as carbon in coal reacts with oxygen in the air, releasing carbon dioxide. On the other hand, the town gas, a mixture of carbon monoxide, hydrogen, and methane, is produced when coal is heated in the absence of air. In the absence of air (i.e., oxygen), coal does not burn but releases gas, which has heating value. The steam engines, which triggered the Industrial Revolution, followed the coal combustion route. These engines were initially used at coal mines to power de-watering pumps, and soon found use in locomotives, industries, steamships, etc. In parallel, the use of town gas also increased, which helped urbanisation. Companies picked it to supply gas to cities across Europe and North America for illumination, heating, cooking, and later to industries as a feed for producing chemicals. These companies flourished in 1850-1950, so much so that they could offer a significant resistance to electricity supply companies established in 1880-1900 period.

The gasification process in the 19th century was inefficient and highly polluting, with hazardous by-products like tar and sulphur, which were difficult to manage. In the early 20th century, scientists began experimenting with more advanced forms of coal gasification, focusing on producing synthetic fuels (or syngas) from coal. Such gasification is carried out by heating coal with a restricted supply of air and steam to produce CO and H_2. In Germany, during the World Wars I and II, coal gasification was refined to produce synthetic fuels such as synthetic natural gas (SNG), synthetic gasoline, and diesel, compensating for the oil shortages. The Fischer-Tropsch (FT) process, developed in 1925, became a critical method for producing liquid fuels from coal-derived syngas. The Nazi government heavily funded the technology development and its roll-out in the early 1930s, sensing Germany's constraints with domestic petroleum reserves. The synthetic oil produced from coal using the FT process became significant in moving the German military machine during the World War II (1939-45) (Jeffreys, 2010).

The synthetic fuel production plants were built and operated by IG Farben in Germany. This was one of the top most chemical company in the world at that time. The company was dissolved after the war for its involvement in war crimes. Subsequently, natural gas from European sources (like Groningen gas fields in The Netherlands) and petroleum imports met the post-war German requirements. The FT process was, however, used in South Africa by its energy company SASOL to produce synthetic fuels and chemical feedstocks as the country remained under embargo due to apartheid charges. Coal gasification is carried out by the Lurgi gasifiers, which are fixed-bed gasifiers suitable for high-ash South African coals. Sasol made significant developments in coal gasification technologies, specifically for high-ash coals found in South Africa. Sasol produced enough oil from coal to contribute over 25% of South African national demand (Sasol, 2024). The 100% CTL synthetic gasoline also received certification for unblended use in international commercial aviation. In 1998, Sasol became the first company in the world to gain approval for commercial use of a 50% blend, which was improved to 100% in 2008. The fuel is fully fungible and aligned with the current aviation infrastructure through its compatibility with existing engine requirements and can be used with conventional crude oil-derived jet fuelling systems (Davies, 2010).

The development remained of interest to other coal-centric economies like India and China. Early fertiliser plants in India were motivated by Sasol. Three urea plants based on coal gasification were established in the 1960s in Uttar Pradesh (Phulpur), Andhra Pradesh (Ramagundam) and Odisha (Talcher). All three plants faced severe technical issues in the gasifiers due to characteristics of Indian coals that were insufficiently understood at that stage. The plants faced closure when faced with competition from fertiliser plants based on natural gas feed in later years (mainly with the advent of the HVJ gas pipeline). Likewise, China established a few facilities in that era while ramping up its efforts dramatically during the last two decades.

Gasification technology was also picked up from Germany by the USA and USSR after the war, along with many other technologies (most notably V2 missiles, which later became the basis for large rockets used for space exploration). A few gasification pilot plants were built in the USA in the 1950s. However, the real thrust on coal gasification came only after the 1973 oil shock. Integrated Gasification Combined Cycle (IGCC) technology was also conceptualised. The idea was to use syngas in gas turbines for power generation, which was quite developed by then based on aeroplane engine technologies. Such use of gas turbines gave higher thermal efficiencies, typically in excess of 45%, compared to about 33% of thermal power plants (based on steam turbines) in those days. IGCC was considered a 'clean coal' technology because it could more easily capture pollutants such as sulphur dioxide, nitrogen oxides, and minute particulate matter than conventional coal combustion. This was considered important as, by the 1970s, coal's stigma in European countries and Japan for smog and acid rains had gained political momentum. It was a significant issue during the 1983 elections in Germany when the Green Party won a national seat for the first time. Subsequently, FGDs (De-SO_x) and SCRs (De-NO_x) were installed at power plants on a war footing in the EU, mainly in Germany. Such a legacy of coal gave a fillip to IGCC when higher efficiency was also sought in the wake of consciousness on energy security. Cool Water IGCC Project, primarily funded by USDOE, was the first such plant built in 1984. The Climate Convention gave further fillip when the Wabash River Plant 262 MW was built in 1995 and the Tampa Electric (TECO) IGCC Plant came up in 1996. The EU and Japan also established several similarly large IGCC demonstration plants in the 1990s.

The global boom in natural gas production took away the interest from the coal-to-chemicals route in developed countries, including IGCC. As natural gas is cleaner and cheaper, many utilities shifted away from coal, including IGCC projects, to gas-fired power plants. Recently, there has been renewed interest in gasification (including coal gasification) to produce hydrogen in the context of a low-carbon energy transition. If combined with carbon capture, gasification could become a key technology in a future hydrogen economy. Combustion with purer oxygen, termed oxy-combustion, can result in products much more amenable for CCS due to low volume owing to the missing nitrogen. Nitrogen plays no role but comes from the air alongwith oxygen, which is necessary for combustion.

China has continued work in this area, along with some activities in Japan and India. Since 2010, China has invested heavily in coal gasification and IGCC technologies to diversify energy sources and reduce pollution from coal use. In particular, it has been scaling up coal-to-chemical plants and exploring gasification to produce synthetic natural gas and chemicals. Japan also continues to develop its technology, albeit slowly. Indian initiatives continue, on and off, with the latest as a gasification mission announced by the government in 2021. It targets gasifying 100 million tonnes of coal by 2030. These efforts, on a full bouquet of advanced carbon conversion technologies, and not limited to coal gasification, need to be streamlined, paced up and expanded. The country has all the ingredients to develop and roll out such technological solutions. As experienced in the AUSC technology, such technologies should be well within the reach of the technology R&D ecosystem and the Indian industry. The sector has come a long way in getting motivated by stories from the Indian space administration and nuclear successes.

Indian coal is characterised uniquely, but as the gas turbine development has exemplified, present-day R&D approaches can develop need-based technologies. There is no reason why the challenges of arriving at the right equipment design cannot be met if sufficient investigation and process are followed. Likewise, the technology costs are a matter of focused R&D, as exemplified in other technology stories, including solar

PV cases. Specific cost reductions are also certainly affected when the technology is rolled out and optimisation sets in. However, experimentation planning/execution and industry internalisation take time. A solution to pace these developments could be to approach the developed countries that have done considerable work in these fields in the 1990s. Developing countries have already raised the WTO/TRIPS amendment to free IPRs. The same demand needs to be reactivated.

Another issue that seems to have been insufficiently recognised is the issue of technology IPs, the trade secret portion (less of secret and more of understanding nuanced reality of technology complexity learned over the period of time) that is not patented or copyrighted but remains with the OEMs. The transfer of such know-how needs to be tied up in parallel as a UNFCCC/COP decision. In any case, such demand will act as a diplomatic lever for climate negotiations when it is resisted or not agreed upon. Technology transfer is a Climate Convention level agreement and a vital element of the climate action architecture based on the CBDR principle. The Paris Agreement extends the spirit in Article 10, espousing global collaboration. The Climate Technology Centre and Network (CTCN) which is part of the technology mechanism of the Climate Convention, can enable the process. Such advanced clean coal technologies can be amenable to carbon capture compared to traditional/contemporary technologies, as the volume of spent gases is much lower and can be controlled to meet the requirements of carbon capture technologies. The R&D work on clean coal technologies will have commonalities for energy sources in other developing countries, including in hard-to-abate sector technologies and sub-systems for a renewable energy realm like batteries, electrolysers, P2X etc.

7. Extreme weather events will embolden coal phaseout calls

The UN Disaster Risk Reduction (UNDRR) report 'Dramatic Rise in Climate Disaster Over Last Twenty Years', released in October 2020, (UNDRR, 2020) indicates a sharp increase in the number of recorded disaster events compared with the previous twenty years period. Between 2000 and 2019, 6,681 climate-related disasters caused 510,837 deaths and affected 3.9 billion people. This compares with 3,656 climate-related events that caused 995,330 deaths (47% due to drought or famine) and affected 3.2 billion from 1980 to 1999.

