APPROACH TO **INTEGRATED ENERGY POLICY**

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CENTRE FOR A **People-centric Energy Transition**

Global Energy Alliance for People and Planet
GEAPP

About Ashoka Centre for People-Centric Energy Transition

Ashoka Centre for a People-Centric Energy Transition (ACPET) is a transdisciplinary initiative focused on advancing a sustainable, secure, and equitable energy transition for the Global South, with a particular emphasis on India. ACPET envisions a pathway where India's commitment to achieving net-zero emissions by 2070 leads to widespread societal well-being. As this transformative journey unfolds, ACPET aims to address a crucial knowledge gap by developing a deeper understanding of energy transition technologies, financing mechanisms, evolving energy markets, and policy frameworks that cater to the unique needs of India and other Global South countries.

ACPET is dedicated to building frameworks, pedagogies, and solutions that are both context-responsive and people-centered, and fostering progress across the three pillars of sustainable development — economic, social, and political. The Centre's work emphasizes not only theoretical model-building, but also on-ground testing, iterative feedback, and the creation of adaptable, responsive processes and solutions. ACPET is among the 28 'Centres of Excellence' within the International Foundation for Research and Education (IFRE) at Ashoka University.

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About GEAPP

The Global Energy Alliance for People and Planet (GEAPP) is dedicated to addressing energy poverty and the climate crisis by scaling green energy solutions in developing and emerging economies. These regions face heightened climate risks, with warming of 2-3°C threatening health, education, job prospects, and gender equality. Without intervention, fossil fuel reliance could lead to 75% of global emissions originating from today's energy-poor countries by 2050, driving a global temperature rise of about 2.5°C. Despite the record-low cost of renewables in high-income countries, developing economies receive only a small fraction of green financing and renewable installations, underscoring the urgent need for investment in sustainable energy access**.**

GEAPP is a collective movement focused on unlocking green energy access across Africa, Asia, Latin America, and the Caribbean, aiming to build an inclusive and resilient future for all.

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- BEE – Bureau of Energy Efficiency
- BRSR – Business Responsibility and Sustainability Report
- CAGR – Compound Annual Growth Rate
- CBAM – Carbon Border Adjustment Mechanism
- CCS – Carbon Capture and Storage
- CCTS – Carbon Credit Trading Scheme
- CERC – Central Electricity Regulatory Commission
- CSR – Corporate Social Responsibility
- DBT – Direct Benefit Transfer
- DSM – Demand Side Management
- ECBC – Energy Conservation Building Code
- ESCOS – Energy Services Companies
- ESG – Environmental, Social, and Governance
- EV – Electric Vehicle
- FAME – Faster Adoption and Manufacture of Electric Vehicles
- GDP – Gross Domestic Product
- GHG – Greenhouse Gas
- GNI – Gross National Income
- GRI – Global Reporting Initiative
- IC – Internal Combustion
- IcoE – International Centre of Excellence
- IEA – International Energy Agency
- IEP – Integrated Energy Policy
- IoE – Institutes of Eminence
- ISA – International Solar Alliance
- LCF – Low Carbon Farming
- LNG – Liquefied Natural Gas
- LPG – Liquefied Petroleum Gas
- MNRE – Ministry of New and Renewable Energy
- MoEFCC – Ministry of Environment, Forest and Climate Change
- MoSPI – Ministry of Statistics and Programme Implementation
- NDC – Nationally Determined Contributions
- NEMMP – National Electric Mobility Mission Plan
- NRF – National Research Foundation
- NZE – Net Zero Emissions

- OSOWOG – One Sun One World One Grid
- PAT – Perform, Achieve and Trade
- PCRA – Petroleum Conservation Research Association
- PLI – Production Linked Incentives
- PM-KUSUM – Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan
- PNG – Piped Natural Gas
- PWHR – Pressurized Water Heavy Reactor
- RE – Renewable Energy
- RPO – Renewable Purchase Obligations
- SECI – Solar Energy Corporation of India
- SERC – State Electricity Regulatory Commission
- SMEs – Small and Medium-sized Enterprises
- SMR – Small Modular Reactor
- TOE – Tonne of Oil Equivalent
- TPP – Thermal Power Plant

Chapter 1.0 Introduction

The Integrated Energy Policy (IEP), a new way of thinking about the policy framework for energy issues in India, is being led by the Founders of the newly established Energy Transition Centre at Ashoka University, with assistance from the Global Energy Alliance for People and the Planet, India. This document, the 'Approach to IEP', outlines the exercise and draws out the principles that will underpin the IEP.

During drafting the IEP and its chapters, the approach in each of these principles is fleshed out and finally synthesized as common principles to be followed by all the energy demand, supply, and interlinking sectors.

1.1 Rationale for an Integrated Energy Policy

There have been several attempts at developing an integrated energy policy. These have gone beyond intersectoral issues and provided detailed suggestions on how sectoral issues need to be handled. The main drawbacks of this approach are that since there is no common policy framework, substitution possibilities between the various energy sectors and sources do not get addressed. Thus, given the fungible nature of energy sources, there is a need for a policy framework that recognizes inter-fuel substitution possibilities and delivers optimal outcomes.

It is also essential as sectors like Power, Renewables, Transport, Information Technology, where long term planning has been done traditionally in separate institutional setups, are now seen as converging. There is a need to have a holistic approach at policy, regulatory and market development levels to enable holistic growth. Moreover, future energy systems will be far more decentralized, and consumer focussed than ever before. This makes the Integrated Energy Policy far more relevant than in 2008-09, when it was first conceptualised.

Further, India has agreed with the rest of the world to move towards Net Zero Emissions (NZE) by 2070, which calls for aggressive interventions for energy transition. Only an integrated approach can address management and attainment of the above transition in a holistic, sustainable, and affordable manner. Also, we need to learn from the successes and failures of the past in different sectors – these have important lessons for the other sectors and the future.

1.2 Objectives

The objectives of this policy are the following:

- Ensure high-quality energy access with "Right to Energy".
- Use of energy in a sustainable manner noting India's net zero commitment in 2070.
- Reduce fiscal burden on the Central/State exchequer in meeting the national energy agenda.
- Utilise subsidies carefully to those sections of the economy that need them to either reduce risk or provide incentives for greater energy development.
- Promote domestic sources of energy and bring down imports.
- Ensure adequate energy to drive India's economic growth.
- Provide an attractive investment regime for the deployment of private capital.
- Promote India as a manufacturing hub for new energy.
- Identify issues/sub-sectors on which detailed policy statements need to be drawn out by the Government.

1.3 Principles

The IEP will attempt to draft a clear statement of the government's outlook on high level issues that impinge on the energy sector. The principles which need to be enunciated underpinning a new policy are set out below.

The Role of Government

There are many views on what the role of Government should be. One view is that the role of the Government should be to enable engagement and investment by private enterprises to achieve the above objectives. This means that the Government should provide the legal and policy framework, promote, and maintain competition, provide business models that allow private sector parties to participate, and ensure risk mitigation to protect commercial capital.

Another view is that the Government must be more actively involved in the operations of sectors. Thus, most of the energy-related sectors are still dominated by Government Undertakings, except for renewable energy generation.

It can also be argued that the Government's role is to correct for externalities and to this extent, the price of greenhouse gas emissions and/or air pollution considerations should be considered. In its role as an enabler, certain business models will need to be rethought or redeveloped. The IEP will clarify where the Government is to play what kind of role, and what the nature of involvement would be, including for example: policy making, regulatory oversight, direct investment, providing fiscal support, etc.

Role of Markets

The role of markets should describe in detail to what extent markets can or should be used to deliver on the Government's objectives. Some sectors are ready to receive large-scale capital as they are in the deployment stage — whereas others such as the hard-to-abate sectors may need some Performance Linked Incentives (PLI) to make technologies viable. The role of government in stimulating multilateral agencies, philanthropies, and others to mitigate business risks — to enable commercial capital in a competitive manner (both public and private sector), is a key market development activity.

Role of Subsidies

Following from the role of the Government and markets, is the case for the application and use of subsidies. One view is that subsidies are to be used in places that deliver the highest catalytic outcomes with the least cost to the exchequer. Other views may not have this overarching objective stated explicitly.

Subsidies may be provided to those who need it most — the poor and vulnerable. Subsidies may also be used to cover investment risk such that private capital can come in, or provide any form of risk mitigation.

The financial instruments that can carry the subsidy should be designed according to how the subsidy monies are to be used and delivered. For example, subsidies may be used to stimulate demand or incentivize supply — and accordingly, may be designed as offtakes, options contracts, capex subsidies, opex subsidies, tax incentives, and so on.

The Role of a Regulator

The most important question is whether India needs an independent statutory regulator for the IEP. At present, India has a full-fledged regulatory system in the power sector, no independent regulator in the coal sector, and a partial regulator for oil and gas. Going forward, India could benefit from independent statutory regulators for coal, oil, and gas. Alternatively, India could have a single multi-sectoral regulator, established with technical and market-based experience. The role of the regulator should be fleshed out, must indicate its own remit and those of the Government, and delineate what it can do, what can be left to the market, and what should be left to the Government.

The Role of Financial Systems

Over time, the financial system should reflect the country's overall objectives listed above. The uncertainty about the timing and severity of climate-related and environmental risks has the potential to threaten the safety, soundness, and resilience of individual regulated entities and in turn, the stability of the overall financial system. At the same time the financial system must be sensitized to the needs of the country's growth objectives. Chapters must address how these sometimes-conflicting objectives are to be handled. And can we derive a uniform principle that can guide the financial sector in providing services to the energy sectors? To the extent possible, developments at the Reserve Bank of India (RBI) must be considered and applied in each of the chapters.

Pricing Including Carbon Pricing & Carbon Taxes

At present, there are no inter–se pricing policies to decide on how resources will be allocated between different sectors. There exists a high level of carbon taxes, not with a view to price externality but to garner fiscal resources. Pricing in each sector follows the history of pricing in that sector. The IEP must provide pricing guidance that is uniformly applied across the different energy sources — what is the best mix of regulation and competition to send pricing signals to the market and to ensure that prices do not create political upheavals that could derail reforms? This will have to be aligned with the earlier sections on Government, Markets, and Regulation — to some extent, all these three mechanisms are working together. What changes are required in each sector needs to be examined. Arising out of this an attempt will be made to have a common pricing policy. Carbon prices must be reflected in all calculations, projections, and policies. Greater clarity will be attempted on the need for carbon taxes and prices, both together or singly.

Transparency

Considerable progress has been made in ensuring competitive bidding for energy resources and contracts. Each chapter must examine what needs to be done to ensure transparency and fulfill the objectives of the policy, sector by sector. Each sector has its own history and experience. Ideally, the policy should be such that there is no scope for arbitrage and rent-seeking.

Taxation

Prices to consumers are determined by a combination of pricing and taxation policies. Taxation policies have evolved over time with considerable differences in the treatment of each sector. How are these differences to be managed? To what extent indirect taxes can be used to promote efficient and green technologies, needs to be studied. The grievances of the resource-rich States for a higher share in taxation and incomes accruing from the energy sector also need to be addressed.

Environmental Management

Environment management needs to be tackled in an integrated manner with the active participation of local people who are the most affected by environmental degradation. Air quality in Indian cities needs serious attention, and its consideration must be built into all chapters. While air quality and climate change are related, their remedies are often different. The overarching objective will have to be reaching net zero by 2070 in a manner that is consistent with other macroeconomic objectives and the requirements of a just transition to a low-carbon future. This is a long-term objective, and, in the meanwhile, what needs to be done to control local pollution and improve the quality of people's lives has to be carefully studied and suitable solutions given.

Revenue Sharing

Should there be a common policy for royalties and cess so that the states get a fair share of the revenues generated by the production of primary energy? Chapters would also need to address how best resources are to be collected into an earmarked pool that would be used for addressing intergenerational issues and local environment management.

The larger issue in this subject is how to garner resources for Just Energy Transition. If the GST compensation cess and related other levies (NMET, excise duties on oil, etc.) are to be garnered by the Centre, then how will the states raise resources from this sector to start weaning away from fossil fuels in terms of developing skill centres, welfare institutions and other measures that will no longer be provided by oil/coal companies in the clean energy era.

Energy Security & Imports

There is a very serious need to reduce dependence on imports of fuel, rare earths, polysilicon, and batteries for the clean energy drive. This reduces the outflow of foreign exchange and provides better control over energy security. Also, greater energy independence buffers against price shocks in the international market causing domestic distress. The implications of this dependence on imports from the energy security point of view and the vulnerability to external price shocks need to be thoroughly understood and policy responses found for these challenges. This dimension must be woven into any inter-sectoral policies so that there is a clear signal that domestic sources will be preferred.

Review & Corrections

Reviews of the policy and its effectiveness should be done on a regular basis and the frequency of review made known to all market players in a transparent manner both ex-post and ex-ante. Such a review mechanism should be a normal part of policy making where the Government monitors effectiveness in a scientific manner, and where necessary, course corrections and adjustments may be made. All reviews shall be done in full consultation with market players.

Role of Civil Society Organisations (CSOs)

Civil Society Organisations, Non-Profit Entities, etc represent a significant portion of our society and are key stakeholders in driving any energy and climate policy discourse. For a “Just Energy Transition,” the role of CSOs becomes even more important. The IEP shall reflect on potential areas wherein CSOs can act as an enabler for faster policy implementation, building the right investment climate, promoting jobs and growth at the grassroot level, nudging public attitude towards energy efficiency/conservation, and catalysing action towards emission mitigation and cleaner air, etc.

Meeting India’s energy transition goals requires much more capital than expected hence a new approach to stimulating public and private financial flows needs to be designed. Philanthropy (both domestic and international) can potentially act as a catalyst for such public and private partnerships. The IEP must reflect the role of philanthropies in accelerating local action — either by taking higher risk investments via catalytic grants or technical assistance, partial risk guarantee fund/venture capital fund, or by driving research and innovations linking to long-term outcomes rather than short-term gains, etc.

Governance of the Energy Sector

India has an ambiguous situation of energy laws being largely in the Central jurisdiction, while the States that are expected to address local energy and environmental concerns. This leads to the larger energy sector goals slipping between the stools. Greater responsibility ought to be devolved upon the States which cannot be done without States being empowered to make energy sector decisions. Another area of jurisdictional inadequacy is the governance of energy and environmental sectors at the Centre. Even if the energy domain is to be handled in different ministries, there needs to be a better coordination mechanism in a body that also has the capacity to engage with specialist Ministries on subject matter issues. The IEP proposes to address these aspects, too, including what might be the mechanism/empowered structures for implementation of the IEP.

1.4 Chaptalization

As the IEP will look at the next 25 years, it needs to be futuristic. New areas such as Heat Strategy, Cooling Strategy, Hydrogen Economy, and Mobility have been added.

ENERGY DEMAND

ENERGY DEMAND
Chapter 2: Buildings Heating & Cooling

2.1 Energy Demand Categories:

The integrated energy policy must address the energy demand from buildings in a comprehensive way. Energy demand due to buildings can be classified into three distinct categories:

1. **Operational Energy**: Energy used by equipment and appliances in the building, ranging from energy used by occupants for cooling and heating, water heating, consumer appliances, and electronics — to energy used by building services such as elevators, water pumping, waste treatment and disposal, power backup, street lighting, etc. Energy used for cooking is also substantial and it often forms a large part of the building's operational energy.

2. **Embodied Energy**: Energy used during construction and in the production of building materials like cement, steel, glass, doors, windows, blockwork, etc., as well as mechanical, electrical, and plumbing systems.

3. **Service Energy**: Energy use for transportation of people and goods, municipal services, like water supply sewage treatment, street lighting etc. during the life of the building. This service energy use includes both operational and embodied energy due to the services and transport infrastructure and falls beyond the boundary of the building itself.

Energy use in buildings in India is likely to look very different in the future. As urban areas expand, more rural buildings are rebuilt in concrete, and appliance use increases, all three categories of energy use will increase. Factors such as; the rapid increase in cooling and heating demand, adoption of electric vehicles, transition to electric cooking, smart controls, and appliances, as well as large-scale integration of renewables in buildings are already changing the way buildings use energy. Buildings, in the future, will also be a source of clean energy with integrated renewables on rooftops and façades.

Buildings are already using integrated building and energy management systems to respond to the energy supply and demand scenarios on a real-time basis. The future lies in the true integration of buildings with energy production and supply systems as the critical last mile of the smart grid.

There is a well-established trend of increasing energy and emission intensity of buildings, which needs to be arrested. A clear articulation of building energy efficiency goals and a pragmatic approach for implementation are essential to achieve this. Energy use in buildings is dependent on the behavior of its occupants, owners, and operators. Managing building energy demand requires multiple agencies and actors to work towards this goal in tandem.

2.2 Objectives:

This Policy document lays out the policy options to address both the increasing energy intensity of existing buildings as well the accelerating energy demand due to new buildings and urbanization. The Policy has the following objectives:

- Decarbonizing the building sector.
- Reduce energy use intensity of buildings and cities.
- Promote renewable sources of energy.
- Ensuring high-quality energy access with “Right to Energy”, especially for the rural and urban poor.
- Use of energy in a sustainable manner noting India’s net zero commitment in 2070.
- Identify issues/sub-sectors on which detailed policy statements need to be drawn out by the Government.

The integrated policy approach proposed in this document considers all these factors in formulating the approach to responding to the future energy demand in buildings.

2.3 Background: Building Energy Use In India

India is set to more than double its building space over the next two decades, with 70% of new construction happening in urban areas. Rural Indian houses are also expected to build more concrete and “pakka” structures. With the urban population projected to increase to 60% by 2050, India’s residential electricity demand will likely triple. Of the total electricity consumption in 2021-22, the residential sector accounted for 24%, the commercial sector 9% (space cooling and heating, equipment, and appliance use), and the municipal sector 3% (electricity use in urban infrastructure — street lighting, water and wastewater treatment and pumping).

Apart from electricity, energy use for cooking is also rising. The IESS projections show that by 2047, energy demand from the buildings will rise to 2,287 TWh/year and from cooking will be 522 TWh/year; and electricity share will increase to 2,332 TWh/year and from cooking to 210 TWh/year.

As per the projections of the India Cooling Action Plan (ICAP), India has one of the lowest per capita energy consumptions for space cooling, at 69 kWh, as compared to the world average of 272 kWh. The aggregated nationwide building sector cooling demand is projected to grow around eleven times by 2037-38 as compared to the 2017-18 baseline.

The Government of India has many standards, codes, policies, and plans being implemented, addressing the energy demand from buildings at its end-uses, such as India Cooling Action Plan (ICAP), the Energy Conservation and Sustainable Building Code (ECSBC), Standard & Labelling for Appliances and Equipment, Model Demand-Side Management Regulation, etc. The Energy Conservation Building Code (ECBC) has been notified in several States and an energy-efficiency-driven market is emerging for building materials and appliances.

These policies are also supplemented by programs implemented in “mission mode” across the sector. For example, Housing for All, Smart Cities Mission, National Mission on Enhancing Energy Efficiency, etc. While actions under these projects in various development sectors will proceed independently, it is imperative that synergies be forged, wherever possible, to leverage greater environmental and societal benefits.

India’s Rooftop Solar (RTS) programme aims at achieving a target of 40 GW rooftop solar capacity addition, by March 2026. JMK research estimates that as of March 2022, a capacity of 11.8 GW is in place, of which only 2.01GW is from the residential rooftop segment.

Energy is essential to meeting the country’s developmental needs and aspirations. The last decade also focused on access to electricity for all households. With electrification, increased renewable penetration in the distribution grid, the addition of end-user loads (such as electric vehicles), and increased uptake of smarter appliances and controls, the buildings, and grid form symbiotic entities of the electricity network.

The uptake of building energy policies (like ECBC) and implementation of energy efficiency programs in the building sector has been slower than expected. Buildings and their energy impact span multiple domains. Lack of integrated approach to policy and program design, low priority by the Govt, and multiplicity of agencies are some of the main reasons for this situation.

2.4 Challenges In Regulating Building Energy Demand

The operational, embodied, and service energy demand of the buildings spans multiple jurisdictions from a policy and implementation perspective. There is also a lack of reliable data on energy demand by buildings. Energy use and carbon intensity are not a priority for regional and urban planning agencies. Embodied energy is not currently regulated, and operational energy is also regulated in a limited way for large commercial buildings.

The lack of data on building energy also makes policymakers wary of introducing policies for regulating energy demand, especially in the residential sector, even though it constitutes the largest part of the building energy use. Any measure to mandate energy efficiency is seen to be increasing construction cost, and therefore making housing more unaffordable. Even though there is sufficient data to show that energy efficiency in buildings is cost effective over the lifetime of the buildings, often with a payback of less than 2-5 years, builders do not build energy-efficient buildings without a government mandate or incentive. The split-incentives make it difficult for a market-driven approach without a strong energy efficiency mandate.

Measures for strengthening the Urban/Town Planning apparatus to implement the Policy are critical. The current mandate for reducing energy intensity in Buildings is a fractured one. The implementation of the Integrated Energy Policy will require integration and linkage with policies and regulations from other departments and ministries, such as:

- Environmental Impact Assessment Notification, India Cooling Action Plan: Central and State Pollution Control Boards (PCBs), Ministry of Environment, Forest, and Climate Change (MoEF&CC)
- Housing for All, PMAY-U and PMAY-G: Ministry of Housing and Urban Affairs (MoHUA) and State Designated Agencies – Housing Development Departments, Ministry of Rural Development
- Energy Conservation Building Code, Benchmarking and Star Labelling of Buildings, Standards and Labelling of Appliances and Equipment: Ministry of Power, Bureau of Energy Efficiency, State Energy Departments

- Unified Development Plans/Regulations – State Urban Development Departments, Urban Local Bodies (Municipalities, Municipal Corporations, Town, and Country Planning Departments)
- Rooftop Solar, Smart City Mission – National Smart Grid Mission, Ministry of New and Renewable Energy
- Manual for Procurement of Goods, Services and Works: Department of Expenditure, Ministry of Finance
- Clean Cooking Fuel, PMUY: Ministry of Petroleum & Natural Gas

2.5 Goal Decarbonising the Building Sector

The Integrated Energy Policy aims to transition towards a net-zero emission building sector by 2047. The key outcomes of the policy and indicators for 2047 are given below. Interim targets can be derived from these objectives. The outcomes of the policy are to:

Reduce Energy Use Intensity in Buildings:

1. 100% building energy code compliance for all new buildings with outcome-based net-zero energy building codes.
2. Limiting cooling energy use intensity based on typology (residential and commercial) 1.3. Mandatory periodic energy efficiency retrofit of all existing buildings older than 10 years.
3. The energy use intensity of buildings benchmarked and communicated clearly.
4. Tariff incentives for occupants with a low energy lifestyle linked to higher per capita energy use.

Maximize Renewable Energy Generation and Storage at Building Level

1. Renewable energy, thermal, and electrical energy storage are integrated into buildings which transition from being “consumers” to “prosumers.”
2. 100% cooking based on renewable energy (electricity or clean biomass-based).

3. 100% of suitable and available roof and parking areas used for solar PV or thermal.

Ensure Grid Interactive & Smart Operations

1. Predictive and AI-based management of energy use with real-time communication between buildings and the grid on peak demand, carbon intensity, and pricing.
2. Buildings provide "grid services" through demand flexibility as a part of the low-carbon grid.
3. Flexibility services available for all utilities and customers to minimize emission intensity.

Decarbonize Building Materials

1. Low carbon materials and circularity as a fundamental approach to construction.
2. Reduce intensity of primary construction materials by 50% (in terms of Kg CO_2/m^2).
3. An emission accounting and disclosure system for buildings with emissions labelling of building materials and products.

Integrated Approach for Urban Design & Regional Planning to Reduce Energy and Carbon Intensity of Cities

1. Regional planning factoring in the energy demand of the cities in the region.
2. Limiting sprawl: balancing the size and density of cities through low-rise high-density development
3. Mixed land use designed to reduce intra-city travel needs.
4. Transit-oriented development with a focus on mass transport and non-motorized transport.
5. Decentralized and low-energy urban services infrastructure.
6. Urban design for reducing heat island and cooling load.
7. Integrated district cooling, heating, and energy systems.

2.6 Elements of an Integrated Energy Policy

Some key programs and policy instruments that will mitigate the GHG emissions and achieve net-zero are presented in this section. Many of the strategies are interlinked and need to be implemented in an integrated approach. The renewable energy integration and smart growth ideas will have to be implemented in conjunction to enable zero-energy buildings in the future. The current technologies of on-site renewable energy generation have restrictions in terms of space requirement, ease of integration, maintenance costs, and initial capital. Beyond a small/medium size building, and in most climatic zones of the country, achieving a net-zero energy balance by building integrated renewable energy systems is possible if approached in a holistic way.

Sustainable Land Use Policies

A growth balance approach effectively limits the supply of land available for urban expansion. The principle here is to promote the basic tenet of environmental stewardship and sustain the long-term productive capacity of land for agriculture, forestry, and valued ecosystems with their important public functions. There is also a need to account for different scales of settlements: a) Big metros b) Census towns and peri-urban areas c) Smaller towns d) Villages. While most of these policies focus on the urban areas and cities, an approach for rural areas and villages must also be developed.

The Draft Land Utilisation Policy 2013 could be referenced in this regard. Additionally, a landscape ecological approach must be used to decide on areas of conservation, etc. Set aside 'environmentally sensitive areas' and identify areas that should be 'no development zones' including productive landscapes, irrigation command areas, pasture lands, critical watersheds for recharging water sources and replenishing traditional water systems, and areas that sustain tribal populations. Identify and conserve all traditional water harvesting systems and surface water bodies.

With rapid industrialization, urbanization is accelerating in the metropolitan cities. India lost about 1.5 million ha of land to urban growth from 1955 to 1985, and a further 0.8 million ha was added by the year 2000. The percentage of people in urban areas has been growing, the size of large settlements has been increasing enormously, their nature has been changing, and to some extent, urban and rural areas have become less distinct, particularly in the metro regions. Urban impacts occur within cities, around cities, and even long distances away. One of the impacts of urbanization with a global dimension is the emissions of GHGs. Industrial growth and increasing urbanization in India have led to associated environmental changes. The vehicular population has grown at around 13% per year during the last decade. Motor vehicles are estimated to contribute 8% of the total fossil fuel-related CO2 emissions in India against the world average of approximately 15%.

One popular approach to assist in smart growth is to require prospective developers to prepare environmental impact assessments of their plans as a condition for state and/or local governments to give them permission to build their buildings. These reports often indicate how significant impacts generated by the development will be mitigated - the cost of which is usually paid by the developer.