The work on the 6th cycle of the IPCC's Assessment Reports (AR6), prepared in the 2015-23 period, was carried out amidst the increasing media reports on extreme weather events in the preceding months, including the record-breaking 'heat dome' in the Pacific north-west in early 2021. The wildfires followed catastrophic flooding in Europe and China and rainfall-induced landslides in India. Extreme weather has frequently hit the headlines in 2021 and continues to do so regarding heat waves, floods, and cyclones worldwide right till the year 2024. The Dubai floods, and heat waves in South Asia provide a flavour of times to come, and the effect on the coal phaseout calls is predictable.

It is fitting that the Working Group One (WG1) section of the IPCC's sixth assessment report includes a dedicated chapter on weather extremes for the first time. The chapter "assesses changes in weather and climate extremes on regional and global scales, including observed changes and their attribution, as well as projected changes", the report says. Among its key conclusions is that it is an 'established fact' that human-caused greenhouse gas emissions have "led to an increased frequency and intensity of some weather and climate extremes since pre-industrial times."

As climate-change attributions for extreme weather events increase, the voices seeking coal phase-out will be emboldened, and those seeking coal phase-out will be encouraged. Despite having low per capita historic cumulative and annual emissions as well as making tremendous domestic and international efforts to address climate change, India will be under renewed pressure to phase-out coal (Carbonbrief, 2022).

Such coal phase-out calls will directly affect India's negotiating leverage on international climate and other platforms despite India's responsible climate record. India should deal with such situations most directly without any diffidence or guilt. It should respond in a timely and adequate manner by pointing out that its per-capita historical cumulative and annual emissions are minuscule. Further, there is no sector of the economy where India has not separated its emissions from economic growth. Apart from persistent domestic actions in all sectors of the economy, India has gifted the world with institutions such as ISA, CDRI, GBA and the international Big CAT Alliance, which are directly relevant in addressing climate change.

The good work on climate action notwithstanding internal proactive action on coal capacity and technology is required as such work on coal outside India is largely coasting down. It is essential to gauge the global pulse, accelerate adding capacities, and adapt advanced carbon conversion technologies. There is a need to de-hyphenate the capacity addition targets with demands for the next 10-15 years. The tariff norms must be linked to lower capacity utilisation for the excess capacity paradigm envisioned here. This means the capex servicing cost and other fixed electricity tariff charges will be connected to a lower Capacity Utilisation Factor (CUF) than the traditional normative standard for the CUF. BIMSTEC nations can be supplied power from coal based plants from India for some years till these nations achieve self-reliance on endogenous energy resources. Such an approach will ensure that the opportunity is used before it becomes too challenging to add coal-based capacity due to global backlash. This is much the same approach as seen in China in the last two decades. China's coal-generating fleet presently operates at low utilisation factors while it continues to build plants at a breakneck pace (Ritchie, 2024).

8. Spin-off distractions of the coal phase-out calls

Focusing on coal alone helps to suggest a link between 'local pollution' and 'global warming,' which tends to promote an impression of early and expensive mitigation even though the two phenomena are NOT linked. Nobody doubts that both local pollution and climate change are serious problems, but such linkage is not the way to a solution. Coal plants are stigmatised when viewed concerning the emissions and discharges from bygone era. However, a modern power plant's state-of-the-art stack emission control technology frees a coal plant from such pollution. The latest environmental standards applicable to power plants promulgated by MOEFCC in 2015 is a step in that direction. It may be pertinent to mention that the exact cause produces the opposite effect concerning the phenomena: better combustion gives less particulate pollution with more CO_2, leading to increased warming, while incomplete combustion gives more pollution with less CO_2, thus contributing less to global warming. While the black carbon from particulate matter caused by incomplete combustion (though it is a case attributable to small industrial ventures like brick kilns and not power plants) is a source of global warming for a few days, it is not a long-lived source of radiative forcing like the carbon dioxide.

Notwithstanding the context of local pollution and its distracting dimension, it may be pertinent to mention that the sixth Assessment Report of IPCC Working Group-I has concluded that historical SO_2 emissions have created a cooling effect that has partly masked GHG warming by 0.5°C. According to a study conducted in China based on the data from Flue Gas Desulphurisation (FGDs) installed in hundreds of Thermal Power Plants (TPPs), the reduction in SO_2 emissions in China due to the operation of FGDs, which are now mandatory due to emission standards for the industry, "will result in an increase in global average temperature between 2016 and 2050, estimated at ~0.6°C" (IPCC, 2021). A troubling dimension to this context has recently emerged in the solar radiation modification (SRM) technology initiative, a method to modify insolation by spraying aerosols into the stratosphere using aeroplanes or balloons. The proposal was pushed to early 2024 by a group of countries led by Switzerland at the sixth United Nations Environment Assembly (UNEA-6). The developing countries have thwarted it as the technology is little known and has uncertain implications. Also, it will become another excuse for the developed countries for not addressing Climate Change in their own territories (Bhatt, 2024).

The above IPCC findings merit consideration concerning FGD deployment in India without prejudice to Indian emission standards, which cover SO_2, promulgated in 2015. A review of the basic need for FGDs in all coal-fired power plants merits consideration because Indian domestic coals have much lower sulphur (0.24 - 0.6%, typically 0.3%) than coals in other coal-rich countries, except for coals from the north-eastern part of India, which are hardly used for power generation. However, the TPPs in India are mandated to install some of the tallest stacks in the world, even though most of these are in regions where the flue-gas plume velocities coupled with the climatological conditions enable the effective dispersion of SO_2 emissions. The impact of a lone coal-fired power plant in India on the ground-level concentration, even though in nearby areas, is a small fraction of the allowance permitted by the national ambient air quality norms. Recent input by the National Environmental Engineering Research Institute (CSIR-NEERI) to the NITI Aayog corroborates this. A view is increasingly building up for a review of the 2015 SO_x emission norms for power plants.

Since the retrofit of the FGD plants in Indian TPPs to comply with the current SO_2 emission norms from TPPs will increase the specific coal consumption by 1.5-1.7%, FGDs will correspondingly increase the CO_2 emission factor of these TPPs. Further, reducing SO_2 levels in the airshed around all TPPs in India to comply with the MOEFCC's emissions standards mandate of 2015 will also decrease the cooling effect of SO_2 aerosol that has partly masked GHG warming. Therefore, considering a 'graded priority' between power plant pollutants in the order of PM (particulate matter- specifically respirable particulates), CO_2, SO_2, NO_x, and Mercury is worthwhile. Such prioritisation is also required, considering that FGDs are cost-intensive equipment in terms of capital expenditure and operating expenses, which eventually increase energy prices, adversely impacting the nation's economy and exacerbating energy poverty.

Particulate matter (PM) emissions can be reduced by installing or upgrading high-performance Electrostatic Precipitators (ESPs), a mature technology. These latest ESP technologies can lessen PM emissions by up to single digits (< 10 mg/Nm3). The norms can also focus on PM10 and PM2.5, which warrant significant attention as biomass co-firing is increasing in Indian power plants, which results in smaller particulates. This would require fabric filters; ESPs are less efficient in de-dusting for low-size PMs.

For SO_x emissions, the FGDs could be suggested for urban areas where pollution loads may be higher and for power plants that fire high sulphur coals, like those from the Northeast region (up to 3% sulphur, i.e., about 10 times regular Indian coals) or certain mines in southern India and certain plants (perhaps a few on the coast) where coal imports are a necessity for legacy techno-economic reasons. In any case, the installation of FGDs in Indian TPPs has been delayed as the industry was unprepared for the sudden mega scale installations required to retrofit all power plants. The non-graded coverage of all power plants also led to importing FGD technology and equipment, a low-tech area that largely uses carbon-steel construction. Many critical components of these FGDs are imported from China. Indigenous technology development can ensure premium quality gypsum due to custom-developed SO_2 reactors matching the Indian limestone. A case-by-case basis evaluation of the airshed around the power plant by MOEFCC at the time of environmental clearance, as was carried out in the pre-2015 period, would be a more cost-effective and climate-friendly approach suitable for energy prices.