As land cover, urban settlement represents the most profound alteration of the natural environment (in the flows of energy, water, and materials) through the imposition of structures, buildings, paved surfaces, and compacted bare soils on the earth's surface. Buildings alter the incoming solar energy, the rainwater from the clouds, and the wind to different paths, leading to pollution and biodiversity loss. While most such changes or environmental impacts are often seen at the spatial scale, these discrete changes reach a global dimension by patchwork addition, in a process identified as globally cumulative (Turner et al .1990b).

Sustainable Urban Development Policies (Smart Growth)

With electricity, there is a cost associated with extending and maintaining the service delivery system, as with water and sewage, but there also is a loss in the commodity being delivered.

Increasingly, environmental impacts associated with these land use conversions are becoming a significant concern in urbanizing and rural regions alike. A sustainable society is still technically and economically possible if public policies are pursued that do not focus on continued economic expansion as a problem-solving strategy but rather a transition to a sustainable society that carefully balances short- and long-term goals with an emphasis on sufficiency, social equity, and quality of life rather than quantity of outputs.

Promote low-rise high-density walk-ups as far as possible to address population pressure, build walkable cities, provide decentralized local water supply and sanitation systems, based on a circular economy (reusing wastewater), move towards treating and supplying only potable water, not all water consumed. Energy demand for water treatment and supply would be minimized.

Net Zero Building Design and Retrofit Codes.

Energy Conservation Building Codes (ECBC) are one of the most effective ways of reducing energy use and GHG emissions in new buildings. The EC Act has a provision to mandate ECBC for all buildings. The initial estimates indicate a saving potential of over 40% for most new buildings. The saving potential can be even higher for buildings that operate 24 hours a day. Total residential sector energy use is significantly more than the commercial building energy use.

Although the ECBC is a big step forward for the current business-as-usual efficiency levels in buildings, there is potential to further improve on the performance levels and efficiency of buildings. These high-performance building codes must have a net-zero energy (net annual energy use from non-renewable sources is zero) target by 2040 and progressively make the ECBC stringent till the target is achieved.

Air-conditioning will be the largest end-user in residential buildings. ECBC must directly address this by ensuring that the buildings are designed to minimize cooling requirements.

To realize building performance improvement ECBC must move to an outcome-based code strategy, one where actual energy use is the metric by which building performance is judged. This approach focuses on real and measurable energy performance improvement. The future ECBC must be outcome-based so that it can account for the way in which a building is occupied, operated, and maintained to reduce annual energy use.

It is important to set policy-based performance goals for the ECBC. Traditionally ECBC have been considered in the context of previous stringency levels. An overall code performance target changes the approach significantly and necessitates new mechanisms and metrics focused specifically on energy use outcomes in the code development and adoption process. Over a defined period, the stringency levels need to increase to usher in technological and market changes.

Net Zero and Grid Interactive Buildings

Grid-Interactive Net Zero Energy Buildings (G-NZEB) can be described as 'highly energy efficient, grid-connected buildings that meet their energy needs through renewable means, while maintaining a two-way communication with the grid' to balance demand with electricity supply. While the net zero energy building targets a net renewable energy balance only.

Buildings are now recognized as the critical last mile of the smart grid of the future. The consumers, utility, and the grid form symbiotic entities of the G-NZEB web. Demand flexibility offered by buildings and equipment is an opportunity untapped. Millions of buildings are connected to the smart grid, and the traditional model of one-way flow of energy and predictable demand is rapidly changing. Energy demand and supply flexibility in buildings along with its connected equipment including electric vehicles, and onsite renewable energy and energy storage, are the most critical aspects of the smart grid.

While grid-scale renewable energy is important for decarbonizing the energy mix of the country, the distributed energy generation and storage at the building level offers the best opportunity for balancing the demand and supply of energy. Therefore, the role of the distribution utility, which interacts with the end-user and is the last-mile connector of the smart grid, assumes the most significant role in grid interactivity. The energy distribution companies and their ability to manage energy use dynamically impacts both the national grid and the customer. Grid-Interactive Net Zero Energy Buildings can serve the needs of consumers and distribution utilities while reducing overall energy consumption, balancing the energy demand, and providing best economic value to the energy supplier and the customer. Grid-Interactive Net Zero Energy Buildings (G-NZEB) use smart technologies, on-site renewable energy sources and load balancing of equipment to provide demand flexibility while co-optimizing for energy cost, utility services, and occupant needs and preferences, in a continuous and integrated way.

Real Time Carbon Intensity Disclosure & Pricing Options for Energy (Electricity & other Fuels)

Carbon pricing is a powerful instrument to drive power sector decarbonization, as it will optimize decisions on energy procurement. End-users should have the ability to switch energy providers easily, based on such information.

Net Zero and Super-Efficient Standard and Labelling of Appliances

The current approach of the Indian Standards and Labelling (S&L) program is to drive the efficiency through ramping up of the Minimum Energy Performance Standards (MEPS) over time. This approach yields gradual increase in a voluntary way; the manufacturers are not compelled to use the most stringent labelling levels.

Significant savings can be achieved if the MEPS levels are more stringent and based on a policy goal rather than discrete potential. This approach for labelling must set the MEPS based on the most stringent technically possible and life-cycle-cost effective levels of efficiency. Higher efficiency ratings with super-efficient technologies will be required for the building energy use to meet Net-Zero mandate. The labelling must account for other energy performance factors like potential for demand flexibility, smart and connected, integrated renewable energy use, as well as low embodied carbon in manufacturing.

Building Energy and Emissions: Benchmarking and Disclosure

Benchmarking means evaluating the performance of buildings compared to others of the same type and usage. The benchmarks can help the users assess the energy efficiency of their buildings and develop strategies to improve it further. Currently, there is very scant authenticated and normalized building energy use data available in India. Globally, building energy use benchmarks have been credited for energy savings in many countries. Development of a building energy-use data collection, collation, and dissemination system will lead to a similar impact in India. Technology changes brought in by India's smart-meter transition can enable almost real-time benchmarking of buildings and energy end-uses. What to do with benchmarks? Voluntary or mandatory?

Every building being sold or leased must get an energy benchmark or energy use certificate. This enables the potential owners or users to compare the building's energy performance with other similar buildings and to assign a value to the building's energy performance in their decision-making. The historical energy use data for existing buildings, both residential and non-residential, can be used as a basis for issuing such certificates. There are several ways of normalizing this data to make comparison with other properties meaningful.

Retrofitting of Existing Buildings

The existing building market is an important untapped area for upgrades and activity. However, the amount of renovation and retrofit activity remains relatively low. There are many reasons for this, including access to funding, insufficient incentives, and lack of interest in upgrading those buildings.

Deep and necessary gains in building energy efficiency cannot continue without considering actual building performance. As the performance demands increase for our buildings – such as incorporating more connectivity, IoT, battery storage, on-site generation, frequent changes in space utilization, and other current trends – a better understanding of buildings as integrated systems is critical. Real-time or near real-time measurement and analysis of actual energy use, to optimize the building as a whole, is critical.

Public Buildings Net Zero Program

Public buildings must lead by example by requiring new government buildings to meet the most stringent energy standards. The government is one of the largest owners of buildings.

The Government, directly or indirectly, influences construction markets. The government buildings sector must lead the movement by setting a high benchmark for the private sector to follow. A comprehensive action for existing and new government buildings is required to achieve net-zero energy and emission transition. The specifications for design, materials, and equipment selection for all new government buildings need to be at par with the best available energy efficiency technology and practices in the market. Agree. Any standards or metrics to aim towards?

Building Material Carbon Labelling and Net Zero Building Materials

One of the largest elements of decarbonizing the building sector is to reduce the embodied energy and emissions in the construction materials. This is dependent on both the design as well as the type of materials used. Cement, steel, concrete, and processed metals are some of the highest embodied carbon primary materials, fuelling India's construction growth. Low carbon alternatives must be promoted through a transparent labelling program that provides information on the embodied energy and emissions of such primary materials. The sustainability building code must set the maximum limit on the carbon intensity of different building types. The carbon intensity of other buildings must be disclosed through a labelling program.

Green Building Certification Integration (Zero Certifications – Water, Waster, Energy, Circularity)

Green building certification programs have made a significant market impact. Energy efficiency and renewable energy use are key features of these certification systems. New and renovated buildings must attain a certain level of green certification. The certification ensures accountability, documentation, and should make such data publicly available.

Onsite/offsite Renewable Energy Incentives/Promotion/Standard

States, local governments, and utilities must mandate the installation of renewable energy systems along with energy efficiency measures. Maximizing the renewable energy potential of buildings must be a part of the code requirements as well as the subject of labelling programs for buildings. The policy must encourage maximizing different renewable options including solar thermal electrical biomass and other options at both the individual building as well as a community level. This is akin to millions of mini-grids working in synchronization with an interactive smart grid of the country.

2.7 Markets and Financing

EE Tax Benefits & Retrofit Incentive Program

Personal tax incentives include personal income tax credits and deductions. Many countries offer these incentives to reduce the expense of purchasing and installing renewable energy or energy efficiency systems and equipment. Similar corporate tax incentives include corporate tax credits, deductions, and exemptions. These incentives should be available to corporations that purchase and install eligible renewable energy or energy efficiency equipment, or to construct green buildings. In a few cases, the incentive is based on the amount of energy produced by an eligible facility.

The introduction of financial incentives will encourage owners to refurbish their existing capital stock and drastically reduce the environmental footprint of the building sector. Tax incentives for capital spending on energy-efficient and green buildings is now seen as a key component of a climate change strategy, which dramatically broadens the policy tools used to reduce greenhouse gas emissions.

The initial reduction in taxes allows building owners to overcome the capital constraints which often act as an impediment to improvements with longer-term payoffs, such as capital expenditures to reduce energy or water usage. The objective of the scheme is to encourage owners to replace old, energy-consuming equipment with more energy-efficient ones and to invest in energy-saving equipment. Inefficient equipment not only incurs high operating costs as they consume more energy but also have a negative impact on the environment because of higher emission of pollutants to the environment. The incentives apply to replacement machines and equipment as well as energy-saving equipment and devices.

Carbon Financing Incentives

Financially incentivizing the GHG emissions reduction in buildings is an effective strategy for goading the building sector to adopt GHG mitigating measures. Carbon financing aids in the implementation of a considered approach to sustainable design, carefully balancing initial capital costs with life-cycle costs to achieve an optimum cost/benefit ratio. Harnessing carbon finance from buildings is financially viable as the quantity of GHG mitigated is substantial.

Demand Response and Utility Incentive Programs

Such incentive programs are typically operated by a local electric utility as part of the utility's Demand Side Management (DSM) program. These programs have the same technical approach as the Demonstration Building Program but are funded and administered by electric utilities.

The electric utility can provide a portion of the incremental cost of higher efficiency equipment as rebates. These can typically target "X" % better than code minimum requirements for specific equipment. The utility should cover enough cost that the owner has a reasonable payback period for investment in efficiency, depending on the package of measures.

Demonstration Projects/Training/Professional Certification

The biggest set of barriers to GHG emissions reduction in the building sector is the lack of awareness and capacity to develop and implement EE projects. This lack of capacity to understand and implement extends from the policymakers to the financial decision makers and the engineers and tradesmen on site. Several capacity building and awareness measures need to be put together to overcome barriers at all these levels. These include demonstration projects, focused training programs, and certification systems for professionals and practitioners.

In addition to energy savings, substantial financial savings can be realized with the implementation of Design Assistance programs. As part of the demonstration, the intent is to determine the extent of energy efficiency achieved. Thus, monitoring equipment needs to be installed in each building to permit the evaluation of the actual building energy performance. Various levels of training programs need to be delivered to address the information and awareness barriers.

Chapter 3: Industrial Energy Demand

The objective of this working draft is to facilitate an informed debate amongst experts in the area of industrial efficiency and energy use. The idea is to bring out new policy drivers to promote India's industrial growth by assuring reliable energy supplies, and by leveraging energy efficient technologies. Thereby, preparing our industries to be financially attractive, environmentally sustainable and globally competitive.

3.1 Context

India, one of the fastest growing economies in the world, derives its growth mostly from agriculture, industries, and the service sector. Industries alone account for 26% of India's GDP, supporting 121 million jobs, and demand 45% of total final energy consumption which is expected to become 55% by 2047. This rising energy demand throws an important opportunity to transform our overall energy sector, which is highly interconnected and integrated, more towards an efficient and sustainable future. Unlike in the past, the future of energy supply will be determined (or driven) by the demand sectors. Industries, being the biggest energy consumers, will drive the energy supply transitions. Hence an integrated energy policy with a special focus on industrial demand becomes important.

India's energy policy, often developed in siloes, is a conglomeration of various visions, missions, commitments, and aspirations which doesn't necessarily add up. For example, India's vision of becoming energy independent by 2047 and net zero by 2070 don't align naturally with its aspiration to become a manufacturing hub for the world. To live up to the expectation is a tough call to action and hence, in this draft, we attempt to highlight a few innovative recommendations that could potentially pave the way for efficient, low-carbon growth of Indian industries and hopefully catalysing new investments into the sector.

The typical approach adopted to manage industrial energy demand in India is by allowing industries to compete and grow within some environmental restrictions and with the certain degree of efficiencies (mandatorily or voluntarily) improvement (YoY) in their processes, in a technical term called the reduction in Specific Energy Consumption (SEC) i.e., more output with lesser energy input. There is a successful market-based program, perform achieve and trade (PAT), designed on similar lines to enable the least cost efficiency gains.

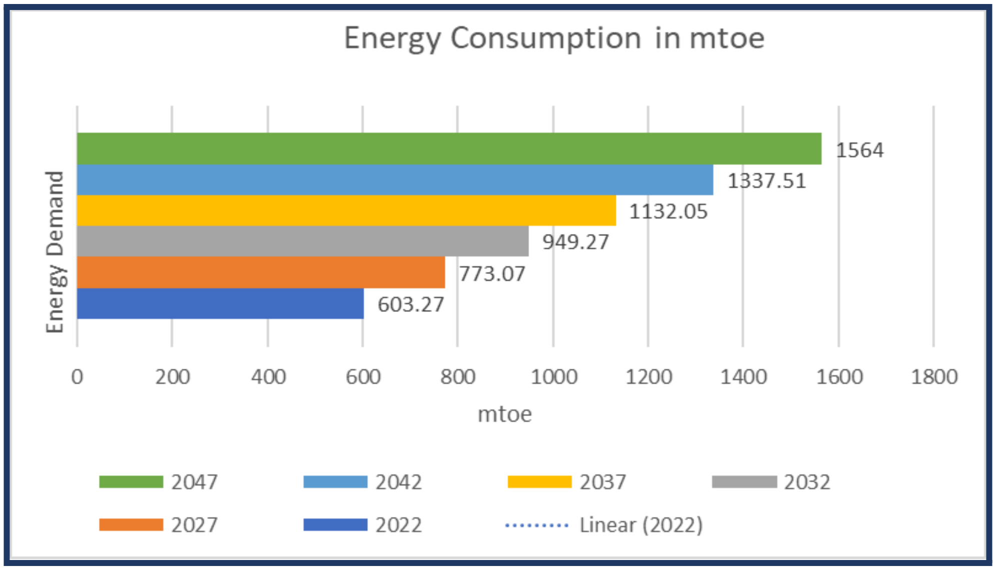
This note takes the learnings from past actions and propose futuristic and wholistic policy recommendations catalysing transformation, around:

- Innovation and technology towards efficient and sustainable growth.
- Industrial competitiveness and making the sector future ready.
- Governance for growth – incentives, compliance, and evolution of markets to drive change.
- Behavioural nudging towards energy conservation.

Box 1: Recent Achievements

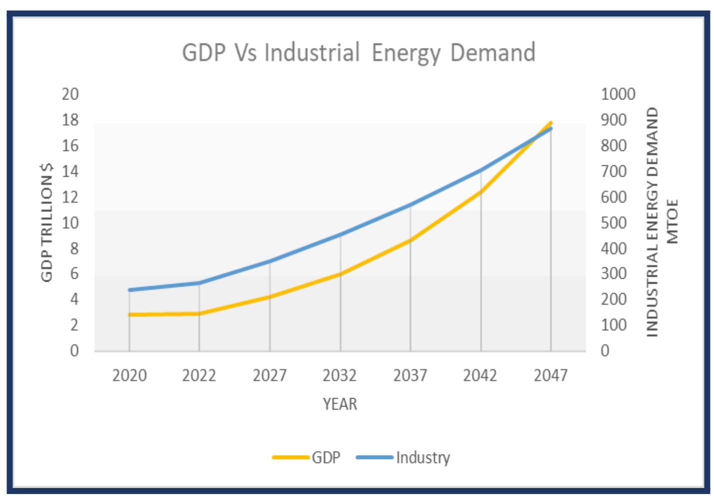
- Amendments to EC Act to include the Carbon Credit Trading Scheme (CCTS).
- CCTS notification by Ministry of Power (MoP) on 28th June 2023 with amendments for inclusion of OFFSET markets in December 2023
- BEE launched PAT in 2012. Till date, 6 cycles rolled out, covering a total of 1073 DCs from 13 sectors, with approx. 26 mtoe of energy saved, translating to 70 million tons of Carbon abatement.
- Zero effect, Zero defect scheme launched, a certification system accounting for quality, productivity, energy efficiency, pollution mitigation and technological in products and processes for SME's
- Super ESCO EESL launched, and subsequently large efficiency programs designed and rolled out Steel Scrap Recycling Policy, 2019 aims to enhance the availability of domestically produced scrap to reduce the consumption of coal in steel making.
- National Green Hydrogen Mission by Ministry of New and Renewable Energy
- Make in India, launched in 2014, aims for a self-reliant economy with global recognition. The objective is to increase the manufacturing sector growth to 12-14% per annum, to create 100 million additional manufacturing jobs, to increase the contribution by manufacturing sector to 25% by 2025.

3.2 Key Trends & Projections



With a growing economy, India's overall energy demand by 2047 is expected to rise by around 2.5 times, of which the industrial demand (particularly) is estimated to quadruple from 265 mtoe (FY 2022) to approx. 864 mtoe (FY 2047). This demand is mostly spread over 8 major energy-intensive sub-sectors, also known as hard-to-abate sectors, as mentioned in the table below, of which the top 5 sub-sectors contribute to about 50% of Industrial demand and about 50% of India's overall emission.

This primary energy demand is mostly met by coal (29%), followed by electricity (22%), oil (20%), natural gas (19%), renewables (6%) and heat (4%). While MSMEs mostly meet their requirements using electricity (76%) followed by oil and coal. (Source: IEA,2020). The energy transition pathway for India would be driven by the type of fuel demanded by the industries of the future.



In order to fulfill our energy security goals, or to achieve NDC commitments, and to move towards nett zero future, Indian industries has to:

- Electrify its energy demand.
- Greenify the electric demand.
- Scale up newer technologies like Hydrogen, 2nd and 3rd Gen Biofuels, CST, CCUS etc.
- Wider and deeper energy efficiency and conservation approaches.

Table-1: Industrial Energy Demand Projection

Demand Sub Sector	Fossil Fuel Only (2022) – exclude electricity, RE etc (mtoe)	Fossil Fuel Only (2047) (IESS) (mtoe)
Aluminium	18.00	105.3
Cement	20.25	41.7
Fertilizers	14.77	18.44 + 4.92 GH2
Iron and Steel	55.95	173.4
Petroleum Refinery	19.71	58.1
Pulp & Paper	11.00	19.6
Textile	10.24	12.8
Chlotr-Alkali	1.53	4.7

* Source – NITI Aayog IESS, BEE - PAT

3.3 Policy Measures

Below are a few suggestive policy measures which would facilitate this much needed transformation.

3.3.1 Technology and Innovation

Advancement of technologies and innovation is at the core of industrial energy transition. Continued research, development, and deployment helps industries reduce their energy demand (and therefore emissions) while continuing to grow at a certain pace.

Some of the innovative approaches and technologies that can help industries transition faster are mentioned below.

Waste Heat Management Strategy

High-grade waste heat recovered from industrial sources or processes is found to generate steam and electricity in Cement, Iron and Steel, Petroleum Refining. and Chemical processing, etc. The total estimated energy generation potential from such waste heat in India is around 5 to 7.5 GW, of which cement has the highest potential of approx. 1.1 - 1.3 GW of clean energy (Source: MNRE). At full potential, WHRS could replace the energy requirement of 8.6 million tons of coal, resulting in 12.8 million tons of CO_2 reduction, just by the Indian Cement Industry alone.

Table 2: Waste Heat Power Potential in Industries

S. No	Industry	Potential (MW)
1	Cement industry	1100
2	Glass manufacturing	50
3	Iron and steel manufacturing	800
4	Aluminum production	100
5	Metal Casting/foundries	150
6	Breweries/food industry	250
7	Petroleum refining	500
8	Chemical industry	100
9	Natural gas compressor stations	50
10	Landfill energy systems	50
11	Ceramic industry	150
12	Pulp and paper industry	50
13	Caustic Soda	400
14	Industrial boilers/commercial sector	250
15	Miscellaneous industrial sectors	1000
	Total potential WHP	**5000**

Low-grade waste heat (< 100 C) accounts for more than 50 % of the total heat generated in the industry. Industries are exploring technologies to utilize such low-grade waste heat for process cooling or heating (absorption and adsorption processes) purposes.

District Cooling and Heating Network (DCHN) using waste industrial heat is potentially an innovative way to make energy systems secure and resilient in India. The underutilized heat can be redeployed as DCHN solutions for consumers, located near a city or dense habitat, during summer and winter season (or in hilly areas).

Recommendations:

- GOI, in consultation with Industries, shall come out with an "industrial heat management strategy". Special focus must be given to renewable energy like Concentrated Solar Thermal (CST), Biofuel, Municipal Solid Waste (MSW), and Green Hydrogen. Technology specific incentives and targets shall be announced. (The Integrated National Energy and Climate Plan for France, March 2020 encourages the use of waste heat through recovery paths from industries in various processes and District Heating and Cooling. Apart from that the Heat Fund is funding and supporting such projects since 2015 for maximum utilization of waste heat)
- A study should be initiated by MNRE on the available potential of low-grade waste heat recovery in the Industry and commercial sector and bring it to the larger ambit of the Carbon Market (recently launched CCTS by MoP).
- Industrialized cities and towns, which are also often highly polluting airsheds, shall come up with a DCHN action plan. Efficient and low cost, digitally enabled heat/cooling for all networks. DCHN could be a net contributor to better air quality. The action plan must have a link to the Building Cooling and Heating Strategy and must explore the possibility of using Hydrogen and Concentrated Solar Thermal (CST) based heating and cooling networks in sync with the India Cooling Action Plan. (The German government introduced the Heating Network Systems 4.0 programme in 2017, which provided grants for investing in heating infrastructures from low and high temperatures from renewable energy and waste heat)
- India must set up a National Centre for District Cooling and Heating Network (DCHN) to work closely with the industry and buildings sector on a range of R&D, testing and piloting projects. The idea is to assess the feasibility, and costs-benefits of various technical interventions.

- The Government to consider the waste heat recovery system as an energy efficiency measure and thus give benefits to the industries through taxes and appreciated depreciation on related technologies and equipment as implemented by the UK. The UK considers waste heat as an energy efficiency measure and a decarbonization strategy through various policy measures like the Industrial Heat Recovery Support Programme (IHRS) and Industrial Energy Transformation Fund (IETF).

Switching Industrial Energy Demand

Heat constitutes two-thirds of industrial energy demand and contributes most of the direct industrial CO2 emitted each year, as most of this heat comes from fossil-fuel combustion. Industrial heat is classified into three main categories, high temperature (above 400℃), medium temperature (150 – 400℃), and low temperature (below 150°C). The high temperature heat is mainly used for material transformation operations like melting, curing, high pressure boiling and is used in industries like iron and steel, glass, ceramic, and cement. Medium temperature heat is used for operations like distillation, dying.

Today, renewables cater to a small portion of Industrial energy demand. With gas playing the role of a bridge fuel, significant efforts are required to manage industrial energy demand. Fuel substitution and alternate fuel use strategies can contribute to increasing efficiency by reducing the consumption of non-renewable resources and minimizing waste and emissions.

Availability of Potential Alternate Fuel in India

In Europe, over 36% of the cement industry's energy needs are met by alternative fuels like biomass and household and industrial waste, and the figure is as high as 65% in Germany, 60% by Belgium, 30% by France, 15% by Japan, 9% by Brazil etc) (IFC, WB,2017). Industries are also looking to the technologies, where alternate fuel like Residual Derived Fuel (RDF), Biomass, Tyre-Derived Fuel could be optimally utilised.

Table 3: Availability of Waste Steam

Waste Stream	Total Availability (MTPA)	Availability for Co-processing in cement Industry
RDF	9.46 (28676 tpd)	4.5
Biomass	145	14.5
Hazardous Waste	7.11	0.71
Tyre Waste	1.29	0.65

In India, the Thermal Substitution Rate (TSR) is hardly 3-4% however, the developed countries are having TSR goes up to 60-80%, India must increase its TSR in a phased manner.

Also, India is bullish on hydrogen with plans to produce 5 million tons of green hydrogen by 2030, however, greening 100% steel production alone requires 20 million tons of Hydrogen every year by 2030. Overall, there is a requirement of 50 million tons of H_2, if all the thermal fuels used in the hard-to-abate sector are substituted. Much more aggressive policies might drive the growth of the H2 economy.

Recommendations:

- The GOI, in consultation with key stakeholders, shall come out with a "fuel substitution and alternate fuel roadmap till 2047" for industries with an objective to achieve its energy security and NZE targets. This policy needs to flesh out the requirements for — technology, financing, and essential materials of the future. This plan shall set the target for 2047, highlighting the Role of Hydrogen in Industrial demand and Use of Biofuel as well as Municipal Solid Waste (MSW) or alternate fuel in Industries.

- Direct heat source like the "Concentrated Solar Thermal (CST)" is a proven technology, especially in temperatures below 400 degrees, and Bioenergy for high-temperature heat demand in industries. [India has approx. 6.5 GWth of CST potential whereas till date the installed capacity is just 39 MWth. (China is leading the installation with 71% of coverage, whereas India stands at 1.4% of total CST installation in the world - India CST Sector Vision 2022).]. MNRE shall come out with guideline for ramping up CST and Biofuel usage for industrial heating purposes and support such technologies through accelerated depreciation and tax rebate on components. EESL shall be assigned to design and implement programs for installation of CST and Biofuel based process interventions in industries, under ESCO mode.

- Co-firing of MSW with Coal in the furnaces of Steel, Cement & Power could significantly reduce energy demand and industrial emissions. At the same time, it can address India's waste management challenge and reduce the burning of crop residue. Enhance the utilization of alternative fuels to achieve "Thermal Substitution Rate" of 30% by 2030 & 50% by 2047 from the current TSR of 3-4% without impacting the productivity or the product quality.

- Government must further push for blending of biofuel and its usage in Industries. The blending targets shall be increased from 20% blending of ethanol in petrol to 40% and from 5% blending of biodiesel in diesel to 10% by 2030. This will reduce the import burden of petroleum products. (India has an ethanol production capacity of 684 crore litres. For the targeted 20% blending of ethanol in petrol by 2030, the country will need a 1,000-crore litre capacity).

- For new applications, where the viability of using green hydrogen is still nascent, like green steel, the government shall consider building production linked incentive (PLI) for manufacturers, especially targeting export markets.

Electrification of Industrial Processes

Electric heating technologies for industrial processes like resistance heating, induction heating, and microwave heating etc have advanced significantly in recent years. This electricity, once powered by renewables, reduces energy demand, and eliminates CO2 emissions and hence plays a significant role in industrial decarbonization. For very high temperatures requirements, like in cement manufacturing, these electric solutions are still challenging, but are getting better acceptance in oil refining industries etc.

Recommendations:

- India must also create a "technical task force" to identify the overall potential of electrification of furnaces. Based on their recommendation the thermal processes, kilns and furnaces etc shall be electrified, in a phased manner.

- Electrification of thermal processes like cement kilns and furnaces is an important step towards decarbonizing the cement industry. A demonstration pilot project, with financial assistance, shall be commissioned in a cement plant. (For instance, CEMEX, a global leader in sustainable construction materials and solutions, has signed a memorandum of understanding with Finnish-Dutch company Coolbrook to explore innovative technology to electrify the cement kiln heating process.)

- Electric Arc Furnace (EAF) can convert direct reduced iron into liquid steel, reaching the same quality that can be achieved in an integrated steel plant. Hence, it is possible to convert from a blast furnace (BF) to an electric arc furnace (EAF) in an integrated steel plant. SAIL to showcase a demonstration pilot in this regard for other industries to learn.

Carbon Capture Utilisation and Storage (CCUS)

Even after significant push towards industrial efficiency there would still be substantial emissions from the industries, hence CCUS is important. CCUS has a potential to reduce 9 % of India's cumulative emissions up to 2050 (IEA, 2019). CO2 captured is split almost equally between the power sector and manufacturing sectors.

To meet India's mitigation targets, an estimated 2000- plus large-scale CCS facilities must be deployed by 2040, requiring hundreds of billions of dollars in investment. Today, there are only 19 large scale facilities in operation and four under construction. The business case for investment in each facility was underpinned by favourable commercial conditions and supportive policies.

Recommendations:

- Even with a higher substitution of clinker, CO2 emissions cannot be eliminated. Therefore, the Indian cement industry needs to actively explore and test carbon capture and storage (CCS) solutions that can be scaled up and rolled out at an affordable cost. Government shall provide interim support to pilot CCUS installations.
- Carbon capture, utilisation, and storage (CCUS) technologies are being viewed as one of the practical ways to achieve decarbonization but due to low utilisation of CO2, CCUS technologies suffer a low take away. Therefore, it is proposed to:

    1. Exploring further CO2 usage by investing in research studies (road making etc) (India to have two National Centres of Excellence in Carbon Capture & Utilization at IIT Bombay & at JNCASR, Bengaluru, supported by DST).
    2. The two R&D Centres need to set up a study on "Carbon Capture readiness" to assess the industries readiness on CCUS w.r.t Space availability, technologies and financing .
    3. Identification of global customers for selling CO2 proceeds at competitive prices.

- To make the technology grow cheaper and work better, the government shall tax carbon (CCTS is a welcome move), make an easy approval process for CCS projects and help set up infrastructure.

3.3.2 Resource Efficiency

Improving resource efficiency (RE) and encouraging the use of secondary raw materials, have risen as strategies for minimizing the potential trade-off between growth and environmental well-being.

Rapid industrialization has resulted in generation of large quantities of industrial wastes such as fly ash in thermal power plants, slag from steel industry, red mud from aluminium industry, copper slag from

Table 4: Waste Generated in Industries

Industries	Waste Generated	Generation in MTPA (2021)
Thermal Power Plant	Fly Ash	232
Fertilizer	Phospho Gypsum	8.46
Iron and Steel	Granulated Blast Furnace Slag/LDSlag	45/15
Copper	Copper lag	2
Sponge Iron	Dolachar	6.3
Aluminium	Red Mud/Spent Pot Lining	9/0.35
Paper	Lime Sludge	4.5
Marble	Marble dust	6

copper industry, dolochar from sponge iron industry, lime sludge from paper industry.

India has increased its material consumption to six times from 1.18 billion Ton in 1970 to 7 billion Ton in 2015, which is expected to double by 2030.

Moreover, India is also highly import dependent for certain critical materials such as Molybdenum, Nickel, Lithium, Cobalt, Copper etc. Hence self-sufficiency and circularity become crucial in defining future energy demand of industries. However, limited access to right technologies together with absence of comprehensive policies and / or incentives impedes the progress towards the same.

The 10R principle for Circularity being followed at international level to minimize waste and the extraction & creation of virgin materials. It needs to be propagated among Indian Industrial processes for its criticality to achieve NZE apart from development of Waste and Scrap management. For instance, in developed nations around 50% of steel production comes from recycling steel scrap while this rate is only 5-8% in India.

Cement manufacturing is the only industry where no waste is being generated, in fact the industries have the potential and ability to absorb and utilize all the waste generated by different sectors as stated in the table.

Recommendations:

- Using virgin material for steel and aluminium production is highly resource inefficient. To safeguard future resource and energy requirements for industries, the Government of India shall come out with a holistic “Resource efficiency policy”, as a guiding document for the next 20-30 years of industrial growth. This shall provide a directional consumption pathway of key options like Hydrogen, MSW, Biofuels, Green Electric Furnace etc. Highlighting the need for blending (including scrap) alongside the incentive’s structure designed to facilitate transitions.

- BEE shall develop a scrapping and/or repurposing program for the end of life of highly inefficient equipment. This will incentivize replacement of older equipment and facilitate “organized” scrap management.

- The government in partnership with Industries shall identify potential sectors and their associated technologies in Cement, Steel, Aluminium etc, where circularity plays a pivotal role. Respective sectoral strategies should be designed based on the industry-specific needs and peculiarities to mitigate carbon emissions through input substitution channels. (Many Countries like Austria, Denmark, Finland, Germany, Netherland, USA, Japan, China, South Korea etc – have dedicated national strategies for material resource efficiency or circular economy)

- The National Policy on Scrap needs to focus on a holistic short-term, medium and long-term vision identifying growth targets for demand augmentation and capacity addition. This requires a strategy for achieving the targets in terms of raw material, infrastructure, value-addition, power, energy requirements and scrap recycling. Currently, there is no proper scrap collection, segregation, treatment, etc. facilities. The government may consider zonal scrap collection / segregation / treatment facilities.

- Ensure the availability of domestic scrap by leveraging instruments like export taxes, export bans or punitive tax rate if the recycler resorts to trade in scrap without processing or adding value in India. This is particularly important as the recyclers have the potential to generate feedstock at lower prices. Industry as well as related departments and ministries must explore ways to increase the availability of scrap from domestic sources.

- A huge reserve of obsolete scrap is available which, if properly utilized, will lead to significant availability of scrap in the country and will boost the growth of steel manufacturing through MSME (secondary sector). There is a steel scrap recycling policy in place, something similar is needed for non-ferrous metals like Aluminium, copper etc

- As a part of the resource efficiency policy, the waste generated from various industries is allocated to different sectors based on their CO_2 intensive reduction potential. For Ex. The clinker substitution materials have a very high potential of reducing 0.8 tons of CO_2 reduction per ton of clinker substitution material. The priority of usage of waste streams should be based on the availability of the national resources in the respective sector.

- The fall in usage of virgin material might impact the livelihood of mine workers hence the government must initiate a state level, just transition task force, starting with Coal, Aluminium and Iron ore mining states. With an objective to create actionable roadmaps for mitigating social or financial impact on local communities.

3.3.3 Financing Industrial Energy Transition

Energy Services Companies (ESCOs)

Energy Services Companies (ESCOs) are a critical building block for scaling energy efficiency. However, ESCO's failed miserably in India due to poorly designed programs, states failing to honour commitments, and low or no risk guarantee to investors etc. ESCO, being a powerful financing instrument, has not really picked up in India. We propose the following to strengthen ESCO's model -

Recommendations:

- BEE and EESL shall engage a third-party independent organization to review the existing ESCO models and propose course correction. The ESCO rating must be revamped considering factors such as financial and technical capabilities, domain expertise, project management and execution capacities, and track record etc.
- Government must create an empowered agency to validate savings, resolve disputes, and inspire confidence of key stakeholders and in all ways the "payment security mechanism to be fixed". BEE shall engage a third-party independent organization to review the existing ESCO models and propose course correction.
- ESCO's capacity on alternative lending options should be enhanced. Efforts should be made to improve awareness and understanding by ESCO of the information required by creditors and other investors to consider their demand for finance.
- The government shall design dedicated ESCO's for MSMEs which will have a positive impact on not just energy demand reduction but also explore localized Carbon emission mitigation.
- Guidelines may be issued by DoE, MoF for procurement of energy efficient equipment through ESCO model.

Carbon Markets

Market-based instruments, in theory, provide the least cost abatement pathway but in practice it's much more complex to design, enforce, and validate such instruments. More so in countries like India wherein "data" is neither reliable nor enforceable. Large scale fuel switch and industrial decarbonisation can potentially be achieved by designing a fully functional carbon market. The MoP and MoEFCC have put together a "Carbon Credit Trading Scheme (CCTS)" for industries in India, which is a welcome move and inclusion of OFFSET mechanism under CCTS shall boost the micro level project market and investors for non-obligated entities, but lots need to be done to make it a success.

The CCTS is being designed on the lines of PAT, wherein instead of absolute emission reduction the target would be based on specific carbon reduction. Though PAT reported energy saving it failed to attain a price discovery in the market. Hence raised questions on its design, target setting, compliances etc.

Recommendations:

- The learnings from PAT shall be incorporated in "Carbon Credit Trading Scheme (CCTS)", and the complex market design issues shall be addressed upfront. Fixation of targets must be based on the Carbon budget assigned to each Industry type. This will push the industries to rethink their carbon emission strategy for their incremental production as well as mitigating carbon emission in absolute terms.
- The CCTS must also look for scope 2 and scope 3 emission which will improve the entire value chain of manufacturing and not just a single plant. This will have a major impact on MSMEs in India.
- Minimise the manual intervention in M&V and fully automate the process subsequently. This will not just give confidence to the investors but all to the Government at large for its transparent approach.
- Fungibility options of CDM projects, Energy Saving Certificates (ESCerts), Renewable Energy Certificates (REC) and Carbon Emission Certificates shall be studied in detail.
- Domestic carbon market can provide some interim thrust for low carbon growth, however, integration with international markets will be crucial to ensure accelerated transition.
- Taxes and/ or subsidies can make or break any potential energy transition. As India is slowly moving towards a functional carbon-market it needs to holistically review its existing taxation and levies across the entire energy value chain.

Financing Energy Efficiency

Various innovative financing techniques and models have been tried for industrial energy transformation. It includes products like the international line of credits by KfW, JICA etc; concessional or priority sector lending, collateral free lending by SIDBI, startup incubation fund, venture capital and partial risk guarantee funds by BEE and World Bank etc. Some of these financing models and products proved useful and showcased good results. Most of these products supported technology upgrades leading to efficiency gains. And some products even had lower uptake due to lower technical assistance inbuilt into the same.

Recommendations:

- To catalyse the uptake of financial products for industrial efficiency there is a need for higher technical assistance (TA). States should be given directions to set up a TA fund in the name of "Industrial Energy Efficiency Fund (IEEF)", with support from corporate CSR and philanthropies. The whole process of funding through IEEF could be facilitated through Banks, which act as a supplement for viability, risk or performance guarantee funds. The purpose of IEEF shall be, to fast track the uptake of existing financial instruments from banks as well as organizing training and behavioral nudging campaigns.

- Govt shall create a national demonstration fund to set up pilots of high potential decarbonization technologies, like - green hydrogen, energy storage, carbon capture and utilization, solar calcination, electrification of the kiln, CO2 curing of precast elements of concrete and also concrete roads, conversion of captured carbon to useful products like methanol, ethanol, polymers and other hydrocarbons.
- To make the new technology commercial projects viable, the Govt may consider fiscal incentives like 0% custom duty for critical parts, accelerated depreciation, lower GST based on its carbon footprint of the product.
- BEE shall develop a scrapping and/or repurposing program for the end of life or highly inefficient equipment or technology. This will incentivise replacement of older equipment or technology.

Green Procurement Policy (GPP)

In 2017, the International Standards Organization (ISO) released a Guidance on Sustainable Procurement (ISO 20400), a signal that green and sustainable procurement is becoming standard practice in public and private organizations around the world. GPP can be a major driver for innovation, providing industry with incentives to develop environmentally friendly products and services. GPP may also provide financial savings for public authorities, especially if one considers the full life-cycle costs of a contract and not just the purchase price.

The Indian government can greatly influence the procurement of industrial products either by directly purchasing from the manufacturer or by putting up taxes, duties, levies or subsidies, on the products, for others to buy. Unless there is a demand for, marginally costlier, green cement or green steel etc businesses would not feel motivated enough to walk the transitions pathway.

India needs a “green procurement policy” to incentivize the production of greener goods, products and even services. This will influence the fuel, raw material and technology choices of the industries (both large and small).

Recommendations:

- To achieve its energy security and emissions target India needs a "green procurement policy", that will incentivise the production of greener goods, products and even services. This will influence the fuel, raw material and technology choices of the industries (both large and small).
- India must develop green labelling certification for goods and / products to popularise the purchase of products and services with lower resource footprints and higher resource efficiency. Carbon labelling and energy intensive labelling to be made mandatory for all products progressively over five years.
- Innovative financing products shall be designed to offset the marginal incremental cost (if any, over the lifetime) of greener public/ private procurement.
- The government shall define the maximum carbon or emission intensity of Steel/Cement/Aluminium etc below which the government procurement is allowed.
- Downstream industries (e.g.: consumer goods) shall be required to use a fixed percentage of low-carbon materials in their products, thereby facilitating demand for low-carbon materials. To start, select sectors can have mandatory purchase obligations, post which such measures can be rolled out across sectors.

3.3.4 Governance, Compliances, and Capacity Building

Energy Efficiency Governance

India increased its NDC target based on past energy efficiency achievements. As we are setting bigger targets for the country, we must ensure better interdepartmental cooperation, better policies with overarching authority to drive change. Hence a need to restructure the current model wherein environment, energy efficiency and industrial growth are all parked with separate ministries. Inter-ministerial coordination is critical for any DSM program.

Recommendations:

- India currently has 5 core ministries dealing with energy – coal, oil and gas, nuclear, renewables and power with a dedicated ministry on environment. All these core energy ministries are primarily mandated to supply energy / power with a limited mandate on efficiency or conservation. Hence no dedicated ministry on managing demand. Unlike the past, the demand will dictate the supply in the future. Hence, we propose a dedicated ministry in India to lead all demand side interventions, coordination with other relevant ministries, developing energy conservation programs etc. In the interim the Niti Aayog must lead the role of coordination with various ministries on interdependent and intersectional demand issues.

- BEE’s mandate is largely electricity efficiency and not the overall energy efficiency which can continue till a dedicated energy demand ministry is fully functional. Thereafter BEE can be merged with this new demand ministry.

Business Responsibility and Sustainability Report (BRSR)

There is a need to improve the culture of transparency and accountability in the industrial sector by promoting best practices, establishing clear standards, and increasing public awareness etc. Environment, social and Governance (ESG) practices are one of the ways to do the same, however, SEBI has introduced new reporting requirements on ESG parameters called the Business Responsibility and Sustainability Report (BRSR).

BRSR mandates businesses to conduct and govern themselves with ethics, transparency, and accountability while providing goods and services that are sustainable throughout their lifecycle. It also considers the well-being of employees, human rights, and the environment while supporting inclusive growth and equitable development as an important element of ESG reporting. BRSR has been designed to reveal the non-financial risk indicators and is focused on the wide-ranging gamut of stakeholders such as the community, shareholders, investors, bankers, policy regulators, employees, customers, and the supply chain. In fact, it covers the entire spectrum of the business ecosystem.

Recommendations:

- Currently BRSR filing is mandatory for the top 1000 listed companies (by market capitalisation). There is a need to implement this reporting for all the companies listed on either of BSE or NSE.
- Also, since most of the ESG rating agencies are housed abroad, India must have its own rating agencies for setting the right framework for Indian entities.
- Recognizing the fact that BRSR is an extensive disclosure and hence, substantial efforts and expertise shall be required. Accordingly, sustainability disclosures based on GRI protocol or internationally recognised until new rating agencies are established for most material topics, or the sectoral topics shall also be promoted.

Third Party Independent Audit

Energy audits have been instrumental in promoting industrial energy efficiency but there have also been issues around data manipulation, improper reporting, and systemic tampering. Moreover, energy audits have been a part of BEE’s programs like PAT, as conducted by Industries themselves, but the audit results are not available for public consumption.

Recommendations:

There is a need for a “3rd Party Energy Audit” program, on randomised sampling basis, for major industry types in India. This will increase the confidence on the quality of data being generated by the industry on many fronts. Such exercise will inform evidence-based policy making in the country. The Government should provide incentives and subsidies for industries to conduct third-party audits and make their data public.

Data Infrastructure for Industries

Impactful interventions are almost impossible to design unless you have reliable, authenticated, and actionable data from the industries. This could be the data on fuel consumption, fuel type, technology in use, emission, air pollution etc. There is a lack of transparency in measuring and disclosure of energy use.

Open data systems will provide a foundational basis for designing workable solutions and help create IOT, AI/ML powered tools for overall demand management. The data developed from different audit programs can be clubbed together to create a “Data Infrastructure Bank”. It would also enable the Government to monitor the energy usage of industries, identify potential areas for improvement, and incentivise deserving industries. Accurate Data plays a pivotal role in shaping the policy in the right direction, decision making, incentivization and identifying problem areas.

Recommendations:

MoEFCC in coordination with MoP and MEITY shall develop a “national data infrastructure bank” of industries for evidence informed policy making and therefore better demand management. Industries must take competitive advantage of automation tools available and build IOT, AI/ML for its deep analysis and process optimisation.

Star Rating of Industries

Behavioural nudging is an important tool to motivate industries towards energy efficiency. One of the tried and tested behavioural nudging programs for industries in the certification program for industries i.e. “star rating program”. Many countries and regions have developed their own certification programs specifically tailored for local requirements. India tested a version of the star rating programs for a small sample of industries in Gujarat, Odisha and Maharashtra with an objective to nudge industrial behaviour towards pollution reduction.

Recommendations:

GOI shall design and implement the industrial star rating programs with an objective to reduce energy intake and hence carbon emission. The program shall build incentives for industries and encourage them to energy efficiency and conservation. The incentives could be non-financial, for eg — ease of compliance, deemed approvals, etc.

International Centre of Excellence (ICoE)

Building awareness and technical capacity is any impactful energy efficiency program. Such capacity building programs shall be co-designed in partnership with technical institutions and the civil society organizations (CSOs). These stakeholders not just bring in technical expertise and international finance (especially the non-returnable finance grant) but also facilitate on ground implementation with minimum disruptions. Few good international examples in this regard are - Energy Ambassador Program – Japan; Community Energy Challenge – United States; Energy Efficiency Roadshows – Australia; Energy Efficiency Adventure – Germany; Energy Efficiency Hackathons – Denmark.

Recommendations:

The office of PSA and DST shall take the lead in setting up multiple centers of excellences, at least one each for hard to abate sectors, in India. Such centers can be housed at the institute of eminence (IIT's, IISC's etc). Such technical institutes will also address the skill gap in the ecosystem in the long run. These centers will help India become the global hub for technological innovation and development.

Box 2. Micro, Small and Medium Enterprises

There are 63 million MSMEs in India contributing significantly to manufacturing output, employment generation, and to the national Gross Domestic Production (GDP). With Micro sector constituting more than 99% of total estimated number of MSMEs. Around 76% of MSME's run on electricity followed by Oil and Coal.

Energy transition in MSME's is a straightforward 3 step process –

1. Greening of electricity
2. Switching from Oil and Coal to Electricity
3. Energy efficiency and conservation

Here are the following 3 main challenges to transition at SME's–

1. Only higher payback ideas are generally implemented.
2. Unawareness of potential benefits of cleaner interventions.
3. Non availability of proper tools to measure impact of interventions.

Recommendations

1. MSME's shall be given special focus by setting up of energy efficiency benchmarks, guidelines, and establishment of standard operating practices.
2. Strengthen and scaling of financing incentives schemes like Partial Risk Sharing Facility (PRSF), Energy Efficiency Financing Facility (EEFF), Collateral Free Lending Facility etc. to facilitate ESCO and Banking system for risk based financing arrangement
3. Dedicated ESCO's for MSME's shall be developed to have a positive impact on not just energy demand reduction but also on local air pollution.
4. BEE shall push for mandatory disclosure from energy-intensive SMEs through implementation of energy management system for SMEs
5. Develop dedicated programs for energy intensive SME's on fuel switching and waste heat recovery
6. Encouragement and enforcement of ISO 50001 in industries and MSMEs
7. Institutional arrangement for fast-track disposal of payment related disputed, baseline and M&V disputes can be contemplated for promotion of ESCO model in MSMEs.

3.4 Hard to Abate Industries

Iron & Steel

The steel industry in India is relatively heterogeneous compared to other countries, with a wide range of different sized facilities in primary & secondary steelmaking. There are several different technologies currently in use, including BF-BOF (44%), coal-DRI (20), Electric Induction Furnace (28%) and Electric Arc Furnace (28%) and gas- DRI.

Table 5: % of Energy among 8 Sectors

Sector	Energy mtoe	Coal mtoe	Gas mtoe	Oil mtoe	Electricity mtoe	% of energy among 8 PAT sectors
Iron and Steel	64.5	53.6	1.4	1.0	8.5	36.13%

Source: IESS, Energy Consumption in MTOE for Iron & Steel Sector for the year 2022

Specific Energy Consumption

The GOI's projected penetration of energy efficiency in the Iron & Steel sector is depicted in the graph. It highlights the futuristic trajectory of specific energy consumption reduction from 0.596 in 2020 to 0.357 mtoe/ton of Crude Steel by 2047, resulting into energy savings of 141 million tons of oil equivalent (mtoe) in 2047 and 555 million tons of CO_2 by 2047, as the specific Carbon emission may be reduced from 2.08 to 1.15 tCO_2e/ton of crude steel.

*Figure SEQ Figure * ARABIC 3: Average SEC of Steel*

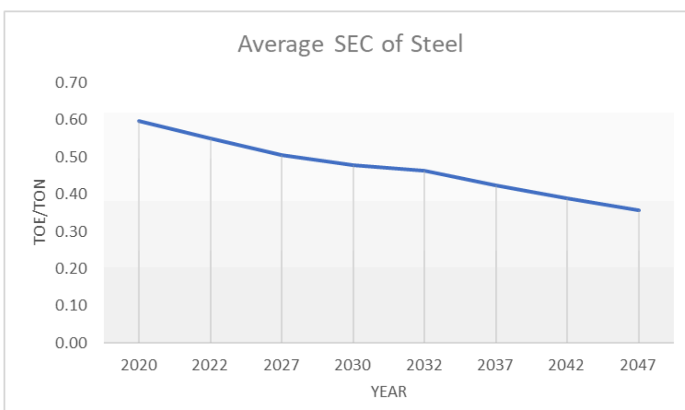
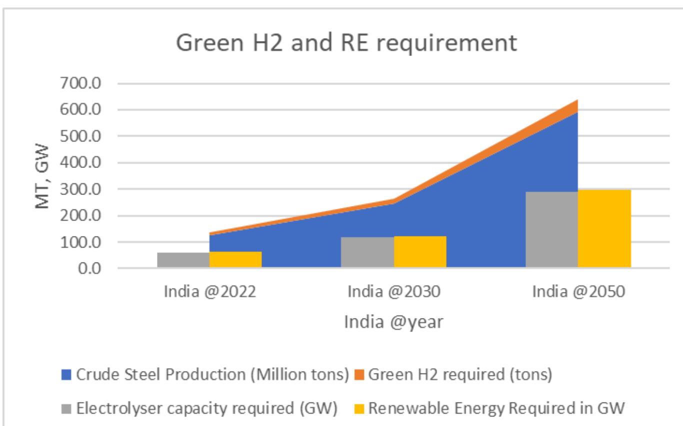


Table 6: Hydrogen in Iron & Steel Sector

Year	Crude Steel Production (Million tons)	Steel production through 10% of DRI production	100% DRI Green H2 Demand [10% of DRI production] (million tons)	Electrolyser capacity required [through 10% of DRI production] (GW)	Renewable Energy Required in GW [through 10% of DRI production] (GW)	Green H2 Demand [100% Steel from Green Hydrogen] (million tons)	Electrolyser capacity required [100% Steel from Green Hydrogen](GW)	Renewable Energy Required [100% Steel from Green Hydrogen](GW)
Green Transition	1		80000	0.49	0.5	80000	0.49	0.5
India @2022	125	13	1.00	6.14	6.27	10.0	61.4	62.7
India @2030	244	24	1.96	11.98	12.22	19.6	119.8	122.2
India @2047	591	59	4.73	28.98	29.57	47.3	289.8	295.7

Source: India @2022 Crude Steel Production as per WSA report

The above table predicts the requirements of Hydrogen in the Iron & Steel sector by 2030 and 2047 based on assumption i.e., 80000 tons of H2, 0.49 GW of electrolyser capacity and 0.5 GW of Renewable Energy are required to produce 1 million ton of Green Steel.



Estimated Requirements for 10 MT of 100% Hydrogen DRI facility (less than 10% of current production) is around 1 MTPA of Hydrogen with renewable energy capacity requirement of ~25 GW (assuming a Plant Load factor of 25%). To put these figures into perspective, it is 20% of India's green hydrogen production target (5 MTPA) and ~5% of the ambitious total renewable energy capacity targets assumed for 2030. India has set itself a target of 250 MT of steel capacity by 2030-31 which means that just ~3% of steel needs can be serviced with these amounts.