Thermal coal deposits in India generally contain high ash levels (typically 35–45%) compared to those mined in other major coal-centric countries like Australia, China and the USA. The Gross Calorific Value (GCV) of coal burnt in TPPs in India is significantly lower compared to other countries (2500-

4500 kcal/kg). Burning coal with a higher ash content leads to erosion and failure of boiler tubes, fan impellers, and flue gas ducts, affecting plant availability, performance, and boiler efficiency. In addition, the transport of unwashed Run-of-Mine (ROM) thermal coal to TPPs often located more than 500 km from the pithead is inefficient as it carries large quantities of waste, causing unnecessary congestion in India's already overstretched rail transportation systems and often leading to coal shortages for some non-pithead TPPs. Therefore, the global practice in all significant coal-producing countries is that the coal miner 'prepares' the ROM coal at the pithead, which sometimes includes beneficiation, before dispatching the same to the consumers. This mandate can be introduced in India to improve power plant efficiency and reduce emissions and pollution. This will be a positive step as we are likely to depend on TPPs for a significant portion of our electricity generation for the foreseeable decades. However, the beneficiation technology options must be custom-developed as the Indian coal matrix binds ash intricately, reducing the yield. Bottom-up customised technology development perhaps also proves a cost-effective pathway. The approach requires revisiting/enlarging the MOEFCC stipulation of 2020, which negated its previous notification of 2014 calling for coal washing. Considering that the high ash content of Indian coals, high size variation of coal and instances of foreign material impact the end-use assets like coal handling systems, coal pulverisers, combustion/ gasifiers/kilns and de-ashing equipment, a comprehensive, neutral study is warranted to understand the techno-economics and technical feasibility of coal beneficiation closely. The extent and type can then be linked to the distance of usage points. Long lead power plants may merit coal washing, while others closer to or at the pit head may simply require baseline preparation. Such coal mine end preparation can also involve better heating value and composition control through supply-end blending. The penetration of such better practices may be prompted through policies and appropriate incentivisation to prevent create adverse atmospherics for the business community when these are improperly complied with or relaxations are sought, or are outrightly revisited.

Contemporary environmental control technologies bring modern coal production and utilisation technologies at par with Petro-hydrocarbons in terms of local pollution. Also, the question of local pollution resulting from coal usage in the industry or power generation is entirely unlinked with climate-related mitigation. At the same time, as India is a coal-centric economy, it may be mentioned that emission control technologies required for the coal industry, specifically power plants and coal mines, are well internalised within the industry over the entire value chain. The early period saw many issues with the equipment as the technology was all imported from the developed countries. However, the same has now been gradually customised. Any visible problems remain local management issues and need not be attributed to coal *per se* as a primary energy source. The present Indian use of coal essentially matches almost all the global best practices. Indian use of coal must be boldly termed as responsible.

This aspect becomes vital to de-hyphenate the two dimensions of the coal question, viz., global and local pollution.

In the context of distraction, it must be mentioned that the focus on methane reductions in the global climate negotiations has grown significantly in recent years. The 26th session of the Conference of Parties (COP26) of the United Nations Framework Convention on Climate Change (UNFCCC) urged countries to consider further actions to reduce non-carbon dioxide greenhouse gas emissions, including CH_4, by 2030, which was reiterated by COP27 and COP28. Such obsessive focus on CH_4 reduction is a serious distraction from the real challenge of limiting and reducing CO_2 emissions, and masks the inability of developed countries to meet their own commitments (Bhatt, 2024).

9. India's Climate Focus Despite Apathy of the Developed World

Overlooking developed countries' largely careless and dodgy response to the climate question, India is doing more than most countries to accelerate the growth of clean energy sources. It continues to build on the foundation laid early in 2008 in the form of NAPCC (National Action Plan on Climate Change), which comprises eight missions to guide India's response to climate change. The progress in solar and wind energy additions is way ahead of most other countries. Today, our installed capacity of solar PV is about 102.6 GW, while wind capacity reached about 48.6 GW (CEA, 2024). In recent years, India has been one of the fastest deployers of modern renewable energy, having recently crossed the mark of 200 GW of renewable capacity (PIB, Ministry of New and Renewable Energy, 2024). India also initiated the International Solar Alliance with France at the Paris Climate Summit and has pursued its development. Such climate initiatives can be seen all over the economy.

India's use of coal is balanced by responsibility for environmental concerns. Power generation is the leading consumer of coal in India. Presently, India has a total coal-based generating capacity of 221.8 GW out of a total installed capacity of 470 GW, i.e., 47.2%. However, the generation from coal power plants was about 74.7% out of 1734 billion units (FY 2023-24), as modern renewable has a low utilisation due to intermittency. India has also retired 170 old thermal generation units with 10.64 GW capacity to check emissions due to their low thermal efficiency.

Similarly, supercritical thermal power units have been put on full throttle in India. From the early units commissioned in the 2010-11 period, the total number has crossed 94, crossing a total capacity of 65 GW in less than 15 years. Further 6 units of ultra supercritical having over 4000 MW were also commissioned. A further 30 GW of supercritical capacity is under construction while another 51.5 GW is being planned, all of which are bound to improve the handling of specific emissions further. At the same time, advanced-ultra-supercritical thermal power generation technology has also been developed indigenously. This was carried out under a national project initiated and funded by the government. The government recently announced a full-scale demonstration plant of 800 MW based on AUSC technology in the Union Budget 2024.

Further, around 83,887 metric tonnes of Biomass have been utilised (till 31st October 2022) as green fuel for co-firing in power plants. Till 30.10.2022, 39 TPPs across the country have started to utilise biomass in co-firing with coal (R K Singh, 2023). It is pertinent to mention that Indian biomass primarily focuses on farm wastes, unlike wood which is pursued mainly by the developed countries.

Owing to taking units with low efficiency out of service, renovating and modernising generating units, raising the efficiency of new builds, biomass firing, and introducing other clean technologies, the average emission rate from coal-based power stations has been reduced from 1.07 kg-CO_2/kWh in 2009-10 to 0.9675 kg-CO_2/kWh in 2021-22 (R K Singh, 2023). Schemes like the UJALA (Unnat Jyoti by Affordable LEDs and Appliances) and the PMUY (Pradhan Mantri Ujjwala Yojana) have greatly enhanced India's push for energy efficiency and clean cooking fuel, thereby reducing the emissions intensity of the country. The National Green Hydrogen Mission has been launched to generate hydrogen from green sources and make India a leading hydrogen economy. The mission has a production capacity target of at least 5 MMT per annum by 2030, potentially reaching 10 MMT per annum (associated with a renewable energy capacity addition of about 125 GW). It includes a framework to support manufacturing via suitable incentives aligned with 'Make in India' and 'Atmanirbhar Bharat'. The existing policies and programmes aim to ensure the availability of affordable and reliable energy for all citizens of India while supporting climate goals.

The push for a greener energy mix is enshrined in the country's Nationally Determined Contributions (NDCs). The original targets committed to the Paris Agreement were, among others, improvement in emission intensity and the addition of non-fossil based electricity capacity. These were achieved nine years ahead of time as per the third national communication (NC3) submitted by India to the UNFCCC in December 2023 (PIB, 2023). Increasing the availability of reliable supply at an affordable price is a developmental imperative. To achieve this aspiration while ensuring sustainable energy growth, India has set ambitious targets of 500 GW of installed renewable energy capacity by 2030. India is adopting a whole-of-government approach to achieve the deployment of renewable energy and energy efficiency at scale and across sectors.

10. The Solar PV and Wind Option for India

In the power sector, RE has slowed the growth of coal, but it cannot displace all coal. While the annual growth rate (CAGR) of coal-based power capacity was around 4.5%, renewable capacity grew by about 24% annually during the last decade. The quick rise in capacity of RE is undoubtedly based on government policy push but has also been aided by the reduction in costs of solar PV panels. However, the cost attractiveness of solar PV will gradually tarnish as variable generation components in the power grid increase. Broadly, the power grid allows up to a 25% - 30% addition of variable RE without measures (Albertus, 2020). This is based on traditional grid frequency control measures like inherent inertia of generating assets, steam turbine governors, external regulation of power plant loads etc. Hydropower plants are much more amenable to load cycling than to coal-fired plants and more so than to nuclear plants. These are also used for quick grid balancing responses. In India, load curtailment has also been used to balance the demand and supply of the grid. New grid control interventions (higher/new transmission capacities, energy storage, grid interconnections, improved metering and so on) will soon be required as the low-hanging fruits of adding RE to the power grid will all get plucked soon.

Over the last decades, pumped storage has been developed as a credible energy storage method in many countries. It was mainly used with nuclear power plants that had difficulty in cycling load. In India, 4745 MW of pumped storage is presently in operation, 2930 MW is under construction, and several thousand more is in the planning stage (CEA, 2024). However, the option has issues with area submergence, so finding suitable locations is difficult (and so are environmental permits). Many energy storage options appear in the current energy storage discourse: batteries, flywheels, compressed air, molten salt, hydrogen/ammonia, pumped storage, supercapacitors, hot rocks, solid gravity, etc. However, most of these are in the initial phases of development and may be decades away from market introduction.

Pumped storage is the only mature option, while Li-ion batteries have recently seen some deployments. Significant battery capacities have come up in Australia, USA, and Europe. Still, these are replacements for ancillary service-providing power plants used earlier for grid frequency control (Ward, 2020). These are costly propositions, as ancillary services are less mature in India. However, the BESS (battery energy storage system) planned by the Indian government should help gain operational experience and accurate inputs on costs, charging/ discharging/ leakage patterns, MRO (Maintenance, Repair, Overhaul) needs, life, etc., and improve grid reliability.

Further, the power grid will require costly augmentation as the component of variable renewable energy in the grid rises. Further variable capacity additions require increased control through power curtailments and load cycling of coal power plants. Both have costs for society and an increase in the risk of coal plant failures because these are not inherently suitable for frequent load changes and too many starts/stops. It is pertinent to mention that current batteries are generally installed with storage for about 4-5 hours. For grid reliability in the absence of parallel despatchble system, storage duration are much longer. One needs to addionally factor in multiple days of missing sun and wind droughts as also seasonal variation in insolation. For the longer term, typically understood to be higher than 8-10 hours, energy storage remains in the development stage only. For instance, the USDOE program, "The Long Duration Storage Shot", aims to reduce the cost of grid-scale energy storage by 90% for systems that deliver 10+ hours of duration within the coming decade (USDOE, 2024). The fate of such R&D initiatives remains to be seen as the new U.S. Presidency is focused on energy costs reduction.

The importance of modern renewable energy cannot be overstated for India. There has been a steady rise in renewable contributions over recent years. The rise of variable renewables like solar PV and wind power has been significant. Different parts of the renewable system execution are getting established in the country. Nevertheless, the questions of technology/ material self-reliance, cost economics, long-term storage technologies, and power grid readiness remain. Each of these requires concerted effort and well-planned programs. Most of the current work is based on the understanding of studies carried out in developed countries on such systems based on models. The shortage of controlled field studies, specifically on the power grid, is surprising, as developed countries are generally inclined towards field trials. In such a scheme of things, creating a power grid test setup of appropriate size seems vital to form a meaningful policy on variable renewables. To the above effect, an appropriately sized and designed power grid with sufficient geographical spread with all the features to be seen as a microcosm of a full-fledged power grid, must be separated for the purpose. A test power system should enable both transmission and distribution system-level studies to ensure a holistic understanding of the impacts of renewable with increasing penetration. Such a power grid must significantly have variable renewable energy, which needs to be incrementally stepped up to very high ratios. Such power grid design needs to have all the features expected on a modern grid, like multiple voltage levels, real-time monitoring and control, automatic curtailment provisions, high-quality metering, energy storage (different kinds of batteries, other energy storage technologies and pumped storage), and automated load controls. Such a controlled study on a small power grid should provide valuable inputs that will enable validation of the models, assess energy storage requirements accurately vis-à-vis different levels of grid supply reliability, assess seasonal variability, measure actual costs, and ensure standards by evaluating reliability/stability and curtailment impacts with increasing renewable penetrations. The results will provide a solid foundation and confidence due to first hand experience for formulating energy policy and grid codes.

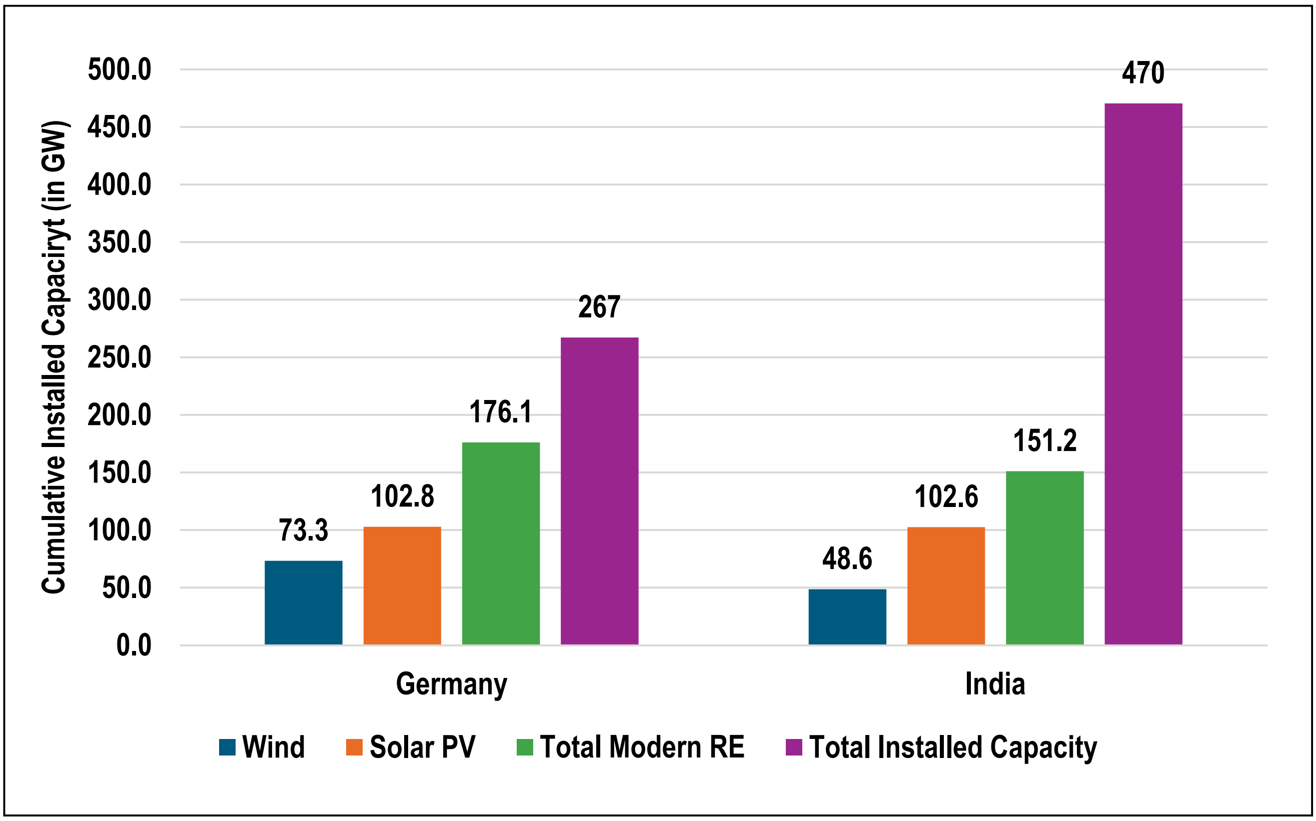
India has large domestic coal reserves estimated to be over 378 billion tonnes, which can last for around 300 years (easily 100 years, even if we reach China-like coal consumption) to meet the country's primary energy requirements at the present utilisation rate. Significant production capacity/ capability must be constantly improved over the complete value chain to optimise this endogenous resource. However, we depend on imports over the entire value chain to create the RE-generating assets. A rapid transition from coal to renewable energy will significantly affect the nation's economy, trade balance, and workforce. We will likely see the developmental deficit widen if we are not given time to augment our manufacturing capacity and ensure a just transition for our energy sector workers.

Earlier, renewable projects were significantly more expensive than thermal power, but long-term agreements for guaranteed power purchases from them were made. So, India is bearing increased costs for the early promotion of renewable. An energy transition of this magnitude, from coal to renewable energy, is expensive both economically and socially for a country such as India, where energy poverty is rife and at a time when the country is making all efforts to remove the development deficit as well as erase the colonial and past wrongdoings in the energy landscape.

'Just transitions' should be 'global just transitions' and not focus on 'intra-country transitions.' Developed countries must take the lead in mitigating climate change, while developing countries, India included, must balance adaptation with their pressing domestic developmental needs in the near term. The developed countries need to honour their commitments under the UNFCCC to provide the means of implementation to developing countries, including climate-specific finance and technology development and transfer that are adequate in scale, scope and speed.