Presently, India does not produce any green hydrogen and has a RE capacity of ~150 GW. As Renewable Electricity accounts for ~70- 80% of the cost of production of hydrogen – its cost and availability will pose a huge challenge for the steel sector.

Green Hydrogen to the tune of ~47 million tons along with ~300 GW of Electrolyser capacity are required by 2047 to cater 100% demand of total steel production.

To meet the demand for steel production, green hydrogen will be needed in enormous quantities. Renewal Electricity and electrolyser capacity needs to be increased significantly to meet the potential demand for producing green steel. Therefore, overall GH2 requirements and corresponding RE capacity for the steel sector are going to be enormous, and it may be desirable to prioritize the sub-sector wise demand, which may be gradually expanded as the availability of GH2 increases.

The Constraints:

- Electrolyser manufacturing capacity around the world: 2-4 GW/annum, countries around the world announced to increase the capacity 200 GW by 2030. But this is not enough to support the rising demand of electrolysers for hard to abate sectors. It is critical to develop a robust domestic electrolyser manufacturing ecosystem in India. So far, India has only one indigenous facility of manufacturing electrolysers.
- The current cost of producing 1 kg of green hydrogen is between $5.5 and $6 which is too expensive for large scale manufacturing. For it to become commercially viable, the price must drop to $1-$2 per kg
- The Green Hydrogen Mission targets to produce 5 million Tons of green hydrogen by 2030, however, greening steel alone requires 20 million tons of Hydrogen (requiring 120 GW of RE) every year by 2030.
- EAF-based steel making facilities require a reliable and cheaper supply of electricity. The electricity tariff for industrial customers is highest in India, unlike many other countries.
- Natural gas direct reduction is costlier in India due to the higher costs of natural gas, as well as uncertainty around its availability. Natural Gas deficiency in India coupled with lack of pipelines infrastructure esp. in East India where most of the steel capacity is located. Moreover, the fertilizer sector gets a priority when it comes to availability of Natural Gas.

Recommendations:

- Substitution of Coal in DRI from GAS/H2: Phasing out coal in DRI through increased uses of Green Hydrogen slowly and steadily in synchronisation with India's production capacity. The DRI with green hydrogen can deliver significant emission reductions of approximately 90-95%. But it is not practically feasible or doable to phase out the small coal DRI plants by GH2 based DRI plants,

- India has around 40-million-ton capacity of Coal based DRI. The small coal based DRI plants can substitute part of the coal used by Biochar/ biofuel, subject to its feasibility; for which R&D and Trials need to be undertaken.

- There could be short term and long-term plans for this substitution gradually from Biochar/biofuel to GH2.

- Hydrogen in steel making: The technologies for use of hydrogen in steelmaking are in pilot stages, and there are major technical and economic challenges that need to be resolved to make them commercially viable. Taking learnings from other developed countries India shall set up demonstration pilot for producing zero emission steel (e.g., Hydrogen injection in BF), this would lay the foundation of use of hydrogen in steel making in the long run.

- Circularity (Scrap based steel making): Scrap plays a key role in suppressing industry emissions and resource consumption. As per WSA (World Steel Association), every tonne of scrap used for steel production avoids the emission of 1.5 tonnes of CO_2 and the consumption of 1.4 tonnes of iron ore, 740kg of coal and 120 kg of limestone.

- Producing steel using scrap through secondary steel making produces about 0.455 tonne CO_2/t of steel, whereas the traditional blast furnace primary steel making route emits 1.7-1.9 CO_2/t of steel. India should mandate, in phased manner, that up to 50% of steel should come from recycled scrap, currently it is between 20-25%.

- India should increase its efforts to end import of steel scrap (by 2030) and meet all its requirements of steel from domestic scrap.

- **Incentives:** For new applications, where the viability of using green hydrogen is still nascent, the government can provide incentives such as a production linked incentive (PLI) scheme for green steel targeting export markets.

- **Green Electricity for Furnace Use:** in order to convert thermal furnaces to electric furnace (esp renewable electricity) India would require 178 GW of renewal capacity by 2030 for steel production. The government shall offer research and development support to existing steelmakers who switch to EAF-based steelmaking. This can include funding for pilot projects or joint research ventures with academic institutions.

For Eg 1 - Austrian steelmaker Voestalpine will convert two blast furnaces at its Linz site and one at its Donawitz site to electric arc furnace-based steel production by 2030 in a bid to reduce carbon emissions by 30%.

For Eg 2 - HIsarna technology: Indian Steelmakers like TATA steel is investing in new steel making technology like HIsarna. It is a completely new technology for producing iron which consists of a reactor in which iron ore is injected at the top. The ore is liquefied in a high-temperature cyclone and drips to the bottom of the reactor where powder coal is injected. This significantly reduces the number of energy-intensive steps required for the traditional steelmaking process. Testing has already shown this technology can lead to a significant reduction in CO2 emissions from the steel production process. It may be possible to achieve a CO2 reduction of more than 50%. If the technology is successfully commercialised and CCUS is feasible, it is going to co-exist with BFs for Hot Metal making for use in BOFs and EAFs.

- **Centre of Excellence for Steel:** Dedicated R&D and Technology Development Programs in the steel Sector is the need of the hour in line with SRTMI. Since any programme is going to be expensive, a joint collaborative R&D programme is considered necessary. There are many unresolved issues like economic GH2, GH2 based economic iron/steel making, H2 injection in BFs, Economic CCUS, Use/feasibility of Biofuel in BFs & Coal based Rotary Kilns etc can be captured in this forum.

- **Carbon Capture and Storage:** In terms of phasing out existing, high emission facilities, there is a relatively significant role for CCUS to help manage emissions from the large number of BF-BOF facilities in India. For the existing capacity base, players must invest in CCUS wherever possible. Relining must be fitted with CCUS to ensure zero emissions in blast furnaces added over 2010-2035 to enable them to continue to operate beyond 2050.

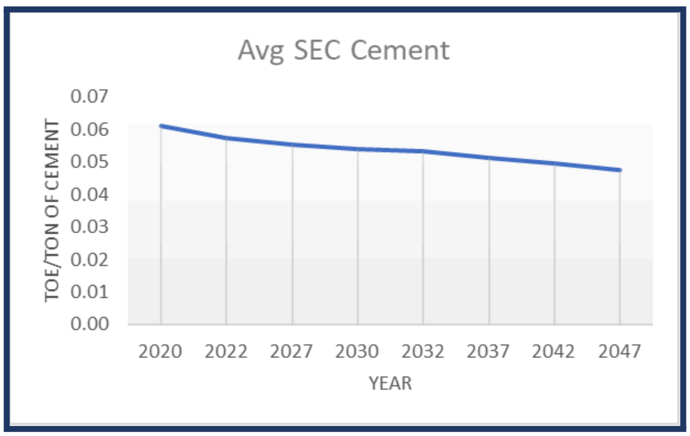
Cement

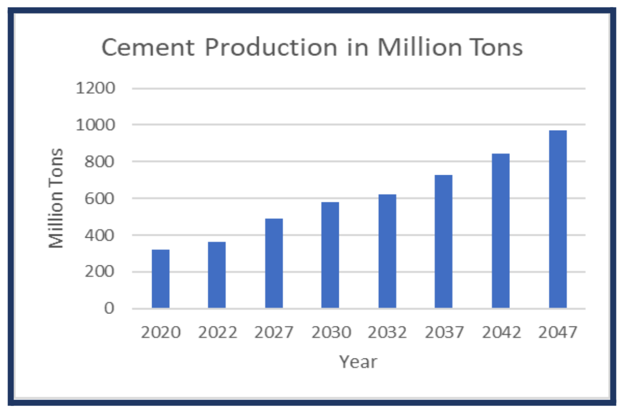
The Indian cement industry is among the most energy and carbon-efficient globally and is the second largest energy consuming Industry in India after Steel. Realizing the uniqueness of the cement process, consuming both hazardous and non-hazardous wastes as alternative raw materials, the future looks encouraging.

Table 7: % of Energy among 8 Sectors for Cement

Sector	Energy mtoe	Coal mtoe	Gas mtoe	Oil mtoe	Electricity mtoe	% of energy among 8 energy intensive sectors
Cement	20.79	20.10	0.00	0.21	0.54	14.45%

IESS: Energy Consumption in MTOE for Cement Sector for the year 2022





Cement production will grow from 356 million tons to 950 million Tons by 2047 (IESS) due to rapid urbanization, increased infrastructure, housing demand etc. As per government's projections the specific energy consumption of cement sector shall come down from 0.061 in 2020 to 0.0476 mtoe/ton by 2047 resulting into energy savings of 12.92 million tons of oil equivalent (mtoe) and 110 million tons of CO_2 by 2047

Historically, India's cement industry has made remarkable progress of reducing CO_2 emission levels by about 36% from 1.12t/t to 0.719 t/t of cement between 1996 and 2017. To further reduce it by half and achieve the target of 0.35t CO_2/t of cement by 2050, the cement industry requires an investment of US$ 29 billion to US$ 50 billion. (RBI, 2022). 50 GW of Renewable capacity is required only for the electrification of the cement sector by 2047.

The Constraints:

- Even with a higher substitution of clinker, CO_2 emissions cannot be entirely eliminated. Therefore, the Indian cement industry needs to actively explore and test carbon capture and storage (CCS) solutions that can be scaled up and rolled out at an affordable cost through feasibility study on requirement of space around the preheater and precalciner section, access to CO_2 transport infrastructure, and a retrofittable preheater tower.
- Unlike the steel and chemical sector, hydrogen has a limited use in producing cement. While it can substitute some of the fossil fuels used in the sector, it cannot be used as an ingredient or reactant in conventional cement production.
- Availability of clay for LC3 with kaolinite content in India, its economic feasibility and the market demand of Pozzolana Cement (Clay, Fly Ash or Slag based cement). Several studies have reported that low-grade clays with a kaolinite content of about 40% may be used for LC3 with good mechanical and durability performance of concrete. Realising the scope for reducing carbon footprint, the actual availability of requisite quantity & quality kaolinitic clay within the country needs to be reassured.

Recommendations:
Material Efficiency

- Reducing the clinker-to-cement ratio along with greater uptake on blended cement (targeting 0.66 by 2030, 0.59 by 2047 from 0.70)
- Clinkers made from alternative raw materials with more R&D are required in this field.
- Use of limestone calcined clay cement (LC3) as an alternate raw material could be the replacement of Fly Ash, Slag etc due to its poor availability, when fossil fuels are phased out. Recently in June 2023, BIS has published the IS 18189 related to LC3 Cement, thus ushering in the new pathway of using LC3.
- The cement industry can help improve the supply of aggregates and reduce the amount of construction waste going to landfill or being dumped illegally by

encouraging concrete recycling. The industry can also use it in co-processing of new cement.

Energy Efficiency and Fuel Switching

- Switching to alternative fuels can help reduce the cement industry's CO2 emissions. At the same time, it can address India's current challenge of managing municipal waste and reducing the burning of crop residue. (In Europe, over 36% of the cement industry's energy needs are met by alternative fuels like biomass and household and industrial waste, and the figure is as high as 65% in Germany, 60% by Belgium, 30% by France, 15% by Japan, 9% by Brazil etc) (IFC, WB,2017), at present Thermal substitution rate in Indian Cement kiln is around 3-4%.
- Research and installation of Concentrated Solar, Waste Heat Recovery, Green Hydrogen production along with Carbon Capture Utilisation and Storage (CCUS) is the key for achieving the humongous task of greening the Cement sector.
- India is yet to make headway in determining Carbon storage potential and the cement sector can drive this imperative of Carbon capture and storage, the only way for the cement sector to become net zero. (the issue of carbon emissions in the cement manufacturing process, the emissions from the calcination stage have to be addressed and the only feasible solution today to completely remove it is carbon capture and storage or utilisation due to the limestone calcination process).
- As part of its climate policy, Norway has supported feasibility studies for three capture concepts in the cement, waste processing, and ammonia industries. CCS will require an initial push in the form of support to piloting installations.
- Electrification of cement kiln: Cool brook's patented Roto Dynamic Heater (RDH) technology aims to revolutionize cement production by replacing fossil fuels traditionally used to heat the kilns with electricity. The breakthrough of the RDH technology is that it is able, using only electricity, to heat the kiln at a high enough temperature, around 1,700 Celsius degrees, necessary to produce cement with state-of-the-art materials. Companies expect this groundbreaking technology to be ready for commercial use at an industrial scale in 2024.
- Solar calcination of limestone, oxyfuel technology for the kiln and electrification of the kiln research need to be accelerated.
- Conversion of CPPs into green assets using concentrated solar steam.

Petroleum Refineries

Table 8: % of Energy among 8 Intensive sectors for Petroleum Refineries

Sector	Energy mtoe	Coal mtoe	Gas mtoe	Oil mtoe	Electricity mtoe	% of energy among 8 energy intensive sectors
Petroleum Refineries	19.71	3.14	9.90	4.78	1.89	14.10%

PAT II: Energy Consumption in MTOE for Petroleum Refineries Sector in the year 2018-19

There are total 23 refineries in the country consisting of 19 set up by Public Sector Undertaking (PSU), 1 by a Joint Venture Company and 3 by Private Companies with a total refining capacity of 249.22 MMTPA. This capacity is projected to increase to 460 MMTPA by 2030 looking at the current development scenarios.

Hydrogen is also used to improve the quality of oil and gas products (e.g. via desulphurisation). While the substitution of the fossil hydrogen used to produce these products would lead to a substantial decrease in emissions, it would not be compatible with climate neutrality in 2050 in the long term. However, the demand for hydrogen will increase from 2.5 million tons to 5 million tons by 2030. (NITI, 2022)

The Indian ammonia market attained a volume of 16.9 million metric tons in 2022 driven by the rising food demand and growing fertilizer demand. The market is expected to grow at a CAGR of 8.2% in the forecast period of 2023-2028, to reach a volume of about 27.12 million metric tons by 2028.

In India, hydrogen is used mainly in the oil refinery sector and in the production of nitrogen fertilizer. The annual hydrogen demand for these two sectors amounted to 4.36 million tons in 2019 and is projected to grow to 137 million tons in 2050 considering future expansion. 30 GW of Renewable capacity is required only for greening Electricity for refinery Sector by 2030

The Constraints:

- The use of low-carbon hydrogen in oil refining is not compatible with climate goals due to the overall emissions associated with fossil fuel use.

Recommendations:

- Hydrogen is used in refineries to lower the sulphur content of diesel fuel. Hydrogen in India is produced mainly from natural gas and is classified consequently as grey rather than green. Production of 1 kg of grey hydrogen is associated with the emission of about 10 kg of CO_2. IOC plans to use natural gas in refineries in place of liquid fuels while replacing grey hydrogen with green one, produced using renewable power. The government must propose clear mandates around hydrogen blending in existing refinery and ammonia sectors. This will provide demand certainty for early green hydrogen projects and encourage market development.

Fertilizer

There are about 32 large size urea plants in the country, of which 19 units producing DAP & complex fertilizers and 2 units manufacturing Ammonium Sulphate as a by-product. (Annual report, 2020-21, DoF). The actual production of all major Fertilizers during the year 2019-20 was 425.92 LMT. The estimated Production of all the Fertilizers during the year 2020-21 is expected to be 478.99 LMT showing an increase of more than 12.46% in comparison of the previous year. The rapid build-up of fertilizer production in the country has been achieved because of a favourable policy environment facilitating investments in the public, co-operative and private sectors.

Table 9: % of Energy among 8 Energy intensive Sectors for Fertilizer

Sector	Energy mtoe	Coal mtoe	Gas mtoe	Oil mtoe	Electricity mtoe	% of energy among 8 energy intensive sectors
Fertilizer	15.11	1.18	13.30	0.00	0.34	10.14%

IESS: Energy Consumption in MTOE for Fertilizer Sector for the year 2022

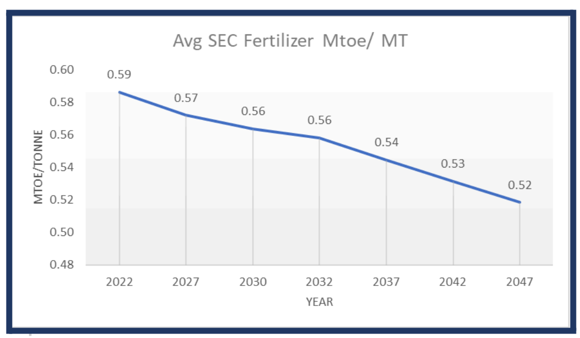
The amount of CO_2 generated is at least 3 tonnes CO_2 per tonne of fertilizer. And 4.3 million Ton of H_2 was consumed in fertilizer plants in the year 2020. There is a need to transition toward domestic feedstocks to ensure self-sufficiency and to keep up with the demand for fertilizers in the country. Green hydrogen can help bridge this gap between demand and supply for feedstock requirements. India with its vast and low-cost renewable energy resources, has the potential to support low-cost electrolytic green hydrogen production at scale.

The Constraints:

- This transition to Green Hydrogen and renewable electricity will require significant investment for various infrastructural additions for adoption of green hydrogen in the fertilizer industry.
- In the year 2020-21, India imported about 10 MMT of Urea, 5 MMT Di-ammonium Phosphate (DAP) and 3 MMT of Ammonia, this can be avoided through competitive bids on supply of green hydrogen in India.
- The Indian government implemented a policy in 2015 to ensure uninterrupted supply of natural gas to urea manufacturing plants (Ministry of Petroleum and Natural Gas, 2015). The fertilizer industry, India's largest consumer of natural gas, was responsible for 12.9 Mt of natural gas consumption in 2018, accounting for 28% of total national consumption (Ministry of Petroleum and Natural Gas, 2020). According to the International Energy Agency (IEA) (International Energy Agency, 2019), the cost for grey hydrogen in India is about $1.8 per kg. In what follows, we shall argue that a significant quantity of green hydrogen could be made available in India at costs competitive with current production from natural gas.

Recommendations:

- Due to various Energy Efficiency initiatives by the industries, the specific Energy Consumption (SEC) may be decreased from 0.59 to 0.52 mtoe/tonne in 2047. But the major CO2 emission saving may be accumulated if the Grey Hydrogen fuel used in Ammonia manufacturing could be converted to Green Hydrogen.



- Green hydrogen for ammonia synthesis in fertilizer manufacturing can support the net-zero vision for India by 2070. It can enable the transition of the fertilizer industry from fossil fuels and wean away dependence on imported natural gas and ammonia.
- As per National Hydrogen Mission, the Ministry of Chemicals and Fertilizers will encourage adoption of indigenous green ammonia-based fertilizers for progressively replacing imports of fertilizers and fossil fuel-based feedstocks (natural gas and ammonia) used to produce fertilizers. This will enable decarbonization of the sector and reduce dependence on imports. The Ministry will

enable procurement of green ammonia for its designated entities to create bulk demand.

- The National Hydrogen Policy says, by 2034-35, it is targeted to substitute all Ammonia based fertilizer imports with domestic Green Ammonia based fertilizers.
- Bulk manufacturing industries like fertilizer, which consume feedstocks like hydrogen and ammonia cannot be decarbonized with renewable electricity alone, green hydrogen could be a big potential.

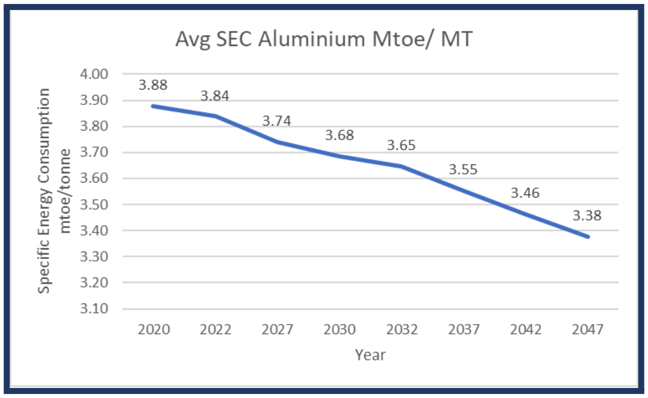
Aluminium

Aluminium is the second most used metal in the world after steel with an annual consumption of 88 million Tons (including scrap). Aluminium Consumption in India at 2.5 kg per capita is much below the global average of 11 kg per capita. To reach the global average of 11 kg per capita, India will require an additional annual consumption of 16mn tons, thus, making it the second largest consumer in the world (absolute terms). The key environmental issues with aluminium production are disposal of the bauxite residue (red mud), high energy consumption, water management along with physical footprint of the plant with infrastructure and the red mud disposal area.

Table 10: % of Energy among 8 Energy Intensive sectors for Aluminum

Sector	Energy mtoe	Coal mtoe	Gas mtoe	Oil mtoe	Electricity mtoe	% of energy among 8 energy intensive sectors
Aluminium	18.31	17.05	0.13	0.82	0.31	9.80%

IESS: Energy Consumption in MTOE for Aluminium sector for the year 2022



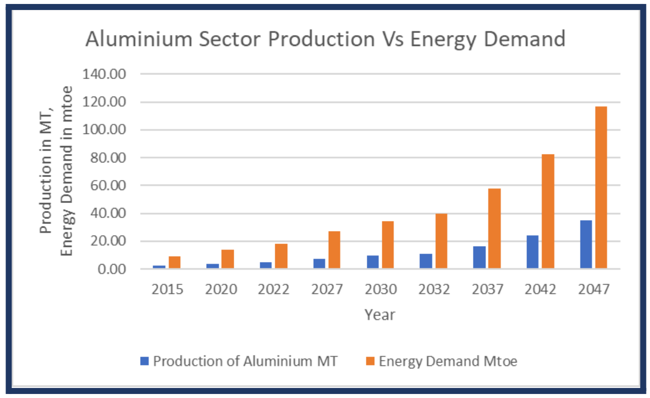


Figure 8a: Average SEC Aluminum

In 2022, India primary aluminium production stands at 3.22 million MT. India's domestic aluminium manufacturers have the highest carbon intensity among global producers, with emissions of 17-20 tonnes of CO2 equivalent per tonne of aluminium (ICRA). The high emissions are due to their significant use of coal in generating captive power. Therefore, to meet their targets to achieve net-zero status by 2050, the industry will require significant investment in renewable energy (RE) or low carbon-intensive power sources.

Due to various initiatives in the Aluminium sector the overall specific energy consumption is projected to reduce from 3.88 in 2020 to 3.38 mtoe/ton of Aluminium by 2047 resulting in energy savings of 17.31 million tons of oil equivalent (mtoe) in 2047 and 121 million tons of CO2 by 2047.

The Constraints:

- Red Mud disposal and utilisation: Red mud is a waste product of the industrial process of extraction of Aluminium Oxide or Alumina from the ore bauxite. Every 1 million ton of Alumina production generates about 1.4 to 1.5 million tons of red mud. Indian Alumina Refinery is contributing around 8.34 Million ton/annum of red mud.
- Generation of Spent Pot Lining (SPL) - Spent pot lining is a waste material generated in the primary aluminium smelting industry. Recovery of Carbon from spent pot lining and reusing as fuel is a technology challenge. Disposal of spent pot lining or its use in totality is itself a technology challenge to primary aluminium producers.

- Unorganised Metals Recycling industry: In India we do not have any formal organized metals recycling infrastructure. The industry is not highly regarded and there are no specially designated zones/areas for metals collection, disposal, trade or reuse. Due recognition of recycling could encourage users of aluminium particularly in transport, housing, packaging and durable sectors to broaden the organised markets for the scrap generated.

Recommendations:

- Coal is used in captive power plants and alumina refining which is a major cause of GHG emissions. Other than this a marginal amount of GHG is emitted during the process, anode effects and anode manufacturing. Aluminium primary smelting uses carbon anodes that release CO2 as a part of the electrolysis process. These anodes can be replaced by inert anodes that release oxygen as they decay. Therefore, renewable energy together with inert anodes is the way forward for a sustainable energy transition of the aluminium sector.

- Scrap Recycling: Recycling of aluminium saves 6 kg of bauxite/kg and 14 kWh of electrical energy /kg of primary aluminium. Since recycling of aluminium requires only 5% of the energy and so it emits 5% of the GHG as compared with primary route. Hence, promoting the share of secondary production, from 30-35% at present, will catalyse decarbonization of the aluminium sector.

    1. This will require an improvement in domestic aluminium scrap collection and disbursal.
    2. Scrap usage in India is diffused and not regulated through standards or end-use restrictions with heavy reliance on imports. India should aim to increase the recovery of secondary aluminium by 50% of the total aluminium scrap domestically; and for this the targeted recycling rate to be achieved could be set at 80 per cent by 2025 and 90 per cent by 2030.
    3. There is no proper scrap collection, segregation, and treatment facilities. Government may consider zonal scrap collection/segregation/treatment facilities. Also recycling zones may be developed to address above issues including transportation, pollution control etc.

- Technologies to reduce process emissions, such as carbon capture and storage, inert anode etc together with fuel switching to alternatives, such as bioenergy and hydrogen for high-temperature processes or near zero-emission electricity for lower-temperature heat processes, are at early stages and may take years to be ready for mass adoption. Hence the government shall support installation of demonstration pilots and facilitate low-cost financing.

- The Aluminum sector generates substantial waste or byproducts i.e. for 1 ton of primary aluminium, the industry produces about 8-10 ton of by-products, like red mud, spent pot lining (SPL), fly ash, dross etc. There is a potential to convert them into value-added products by setting targets on resource recovery and reuse. For eg - cement industry can successfully use SPL; coal can be mixed with carbon rich SPL etc.
- At National level a comprehensive strategy needs to be made on utilization of red mud mainly in following 5 areas:
    1. Cement making
    2. Bulk construction – road, embankment, marine clay reclamation and mine backfilling
    3. Brick/block/paver block/plaster etc for housing and roads
    4. Man-made soil for green belt development
    5. Metal/non-metal value recovery
- In each of these areas a National level Mission Projects need to be launched and these projects to be executed in parallel. The projects should focus on complete solutions including commercial scale technology development, demonstration & implementation, preparation of policy guidelines and standards.