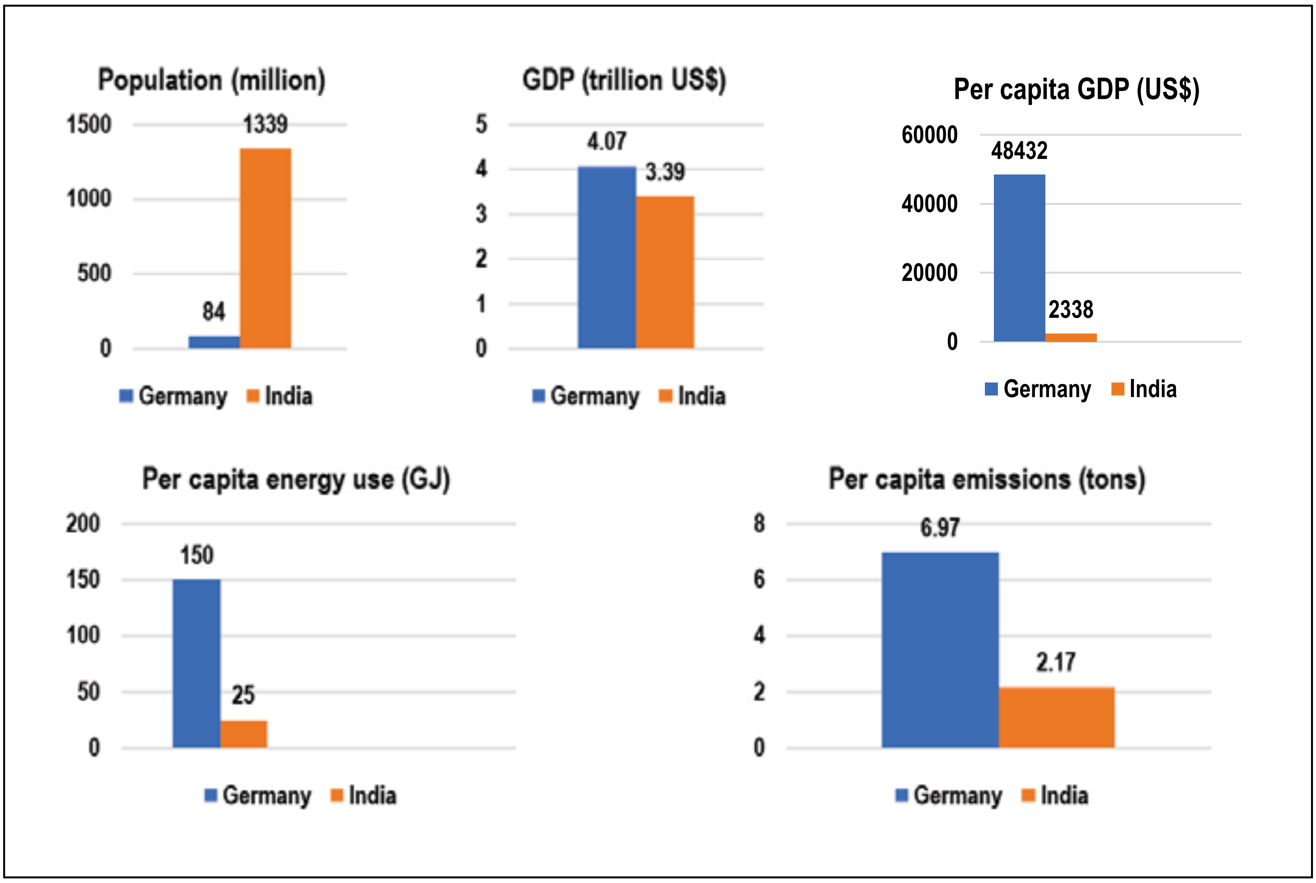
Public and publicly mobilised private climate finance flows from developed to developing countries have been below the collective goal set under the UNFCCC and its Paris Agreement to mobilise US$ 100 billion per year by 2020 in the context of meaningful mitigation action and transparency of implementation (IPCC, 2022). What was initially envisaged as a mechanism of providing pure grants and concessional loans to four-fifths of the world, who bore minimal responsibility for global warming, has become a mechanism for the

Figure 3: Modern RE capacity in India and Germany



Source: For India - (CEA, 2025); For Germany – (Fraunhofer Institute for Solar Energy, 2025)

Figure 4: Germany and India economic-emission snapshots (2022)



Source: (World Bank Data- India, 2022) (World Bank Data- Germany, 2022)

developed countries to further earn through climate finance. Like the drowning person clutching a straw, the developing countries still keep their hopes alive, thinking that the new and additional financial resources and technology transfer, as promised at the Rio Earth Summit, will be forthcoming one day, having waited more than three decades with little to show, even as the billions needed have escalated into trillions of dollars.

The New Collective Quantified Goal on Climate Finance (NCQG) is a new global climate finance goal that the Conference of the Parties, serving as the meeting of the Parties to the Paris Agreement (CMA), shall set before 2025. Unable to fulfil the promised goals of financial assistance, the developed countries have created a new narrative and false hope. Yet, the new goal popularly called NCQG on Finance is like a game of 'The Mirage Quest' or 'Carrot on a Stick' for negotiators to play in the future, as has again been witnessed at COP29 held in Baku.

11. India's Impressive Green Progress

Indian modern renewable energy (solar PV + wind power) is better placed in perspective when compared to countries like Germany, which is long known as environmentally hypersensitive. Present capacities are tabulated in Figure 3 (CEA, 2025; Fraunhofer ISE, 2025).

Notably, India's cumulative installed capacity of modern renewable energy is only slightly lower than that of Germany despite the absence of historical responsibility for global warming. The numbers displayed in Figure 3 can be better appreciated when evaluated within the development data in Figure 4 (World Bank Data India, 2022) (World Bank Data- Germany, 2022). For instance, in comparison to Germany, India's per capita GDP is 20 times lower, while the energy consumed is 6 times less, resulting in emissions that are five times lower. With such an incomparable economic, energy, and emission snapshot and no historical responsibility for carbon accumulation, the country's focus on modern RE can be explained only by the drive of its value system, which stands committed to the cause of global environmental protection.

It is essential to understand that integrating sustainable energy technologies is still expensive, even after the rapid reduction of the unit costs of solar technology. There are multiple elements to this cost – i.e. the cost of grid integration, the cost of grid balancing, the cost of increased curtailment, the cost of reduced reliability of baseload generating assets, the cost of storage, etc. The government also supports renewable energy through 'must run' status for renewable plants and RPO (renewable purchase obligations) for distribution companies (MOP, 2022), open consumer access, and captive power plants. This means that energy produced by solar and wind plants have to be purchased by distribution utilities, irrespective of its cost, whenever and wherever it is generated. So, when demand is low, utilities must absorb solar energy during the day and then ramp up other resources in the evening to meet peak demand. Renewable energy sources are rapidly adding the generating capacity to the power grid. While this has facilitated significant increases in RE capacity in India, there is a considerable cost associated with this policy, as utilities have to forgo cheaper thermal power to be able to absorb the more expensive RE power as it becomes periodically available. There are costs of managing higher RE variability, such as higher ancillary services costs and seasonal storage costs, especially when wind generation declines. Studies have shown that states in southern India, the region with the highest deployment of solar and wind energy, paid ₹1400 - ₹2400 crores in additional costs for absorbing RE under the 'must-run' policy in just one year (2018) (Kanitkar et al., 2021). This is the cost on the basis of which consumers eventually have to pay. Thus, India, on its own volition and unreserved commitment to protect atmospheric global commons, is investing substantial financial capital to ensure renewable energy's 'must-run' status and absorb it for energy transition. In this context, it would be worthwhile to recall here that the developed countries with all the wherewithal at their command are not transiting directly from coal to renewable energy but are using the crutches of natural gas while terming the gas as 'green' or 'bridge' fuel for face-saving.

To remove barriers to the availability and utilisation of RE and to promote open access, the Green Open Access Rules 2022, were issued. The Rules reduce the Open Access limit from 1 MW to 100 kW, paving the way for small consumers to purchase RE, and there is no limit for captive consumers. Considering the need for large-scale renewable integration with the grid, the Bidding Guidelines for Procurement and Utilisation of Battery Energy Storage Systems (BESS) were notified on March 11, 2022. India is spearheading the concept of 'One Sun, One World, One Grid' (OSOWOG). The vision behind the OSOWOG initiative is the mantra that 'the sun never sets'. The OSOWOG concept compensates for the movement of the Earth around the Sun by spreading out the solar PV locations and power grid expanse over longitude. The idea is to harness solar energy from different parts of the world, where the sun is shining at any given moment, and efficiently transmit that power to areas where it is needed. Initial studies have commenced with the lead taken by the Ministry of Power (PIB-MOP, 2022). The country is making every effort to green its energy profile by promoting non-fossil fuel-based energy resources and increasing its total share in the energy mix, treading on a moderately knowledgeable pathway informed by science and evidence.

12. Fossil Fuel Non-Proliferation Treaty

The Fossil Fuel Non-Proliferation Treaty (FFNPT) was conceptualised on the lines of the treaty on the non-proliferation of nuclear weapons (NPT), which was introduced in 1968 (The Fossil Fuel Non-Proliferation Treaty Initiative, 2024). Akin to the NPT, the FFNPT is discriminatory as it restricts developing countries from mobilising their endogenous strategic fossil fuel reserves. The treaty pressures developing countries to decarbonise when they have not even fully carbonised. In contrast, the developed countries have been fully or even adequately carbonised by reaping the benefits of the Industrial Revolution and by appropriating the Global South's resources and amassing the wealth through colonisation.

The FFNPT will create a club of 'haves' and a larger group of 'have-nots', similar to the NPT, which made the distinction between 'nuclear haves' and 'nuclear have-nots', with the 'haves' deciding terms for the 'haves-nots'.

13. Energy affordability will determine the pace of the transition from coal to renewable energy.

As for other developing countries, India's development is more than just an incremental growth. The country needs to undertake sizeable infrastructural development, substantial augmentation of industrial production and productivity, improve supply of amenities and services, and create employment opportunities for a vast majority of the demographically youngest population in the world. This requires affordable prices for essential inputs such as energy and its easy accessibility. Presently, coal essentially determines the baseline energy prices in India. As the energy storage technologies develop and become more cost-effective and the cost of solar panels and wind turbines is further reduced, the energy supplied by modern renewable-storage systems will gradually compete with coal power independently in the market. However, the displacement of coal power by renewable will take place only once the costs and bankability of latter cross certain thresholds securing margins for the industry. This will take time if we consider past energy transitions. Notably, solar PV and wind penetration in global primary energy today have reached 2.3% only after over three decades of the Climate Convention.

Developed countries' experience of deploying solar PV and wind power is insightful in this context. The rising share of solar and wind correlates well with the domestic and industrial supply tariffs. Bjorn Lomborg of Copenhagen Consensus, Denmark (Lomborg, 2024), examined domestic and industry electricity supply prices in countries worldwide. The trend indicates that higher supply prices correspond to higher solar and wind generation in a country. Denmark, with the highest renewable penetration of 60%, emerges as the costliest, with about 42 cents per KWh supply price. The Netherlands and the U.K. followed with a tariff of around 35 cents per kWh with about 30% penetration. Several other EU countries crowd around 30 cents per KWh. The USA, with about 15% penetration, is at 14 cents per kWh, while India, with 10%, is at 10 cents per kWh. In this context, reflecting on the cost of renewable energy integration, Vaclav Smil, in his article published (Smil, 2021) in IEEE Spectrum in November 2020, notes about the situation in Germany:

> "The new system, using intermittent power from wind and solar, accounted for 110 GW, nearly 50 per cent of all installed capacity in 2019, but operated with a capacity factor of just 20 per cent. (That included a mere 10 per cent for solar, which is hardly surprising, given that large parts of the country are as cloudy as Seattle.) The old system stood alongside it, almost intact, retaining nearly 85 per cent of net generating capacity in 2019. Germany needs to keep the old system to meet demand on cloudy and calm days and produce nearly half of the total demand. As a consequence, the capacity factor of this sector is also low. It costs Germany a lot to maintain such an excess of installed power. The average cost of electricity for German households has doubled since 2000. By 2019, households had to pay 34 US cents per kilowatt-hour, compared to 22 cents per kilowatt-hour in France and 13 cents in the United States.".

The above two analyses of the developed countries' experience point to essentially two broad aspects: (1) Solar PV and wind power supply to a grid is quite costly (2) Dispatchable capacity needs to be maintained in parallel to supply when the sun is not shining, or wind is not blowing.

On the other hand, despite the massive solar PV and wind energy program underway in India, the impact on the electricity tariff (household and industry) is not generally directly discernible. This is primarily due to the low power grid penetration of renewables, which is only around 10% presently, and how individual cost elements get obscured in the electricity accounting and tariff structures. However, as observed in the developed countries, the rise in electricity tariffs will become visible in India as well. It could be higher depending on the investment required to augment the Indian power grid. Notably, the EU power grid is metaphorically referred to as the 'copper plate' by some, suggesting an idealised notion of freedom of power to flow freely without experiencing the bottlenecks. The correlation between variable generation grid penetration and electricity supply prices is appreciated for other factors while implying causation, as utilities and the government occasionally bring many cost elements into the supply prices. At the same time, a correlating pattern between supply prices and grid penetration is reasonably apparent. The paradigm is further examined concerning significant cost blocks, which better clarify this generally vexed situation.

The recent pace of solar and wind capacity addition worldwide has been triggered by governments' incentivisation and dramatic cost reductions driven mainly by technological advancements and economies of scale. The sectoral enablement, however, shows up in the tariffs for the end customer. Further, the existing dispatchable capacity (over 70% for the EU grid), mainly hydro, coal and nuclear, absorbs the renewable variability. However, the case for developing countries, many of which have barely started building the electricity infrastructure, is different. They cannot make two parallel systems based on variable renewable and other assets providing dispatchable power. At the same time, as the penetration of variable capacity will increase in India, it will require, in addition to specific grid augmentation, either further buildup of dispatchable capacity or installation of energy storage assets, lest the power grids become unreliable.

Both the above mentioned grid stabilisation approaches have significant costs. The experience of developed countries, which is presently preliminary as energy storage is in its infancy, is in front of us. Additionally, the cost of cycling the dispatchable assets is often overlooked. The increase and decrease of load of a coal plant (also nuclear) reduces hardware life and increases unplanned outages. The resulting costs are difficult to capture in tariff calculations but must ultimately factor into the supply prices.

On the other hand, energy storage has its challenges, both technological and cost related. Pumped storage has permitting/ siting issues but remains the only mature option. Many other technological ideas are being pursued but stay in the ideation or developmental realm. Different types of batteries, compressed air, hydrogen, ammonia, hot rocks, weights etc. are being tried. Market penetration of new technologies, however, takes time.

Popular perception places Li-ion batteries as a viable energy storage option. However, their present usage is mainly for short-term reliability services like grid frequency regulation, energy arbitrage etc. as these batteries fare well as an alternative to gas turbines used for such grid ancillary services. The operational duty here is short exchange of quick energy rather than long-duration storage. In the context of storage, it is essential to distinguish day-to-day variability (random changes in clouds/wind) from long-duration absence of generation during nights or prolonged cloudy or low wind days. Long-duration storage (generally anything higher than 8-10 hours) requires deep charge-discharge cycles, unlike low-depth charge-discharge in presently deployed batteries, resulting in reduced battery life. As it is, the typical life of contemporary batteries (like 15-20 years as an order of magnitude) does not compare well with the long life of dispatchable assets, like coal-fired plants, which can easily have a life longer than 5-6 decades.

The current atmospherics around renewable energy, specifically solar PV, due to cost reduction and government incentivisation, has fuelled worldwide enthusiasm. Indeed, there are situations where solar PV and wind value exceed their costs, particularly as replacements for diesel generators and schools, hospitals, etc., in off-grid locations. The current momentum overlooks the layered reality of additional expenses, which appears only after reaching a certain threshold in grid penetration. These systems' costs and the fact that 1000 MW coal substitution requires more than 3000 MW solar/wind make variable renewables costlier. The misleading nature of the 1:1 comparison of per MW costs easily misses additional costs. The rising extreme weather events and the renewable euphoria bring an expectation for developing countries to transition to solar PV and wind quickly. The challenge-laden reality will eventually precipitate, but by that time, these countries' dispatchable assets industry (hydro, coal and nuclear) would have weakened beyond recognition. The utility of solar and wind in certain specific situations, and perhaps in the long term due to the energy security it entails, is undeniable. However, the high costs place them beyond any immediate consideration for national energy strategy, unlike coal, hydro, and nuclear.

Before we rush to kill all coal, the world first needs to focus on the extravagant lifestyles of developed countries. The need for superabundance and excessive consumption in their highly materialistic societies, personalised as well as superfast transportation and wasteful food habits, which all require hyper-industrial activity in these countries, may be worth the pause.

In the same vein, the natural gas linkage to the suddenness of energy security sensitivities displayed by the developed countries also needs some reflection. Looking closely, natural gas is just the current energy flavour; otherwise, the last century is replete with examples of the centrality of coal and oil based energy and the position of paramountcy accorded to them by the developed countries in all governance matters. Energy was somewhere at the root of the two great wars. Japanese incursions in Manchuria (1931 onwards and offensives starting 1937), and the German Wehrmacht movement towards Azerbaijan in 1942 may be recalled as these were tied to their strategic interests with the primary aim to secure the oil fields. The well-known oil shocks of 1973 and 1979 are just another reminder of energy being used as a weapon. These events changed the world forever, establishing the link between energy and national security. The first resulted in the shortages and quadrupling of oil prices in the after-months of the Yom-Kippur War. The second was the result of the Khomeini taking over after the ouster of Mohd. Shah Reza Pahlavi. The event created a shift in relations of the developed world with Iran, specifically, following the 444-day hostage crisis at the American embassy in Tehran. Oil prices, which generally remained around $3 per barrel, went up in the $12 to $13 per barrel range in 1973, and crossed $38 in 1979. The events broke the monopoly of a few companies, freeing oil while the spot market was established making oil much more costly. (Amman, 2009). The Russia-Ukraine war is simply another replay where the politics of hydrocarbon (natural gas in this case) supplies among countries exemplified that centrality again. It does not require any explanation that energy security applies equally to all nations, including the developing ones, as the format of modern societal evolution broadly remains essentially the same with all countries.