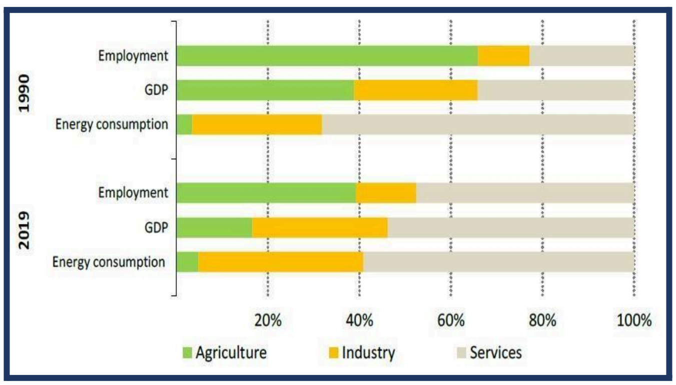
Chapter 4: Agriculture

The objective of this chapter is to propose potential policy options that will facilitate better management of agricultural energy demand in the future.

4.1. Key Trends & Projections

India is an agrarian economy with about 116 million farm holdings having an average size of 1.4 ha (FAO, 2005), accounting for about 17-18% of GDP and employing about 40% of the country's workforce. The cultivated area is about 141 million ha and has remained constant for the past 30 years although the cropping intensity has increased from 118 to 135 percent during this period.

Compared to other demand sectors Agriculture's contribution to GDP and to employment generation is decreasing. The sector is growing at 3.5% against a targeted growth of 4% with heavy dependence on traditional Agro methods as a result the energy demand increased only marginally.



For higher productivity and profitability, the transition to modern Ag techniques is essential. Such modern technologies require energy at all stages, such as for "direct use" in farm machinery, water management, irrigation, cultivation, and harvesting. And, for "indirect use" in the form of mineral fertilizers and chemical pesticides, insecticides, and herbicides etc. This chapter focuses only on the "Direct use" of energy in the agriculture sector. The "indirect usages" will be captured in other sections like Industry demand etc.

Electricity is a critical source of energy for the agriculture sector in India constituting 16% of the overall electricity demand. Mostly used for irrigation, powering pumps, lighting, and running agri-processing units etc. **Fossil fuels**, especially diesel and petrol, constitute around 8% of overall fossil fuel demand. It is widely used in areas like powering tractors, transport, and agri-processing. However, the rising costs of fossil fuels, along with its environmental impact, have raised questions around its sustainability in the long run.

Table 11: Future Energy demand for Agriculture Sector

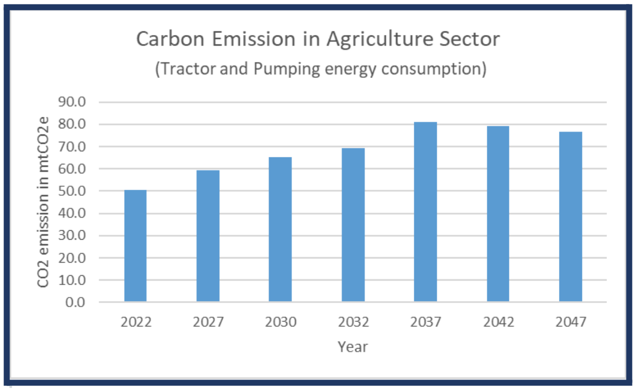
Item	Energy Demand	2020	2022	2027	2030	2032	2037	2042	2047
Diesel Demand for Ag (mtoe)	Tractors	8.1	8.9	11.2	12.8	14.0	17.5	16.7	15.8
	Pumping	7.15	7.35	7.82	8.08	8.24	8.56	8.75	8.75
Electricity Demand for Ag (mtoe)	EV Tractors & Pumping	15.75	16.77	19.61	21.56	22.95	26.89	31.50	36.92
Renewable electricity penetration in Ag	Pumping	0.13	0.40	1.21	1.82	2.29	3.70	5.53	7.88

The future energy demand for agriculture sector is highlighted in the table below- (Source: IESS 2047)

The energy demand in Agriculture sector shall increase to 70 mtoe in 2047 from 33 mtoe in 2022 @CAGR of 3.01%, primarily having demand in Tractors and Pumps due to increase in nos. of Diesel Tractors from 70 Lacs to 165 Lacs by 2047 and Pumps from 313 Lacs to 570 Lacs by 2047. There could be some penetration of Electric Tractors starting from 2027, which will continue to grow and reach 12% of total tractors by 2047 in the Agriculture sector.

Figure 10 a&b: Energy Demand & Number of Pumps & Tractors Agriculture Sector

Similarly, the share of electricity consumption[2] in the Agriculture sector will decrease from 15% to 12% by 2047 due to the increase of shares of Solar based pumping.



The carbon emission will start decreasing from 2037 onwards due to high penetration of solar pumping and low carbon farming besides other sustainability activities. However, the energy produced from Agricultural crops has not been reflected in the scenario, perhaps achieving net zero if properly planned.

4.2. Agriculture a "Prosumer"

India's agricultural growth must be farmer centric, driven by technology, equity, affordability, economics, and sustainability. The future of India's agriculture growth will depend on two types of crops 1) Energy crops and 2) Food crops. The sector needs to be self-sustainable w.r.t. energy use. Which is possible when energy and food crops share equal share in cultivation.

4.2.1 Crop residues generation and Potential

The current availability of biomass in India is estimated at about 750 million metric tonnes per year. The Study indicated estimated surplus biomass availability at about 230 million metric tonnes per annum covering agricultural residues corresponding to a potential of about 28 GW. This apart, about 14 GW additional power could be generated through bagasse-based cogeneration in the country's 550 Sugar mills, if these sugar mills were to adopt technically and economically optimal levels of cogeneration for extracting power from the bagasse produced by them. As on 31.10.2022, a total capacity of 10.20 GW has been installed in the Biomass Power and Cogeneration Sector.

4.2.2 Biofuel Potential

National Biofuel Policy was enacted in 2018 to promote the production and consumption of Biofuels. Ethanol-blending percentage in petrol rose sharply from

0.67% in 2013 to 10% in May 2022. The policy has translated into a reduction of 2.7 million tonnes of CO2 emissions. India's ethanol demand is poised to grow to 10.16 billion litres (5.67 mtoe) by 2025. India is set to launch a Global Alliance on Biofuels, along with the USA and Brazil.

Global biofuel consumption can increase in a sustainable way from 55 million tonnes of oil equivalent (Mtoe) today to 750 Mtoe in 2050. This would mean that the global share of biofuel in total transport fuel would grow from 2% today to 27% in 2050.As per new National Biofuel policy, India poised to increase Ethanol-blending percentage in petrol by 20% by 2025-26.

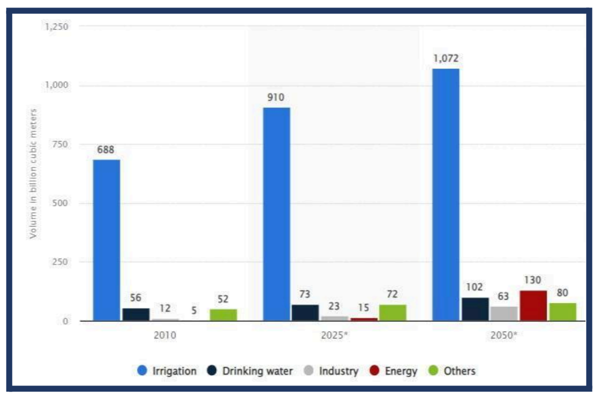
4.2.3 Solar Power Potential

The PM Kusum program by MNRE aims to add solar capacity of 30.8 GW till 2026.
It includes

Component A: 10 GW of solar capacity through installation of small Solar Power Plants of individual plants of capacity upto 2 MW.

Component B: Installation of 20 lakh standalone Solar Powered Agriculture Pumps. Component C: Solarisation of 15 Lakh Grid-connected Agriculture Pumps.

4.3. Water Energy Nexus



Agriculture accounts for 5% of overall energy demand and about 85% of India's water demand. Both water and energy intensive crops like rice, sugar, maize and cotton are most prevalent, and their export means that India is effectively the world's biggest water exporter. Water use efficiency on farms in India is among the lowest in the world: three to five times more water is used in Indian farms than on farms in China or the United States to produce the same amount of crops, having a direct bearing on energy (NITI Aayog, 2018). Free (or low cost) electricity and poor governance contributed to the rapid decline of India's groundwater resources.

Recommendation:

- Schemes like "Direct Benefit Transfers of Electricity (DBTE)" for agriculture consumers, shall be scaled up with the objective of saving both the groundwater and electricity together.

- The Government shall also review the aggressive Agriculture pump rollout schemes like PM Kusum from a water saving perspective.
- State Government to promote innovative cooperative mechanisms like Community owned and managed irrigation Pumps with low upfront cost consisting of 5-10 low-income farmers as piloted by Professional Assistance for Development Action (PRADAN) in the Bastar district of Chhattisgarh. Such approaches can also Leverage existing networks of self-help groups (SHGs) created under the National Rural Livelihood Mission

- India needs a clear policy direction to switch from flood irrigation practices to targeted irrigation techniques (micro irrigation), together with water management practices, such as water harvesting, storage, and recycling, these efforts could save up to 47% of irrigation water and save 250 TWh by 2030 on a cumulative basis.

- State nodal agencies (SNAs) need to work with financial institutions to try innovative models such as the farmer-developer special- purpose vehicle (SPV) piloted in Karnataka to overcome financing challenges with farmer-owned power plants. RESCOs can be a big support in this mode. Awareness on RESCO and ESCO projects needs to be disseminated by these SNAs.

- Innovative cooperative mechanism for implementation of PM Kusum can be thought of through successful model like - Surya Raitha Scheme –Karnataka through Creation of Farmers Cooperatives, channel subsidies, soft-loans to the farmers., Power Purchase Agreements for a span of 25 years and ensure proper power supply to the Pump Sets.

4.4 Promoting Low Carbon Agro products

Market plays a significant role in the growth of the Indian agriculture sector. By aligning market forces with sustainable practices, the agriculture sector is likely to achieve energy independence much faster.

Recommendations:

- Promote low carbon products market through certification, proper branding, together with behavioural nudging campaigns. Higher demand for low-carbon organic and sustainably produced food, can incentivize farmers to adopt practices that reduce emissions and local pollution.

- Certification schemes can enable farmers to access premium market rates for their products, and gain a competitive advantage, which can encourage the adoption of sustainable practices. Awareness to the consumer and its health benefits are the key factors to promote the Carbon free or low carbon product.

4.5. Low Carbon Farming (LCF)

India has signed a sustainable agriculture action agenda at COP26 Summit. The aim is to make farming sustainable and environment friendly. Low Carbon Farming (LCF) has the potential to provide multiple benefits to the farm sector like improved soil health and fertility, increased water retention, enhanced biodiversity, increase in jobs, and sustainable agricultural production etc.

Recommendations:

- For the overall framework of carbon farming to be successful, it would have to include sound policies, public-private partnerships, accurate quantification methodologies and supportive financing to efficiently implement the idea. It requires it to be done at a scale where measurable carbon capture can be achieved along with maintaining healthy soils that absorb and store carbon.

- Recently announced market mechanisms such as “green credits” can create financial incentives for farmers to adopt climate-friendly practices, such as agroforestry, crop rotation, organic farming, which can sequester carbon from the atmosphere and promote energy efficient farming machinery to reduce GHG emissions.

4.6. Support to R&D and Agritech

Energy efficient technologies in agriculture tend to require substantial upfront investments to support the transformational changes necessary to heighten farmers' productivity and their capacity to adapt to climate change while reducing the emission intensity of what they produce.

Recommendations:

- The budgetary support to the R & D and Agritech sector needs to be continued and should be increased in the later years as this will not only help in optimizing Agri resources but also provide a required boost to the climate change issue.

- The subsidy needs to be designed in such a way that it covers upfront investment for longer period with more flexible conditions (repayment schedules adjusted to cash flows) so that farmers can make the necessary investments to maintain or increase current yields, produce more food on less land, and adopt climate smart practices and technologies to increase their resilience while also reducing emissions.

4.7. Role of Regulators

There have been multiple regulators influencing Agriculture sector growth, having different backgrounds, skills and expertise. The Ministry of Agriculture and Farmers Welfare promotes the increase of Ag productivity, MNRE regulates the Renewable penetration into Agriculture; BEE pushes for energy efficiency by setting standards and ratings; MOEFCC/ PCB's regulate the environmental impact from Agriculture practices etc.

Recommendations

There is a rising need to have a single commission on Agriculture demand management that could ensure sustainable and low carbon growth of the sector. This authority shall develop:

- Conducive low carbon growth strategy for Agri sector suiting farmers' needs. Initiate a redressal mechanism to address complaints, concerns, and feedback from stakeholders regarding the implementation of the policy.

- Robust monitoring and evaluation mechanisms to assess the progress and impact of policies in the agriculture sector like – PM KUSUM, Pradhan Mantri Krishi Sinchai Yojana (PMKSY) etc. This includes regular data collection, analysis, and reporting on key performance indicators (KPIs) and outcomes related to climate change mitigation, adaptation, and sustainable agricultural practices

.

- Co-design new interventions for Agri sector reform and co-ordinate with other energy and environment departments and ministries. Eg – Carbon Market for Agriculture could be initiated by this regulator.

- Conduct pilot on Smart Farming techniques, using IoT based devices for smarter demand/load management, for better managing time-of-day issues, and thereby encouraging farmers to use grid electricity only on non-peak hours.

4.8. Role of Financing

Majority of Indian farmers are poor, own less than 1 hectare of land, and are vulnerable to climate change. It re-emphasises the need for climate-resilient agriculture practices, risk management strategies, access to credit and insurance, market diversification, and supportive policies to mitigate the financial impacts on such marginalised communities.

So far, the climate bonds announced by the government have looked at mitigation solutions mostly in the urban setting, transport and built environment. More innovative financing options like green bond, blended financing, risk guarantee and weather insurance products will enhance the resilience of the Agriculture sector.

Recommendation:

- Clean agriculture finance - mainly from national, bilateral, and multilateral sources, and DFIs - shall be catalysed, for which an enabling environment must be created. "Dedicated line of credit for clean agriculture" shall be introduced to promote workable solutions.

- Innovative ESCO models and/or Farmers-Private Partnership (FPP) models shall be developed for large scale procurement and implementation of energy efficient farming technologies, as was achieved under UJALA LED program. EESL's capacity shall be enhanced for developing and piloting such business models. Awareness on

RESCO and ESCO projects needs to be disseminated by State Nodal Agencies (SNAs).

4.9. Transparency

India shall practice an open, transparent, evidence based and engaging policy making process for the agriculture sector. This will minimise the implementation challenges.

Recommendations:

- **National data bank** on Agriculture sector, wherein data on sustainable Agriculture and climate change could be made available for Research and development by the Regulatory Authority.

- **Knowledge Exchange Platform (KEP)** could be established for transparent sharing of proven and established information to the farmers on this subject. Linked to mission LIFE for nudging farmers behaviour towards sustainability.
- **International Centre of Excellence (ICoE)** required for awareness, knowledge dissemination, training and capacity building of farmers in India through internationally acclaimed Institutions.

4.10. Role of Government

There exist rightly intentioned programs like National Mission for Sustainable Agriculture (NMSA), PM KUSUM; Pradhan Mantri Krishi Sinchai Yojana (PMKSY); Agricultural Mechanization Program etc that together with state policies supplement energy use and its conservation.

Recommendations:

- A mechanism should be designed to conduct third party impact evaluation of such critical missions and programs to address the loose ends (if any), share learning and scale workable solutions. There is a huge demand from the global south to learn from India.

- As agriculture being a state subject, the state government is primarily responsible for the growth and development of the sector. The state shall therefore Create an Energy transition task force in Agriculture sector consisting of Ministries, NGOs, technocrats, think tanks and private sector with a task of reducing emissions, and renewable energy sources such as solar, wind, and bioenergy can help in reducing the agriculture sector's reliance on fossil fuels, the job of the task force would be:

1. Transition to electric power and robotics in agriculture involves internal combustion engine driven vehicles to battery or solar energy electric driven farm vehicles.
2. Energy Smart Agriculture (ESA), for reducing emissions include crop-diversification, improving water productivity, and manure management.
3. Digital Agriculture technologies to be used to promote crop assessment, digitization of land records, spraying of insecticides, and nutrients.
4. Development of Bio-Brick Industry for manufacturing Bio Brick from Agro Waste or Agro based (straw bales, bamboo, bagasse residue, corn cobes waste, coir fibre, hempcrete) as an alternative and sustainable building material that acts as an alternative to stubble burning.
5. Development of Measurement tools for farming to achieve sustainability goals.

- The Skill Development Department of each State shall empanel the Training of Trainers (ToTs) as Kisan MITR to provide required capacity building and awareness to the local farmers.

4.11. Role of Technologies in Agri demand management

- In recent years, many Indian farmers have started to consult data about important Agri variable factors like soil, crops, livestock, and weather. Yet, few of them have had access to advanced digital tools that would help to turn these data into valuable, actionable insights. In less developed regions, almost all farmwork is manual, involving little or no advanced connectivity or equipment.

- With the advent of smart connectivity to the remotest places of the country, the advanced connectivity has the potential to radically transform the aspects of farming.

- **Smart Crop monitoring:** Aimed at optimising resource usage and crop growth through real time, precise location dependent adjustments.

- **Drone Farming:** Drone surveillance and remote interventions based on image analysis and connected sensors. Kisan drones are being used for crop assessments, digitization of land records, and spraying of pesticides and nutrients. The Union budget 2023 provides a boost to smart agriculture through Kisan drones, digital agriculture are all potential sustainable alternatives to traditional energy-intensive practices.

- **Energy Smart Agriculture (ESA):** for reducing emissions include crop-diversification, improving water productivity, and manure management. ESA practices such as laser land levelling, zero tillage, direct-seeded rice, site-specific nutrient management, and precision irrigation management are reducing energy inputs in various farm operations.

- **Digital Agriculture technologies:** Being used to promote crop assessment, digitization of land records, spraying of insecticides, and nutrients.

- **Development of Measurement tools for farming to achieve sustainability goals:** Transition to electric power and robotics in agriculture involves internal combustion engine driven vehicles to battery or solar energy electric driven farm vehicles, Agriculture Robots for performing complex tasks, Solar powered or electric driven Precision agriculture practices, Mobile agricultural robot swarms (MARS), and Solar or Battery Powered Weeding Robots (SPWR).

- **Autonomous farming Machinery:** Self-operated machinery and robots able to perform targeted interventions based on sensor data, GPS data, imaginary analysis, aimed at optimising resource usage, reducing labor requirement, and boosting yield through more precise and individualised attention.

- **End to End platform for Crop Advisory:** An end-to-end platform for crop-advisory is a platform that provides farmers with personalized crop advisory services using digital crop monitoring platforms. The platform is designed to provide farmers with site-specific crop advisory services that are tailored to their specific needs. (The Indian government has proposed to create an AgriStack - a unified platform to provide end-to-end services across the agriculture food value chain to farmers. Microsoft has also signed an MoU with the Indian government to create a Unified

Farmer Services Interface through its cloud computing services). In addition, there are several private companies that are building end-to-end platforms for farmers. For example, AgroStar is building the largest and most impactful agri-solutions platform to provide end-to-end solutions for Indian farmers. Similarly, Famrut is an innovative ecosystem that delivers future-ready farming solutions and connects farmers with all relevant stakeholders of the entire agricultural sector.

- E-Tractors: Electric tractors are becoming increasingly popular in India due to their low operating costs and environmental benefits. There are several electric tractors available in India. (For example, Sonalika has launched the first field-ready electric tractor in India called the Tiger Electric. The Tiger Electric has a 25.5 kW battery that can deliver a maximum power of 34 HP and a lifting capacity of 1,500 kg. Another option is the HAV 45 S1 electric tractor which has a 44 HP engine and a 40 HP PTO power. The Autonxt X45H2 is another great option for an electric tractor in India. It has a 32 KW battery that can deliver a maximum power of 45 HP and a lifting capacity of 1800 kg.)

Chapter 5: Decarbonizing Mobility

5.1 Background

India's passenger and freight transport demand in 2020 stood at 3.44 trillion passenger-kms and 1.3 trillion ton-kms, requiring over 4700 peta-joules of energy during the year (see Table 12). This is projected to almost quadruple by 2050 in the business-as-usual scenario. The growth will largely be driven the following three factors:

1. Increasing economic growth, since India aims to become a $10 trillion economy by then.
2. Increasing income levels of the people enabling many of them to start using motor vehicles and travel more frequently.
3. Increasing urbanization, which requires more frequent travel and longer distances, necessitating the use of motorized vehicles.

All of these are positive trends for any developing country and the growth should not be constrained. However, constraints of energy availability and commitments on climate change will require policies to explore how the growth can be accommodated but with a reduced demand for transport and, consequently a lower requirement of energy. This paper suggests policy interventions that will help achieve this. enable the growing transport demand to be met with lower energy needs. In some cases, it has also suggested options that may not necessarily reduce the travel demand or energy requirement, but helps a shift towards cleaner forms of energy, and hence it has been retained.

At the outset it highlights the current challenges in the transport sector and thereafter proposes a five-pronged approach to reducing the transport demand and consequent energy requirements. It goes on to highlight the respective roles that different stakeholders will have to play towards achieving the desired reductions. It specifically focuses on the urban transport and inter-city freight transport sectors as these are likely to see the highest growth.

Table 12: Transport demand, and emissions across sub sectors for 2020

Mode	Passenger/ Freight demand	Energy Demand (petajoules/ year)	CO_2 Emissions (million metric tons/year)	Co2 per year *
Road Transport				
Passenger (trillion PKM/year)	2.94	2036	150	51
Freight (trillion freight ton km/year)	0.65	2280	153	235
Railways				
Passenger	0.47	58	3	6
Freight	0.34	79	4	11
Aviation				
Passenger	0.04	130	9	225
Freight	0.0002	4	0.3	1500
Shipping				
Passenger	NA	15	1	-
Freight	0.31	118	9	29
Total				
Passenger	3.44	2238	162	47
Freight	1.30	2480	166	127

*CO2 per year/trillion passenger km for passenger and ; CO2 per year /trillion ton km for freight

As may be seen from the above, the transport sector energy requirement is 4718 peta-joules. This will nearly quadruple by 2050 in the business-as-usual scenario. The table also shows that on a passenger – km and ton - km basis, rail and marine systems are much more energy efficient and cleaner than road and airline systems.

5.2 Challenges with the current transportation systems

The transport sector in India is currently facing several challenges. Some of the most important ones are highlighted in the sections that follow.

5.2.1 Rapid motorization

India has seen a very rapid growth in the number of registered motor vehicles since the middle 1980s and an even steeper growth since the economic liberalization in 1991. The entry of a large number of foreign car and motorcycle manufacturers has spurred interest in personal motor vehicle use, in a market that was otherwise stuck with outdated technologies.

Figure 11 below shows the growth in the number of registered motor vehicles since 1951.

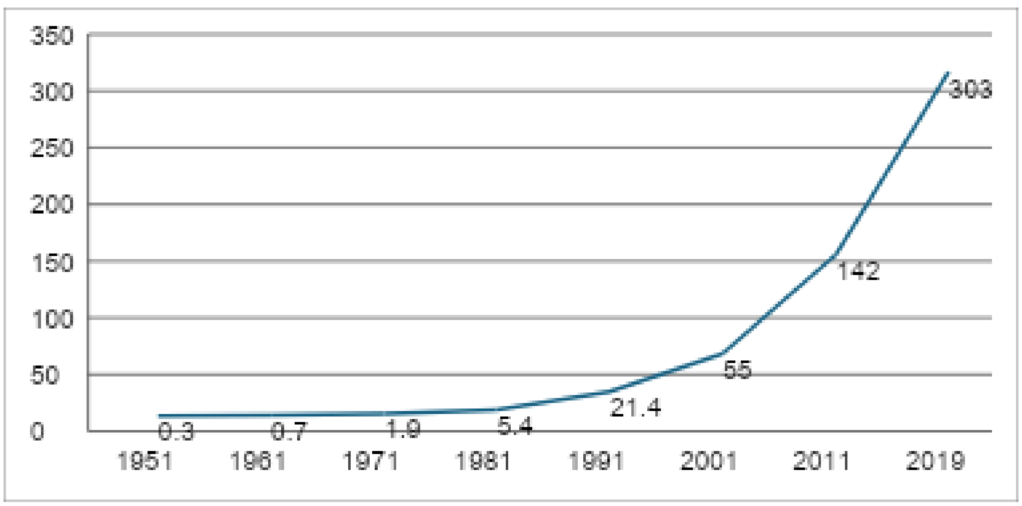


Figure 13: Growth of registered motor vehicles (Million vehicles)

This has resulted in a growth of per-capita car ownership which went up from 8.9 per 1000 population in 2006-07 to 22 per 1000 population in 2016-17. By international standards this is still very low and indicates every possibility of even further growth if things were to continue as usual.

Apart from this rapid growth in the total number of motor vehicles, there has also been a sea change in the profile of motor vehicles on the roads. Two-wheelers now dominate the motor vehicle fleet as shown in Figure 12 below.

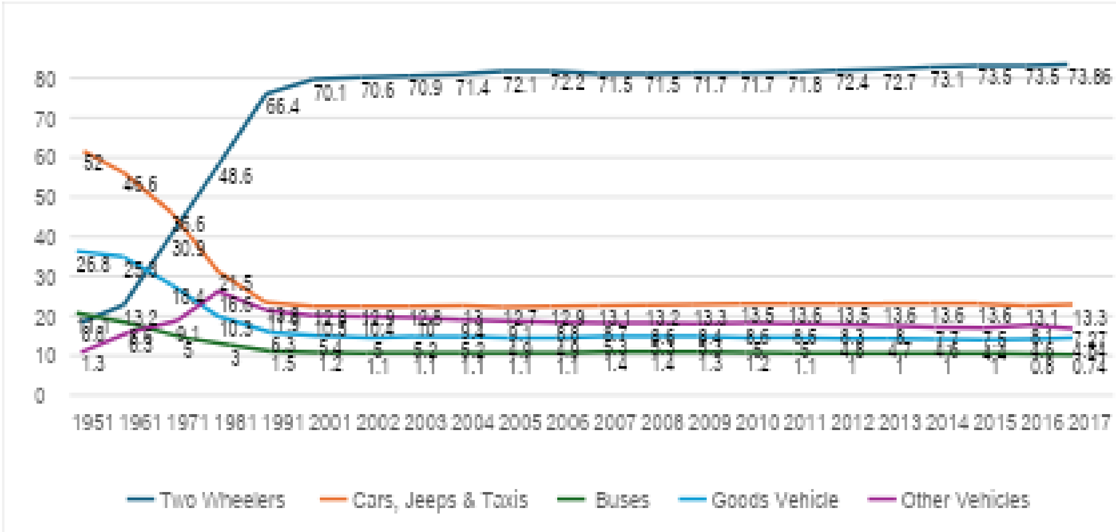


Figure 14: Year on year growth of different types of vehicles

This figure also shows that the share of public buses has fallen from 11% in 1951 to less than 1% now, demonstrating reduced importance of public transport systems in the country. More strikingly, during 1981 to 2019, while the country's total population grew by 90% the number of registered motor vehicles grew by 5511%.

5.2.2 Poor Public Transport Systems

Part of the reason for the steep growth in personal motor vehicles has been the poor and inadequate public transport system, especially in India's growing cities. India has only 1.3 buses for every 1,000 people, much lower than other developing countries such as Brazil (4.74 per 1,000) and South Africa (6.38 per 1,000).

Public bus systems especially in urban areas are largely operated by publicly owned state transport undertakings (STUs). Their services have been incurring heavy losses, to quite an extent due to their inefficient and high cost operations. The result has been an inability to augment their fleet with the growing demand, thereby nudging people to move away from them. Besides, many of the cities, especially those with 0.5 million people or less have no structured public bus system and rely on informal paratransit services like tempos and mini buses to meet the travel needs of those who cannot afford a personal motor vehicle.

Most services, wherever they do exist, have been focussed on providing affordable services for the poor. Quality of service, or premium services, have not been a priority. As a result, efforts at attracting personal motor vehicles back to public buses have not been successful.

Recommendation:

The National Urban Transport Policy of 2006 strongly recommends the promotion of public transport, but it does not, parallelly, suggest any measures to discourage the use, or ownership, of personal motor vehicles. The time has come to bring in policies that will discourage the use of personal motor vehicles. Policies like high taxes on the purchase of a personal motor vehicle, and high usage charges, as have been imposed in cities like Singapore, Seoul and London, need to be considered.

Further, the current bus systems have been put in place with affordability in mind as the objective was to offer a mode of travel to those who could not afford a personal motor vehicle. Affordability was important for them. However, today, when we are looking for personal motor vehicle owners to also shift to public transport, the key determinant will not be affordability but quality. Accordingly, it will be essential to adopt policies that permit premium bus services to be available in all cities to attract personal motor vehicle users. These services will help reduce the energy demand by drawing personal motor vehicle users towards shared modes. These services may not need a public subsidy but will help reduce energy needs.

5.2.3 Dominance of Road Transport

As seen from Table 12, 91.5% of the energy demand from the transport sector is for road transport. The same table shows that 85.5% of the passenger transport demand and 50% of the freight transport demand is from the road sector. Only a meagre 17.5% of freight traffic is transported by the railways. In fact, the share of road freight is higher than in major economies like the United States and China where it is between 45–50%. Surprisingly, this is so, despite road freight being the more expensive mode. The main reason for this is its ability to provide door to door service and the lack of mechanisms that enable better integration between rail and marine systems with road systems. Besides, the railways give higher priority to passenger traffic, thereby adversely impacting the reliability of their freight movements.

Decreasing reliance on coal for power generation is likely to create excess capacity in rail systems for freight movement. Besides, dedicated freight corridors will add rail freight capacity. Therefore, bringing about a shift to rail freight will be imperative not just to reduce energy demand but to ensure that the large investments in rail capacity do not prove infructuous.

Coming to urban areas, road transport continues to dominate. A few cities have built metro rail systems but their prohibitive cost (over Rs 300 crores per km for elevated systems and Rs 500 crores for underground systems) coupled with the high carrying capacity that justifies them, has meant that only a few cities have been able to build them. Even where they have been built, ridership levels are very low in the absence of last mile connectivity and poor integration with other modes of travel.

Coming to long haul passenger services airline traffic has grown by leaps and bounds, with a significant share of the erstwhile rail traffic having moved to air. The entry of low-cost airlines has made air travel eminently affordable. Besides, with increasing income levels and a highly competitive airlines market, many prefer air to rail for long trips.

Recommendation:

- Aggressively promote better integration of rail with road systems to enable good last mile connectivity and thereby a pronounced shift in road freight to rail freight
- Undertake comprehensive planning for metro rail systems to enable better integration with land use and road systems to enable greater usage of these high cost systems.
- Discourage short haul flights and persuade a shift to rail systems for distances up to 300 – 350 kms and as high-speed rail corridors get built up these can be extended up to 600 – 650 kms.

5.2.4 Inefficient Trucking Industry

Medium and heavy-duty freight trucks contribute to 40 percent of vehicular energy requirements. Furthermore, trucks in India run an average of 300 km per day in comparison to the global average of 500-800 km per day, with empty running rates of 40%. The trucking industry is dominated by a large number of those who own small fleets. With the high level of competition, they operate on very small profit margins and do not have the financial muscle to replace old and polluting vehicles. Often, these are poorly maintained with the result that they are even unsafe.

Recommendation:

Stringent truck maintenance standards, strong enforcement of these standards, and incentives to nudge a better organized corporate trucking industry will go a long way in making this industry more efficient. Besides, advancements in electric vehicle and charging technologies are making it increasingly possible to shift from ICE trucks to electric trucks. Financial incentives are necessary to nudge such a shift till such time as the entire eco-system for such vehicles attains maturity.

5.2.5 Inadequate Attention to Inland Water Transport

Despite there being 111 national waterways, with a length of over 20,000 km, inland waterways have clearly been a neglected mode of transport. The Inland Waterways Authority of India (IWAI) was set up, in 1985, to create the required infrastructure to make the national waterways navigable. However, inadequate efforts at encouraging this sector has meant that there are few operators and it has a miniscule share in the freight movement. Being one of the cleanest modes of transport, it can take on a larger burden in moving freight traffic. Lack of last mile connectivity and relatively slower speeds make them unattractive, but for many non-perishables the low cost of this mode can make it very attractive.

Several initiatives have been taken up recently to scale up the use of IWT. 111 river stretches covering a length of 4332 kms have been declared as National Waterways under the National Waterways Act of 2016. This allows the central government to take responsibility for development of these stretches for greater use as transportation facilities. However, there are 14,500 km of navigable waterways in the country leaving plenty of opportunity to take advantage of these as sustainable transport systems.

Like in the case of inland water transport, coastal shipping is also not carrying an adequate share of freight traffic and needs to be scaled up.

Recommendation:

An aggressive push to scale up IWT and coastal shipping is needed by making investments in the needed fixed infrastructure and the vehicles. Innovative PPP models where the public partner invests in the fixed infrastructure and the private sector does so in the vehicles can be a winner. Cargo from public agencies like the FCI, and others can seed the demand, especially on identified routes such as to the Northeast and along coastal routes can be good starting points. Enhancing IWT to the NE may need persuasive negotiations with Bangladesh that will demonstrate win-win situations for both countries.

5.2.6 Slurry Pipelines

Movement of iron ore and similar materials by slurry pipelines instead of road or rail is yet another option to tap a sustainable mode of transport. They are environment friendly and since they are buried, they are invisible and silent. CO2 emissions are also very low compared to other modes.

5.2.7 Institutional fragmentation

India is perhaps the only country in the world where, even at the national level, policies relating to transportation are dealt with through five different ministries – Ministry of Road Transport and Highways, Ministry of Railways, Ministry of Ports & Shipping, Ministry of Civil Aviation and Ministry of Housing & Urban Affairs. There is no institutional mechanism for meaningful coordination amongst these ministries, with the result that each is developing its own policies and plans. All of this translates into even greater fragmentation at the local level. In particular, if we look at cities, there are multiple agencies involved with transport, with very little coordination between them.

The national urban transport policy, which was adopted in 2006, with the approval of the national Cabinet, has recommended the setting up of Unified Metropolitan Transport Authorities in all the large cities. While several of them have notified these authorities, with Kerala even having passed legislation for a Kochi Metropolitan Transport Authority, none of them have really started effective operations. In the absence of this, urban transport systems are also highly fragmented thereby hindering the possibility of integrated and multimodal systems coming up in the cities. This results in a greater preference for road-based systems, especially the personal motor vehicle, which is the only way of ensuring good last mile connectivity.

Recommendation:

A national level apex entity needs to be created to coordinate transport policies and plans across all modes. This could either be in the form of a Cabinet Committee on Transport or, better still, have one Ministry of Transport and mode specific departments, or mode specific technical agencies, reporting to the Ministry.

In each city of over one million people, there should be a coordinating agency in the form of a Unified Metropolitan Transport Authority (UMTA).

5.3 Reducing Transport and Consequent Energy Demand – A Five-Pronged Approach

A five-pronged ground approach is being suggested to reduce the energy demand from the transport sector. These are highlighted in the sections that follow:

5.3.1 Enhancing Energy Efficiency

Primarily the objective is to reduce the amount of energy consumed per vehicle kilometre of travel. In other words, the idea is to meet the transport demand but with a lower consumption of energy in doing so.

Several initiatives in this direction are already on. The series of initiatives for tightening emission standards, though undertaken primarily for reducing air pollution, are also supporting the reduction in the amount of fuel consumed. These initiatives need to be made more stringent by setting tighter standards and requiring the use of lighter vehicles which are more aerodynamic. The outdated designs for trucks and buses need to be transformed into more aerodynamic designs that would save fuel. This is particularly important for long distance road freight vehicles. Thinking in terms of smart vehicle designs would help reduce energy consumed in the road freight sector.

5.3.2 Accelerating the Use of Clean Fuels

While a shift to clean fuels like electricity or hydrogen, by itself, will not reduce the transport demand, it is not very clear whether it helps reduce the energy demand, in terms of joules. Yet a section on clean fuels has been added as it supports reducing emissions both from a climate perspective and from a local air pollution perspective.

The National Electric Mobility Mission Plan (NEMMP) seeks to convert IC Engine vehicles to Electric vehicles (EV). The Faster Adoption and Manufacture of Electric Vehicles (FAME) program offers financial incentives for the purchase of EVs and also for setting up charging facilities. A recent initiative for aggregating the demand for electric buses and shifting them towards private operations has shown immense promise for a large-scale shift to cleaner fuels for buses. This initiative needs to be scaled up manifold.

There has been discussion around several clean fuels. While electric vehicles have dominated the discussion, there are options in bio-fuels, hydrogen, CNG, etc. There are also discussions around pure electric vehicles and hybrid vehicles. At this stage, as these technologies are evolving, it would be most appropriate to allow a level playing field to all of them and let the market determine what the Indian consumer prefers. In the interim, it would be prudent to ensure a level playing field by not having a tax structure that tilts the scales in favour of one or the other. A degree of uniformity in the tax and incentive structures would be the right approach.

While developed countries have been concentrating on shifting a large share of the vehicle fleet to electric, in India our focus should be on shifting a large share of vehicle miles to electric. Savings in emissions accrue on use and not on the number of vehicles themselves. Therefore, the types of vehicles that need attention are public buses, urban freight vehicles, taxis, and auto rickshaws. All of them typically have a more intensive use across the day.

An important barrier to scaling up the transition to electric vehicles is the low energy density of batteries. A fully charged battery can power a car to travel only around 200 – 300 kms, depending on the type of vehicle and size of the battery, before it needs charging again. Charging itself needs several hours ranging from 2 to 8 hours, depending on the type of battery. Hence, it will be necessary to continue research on battery technologies to develop models that have a higher energy density to suit the needs of long-distance travel. New technologies that emerge in this regard would make it possible for long distance trucking, and possibly even shipping, services to move to electric traction. Battery swapping is emerging as a good option and is yet another alternative to encourage and support.

Green hydrogen is another potentially clean fuel, especially for the transport segments where electrification may be difficult. Long distance trucking, shipping and aviation could, someday, move towards green hydrogen as a clean fuel. Unfortunately, at today's level of development this is going to be prohibitive. Storage and transportation of green hydrogen is going to be a highly risky proposition. Investments in R&D for lowering the cost of green hydrogen as well as making its storage and transport safe would go a long way in enabling the transport sector to move towards net zero. Coming to rail transport, the Indian Railways has already been working on moving from diesel traction to 100% electric traction and hopes to do so in the next few years.

5.3.3 Shifting to Cleaner Modes of Transport

It is well known that air transport and road transport emit far more greenhouse gases compared to rail and waterway transport. This is largely due to the reduced friction between a steel wheel and a steel track on rail compared to the friction between a rubber tyre and a bituminous surface in the case of road transport. As a rough example, for carrying 1000 ton-kms of load, a truck would consume 30 litres of diesel as against about 4 litres by a locomotive. It would, therefore, be logical that a larger share of passenger and freight transport moves towards either rail or marine systems. Similarly, aviation uses a lot more fuel than rail (approximately 14,000 litres per hour of flying as against 400 litres per hour by train). It would therefore be logical to shift as much of air travel to rail as possible.

Unfortunately, these shifts have been difficult mainly because each of these modes is managed through separate ministries. This position is unique in India as most other countries have a single ministry for transport, even if there are separate technical bodies under the single ministry. Such a structure allows better coordination across modes, especially at the policy and planning levels.

Several ongoing projects can be leveraged towards effecting a transition to cleaner modes. The Indian Railways is building dedicated freight corridors across the country. Plans are to build 6 corridors covering a length of 8359 kms. Similarly, it has plans to build 12 high speed rail corridors covering a length of 7856 kms. The dedicated freight corridors can be leveraged to affect a shift from road freight to rail freight, especially by ensuring last mile road connectivity. The high-speed rail systems should be leveraged to affect a shift from short haul flights to high speed rail, by either higher taxation or limiting permits for short haul flights.

This kind of a transition will not happen organically. It will need policy leadership and some proactive measures such as limiting the number permits given for short haul flights and ensuring that the Indian Railways ties up with the trucking industry for last mile service, to offer shippers a single window for door-to-door service. The Gati Shakti platform and the National Logistics Policy 2020 are promising initiatives that could facilitate this transition and need to be accelerated.

Coming to urban transport systems, public transport and non-motorised modes of travel, like walking and cycling, are the cleaner modes of transport, as evident from the simple back of the envelope calculations given in Table 13 below.

Table 13: Fuel consumed per person–km with different types of vehicles

Vehicle type	Fuel consumed per 100 kms (litres)	Persons per vehicle	Fuel consumed per person km (litres)
Personal car	8	2	0.04
Motor bike	2	1	0.02
Bus	22	40	0.0055
Bicycle / walking	0	1	0

As may be seen from the table above, on a per person basis, public bus systems emit less pollutants than personal cars and motorbikes. Walking and cycling are, of course, non-polluting as they do not consume any kind of fossil fuel. It is necessary to bring about a greater shift from personal motor vehicles towards these modes. This is, in fact, the prime objective of the national urban transport policy adopted in 2006.

Recommendations:
The earlier recommendations relating to having an apex entity to plan for transport in an integrated manner would apply here as well. The policy direction should clearly be towards increasing the share of rail and marine systems and reducing the share of road and aviation.

The National Urban Transport Policy of 2006 makes a strong recommendation for increased share of public transport and non-motorised modes of transport, like walking and cycling. While investments in public transport have gone up, similar emphasis on non-motorized modes needs to scale up.

5.3.4 Optimal Utilization of Available Capacity

Optimizing the use of available capacity has two dimensions. First, transport demand, by nature, has peaks and off peaks. However, transport capacity is available throughout the day/month/year. Therefore, off peak periods entail low-capacity utilization.

Second, transport vehicles often move around without their full capacity being used up. Many personal cars have a single occupant despite having a capacity to seat four people. Buses can seat around 40 people but often have fewer passengers.

This kind of unused capacity is wasteful as the fuel for carrying this additional load has already been consumed. It is therefore important to ensure that all available capacity is fully used to minimise fuel consumed in meeting the complete travel demand.

Coming to long distance freight movements a similar problem is seen as freight movements tend to be skewed in one direction and the reverse movement often involves empty haulage. This is also a wasteful use of available capacity.
Capacity utilization could go up if suitable platforms are created for better information exchange and a certain amount of dynamic pricing which allows lower prices based on marginal costs rather than levying a fixed price. This can be done both for passengers as well as freight traffic. For airline travel this is already in place as most airlines have a system of dynamic pricing depending on the number of seats available on a flight.

Recommendation:
The emerging innovations that use technology to enable sharing of available capacity need to be given strong emphasis by modifying legislation that may restrain them. Car-pooling and aggregator systems need to be promoted and not restrained. Aggregator systems should also be encouraged for small sized buses as a kind of premium bus service.

5.3.5 Transport Demand Management

As seen earlier, rapid urbanization, coupled with growing income levels are expected to increase passenger transport demand, especially in urban areas. However, effective methods of demand management can be deployed to reduce this growth, as demonstrated by initiatives in several countries. Passenger travel demand is a function of:

- The number of people travelling,
- The average number of trips made by each person daily,
- The average length of their trips, and
- The average number of people per vehicle.

While it may not be possible, or even desirable to reduce the number of people travelling, the average number of trips made by each person daily can be reduced through measures like:

- Policies relating to working from home.
- Reducing the number of working days, especially the number of days requiring working from the office.
- Online shopping and eCommerce: The average trip length can be reduced by adopting planning principles that encourage compact cities and discourage sprawl. Similarly, mixed use planning will also help reduce the average length of trips.

The number of persons per vehicle needs to be increased so that the transport demand can be met with fewer vehicles. This is possible by encouraging public transport and also other shared modes of travel like car-pooling. Measures that discourage the use of personal motor vehicles, like high parking fees, high taxes on personal motor vehicle ownership, high fuel taxes and congestion pricing are initiatives that many cities have adopted to nudge a shift to shared modes of travel.

5.4 Respective Roles

Attaining net zero in transport will require major changes in the way transport systems are managed. Multiple stakeholders will have to play an important and transformative role. These will include the government, independent regulators, private operators, financial institutions, think tanks and academia, civil society, and the market in general. The following sections highlight the role that each of these stakeholders will have to play, and the changes they will have to make in their current policies and practices.

5.4.1 Government

Reforming Urban and Sub-Urban Public Transport Entities

Most states have a government owned state transport undertaking (STU) that operates both intra-city and inter-city public bus services. Intra-city services are much more complex and loss making compared to inter-city services and therefore suffered considerable neglect. However, the growing congestion and air pollution in cities made them extremely important. As a result, several states, such as Karnataka, Tamil Nadu, Maharashtra, Madhya Pradesh and Gujarat have created separate entities only for operating city bus services in their major cities. But, in all these cases it is still a state-owned undertaking that is operating the services.

The arrangement of Government led operation was put in place at a time when many cities were faced with the situation of a large number of small bus owners providing low quality services. Competition on the streets made them unsafe and the high degree of competition forced them to operate on small profit margins. The services were of poor quality and capacities did not expand to meet the growing demand. It is for this reason that the government had to take over these services in many cities around the world. The objective was that a government agency would be able to provide better services, in all parts of the city, and at an affordable price, even covering non profitable routes. Unfortunately, publicly operated services have proved to be extremely expensive, largely due to the inherent inefficiency of public agencies to operate such services. They have also lacked customer focus and not been innovative enough to align services with changing demand patterns. They incurred huge losses and needed high levels of financial support from the government. This was a huge drain on the public budget, compelling many cities to look at alternative delivery models.

New models for providing bus services have since emerged, wherein a government entity decides on the routes, schedules and fares, but contracts a private party to operate services. London has been a pioneer, and many others have followed suit. Commonly known as the gross cost contracting model, this requires a private operator to procure the buses and operate services in accordance with the schedules given by a public agency. The private operator incurs all operational expenses and is compensated on the basis of the kms operated. The per-km compensation is pre-decided through a competitive bidding process. The public agency collects the fares and uses it to compensate the private operator.
On some routes the fares collected may be higher than the amount paid by way of compensation whereas in others it may be the reverse. On an overall basis, however, adopting such a model result has seen a significant reduction in the overall outgo from the public budget, largely due to the operational efficiency of the private sector.

This fact is now widely known. Yet, STUs in India, as in several other countries, have been hesitant to undertake the needed reforms, primarily apprehending a political backlash from the large complement of drivers and mechanics who would be rendered surplus. It has, however, become increasingly important that this reform be carried out and ways of either redeploying the surplus staff or offering them a generous voluntary retirement package be undertaken. This would not only lead to a reduced outgo from the public budget, but also give cities a vastly improved bus service that may be more effective in attracting personal motor vehicles users. This would help reduce emissions from the transport sector.

Private operators are also hesitant to respond to invitations for operating city bus services, primarily for two reasons. First is the lack of capacity to operate city bus services as they have not had the opportunity to do so over the last few decades. Second is the apprehension of delayed payment of compensation, or even non-payment of the same.

Recommendation:

Given the above, Government's must look at reforming public bus services in three ways:

- Becoming regulators and facilitators of these services rather than operators of the same. This will require building the capability to procure, contract and monitor rather than operate services.
- Becoming owners and providers of the fixed infrastructure, like depots, Use of the private sector beyond operating urban public transport
- Establishing independent regulators for price determination wherever a fair interface is needed between private operators and public agencies.

Use of the Private Sector in Other Areas

Government must also have a greater involvement of the private sector in many other segments of the transport ecosystem. The government has already given up all its stakes in airline operations. Some of the bigger airports have entered PPP arrangements and more are planned. It must look at similar roles for the private sector in railway systems and in managing ports and shipping services. A similar role is easily possible even in inland water transport systems where publicly owned entities continue to dominate today. Greater involvement of the private sector can lead to significant efficiencies in operations and reduced fuel consumption.

- **Fuel Efficient Trucks**

As noted earlier a large share of the intercity freight traffic is carried by trucks. Unfortunately, the trucking industry in the country comprises many small truck owners who, due to intense competition, function on very thin profit margins. The result is that old trucks are generally not replaced and even their maintenance is inadequate. They tend to become highly polluting and even unsafe. It is therefore necessary for the government to formulate clear and stringent policies requiring a modernization of the trucking industry, if necessary, by offering financial incentives for fleet renewal and replacement. When coupled with stringent and well enforced regulations the change to more efficient trucks will be possible.

- **Facilitating Multi-Modalism**
  On another front the government must also emphasise multi-modalism, both in urban passenger transport and inter-city freight transport. This will have to be done by creating multimodal transfer/logistics hubs where easy transfers are possible, between modes, especially between road and rail as well as between ships and road. Similarly, for urban passenger transport it will be important to create lead entities that can effectively coordinate between different segments of the transport ecosystem. The Gati Shakti platform is an excellent tool to facilitate this. However, this platform is good for coordinated project delivery. A similar platform will be needed to coordinate operations.

- **Pricing, Taxation, Incentives and Subsidies**
  Effecting a shift to cleaner modes or cleaner technologies will require these desired modes and technologies to be more economical and more convenient. Taxation policies of the Government must reflect a strong interest in reducing the demand for energy by levying deterrent taxes on modes of travel that use more energy and lower taxes on more efficient modes of travel. Therefore, personal motor vehicle use must be taxed high and public transport systems must be taxed lower, or not taxed. Even within public transport, cleaner technologies must be taxed lower than technologies like diesel buses. Overall, there must be a proper gradation of taxes to encourage a move towards less energy intensive modes of travel. In the initial years, say till 2026, it may be necessary to use the additional taxes to subsidize cleaner modes wherever they are unable to compete with the traditional technologies, or use these proceeds to invest in the supporting systems needed. An example will be charging facilities for electric vehicles or R&D for better battery technologies.

- **Periodic Review of Policies, Regulations and Laws**
  It would also be important for the government to review various laws, regulations, rules and policies at a certain periodicity to ensure that they are better aligned with the changing needs and demands of the day. Technologies are changing rapidly, and new paradigms are emerging across the world. All of these are working towards

more efficient transportation of people and goods as also towards cleaner transport. Unless our policies and laws are reviewed periodically, we run the risk of being stuck in outdated systems which would be to our disadvantage. Ideally these reviews should take place at 3-to-5-year intervals. It is also important to ensure that exhaustive data is collected regularly to monitor progress and make changes to our policies and laws based on what the data tells us.

As an example, our Motor Vehicles Act is outdated in many respects and needs to be comprehensively reviewed. The emergence of electric mobility, the usefulness of app-based aggregators, the need for vehicle pooling systems, etc. are essential today. However, the motor vehicles act does not seem to recognise this and, in fact, penalises them. Yet another example is the national urban transport policy which was adopted in 2006. It has served the needs of that time very ably but with the new technologies and systems that have emerged for urban travel this policy needs to be reviewed and updated.

5.4.2 Markets

If the government were to transform its role from being a regulator and a facilitator of public bus services instead of being an operator, the market must respond by building up its own capacity to be efficient operators and appropriately respond to invitations for operations. Currently the private sector does not have the requisite capacity, largely because it has not had the opportunity to operate city services over the last several decades. Yet, such services are going to be a big opportunity and where considerable demand for good quality bus services would emerge. It would also be a way of significantly reducing emissions from the urban transport sector.

Markets must also build up capability to manage a lot of the fixed infrastructure facilities that may become available to them, such as airports, bus depots, bus terminals and other fixed infrastructure. Opportunities will also emerge for the private sector in port operations, multimodal logistics hubs and possibly in inland water transport systems.

This will also require the private operators to build up capability in credible financial analysis so that financial institutions are able to trust them for making their lending decisions.

5.4.3 Regulators

Currently, there are no independent regulators in the transportation sector. Yet, there are suggestions for a greater involvement of the private sector in the operation of public transport systems. For this to happen in a fair manner, it will be necessary to set up independent regulators. Such regulators must make a special effort at nudging a shift in demand towards off peak periods by pricing public transport systems higher during the peak and lower during off peak.

Several cities around the world have adopted the concept of differential pricing between peak and off-peak periods for public transport and also parking charges to nudge better utilization of available capacity. Similarly, cities have adopted principles that allow easier movement of vehicles that are occupied by two or more persons as against those with only one passenger. Parking fees in areas well served by public transport can be an effective nudge in favour of public transport as would congestion charges for entry into central city areas in personal vehicles. Regulators must deploy this thinking into the tariff determination process.

5.4.4 Financial System

If private operators were to enter into operating public transport systems, especially those using clean technologies, the financial system must develop innovative instruments to finance them. These instruments must recognise the risk of new technologies and add innovative insurance instruments that would de-risk non-payment, or delayed payment, of dues by public agencies.

In a recent example financial institutions had expressed hesitation in financing potential private operators of electric buses due to concerns about timely payment of dues by the STUs. Innovative escrow mechanisms and insurance systems would be needed to provide greater assurance that the operators would be able to pay back their debts.