Notions that India can go completely 'green' immediately or take dramatic steps, such as ceasing all old and new coal commitments with immediate effect are beyond even the realm of speculation. Post COVID-19, when the world is at a crossroads, torn by wars, the foremost priorities of the Global South lie in restoring the economy to its normal condition, restoring normalcy in businesses, commercial and social life, and partnering in global endeavours to address climate change. The Global North must not procrastinate anymore or free ride but rise and live up to their promises of providing new and additional financial resources, technology transfer and capacity-building support to the Global South so that climate action can take new steps forward.

The climate question, therefore, is all about the extremely high energy emissions of the developed countries. There were no international conventions or treaties when the Global North developed, mainly by amassing wealth through industrialisation enabled colonialism. Coal was the engine behind the booming growth in the developed countries during this industrialisation. Today, the focus of current climate negotiations is more on who will use how much energy in the World and how not to allow the developing countries to use their endogenous resources and throttle their growth, rather than meaningful emission reduction in their own territories by the developed countries. The sudden obsessive focus on coal, though understandably symbolic and targeted to blame the developing countries, only derails global climate action from the path of the Paris Agreement. The core of this agreement remains in the voluntary nature of selecting NDCs (Nationally Determined Contributions) along with the continuous ratcheting of ambitions. The Indian NDC ambitions were revised upward in 2023. Being home to one-sixth of humanity, India walks the talk on climate change and is committed to immediate, consistent, ambitious, and planned efforts to address climate change, covering every sector of the economy. Being an ancient civilisation with no history or ambition of subjugating or conquering any other nation, and being the largest democracy with profound reverence for mother Nature, empathy for all fellow species on Earth and being a leader with climate-friendly lifestyles, India speaks from a position of strength and responsibility on the global commons.

From such a perspective, considering India's low coal consumption and emission levels and the fact that India is well within its fair share of the global carbon budget, the call to stop coal sounds ridiculous. External agencies' micro-management of the country's energy planning distorts the economy, breaking the clean energy momentum. India, relying on its endogenous strategic coal reserves and its climate-friendly lifestyles, merits appreciation from the world.

Eventually, all countries need to decarbonise. In the pursuit of embarking on a long-term low emissions development pathway, India will continue to use a judicious mix of solar, wind, geothermal, biomass, nuclear and hydro (both small and large) resources, constantly separating its economic growth from carbon emission to reach the promised net-zero goal by 2070. During this spectacular journey, coal will be a constant companion and supporter, helping generate the resources that will make a shift to modern renewable technologies possible at our own terms. Climate change is a global collective action problem. Besides robust domestic efforts to separate carbon emissions from economic growth, India has also conceived, mooted, formalised, and nurtured global alliances such as ISA, CDRI, and GBA to address global climate change. As the World's largest democracy with a climate-friendly lifestyle, the 1/6th of the human population it represents, India spreads the message of hope and optimism, believing and advocating that the whole planet Earth is one family, reiterating its ancient wisdom.

14. Climate Leadership espousing energy self-reliance.

With its ~1.4 billion population and abundant natural resources, India stands as a world in itself. The transformation of the country into Viksit Bharat by 2047 requires an adequate energy quantum to match the requirement of raising per capita consumption from current meagre levels. As said before, the annual per capita consumption is only 27 GJ, which is much lower than developed countries, which are higher 7-10 times. The energy vision ought to consider such chasm as targets espoused by developed countries for Global South like the DSL (decent living standards) were palatable in the times when poverty alleviation used to be the only political slogan. The very high energy consumptions in certain middle eastern countries or the USA may be profligate, nevertheless, some regions of India mirror the future which will be far higher than the DSL concept. The exact energy target numbers will unfold only over coming decades as these among other factors are linked to the technologies at hand. Obviously, the current per capita 27 GJ which is over 60% less than the world average cannot continue. It will need to be significantly ramped up to meet the social and development needs of India.

India's energy policy, therefore, must adopt a holistic approach encompassing all energy options at its command, i.e. coal, hydro, nuclear, solar PV, wind, and biomass, while giving a hard look at the petroleum and natural gas situation and even exploring geothermal, tidal, and wave energy. Extremely high dependence on hydrocarbon imports while having SPR (strategic petroleum reserves) of only of 9.5 days (GOI, 2024) need to be a top priority. Many developed countries comply with the IEA guidelines of 90 days (of previous imports). Recent Indian activities in coal mining, coal gasification, coal generation fleet, etc., indicate a general coal-inclined approach after a decade long pause. However, a clear, long-term coal policy remains essential as it fosters industry trust and stimulates private investments. This is essential not only for reducing energy costs but also for garnering energy security. Stable policies encourage coal-specific manufacturing infrastructure and services, expertise development/retention, and technological advancements, especially as coal faces global criticism and phasedown. The focus on advanced coal technologies based on gasification, pressurised combustion, oxy combusion etc. can further reduce local pollution (ash, SO_x, NO_x, mercury, etc.) and also carbon dioxide emissions. As it is, even contemporary technology for coal utilisation is a far cry from the stigmatised past of coal, which resulted from excessive use in the developed countries based on primitive technologies to amass wealth. The bottom line is atmanirbharta, not only for primary energy supply but also for the technologies and the materials required to construct the energy infrastructure assets.

Energy affordability must remain a central consideration in selecting and developing the right energy strategy for India. Ignoring this reality will only slow down the energy transition from coal to renewable which is such a crucial dimension to the global climate action. Economic situation and realities of India will keep bringing the energy workhorse back to coal irrespective of the strategy adopted. Last year saw a sudden rush to add power generation coal capacity, focus on coal mines auctions and so on after a long glut. Policy zig-zag however results in increased costs as it disturbs the industry flows and trust which is the foundation for private investments and bankability of projects. Such increased costs and disturbed industry resources including competence, expertise etc. adversely affect clean technology development.

Energy transition requires confident and steady march on the right path howsoever radical it may appear in the short term. Pressing the modern renewable pedal by importing technology and materials will only amplify this zig-zag. The experience from other countries of rising energy prices stands before us. The slightest hint of war put the Europeans back in the arms of coal. LNG procurements from the USA and other countries are being frantically resorted. We ought to notice that Indian energy imports are already high. Social and developmental needs and aspirations of ~1.4 billion are to be met, which have hitherto remained neglected. India will need to develop all the primary energy sources including the untapped nuclear and underutilized small and large hydro, geothermal and marine resources, leaving no stone unturned. Our own policy analysis should suffice to select the right pathways without the need for costly back and forth field/societal experience which also has social pitfalls as higher energy prices directly impact the common man across the country. India's vision of Atmanirbhar Bharat will appeal to all self-respecting nations. Such nations should also adopt a responsible attitude towards the global climate, especially if protecting it is feasible within the broad ambit of acquiring self-reliance. Each nation has to find its calling and build its destiny. Each has to utilise its strengths and natural and other resources. The strategy to utilise endogenous energy reserves while using technology to make a responsible impact on global climate action can motivate all developing nations. The fundamental weakness of building up their nation's journey paths on maps created by developed countries for their perspective and consumption mostly suiting to their interests is universal. The energy strategies, net-zero pathways and dialogues seldom have a bottom-up approach and originality.

An energy strategy for India largely based on coal, aligning with a net-zero pathway, may raise concerns about local pollution due to the popular perception about coal. Such views stem primarily from the historical experience of developed countries, where industrialization unfolded under the skies choked with smog and the sharp bite of sulphur for centuries. Chinese cities also faced similar situation till recently which was due to rush of low technology deployment with an intention to pace up development during former times. Coal's image remains trapped in that past, overlooking the significant technological advances made in recent decades. Today, pollutants like $PM_{2.5}$, SO_2, NO_x, Hg, and dioxins can be effectively controlled through flue gas desulfurization (FGD), NO_x reduction systems, electrostatic precipitators, bag filters, tall stacks, benign coal ash utilization and so on. Advanced coal conversion technologies promise near-zero emissions and discharge. Indian coal, with its naturally low sulfur and chlorine content, is inherently less polluting. Its very high ash content, which posed disposal challenges in the past, binds many pollutants, lowering their atmospheric release. The ash has found its own place in brick making, cement, road construction etc. Today coal ash produced in power plants is sold. India has learned how to burn its coal responsibly and minimise and mitigate the pollution.

The developed countries themselves were on course to continue coal use, not by tolerating pollution but by improving emissions performance. Until recent years, their strategies focused on enhancing coal plant efficiency. The shift away from coal in countries like the United States was driven not by pollution concerns, but by the sudden availability of cheap natural gas. Without these gas finds, the trajectory would have been to clean coal, not abandon it. Unable to address climate change concerns in their own territories and yet in the zeal to appease domestic climate constituencies, the Global North is of late, portraying coal as the chief villain— a narrative that can be challenging for many developing countries. For India and other emerging economies, the question is not whether to use coal, but how to use it sustainably. In the context, we must remind ourselves that energy access remains the first rung on the ladder to human development— a stage where developed countries stood not too long ago. India has both the technical solutions and institutional capacity for developing and deploying technology to minimize pollution risks. Only little more focus, investment and faster implementation are needed. For Global South coal shall remain a constant companion and a pragmatic bridge towards prosperity as well as net-zero as the available technology has made its use cleaner, smarter, and more accountable.

Once India broadcasts its coal-based vision and strategy to the world, coal-rich developing economies will be directly attracted. Other developing nations would like to imbibe the approach of achieving self-reliance through correct path selection enabled by technology. The industrial technology R&D can also be harnessed to help other countries. India has the competencies and skills, and institutional set up for such purposes. This will also be a powerful lever for bilateral diplomacy channels.

The specific strategic elements need to be based on the following actionable thematic paths:

- Developing a long-term coal use trajectory as part of the overall energy strategy and clearly voicing the intention to the world and own industry as part of the net zero pathway.
- The energy strategy must target the dramatic reduction of oil and gas imports based on coal-to-chemical pathways, reinforced using renewable energy sources (EVs, hydrogen, ammonia, etc.).
- Hydroelectric, nuclear, and variable renewable sources are to be ramped up with a hawk's eye on the price of energy to ensure that it remains within the affordability of the masses.
- An intense national focus on domestic R&D for clean coal technologies unto advanced carbon conversion covering power generation and chemicals while synergising with modern renewable technologies.
- Establishing a controlled long-term test on a large pilot power grid microcosm fed by incrementally increasing contributions of variable renewable energy to confirm the design features/assumptions, storage needs, accurate detection of costs, etc.
- The WTO/TRIPS amendment for technology IPRs initiated by the developing countries is to be concluded with reinforcement by the UNFCCC's decision to transfer technology IPs under the aegies ot CTCN to enhance global cooperation.
- Powerful advocacy on all international platforms of India's strategy and necessity of coal energy, with a firm, actionable, visible pathway commitment towards net zero by 2070.
- Focus on climate negotiations to acquire leadership among developing countries with the new 'climate through technology' strategy to be pushed through the G20 on the march towards COP33 to UNFCCC.

Each of these paths requires full-fledged program development, appropriate resource allocation, and astute project management. The existing budget lines of different Ministries should be sufficient to cater to such works as most are soft initiatives, while for technology development, reappropriation/diversions from current R&D spending, energy/climate levies/subsidies/etc. could be planned. Radical as the pitch may appear, the brave ideas are original and developed ground-up with little possibility of alternative routes. Under Article 10 of the Paris Agreement, technology cooperation will also be a good negotiating lever. Any delay or laxity by developed countries will give India a countering story. This does not conflict with the above-suggested approach, as IP and IPR technologies will only accelerate the Indian program. Otherwise, India has all the capability to develop such technologies, but these are time-consuming undertakings. Such developmental work includes lab experimentation and field trials, which take months in planning, procurements, installations and test periods.

An alternative path has opened up with the Republican Government in the USA during the Trump 2.0 Presidency. The new President signed a slew of office orders on the first day of joining. Energy appears to be a key dimension which has been targeted by the new administration. President Trump declared a national energy emergency, promising to fill up strategic oil reserves and export U.S. energy all over the world. Despite the USA being a developed country in the world, he laid out a plan to maximize U.S. oil and gas production - including by declaring a national energy emergency, stripping away excess regulation, and withdrawing the U.S. from the Paris Agreement (Biniaz, 2025). The orders are envisaged to reduce consumer prices and improve U.S. national security. He also signed orders aimed at promoting oil and gas development in Alaska, reversing efforts to protect vast Arctic lands and waters from drilling. The U.S. also will end leasing to wind farms and revoke electric vehicle mandate. The moves signal a dramatic U-turn in the USA's energy policy after Biden administration sought to encourage a transition away from fossil fuels. The new administration's Greenland strategy is also foundationally anchored into the vast oil and gas reserves. USGS (US Geological Survey) had earlier confirmed such undiscovered reserves to be potentially among the world's biggest. The move indicates deep energy focus of the new administration as its both neighbours, Mexico and Canada besides USA itself already have abundant oil and gas reserves. Ironically, the fossil energy reserves, hitherto commercially unminable due to thick ice sheet, are becoming available due to climate change as the ice sheet is thinning down.

The controversial nature of many of the new U.S. administration's decisions aside, the critical role of energy in a nation's economy, industry, and specifically employment is undeniable. When energy can reshape the politics of a wealthy democracy like the U.S. prompting declaring a national energy emergency, India's case—given its long journey toward Viksit Bharat 2047—cannot be more pressing. The rise of industrial economies has, without exception, relied on the availability of cheap energy. Initially, coal was the driving force, much later supplemented by oil in the last century and more recently by natural gas. The significance of this foundational element, upon which macroeconomic expertise and technology R&D ecology thrive, is deeply rooted in history. Developed countries have always understood it well. They suffered the coal smog and smells from its burning sulphur for centuries. Oil gave rise to new dimensions of geopolitics the way we know it today. Utilisation of such cheap energy became the foundation on which all wealth was amassed. China is the latest beneficiary of this modern age reality. For India, with its vast population and development aspirations, the importance of affordable energy is imperative and cannot be overstated. The actions of developed nations—and most recently the U.S., in its pursuit of self-interest—offer crucial lessons for developing countries.

Considering the approach of the new administration, Americans are likely to be open to similar carbonisation strategies by India for removing its developmental deficit. Many clean coal technologies were also developed by the USA until the early 2000s. The resulting technology IP and IPRs are of no use to Americans, who are now fully tilted towards the natural gas. These can be acquired on bilateral terms or under the Article 10 of the Paris Agreement. Such IP and IPRs can easily be independently generated in India, but the time to harness technologies will be significantly reduced if these are acquired even partially from outside. In any case, specific minimum work needs to be carried out within the Indian institutional set up of labs-academia-industry as one key aim will be to develop the necessary ecosystem for technology development and innovation. This will get transferred to renewable technologies and the hard-to-abate sectors, enabling other developing countries to follow bilateral terms.

The new pathway embracing all available sources of primary energy with coal at the centre stage becomes an excellent strategy to unfold and navigate as we move towards the forthcoming COP33 proposed to be hosted by India. It would create an example for other countries, specifically developing countries, to chart their own custom-created developmental and climate trajectories rather than traversing borrowed roadmaps.

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सत्यमेव जयति नानृतं सत्येन पन्था विततो देवयानः।
येनाक्रमन्त्यृषयो ह्याप्तकामा यत्र तत् सत्यस्य परमं निधानम्॥

"satyameva jayati nānṛtaṃ satyena panthā vitato devayānaḥ.
yenākramantyṛṣayo hyāptakāmā yatra tat satyasya paramaṃ nidhānam.."

--Mundaka Upanishad 3.1.6

Truth alone wins, not falsehood; by truth, the path of the Devas (the Devayanah) is widened, that by which the seers travel on, having nothing to wish for to where there is that—the highest treasure attained by truth.

Cover: *Back*

A stockpile of coal.

Coal pricing in India, until the 1990s, was determined by the Government under the Colliery Control Order of 1945 and the Essential Commodities Act, 1955. Thereafter, steps were taken towards sectoral deregulation with the introduction of the Colliery Control Order, 2000 which superseded the earlier order. The pricing of non-coking (steaming) coal was based on grades determined by Useful Heat Value (UHV), which was calculated using a formula considering the coal's ash and moisture content. However, about a decade ago, the traditional UHV based classification was replaced by a more precise Gross Calorific Value (GCV) based system. The new system is based on heating value of coal, expanding the older 7 grades system into 17 grades.

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