There are concerns that the use of private operators for public transport systems may lead to job losses as they would be more efficient and would bring in new technologies. However, there is an immense amount of unmet demand for public transport which the private sector would be well placed to serve. For example, there is a need for premium services and services that can meet special needs like travel to airports and railway stations as well as employment hubs in a city. The private sector will help expand services and may actually create more jobs.

5.4.5 Civil Society

Think thanks and academic institutions have a critical role to play in furthering the move towards net zero in the transport sector. They need to undertake the necessary analysis to suggest the right pathways for government policies. They need to handhold implementation of these policies at the ground level and finally they need to contribute towards building the right capacities and awareness so that appropriate policies are understood and supported by people at large. They would also have a critical role in pointing out gaps and suggesting changes that may be needed. They would serve a useful purpose as friends, philosophers and guides of the public system rather than being adversaries.

5.5 Overcoming Barriers

There are several barriers to implementing these suggestions. These barriers need to be clearly understood and worked around.

- First, and foremost, is the institutional fragmentation as highlighted earlier. This does not permit integrated policy and planning. Coordinated action across different modes becomes extremely difficult when policies and plans are developed independently across multiple ministries. Getting around this will require either the creation of a single ministry of transport which takes responsibility for policies and planning, with separate agencies, working under them, to take responsibility for technical issues only. An alternative would be to create a high-level transportation policy and planning unit either in the cabinet secretariat or in the Niti Aayog where all transport related policies and plans are formulated in an integrated manner, Funds for implementation of these policies and plans should be allocated to this unit, who should then sub allocate for different modes of transport. Similarly, for city transport systems a Unified Metropolitan Transport Authority should be set up and made effective in all cities with over a million people.

- The second barrier is the lack of professionalism in most of the transportation sectors especially at high levels. People join the Indian Railways or state transport undertakings without any professional academic background in transportation. They come from a variety of academic backgrounds but learn on the job. While this may serve our basic purpose, it does not give the needed professionalism that is necessary in the country today. The setting up of the Gati Shakti Vishwavidyalaya to help build professionalism in the country, is a step in the right direction. IIT Roorkee has set up a Centre for Transportation (CTrans) with precisely this objective. Other institutions must also be encouraged to set up professional transportation programs that go beyond purely technical and engineering aspects, to cover a wider gamut of disciplines such as economics, social, political, behavioural, sociological and environmental dimensions.

- A third barrier is the lack of reliable data. While railway systems, being centrally managed, have good collection protocols, these are sorely lacking for road transport systems, which are the most polluting. This is largely due to very decentralized operations and the absence of a single data management entity. It is extremely difficult to get reliable data on the movement of trucks, the origin and destination of different commodities and passengers moved by road, and the movement patterns of people in cities.

  In the absence of such data, it becomes very difficult to understand the current demands in the market and the kind of policies that could help move towards reduced emissions. Therefore, intensive work on developing protocols for data collection and management will be necessary. The government may like to set up a special task force to come up with ideas on this and also mechanisms for implementing them.

5.6 Summary of Recommendations and Way Forward

In conclusion, the transport sector is a significant contributor to GHG emissions in India and its share in the total emissions will grow with urbanization, increasing incomes and the overall economic growth of the country. A highly skewed share of road transport and the rapidly growing share of aviation will be major concerns in moving towards net zero in the transport sector. A five-pronged approach covering stringent fuel efficiency standards, use of clean technologies, a shift towards cleaner modes of transport and a more optimal utilization of available capacity should be the one that the country should adopt. Given below is a summary of the recommendations contained in this paper towards reducing the growth in transport demand and consequently the energy demand:

- A national level apex entity needs to be established to coordinate transport policies and plans across all modes, even if implementation remains the responsibility of mode specific ministries or agencies.

- Each city of over one million people, should set up a coordinating agency in the form of a Unified Metropolitan Transport Authority (UMTA).

- The National Urban Transport Policy of 2006 strongly recommends the promotion of public transport, but it does not, parallelly, suggest any measures to discourage the use, or ownership, of personal motor vehicles. The time has come to put in policies that will emphasize demand management measures such as working from home, reducing the number of days requiring staff to go to office, scaling up e-commerce, adopting measures that discourage the ownership and use of personal motor vehicles.

- Aggressively promote better integration of rail with road systems to enable good last mile connectivity and thereby a pronounced shift in road freight to rail freight

- Discourage short haul flights and persuade a shift to rail systems for distances of 300 – 350 kms and as high-speed rail corridors get built up these can be extended to 600 – 650 kms.

- Undertake comprehensive planning of metro rail systems to enable better integration with land use and road systems to ensure improved usage of these high-cost systems.

- Improve public city bus systems by leveraging the operational efficiency of the private sector, even if public entities determine the level of service needed. Introduce premium bus services that will be attractive enough for personal motor vehicle users to consider a shift to them.

- An aggressive push to scale up IWT and coastal shipping using innovative PPP models where the public partner invests in the fixed infrastructure and the private sector operates cargo and passenger services.

- Aggressive push towards adoption of electric vehicles, with a focus on shifting vehicles – miles more than shifting the number of vehicles.

- Keep up the efforts on developing green hydrogen as a potential clean fuel for transport systems.

- Modify legislation as may be needed to scale up technology-based initiatives that encourage car-pooling and vehicle sharing.

- Establishing independent regulators for price determination wherever a fair interface is needed between private operators and public agencies.

- Formulate clear policies requiring modernization of the trucking industry, if necessary, by offering financial incentives for fleet renewal and replacement.

Introducing smart freight vehicles and systems to reduce emissions and empty haulage.

In doing so some of the major barriers it would face would be the institutional fragmentation, the lack of reliable and comprehensive data as also the lack of professional manpower in the transport sector. It would have to significantly improve the quality of its public transport systems in order to attract private motor vehicle users. For these the current governance mechanisms operating public transport will need to be reformed with a greater involvement of the private sector in operating city bus services.

At the national level a mechanism for integrated policy making and planning for transport across all modes must be put in place. At the city level unified metropolitan transport authorities need to be set up in all the large cities for integrated policies and planning as well as coordinated operations. Academic programs that would ensure professional manpower and mechanisms for reliable database management will also be needed.

Review of outdated laws, regulations, rules, and policies will be necessary to make sure that the current philosophy adopted is in line with the demands of the market and the latest technologies currently available. A major effort at moving from road and aviation to rail-based modes will be essential, and certainly possible. Inland water transport needs to get far more attention than it is getting today. A significant reduction in emissions is certainly possible, but it needs concerted action and a coordinated approach.

ENERGY SUPPLY

ENERGY SUPPLY

Chapter 6: Coal

6.1. Introduction

The status of coal in the energy basket of India is pre-eminent. It comprises nearly 36% of commercial Primary Energy Source [PES] and nearly 72% of power generation. India is endowed with a large number of 'major' minerals such as iron ore, manganese, bauxite as well as limestone (a 'minor' mineral). The processing of these minerals into core products is mainly done with coal as a critical fuel and feedstock. The demand for both end products — power and metals/cement—is likely to keep growing for the next several decades. With the fifth largest coal deposits in the world, coal availability is also ample. Hence, coal mining is expected to keep increasing also because domestic coal could replace coal imports and help conserve foreign exchange. On the other hand, coal has a high emission factor. Nearly half of India's carbon-dioxide emission comes from coal-based power plants. In the drive to achieve Net Zero Emissions [NZE], the curbing of coal power will be a key element of the strategy. Therefore, the Integrated Energy Policy [IEP] will have to carefully calibrate the outlook towards coal consumption. In this chapter, we concentrate on coal mining while demand aspects are dealt under different chapters.

- Until several years back, the country was unable to harness its vast coal reserves. But the situation changed in 2020 when commercial coal mining was launched, and the private sector also became engaged with mining. Even Coal India Limited [CIL] has boosted its production, and it is likely that in the next few years, India may have an exportable surplus. However, India has low reserves of coking coal for which it is almost fully dependent on imports to meet the demand of steel and allied sectors. As discussed here later, various steps are being taken to enhance the supply of coking coal and the import dependence could come down. The demand-supply match for thermal coal is also a factor of how much thermal power may be needed. If the Government's lofty target for RE is achieved by 2030, then the pressure on coal may ease. The growth in power demand is a logical factor, too. The share of electricity in the final energy demand of the country is lower than the developed world, and even the per capita electricity consumption is just one-third of the global average. There is a vast scope for electrification of demand in various sectors such as cooking, manufacturing, mineral processing and mobility. It is a given that power demand will increase and RE needs to grow at a much higher rate than in the past, failing which, dependence on coal-based power may even go up. As coal is a domestic resource, there will be an expectation from the Government that it provides a conducive policy for coal mining, and lets the markets determine when domestic production ought to plateau and fall. Therefore, the IIEP prescriptions are favourable to coal production.

- Current indications suggest that coal-based capacity and PLFs from existing plants may rise for the next 10-15 years. MOP’s draft NEP suggests that there will be a growth in thermal generation capacity. And the coal demand for the power sector is likely to grow from 738 MT/year to 1019/year in 2030. Similarly, increasing demand for metals and cement will also pull coal demand higher. The production of steel is expected to grow from 125 MT/year to 300 MT/year by 2030. Even aluminium production and cement production is poised to grow significantly. As of now the current production processes in these industries are coal-intensive and are unlikely to see a high degree of adoption of hydrogen and DRI in the near future. The Ministry of Coal is aiming to enhance coal production from nearly 900 MT in 2022-23 to 1.5 BT by FY 25. This may even grow to 1.8 BT by 2030 or so, which is a near double from the present levels.

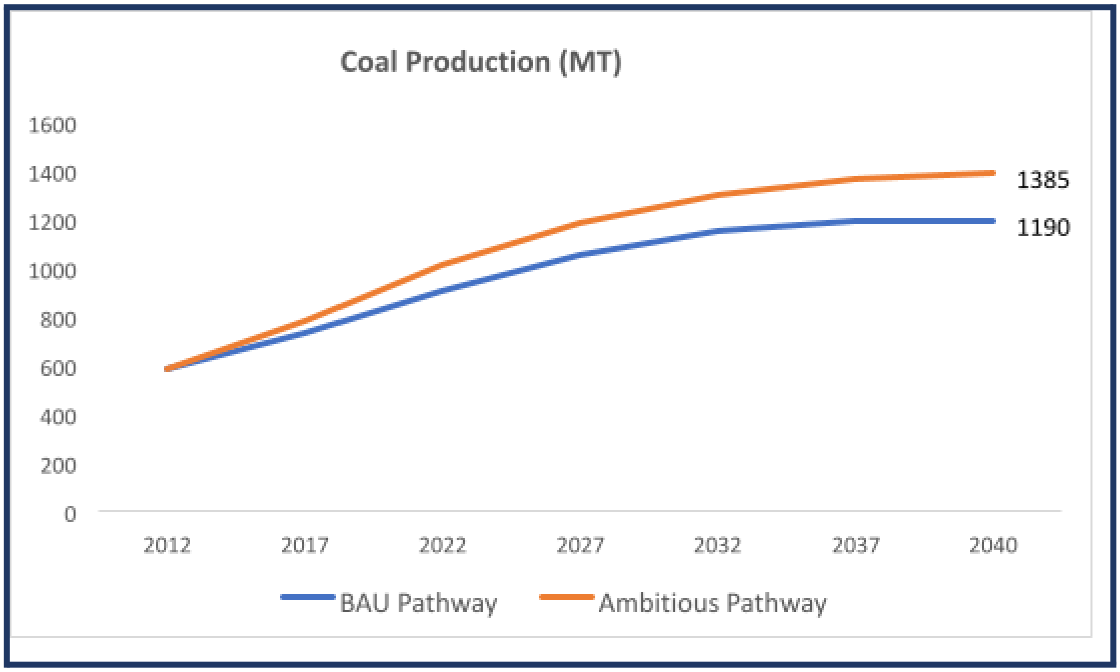


Figure 15: Coal Production [MT]   Source: Derived from IESS

- Consistent with our climate commitments, the policy framework towards coal production will have to be mindful of not appearing to be encouraging consumption of fossil fuels. The policy for carbon pricing, levy of any such nature that reduces the competitiveness of coal, and also reflects the true lifecycle cost of coal mining and its footprints on the environment will be addressed in separate chapters of this document. Experts agree that once the costs of supporting technologies such as battery storage (already falling at the rate of 10% per year) make the cost of variable renewable power viable, coal-based power will phase out. Present day coal prices do not cover the cost of full restoration of deforestation and mined out areas. The environmental clearances and mining plans will be suitably buttressed to address the environmental concerns. The reducing cost of renewable technologies is already closing the gap between round-the-clock cost of power from the two technologies. It is not that fossil-based power is restraining the growth of renewable technologies in any way. It is only the pace of increase in the non-fossil capacity that needs to be stepped up. In the past 5 years, the addition of conventional power generation capacity in India was surpassed by addition in the renewable sector. The IIEP proposes that different fuels are allowed to compete for market and administrative directions to invest or not invest are not given. This will also allow our public sector units to make judicious decisions on how much capital they ought to invest on greenfield coal mining operations, and not be driven by top-down decisions.

6.2 Exploration & Production

- GSI has done initial exploration and has already established the presence of coal deposits, but detailed exploration and evaluation is required before an investment decision can be made. CIL does this work in its own areas acquired under CBA Act at its own cost. For other lands, the Government funds the exploration through budgetary grants that are put at the disposal of CMPDI. A view has been advanced that now India does not need any fresh exploration because the coal production may peak shortly, and adequate mining reserves are available with mining companies including CIL. Such a view is also advanced on the ground that adequate explored areas which are yet to be exploited, are available with the Government for allotment both under MMDR Act and CMSPA. The latter comprises the balance of the 204 coal mines cancelled by the Supreme Court in 2014 and are being auctioned currently by the Nominated Authority of the Coal Ministry. Another factor is that the amendments made to the MMDR Act now place the onus of detailed exploration on private entities that participate in auction of un-explored or partially explored areas under the PL-cum-ML regime. Hence, even the allottees can undertake the necessary exploration, thereby supplementing the Government's efforts. While there is no straight answer to the issues raised regarding fresh areas being brought under mining, there is every merit in enquiring what might be the quantum of coal deposits and the annual PRC of areas possessed by CIL. The requirement of coal by 2047 is not more than 2 BT at the outermost. The Government will model the future energy requirements and the share of coal in it. If the areas held by CIL are more than what it might need in the near future, the same should be released from the coverage of CBA Act and auctioned to anyone interested in mining. So far this exercise of exercising areas in the possession of CIL has not been done. This may also call for an amendment in the CBA Act. There is no wisdom in dispossessing fresh landholders when sufficient un-exploited lands already exist with the CIL. Another decision area is whether GSI has established resources of the varieties of coal that India is currently import dependent, such as high GCV and coking coal. Such lands need to be further explored and offered for mining.

- Coal India Ltd (CIL) is expected to remain the principal vehicle of coal production in the country in the immediate future. It produces nearly three fourths of India's coal production, and nearly 70% of the country's thermal power comes from coal supplied by it. Even after the private sector emerges as a significant coal producer, since CIL being a CPSE, it will hold the predominant share. As there are restraints on it to raise coal prices for the power sector at least for the current FSAs, its linkages will continue to stay valid and even grow in volume. However, opening of new mines is a front-ended capex commitment, be it by CIL directly, or through its MDO contracts. CIL will ensure that there is adequate buying assurance before it ratchets up its coal production from 703 MT in FY 23 to 1 BT and above. While it does sign up contracts both in the private and public sector demands, for power and non-power alike, however, the private consumers have had the tendency to annul their buying commitment when coal is available at lower prices in the market. There is every likelihood that this situation may also emerge in the power sector, and they too relinquish linkages. Therefore, CIL will provide adequate protection in its FSAs so that there is no one-sided action from buyers. In any case, looking at the continued coal imports even for power generation, CIL is expected to keep enhancing its coal production for the coming few years.

- SCCL is another important player in the coal sector. While production from its coal fields in Telangana is not even 10% of CIL's production, it plays an important role in more than one way. It makes coal available in southern India which would otherwise have to be hauled over rail and sea networks from the eastern region over long distances. It comes to the rescue of the CIL in easing the overall power situation. It has now acquired mines in the coal prolific regions of Odisha and will enhance its coal supply in the years to come. State Gencos and NTPC have also entered coal mining in a big way especially with the coal mines allotted to them after the SC's coal mine cancellations in 2014. Their production is picking up only now. Once they achieve their PRC, the CIL will end up with released linkages which will go to meet the demand of the non-power sector.

- As regards the commercial coal mining policy, there appears to be an appetite in the private sector as well as public sector coal consumers (both in power and nonpower) to assure their captive coal demand, and that too at stable prices. The Government has to respond to this demand and continue to offer coal blocks. As discussed earlier, there should be adequate supply of coal blocks/mines either through areas not required by CIL or lands freshly explored or the PL-cum-ML route. Coal production from these sources will in the medium-term offer a challenge to CIL both in terms of quality and price. This augurs well for the development of a coal market.

- The issue of land access for coal mining has been a perennial hurdle. While mines lying in forest areas of High Conservation Value (HCV) cannot and ought not to be diverted for coal mining, there is the additional concern of displacement of tribals and other under-privileged communities. This problem has been attempted to be resolved by offering better compensation including jobs by the coal companies. However, looking to the finite future of coal, it is inadvisable for coal companies to be saddled with permanent manpower, whose job tenures may continue beyond the life of coal mine. It is undisputed that the land oustees have to be given fair compensation and with consent as per the laws of the land. What the coal companies might do is to build-in a corpus of funds that may be applied for compensation in the event of retrenchment of coal mine workers before their age of retirement. Therefore, the coal prices should be reflective of the liability carried by the coal companies.

- Coal supply assurance to the nation does not come only from land and capital deployment. It also needs logistical support. The historical growth of thermal power generation in the country has seen States setting up TPPs in their own jurisdiction and hauling coal over long distances. This has been facilitated by coal linkages and IR augmenting its logistical capacity—connecting the mining areas with the TPPs at distant locations. Whether the above logic of long leads between coal mines and TPPs is still maintainable has been discussed elsewhere. All that concerns the coal companies is that their coal production may be swiftly delivered to the TPPs. The IR looks upon coal business as a provider of surplus revenue that goes to subsidise passenger traffic. Therefore, it is continuously upgrading its infrastructure. Even coal companies are mechanising their first mile connectivity operations so that they can quickly evacuate coal from the mines and load it on the train. This calls for close coordination which is an ongoing operation.

- While on coal logistics, there remains a large potential of utilising the marine transport option from the ports of eastern India to the ports in southern and western India, that may ease the burden on IR and also add to the overall coal logistics capacity of the country. Even IR is in a comfortable position to supply in-bound rakes from ports to the hinterland. If the eastern India ports could be deployed to their optimum, the TPPs in Gujarat, Maharashtra, Rajasthan and even the northern States may not have any coal logistics issues in the future. There has been an appreciable increase in the handling capacity at ports. But looking at the fact that this option may be more expensive than the default option of railways, the Gencos have been lukewarm to the idea. Even faced with delays in coal receipt and power outages, they have so far not been keen to resort to the sea route option. It is high time that they realized the efficiency and certainty of sea transport, especially when the alternative of imported coal would be far more expensive.

- There are seasonality issues that affect the coal mining and power sector in a directly opposite manner during the monsoon period. In the rainy season, when coal mines are flooded and coal cannot be swiftly evacuated, this is the same time (June-September) when thermal power demand is also sustained. Other than coal storage outside the mines, both by the coal mining company and the thermal plants at their locations, there is no other solution. This can be enabled by suitable compensation to whichever agency locks up its capital in stock building, to be passed on to the power consumers. There are issues from the IR, too, as monsoons are not conducive for loading and movement. Therefore, the balance of convenience is tilted more towards stocking at TPPs, or finding other solutions such as flogging the pit-head plants during such periods of coal stock crisis.

6.3 Coal Distribution and Policy of Coal Linkage

- The current policy of coal supply from Government coal companies is a historical relic. The Gencos have coal linkages that are contained in Fuel Supply Agreements (FSAs) with prices that are left to the coal companies. In the real world, due to government agencies involved on both sides, the prices are not raised at all. The committed supply volumes and other conditionalities though provided in the FSAs are also not cast in stone. In effect, the whole contract and pricing is an administrative arrangement between government-controlled coal selling and power generating companies. It is another matter that even the power companies have an administrative arrangement when it comes to power prices - the cost of coal is a ‘pass-through’ under most contracts. Many power companies also have prices determined by a bidding process, but they comprise a small minority. Even the private generators who supply power under PPAs also enjoy the same liberalised contractual framework with CIL. The above opaque economy has resulted in the following mal-practices. The allocation of coal from different mines spread over 7 States is subject to arbitrary decisions of source, quality and quantity. This affects the supply and cost of power. The IR is under no contractual commitment either. So non-placement of rakes is an alibi taken by all sides depending on their own interest. Coal is supplied (and demanded) as per availability, with no penal consequences of substance. Quality issues are a perennial source of attrition, with a Committee of Secretaries authorised to intervene. Pricing system and division of coal into 17 grades may call for a revisit. The present system gives margin for a near 15-20% slippage in GCV fluctuation. A reform in the grade fixation may help reduce scope for quality issues. As the coal is supplied to the power sector at prices that have not been revised in 5 years, there is considerable premium on it in comparison to the non-power sector, leading to all kinds of bureaucratic controls and consequent red tape. The flexibility needed by TPPs to obtain their coal supply expediently does not exist. The coal companies do not have much incentive to improve efficiency as their performance is evaluated more by quantity of coal supplied, and not by efficiency of operations or quality of coal. This leads to a standing war of sorts between different stakeholders.

- The above arrangement needs to be phased-out in a manner that retains good aspects such as reliability of supply and prices, but with the change that the prices might be market reflective and even supply would be assured through 'supply or pay' provisions. The new arrangement may bring in greater accountability and efficiency. The loss-making coal mines of CIL may be shut down as their cost may not find acceptance. In this regard, a leaf can be taken from the natural gas sector where a phased evolution to market-based gas linkage has recently been mooted by the Kirit Parikh Committee. (This recommendation has so far not been accepted) As a first step, the coal linkage volumes should be reduced gradually over 5 years with a 20% cut in the supply every year. The TPPs would be free to secure the non-FSA volume from CIL or private miners, on agreed terms of price, quality and supply assurance, that are mutually negotiated provided the price is freely discovered. Even the coal companies would then be free of the FSA obligations over time, and the coal so freed could enter the market to be sold on best terms. Over a period of 5 years, the 'administered arrangements' would have been replaced by free market-based coal supply arrangements on competitive terms. For RE to increase, the Discoms also need to have flexibility in their PPAs. Hence, the share of their long-term contracted thermal power needs to decrease with RE contracts substituting them.

- The above does not suggest that there would be no long-term supply agreements. CIL itself could enter the market with contracts of different durations consistent with what the private miners might do. It is notable that under commercial mining policy the private coal miners have been given marketing freedom. All that is being proposed here is that both the CIL and Gencos would be motivated to enter into tight supply and quality arrangements that are mutually agreed without the intervention of the government. The coal companies would have to improve their quality and efficiency failing which they would lose business to their sister companies (CIL has 7 subsidiaries) or even the private sector. Even the power companies would have to strive to get coal on quality and competitive price basis, otherwise they would also lose their business. They may even be keen to be rid of firm price contracts as many Gencos have acquired captive mines and would now be souring their own coal at cheaper prices. There would be a churn in the coal market. It is notable that under the merit order policy (MOD), the power sector has already adopted efficiency in power markets with several phases of deepening of power markets. They should have no difficulty in transitioning to market-based coal supply. It is the coal sector that has not moved in tandem with the power sector reforms.

- There is already a move afoot to list 2 subsidiaries of CIL which should soon go all the way with all 7 subsidiaries. This would be the first step towards their privatisation. Even under the current corporate structure, there is no obstacle for the CIL companies to sell coal in competition to one another. Presently, the coal auctions are done on a mine/siding basis, even a step deeper than company level. The Power Ministry has been advocating coal auctions basis with different subsidiaries of CIL competing with one another. Under the above proposed arrangements, there will be a meeting of this expectation of MOP, too. The customer is likely to benefit from the efficiency which the above arrangements will derive. Even the CIL will gain enhanced efficiency from the market giving a negative signal to the inefficient coal mines.

- In the light of coal shortages and priority of the power sector, the non-power or NRS sector has been the loser. This is set to change as coal availability will now be ample. With the ramping of coal supply from the CMSP-allocations and commercial mining, not only is the overall availability likely to go up, even the satiation of demand of the power sector will lead to enhanced supply to the nonpower. As all the statutory levies and revenue shares are to be determined on the basis of coal prices realised, that cannot be less than the NCI-determined price (for the post-2020 coal mines), there is need for a functional coal sale platform. So far, the auctions of CIL/SCCL were either on an open bid system or on CIL's own platform. The latter is a 'one-to-many' price determination platform and cannot cater to the requirement of private coal miners who ought to sell on 'many-to-many' platforms. There is a need for a new forum for which the Coal Ministry has conceived a Coal Trading Exchange (CTE). The latter will be set up forthwith so that the States are able to determine their rightful share of levies and coal markets deepen. Once this forum is in place even CIL will migrate to this open platform for a competitive trade with other coal suppliers.

- The coal supplies to NRS are already on a 5-yearly based linkage policy. It will be appropriate that the prices so fixed on the auction platform, ought to move during the linkage period (on percentage basis) in tandem with the NCI. This will be equitable for both sides, and will not result in coal buyers walking out of contracts when the coal prices drop due to market forces. And, also be helpful to CIL which is in the danger of losing its business to newly started commercial coal miners, whose prices may be flexible as per NCI. To enable the above, the Government may consider directing that all mines bid out on revenue share basis will have to maintain the floor value of NCI-based price for determination of levies and other payments to the States. This will also be true for future NRS auctions.

6.4 Coal Markets and Pricing

- The launch of commercial coal mines has liberated coal from quotas and shortages. The coal to be produced from these coal mines can now be sold in the open market without any riders. The appetite for these mines, as is evident from the response to recent bidding rounds, shows that the bidders are confident of competing with the large coal production coming from CIL. It is indicative of the inefficiencies inherent in a mammoth organisation like CIL, including the opportunity of tapping the growing demand of coal at TPPs and other consuming NRS units in close vicinity of coal producing regions, who can avoid the cost of transportation involved in long distance haul. This is likely to shift power generation and other end-use units to the vicinity of coal mines.

- This is going to trigger the growth of a vibrant coal market in the country. A large number of public-sector owned generation companies may have their own captive supply of coal. This will lead to more market-determined sale of coal by CIL. The latter may even enter into long-term bilateral deals with large consumers who are located close to CIL mines and who may invest in beneficiation and logistical infra in the mines. It is notable that a number of NRS consumers have also picked up captive coal mines. As discussed earlier, the formation of a CTE will enable the trade of coal on free market principles, and the attraction of floor price as determined by NCI will prevent any under invoicing and denial of true share of coal price as levies and revenue share to the Government. The Government will further improve the build-up of NCI so that the looping of administered price of CIL does not impact the free price discovery. As coal linkages get surrendered, including greater share of CIL's production and production of commercial mines arriving in open market, and lesser coal imports, coal prices will fall and benefit the energy economy. Allowing the market to determine the price of domestic coal will also help eliminate inefficiencies arising from administered prices of domestic coal visàvis imported coal. As long as the delivered price of domestic coal is lower than that of imported coal, no imports would take place. Imports will only come up to the point that the delivered import price equals the delivered price of domestic coal. This will also ensure that at the margin the costs of electricity produced from using domestic and imported coal are equal.

- However, the concept of 'pass-through' of coal price in the power sector will challenge the formation of coal markets and needs to be phased-out over time. If this is done, then TPPs will strive to get coal at competitive prices rather than 'notified price'. There is presently a belief that the price of coal supply to Power will go up impacting power prices if CIL were to price the coal on open bidding basis. With large increments to coal availability, this may no longer be true. Even if this was true, the PPA regime allows the Gencos to find a market for their high-cost power that has a high cost of coal due to the high transport cost loaded on the notified price of coal. If long-term PPAs were to give way to market based power, then the pit-head plants would be able to supply cheaper power to the States, even from IPPs. The inefficient load-centre plants need to be taken off the line or retained as capacity plants. The above intent has not been realized so far due to lack of support from State Governments and can receive impetus if competitive power markets were to replace pass-through pricing. As stated above at another place, once the TPPs with captive mines (including NTPC) start using their own coal, and also when coal markets determine softer coal prices, there will be a churn in the power markets. The Discoms might want freedom from PPAs that deliver higher price of power especially in the case of distantly located TPPs, who get coal at high price due to the haulage cost. Not only will this move generation closer to pit-heads, rising deployment will drive down the cost of renewable power. This will shake the concept of 'pass-through' and TPPs may want to obtain coal from wherever they may get cheaper coal. This will be a salutary development and may further support the development of a coal market. For the above hypothesis to work, the Ministry of Power may have to look at reforms in the power pricing and consider freeing the Discoms from PPAs.

- As regards the 'stranded power plants' they may now be able to obtain coal supplies both from CIL's open market sales as well as from commercial miners. The SHAKTI policy may need to be re-considered in the light of the above developments. The latter was written in an era of shortages. Now there should be no problem in allocating long-term coal to these plants at prices that may be linked to NCI without any rider of PPAs. The freeing of coal allocations has to move in tandem with the power sector reforms. There may be a period of uncertainty when linkages are tapered for TPPs to gradually move to open market coal purchases, and the same will be the case for CIL who will no longer have firm contracts for its coal production for a particular mine. That is why the tapering of linkages will be helpful in management of the transition.

- CIL's rising production may offer it the option to export coal in the near future. This will call for a close study of export possibilities failing which domestic coal production strategy may call for slow-down in the pace of coal production particularly by CIL. There would be headwinds as Indian coal has high ash which may not be acceptable to the boilers in operation in other parts of the world. The quality of coal may need to be upgraded to the requirement of traded coal as is available from Indonesian and South African exporters. It is likely that the coastal mines in Odisha may be the prime sources of exportable surplus. This may also call for upgradation in logistical infrastructure from mines to the ports, and at the ports, too. The related Ministries/agencies may not collaborate to make exports possible.

6.5 Just Energy Transition (JET)

- The issue of JET has emerged as one of great importance and will keep rising in importance. The phase-down of coal will be a consequence of market forces driven by rising volume of cheap clean power. The pace of growth in the latter has been discussed elsewhere. What we are concerned here is that the coal sector itself should not be subject to sudden shock of dwindling demand and infliction of economic damage to the stakeholders. If the latter were to happen, it will spiral into social and fiscal consequences. The coal companies may be saddled with capital expenditure sunk into mines and infra that may not have recovered the costs, and the large number of workers and communities dependent on the coal sector directly and indirectly for their livelihood may be rendered jobless. Even the infra created by IR and others in cleaning, processing, transporting etc. may be under threat of losses. The State Governments may find a major source of revenue vanish with the responsibility of providing health, educational and such services which are presently being provided by the coal companies especially the CPSEs. The IIEP must address JET planning not only in the coal sector but in the fossil fuel sector as a whole.

- This is a vast subject, and it may be desirable only to briefly state the challenges and possible planning steps that JET calls for. Firstly, the coal companies need to diversify into the non-coal sector in the same regions that form their operational areas. They have a long experience of mining and understand the local economy quite well. They have a large pool of officers and workmen who could be deployed in the minerals sector generally. It is a good coincidence that the coal bearing regions are in most places also endemic in other major minerals such as iron ore, bauxite, copper and limestone. These minerals are of vital importance to India and are poised to grow. However, their processing has so far involved coal which needs to be substituted by clean energy. The coal companies and thermal power sector have to pioneer the latter clean processes so that they do not lose this business to newcomers. A Diversification agenda needs to be developed.

- The issue of employment of formal and informal workers can also be addressed by diversifying businesses discussed above. For this there would be a requirement of skilling the manpower. The related infra for skilling, relevant infrastructure and capital expenditure for which State support may be necessary, needs to be carefully thought through. The coal sector is a major revenue source for a number of agencies, both the Government and others like the IR, Finance Ministry for GST compensation, DMF and NMET among others. What might be the carrying capacity of the coal sector to continue to fund the above enduses along with support for a diversification agenda needs a careful analysis.

- Above all, the exercise of conceiving and implementing a JET strategy needs a management of a high order, seldom seen earlier. In a finite time space, the fossil fuel economy has to be re-fashioned into a clean energy economy. There will be issues of amending laws, enacting new laws, re-negotiating contracts between government and private parties as well as between private parties, finding financial resources, creating a framework of cooperation between central and state Governments, obtaining willing support of TUs and local communities, as well as political parties. A management team charged with this multi-year responsibility will need to be put in place armed with necessary authority, capability and resources. This kind of strategy will call for a high level thought and action for which the coal sector may not be capable itself and will need the involvement of top leadership.

6.6 Other Interventions

- The coal companies, particularly, need to develop a strong Diversification Agenda for them to maintain their topline when Energy Transition happens. This need not be entirely non-coal based. The Government has already announced a target of gasifying 100 MT of coal by 2030. This can yield fuel, petrochemicals and pharma ingredients locally at a cheap price instead of expensive imports. DME and methanol can replace fuels obtained from imported crude oil and natural gas. Clean coal technologies have a large potential of catalysing a hydrogen economy. Coal can be a cheap feedstock for hydrogen on the basis of which a grey hydrogen economy can be established until electrolyser costs fall and a green hydrogen economy takes over.

- An old and burning issue has been conflict between consumers and CIL on coal quality. The elaborate structure developed nearly a decade back of third-party sampling through CSIR labs needs to give way to mutually agreed quality certification norms. The two sides can also agree to introduce a logistics company as an intermediary who can deliver quality by supervising the dispatches for a fee from the consumers. It is also desirable that Railways, which transport coal, need to be party to this arrangement. Due to their not taking responsibility for quantity and quality, even coal companies are able to escape any liability. The above disputes are presently being brought before a Committee of Secretaries where these matters don't get resolved for years due to dis-agreement even at this level. This is another reason why a Coal Regulator must be put in place. With a large number of commercial coal mining contracts in place, there is a need for an empowered mechanism at an arm's length from the Government to sort out disputes, enforce contractual obligations and also provide support to the companies.

- Coal mining is responsible for substantial environmental damage to the immediate vicinity around mines. So far, the Mining Plan/EC conditions did not require the mining companies to complete a robust mine closure programme after mining activities get over. What is needed is that the land be restored to the original shape to the extent possible, so that the local community/State Governments can repurpose the depleted mines. These lands are vast and command a premium if they could be allowed to be put to use. Even on 'polluter pays' principle the coal companies will be required to do a scientific mine closure framework, and then the lands will be returned to State governments for useful application, including financing the JET.

Chapter 7: Oil and Gas

7.1 Introduction

India is highly dependent on import of oil & gas. The import dependency in 2021-22 based on consumption for oil and natural gas is about 85.7% and 48.2% respectively. Such high import dependency for these two fuels that comprise nearly one-third (32.9%) of India's commercial energy supply, makes the country energy insecure. On the other hand, India has surplus refining capacity if compared with consumption of petroleum products leading to export of petroleum products. Hence, the Indian refining industry is even in a position to cater to rising domestic demand.

The share of different fuels in India's energy mix in comparison to global average is given as under:

Table 14: Share of fuels in energy basket in India vis-à-vis Global average

	Oil	Natural Gas	Coal	Nuclear energy	Hydro Electric	Renewables
India (%)	26.6	6.3	56.7	1.1	4.3	5.0
World (%)	31.0	24.4	26.8	4.3	6.8	6.7

Source: BP statistics, 2022

7.2 Natural Gas: Cleaner Pathway

Fossil fuels such as oil and natural gas are targets of phase-down as per net-zero emission (NZE) timeline of 2070. While this does not in any way mean that there will be no emission, but lesser the emission, easier will it be for a nation to attain its ambition. Barring recent exponential rise in the price of all fuels including natural gas arising out of the Russia-Ukraine war, it has also traded cheaper than oil on calorific parity basis. The price has already started softening. It is notable that natural gas is nearly 30% less emission-intensive than oil. Many developed nations have higher share of oil and gas cumulatively, with less share of coal. In India the situation is different. With a rising energy demand, India needs to craft its independent strategy of what might be its future energy mix. This gives an opportunity to enhance the uptake of clean fuels and check demand growth of oil, and even substitute it with natural gas. This offers a huge opportunity for attainment of NZE by adopting a cleaner pathway.

7.3 Energy Transition: Oil to Alternatives

In the march to NZE, what matters is whether the current state of play of clean energy is on track to replace these fuels. In this respect, these two fuels – oil & gas — display differing prospects. In the transport sector, petroleum products dominate. Nearly 50% of all petroleum products sold in the country are consumed in this end-use (FY22). Similarly in cooking, another liquid fuel, LPG, is the fuel of choice and goes on to have a 14% share in all petroleum products consumed in India (FY22). A highly successful national programme, Ujjwala, has made it almost a universal cooking fuel. Going forward, the fuel choices in transport and cooking are likely to undergo a change. Both transport and cooking end-uses can be electrified. The substituting fuels may vary, with natural gas as the preferred fuel in cooking and EVs in transport. In the initial stage, CNG is also likely to be the bridge fuel. The transport sector is witnessing a mixed scene depending on the vehicle type. Nearly 60% of petrol goes to 2W/3W, which is electrifying at a rapid rate. About 80% of diesel goes to transport, which may also convert to CNG/hybrids/LNG. The car segment is also seeing a transition towards electric/hybrid. Compressed Natural gas (CNG) is also emerging as a fuel of choice for transport and is less emission intensive than liquid fuels. However, even though natural gas is less evil in comparison to oil, it also needs to be reigned-in over the medium term of this Policy. Being a fossil fuel, it may itself be included in the global fight against climate change. In cooking, which is the second most important use of liquid fuels (after transport), it does seem that Liquid Petroleum Gas (LPG) may continue to be a dominant player for the next 15-20 years, unless Piped Natural Gas (PNG) and electric cooking dislodge it Other end-use sectors like road construction, diesel gen-sets, aviation are also likely to see a transition away from petroleum product use. To hasten this, environmental action may work well as Europe has done by penalising airlines that use aviation turbine fuel (ATF), thereby making biofuel blending a viable option.

7.4 Energy Transition: Oil to Alternatives

Therefore, petroleum products will continue to be in demand while the slow transition is at play. As of now clean energy (electricity/renewables) is not in near-sight and the demand for liquid fuels and natural gas are likely to be sustained. On natural gas, cooking and transport end-uses together combine to be

19.8 % in all-natural gas consumed, and what follows is, that they may rise in importance as a substitute for oil, only to reduce in the medium term when cleaner substitutes (electricity, hydrogen etc.) enter these two consumption sectors in a big way. Therefore, during the proposed India Integrated Energy Policy (IIEP) tenure until 2047, the two fuels are likely to grow with gas even displacing oil. In what period might their demand plateau and eventually fall, would be known only in the next few years when demand scenarios are generated and detailed policy statements are issued by the Government. Perhaps, when renewable solutions become available as possible substitutes for transport, cooking and other end uses, then even oil and gas E&P, refining and marketing will have to be phased down. The steps to plan for a Just Energy Transition (JET) in the petroleum sector need to be conceived well in advance of this actually happening. This will ensure a well-financed and orderly transition.

7.5 Distinct Strategies for Oil and Gas

Due to the above differences, the two fuels — oil and gas — need a differential treatment. The policy framework may support gas as the transitional fuel. In the Indian policy framework, because oil and gas are generally found together, while the upstream policy has been common, the pricing and distributional policies have been different. This is rightly so, as globally the share of gas is rising mostly at the cost of oil. Also, because the two fuels have separate emission and calorific properties. From global shares of oil and gas of 31% and 24.4% in energy consumption in 2021, respectively, the IEA estimates the respective shares of oil and gas to converge with the share of gas rising and may report about 26% and 27% by 2035. On the other hand, the shares of oil and gas in India's energy consumption in 2021-22 were 26.6% and 6.3%, respectively. The share of gas is falling in India over the years, and even if we wish to achieve a share of half of the global average, a supportive regime is necessary. The national ambition is to reach 15% share by 2030. Based on the present extent of knowledge of the hydro-carbons potential, **Table 15** provides the domestic production potential of the two fuels in India. The IIEP proposes specific actions for oil and gas to achieve the stated objectives herein.

Table 15: Domestic Production Potential of Different Fuels in India

	2022	2030		2040	
		BAU	Ambitious	BAU	Ambitious
Oil (MMT)	29.7	29.0	32.0	57.0	68.0

Gas (BCM)	34.0	39.8	44.0	90.0	120.0

7.6 Enhancing Domestic Oil and Gas Production

Raising domestic production is the primary objective of the policy framework. During the last decade (2011-12 to 2021-22), the country's oil and gas production has fallen at **a CAGR of 2.7%** and 2%, respectively. On the other hand, the demand has been growing. Oil production decreased from 37.9 Million Metric Tonne (MMT) to 29.7 MMT, while that of gas from 40.7 Billion Cubic Metre (BCM) to 34 BCM, in the same period. On the other hand, consumption of petroleum products has increased by 3% CAGR from 157 MMT to 204 MMT, and of gas by 1.2% Compound Annual Growth Rate (CAGR) from 57.36 BCM to 63.9 BCM over the same decade. Consequently, India's import dependence and vulnerability to external price and supply shocks in the oil and gas domain has increased. Their import dependence has gone up in the same period as above by 10.1 % and 22.2% points, respectively. This has awakened a sense of urgency in the Government, and it has pulled all stops to liberalise the regime and attract investment by providing ease of doing business in a bold way. It is likely that results of these interventions may be seen in the next few years. The proposals herein will go even further to suggest reforms. It is also notable that developments such as environmental action, technology advances such as the advent of EV and recent successes in biofuels are also likely to help lower demand.

7.7 Cross-Fuel Substitution

An important aspect of the proposed strategy is inter-fuel substitution between oil and gas, which will be beneficial both from emission and competitiveness perspectives. The coverage of the entire country under CGD network and opportunity to substitute transport and cooking liquid fuels by natural gas may be possible by raising LNG imports in lieu of crude imports. Similarly, if the adoption of electric mobility were enhanced wherein green power was supplied, we could even re-consider the CGD strategy. However, the pace of growth of RE needs to pick up before we curb the consumption of liquid fuels. The above will have ramifications on refinery capacity growth as much as on LNG regasification capacity. Looking to the opportunity of a cleaner and cheaper energy source, the country needs to seriously examine this prospect also with a view to improve air quality and achieve climate goals. This is a strategic prescription, and the Government ought to delve deeper into the option of fuel substitution at least for the new demand for liquid fuel. The non-inclusion of oil and gas in the ambit of Goods & Services Tax (GST) has dealt a blow to the competitiveness particularly of a clean fuel like gas. This is an anomaly of old, and needs to be corrected at the earliest.

7.8 Balancing Petrochemicals and Energy Policies

While the IIEP is concerned with energy and not Petro-chemicals, the discussion on these two products gets linked when oil/gas issues are discussed. An important byproduct of crude refining is naphtha and that of gas processing is ethylene, both being the feedstocks for petro-chemicals. There is a large demand for the latter, and India is keen to produce downstream petro-chemical products domestically rather than import them, even if the basic raw materials (crude and natural gas) are themselves imported. This reminds one of the policies adopted in the nineties to import crude and value add by refining, rather than import petrol and diesel. While this has worked well for the country in ensuring availability of products and other fiscal gains have also accrued, but going forward it remains to be seen whether the NIMBY (Not in My Backyard) issue would hurt the country when phase-out of fossil fuels happens. As of now, the Government needs to balance the issue of meeting the rising demand of petroleum products and Petro-chemicals, while being watchful of the locking-in of carbon emission levels and challenge from clean technologies. This aspect has to be dealt with by the Government cohesively.

7.9 Upstream

- India has nearly 3.36 million square km of sedimentary area and for expeditious exploration, the Government has been attracting public and private investment into Exploration & Production (E&P). To enable the above, good quality data has to be made available for E&P companies to identify prospects. One way of securing this objective without the Government undertaking data acquisition can be offering attractive terms of priority allotment of acreage to interested companies such as what used to be earlier the Reconnaissance /Prospecting Licenses in the mining sector. Large tracts of land can be offered particularly where data availability is scarce with a pre-emptive right to produce hydrocarbons, should the company find the area prospective after it has done exploration. As at this stage, the interested companies may only be asked to submit a minimum, time-bound exploratory programme; it would be a variant of the Open Acreage Licensing Policy (OALP) in which commitment for a definite revenue share is sought at the entry stage itself. This will be particularly helpful in Category III basins where no hydrocarbons have been discovered so far. The Government has already offered very attractive terms by doing away with revenue share in category II and III basins. This has still not yielded desired success and something more needs to be done, particularly for category III. As even category I basins have not seen much private sector enthusiasm, the same terms could be offered for it as well in a phased manner. In order to address the rent-sharing concerns across different categories of basins, the Government could have a differential royalty rate for different basins, with a higher rate for category 1.

- There are several global scale data companies who are in the business of acquiring seismic and other data and offering it to E&P companies. Their business model is centred around acquisition and sale of data to interested E&P companies. They have been active in India, too, under differing contractual conditions. In order to complete the appraisal of India's sedimentary basins within 5 years (2023-28), the Director General of Hydrocarbon (DGH) may promote multi-client speculative surveys at the expense of the former (and also from the RP licensees discussed above). The data companies who acquire the data by investing in this exercise will be entitled to recover their cost via sale of this data by hosting it on the National Data Repository (NDR). As there is a risk perception for Category II basins, the Government may consider offering a subsidy for their investment, to be determined on a bidding basis. This policy would sit well with the Reconnaissance Permit (RP) regime recommended above. DGH may explore other options for completion of appraisal of Indian sedimentary basins within a fixed timeline of 5 years. (**Role of private sector**)

- A satisfactory development has been the launch of OALP. Looking at the headwinds being faced by fossil fuels, it is desirable that oil and gas reserves of the country be quickly discovered and brought to the nation's service. Oil and gas majors may not be interested in rank exploration acreages. This calls for India to look at mid-size and smaller companies to exploit our basins. These players are also active where discovery sizes are small as has been the case with Indian sedimentary basins. Any delay in prospecting the country's sedimentary basin may result in our resources remaining undiscovered. It is desirable that the entire area is awarded for exploration by 2028.

- There is a wide variety of geological and geoscientific data types that are useful in making/developing hydrocarbons discoveries. The past several decades of exploration have yielded a large harvest of data held by public and private sector companies. This entire body of data ought to be made available to interested companies for better appreciation of the areas held by others who are yet to make discoveries. Complementing this is the proprietary data of existing operators. The latter have invested in data processing and software etc. to upgrade raw data leading to a good understanding of the sub-surface. There is every reason this proprietary data is brought into public domain after the lapse of a time-period so that it can be harnessed in national interest. This will also help in improved success rate in exploration of areas held by others in close proximity to discovered areas. Further, the Government will also harness this data by investing in better analytics and processing. DGH may publish the updated data analysis reports for 26 sedimentary basins in public domain so that there may be a higher uptake of greenfield projects. For this, DGH may need to upgrade its own technical capacity. (**Governance**)

- There is a need to review the existing New Exploration Licensing Policy (NELP) contracts signed over a period of 25 years since 1998. These contracts have tight provisions on timelines/cost recovery and other stipulations on development of discoveries and sharing of production. Despite announcement of a large number of discoveries in NELP fields, only few went on to be developed, rest having been surrendered due to a variety of reasons such as sub-optimal size of the finds, timeline issues and viability concerns. The Government may consider migrating these contracts from earlier profit-sharing contracts to a less onerous royalty regime (on similar lines to the new rent-sharing regime. This might enhance domestic oil and gas availability. Earlier, in the telecom sector, spectrum auction premia regime was migrated to revenue sharing. Therefore, the nation's interest in reducing import burden should be foremost and all efforts be made to find and produce hydrocarbons domestically. A comprehensive review needs to be done on how these discoveries could be converted into commercial prospects, by measures including pooling the infrastructure and reducing per unit cost of the hydrocarbons produced. The boundaries of the blocks could be re-configured and the pre-existing evacuation/processing infra of others could be considered for sharing. The surrendered discoveries may be offered to interested bidders via a separate focussed contractual framework. (**Revenue sharing)**

- From the achievements in oil and gas production, it does appear that the policy of bidding out marginal discoveries of National Oil Companies (NOCs) under Discovered Small Field (DSF) to interested E&P companies has not been a success so far. A review of the reasons behind poor success needs to be undertaken. In order to avoid mismatch between actual reserves and the prognosticate ones, before offering DSF blocks, DGH should arrange for auditing of the reserves by an internationally reputed agency. An express identification of existing pipeline and processing facilities may be done with capped charges. Oil PSUs may be encouraged to participate in the DSF blocks subject to forming a joint venture / consortium with private companies. This would mitigate risk and also help develop vibrant private enterprises in this niche sector. The participating Interest (PI) transfer of the block should not be restricted and may be transferred at any time after award of the block. One problem with DSF has been poor access to capital. The FIs are reluctant to extend loan to the private bidders as they lack expertise to evaluate the reserves as collateral/future revenue streams, and also because the reserves are presently not allowed to be taken on the balance sheet of the E&P companies. The Government should clarify that for purpose of serving as a collateral, the reserves as certified by DGH may be allowed to be pledged just as other minerals are allowed in the case of mineral leases. This may help bring capital to the upstream sector while assuring the financiers. The conditionalities related to transfer of these contracts may also be made efficient so that the liabilities of the outgoing entity do not impede their transfer.

- The large number of E&P contracts with ever increasing numbers call for a strong institutional decision-making mechanism. Directorate General of Hydrocarbons (DGH) supports the Government in administration of contracts, monitoring, and regulatory functions, with no independent authority. The time is now right to transfer those upstream regulatory matters from the Government to an independent body. Petroleum and Natural Gas Regulatory Board (PNGRB) could be considered for such a role. Some example decision areas that could be entrusted to a Regulator are reserve declaration, revenue sharing, data disclosures, sharing of infra and cost approvals etc. DGH may become the technical arm of the Government in helping policy formulation. In due course of time, the sheer volume of work and record keeping will become too large for the Government to manage. The PNGRB Act could be amended to enable upstream work, which was the founding ambition when a regulatory mechanism was being considered for this sector. (**Role of a Regulator)**

- One way to achieve energy transition away from fossil fuels is to allow market prices to govern fuel choices. This calls for retail prices of petroleum products/gas to be determined freely at the marketplace. This will also lead to alignment of

India's energy sector with the international one. Both the Government and corporates have to gradually fund energy transition which would become efficient by charging market prices that reflect the externality. This will help avoid future market shocks that might come with mandates imposed on a single entity to finance the transition, be it the refiners or upstream companies. Therefore, pricing of oil and gas ought to be on market principles, and the cost of energy transition be internalised. This will perhaps make fossil fuel prices cost reflective and may even help usher in clean energy on a free market basis through price cues. Wherever free markets do not exist, efforts must be made to provide conditions that mimic markets. And even subsidies in this sector ought to be focussed on identified vulnerable groups via Direct Benefit Transfer (DBT). (**Role of markets, Pricing, Subsidy**)

- Upstream infrastructure is often a challenge for E&P companies especially for smaller finds and for discoveries in offshore and difficult terrains. The Government will issue guidelines for mandatory sharing of surplus infra on the lines of 'common carrier' downstream infrastructure. This will help in quicker monetization of smaller discoveries and make infra investments financially viable, too. More than 160 hydrocarbon discoveries exist under the nomination and PSC regimes, which have not been put to production. Joint development of discoveries by multiple operators may also be encouraged. The Government may put a mechanism in place to help bring hydrocarbon discoveries into production through clubbing them or funding infra on user charge basis so that financing concerns may be taken care of. This has already been done by providing VGF for erecting trunk gas pipelines. (**Role of a Regulator**)

- National Oil Companies (NOCs) are producing 75.6% and 69% (2022), respectively of India's oil and gas production. Their salience has been unchanged over several decades despite the launch of several policies for entry to the private sector. But there is a higher expectation from them. It is a fact that International Oil Companies (IOCs) have developed large expertise by virtue of long experience of E&P activities over several geographies. ONGC, our premier NOC, has little success operating in deep-water. It has been able to bring only a small production from deep-water in the eastern offshore.

- While the Reserve to Production (R/P) ratios of most global oil majors is 10-12 years, that of ONGC has been static at above 30 years. Even the recovery factors have been around 30% from its most prolific Mumbai High whereas it is much higher in other oil and gas fields of the world. ONGC is partnering with several IOCs in different parts of the world including Russia, Vietnam, Brazil and elsewhere. Consortium approach is an accepted way globally. There is every reason that our NOCs should also attract financial collaboration in their acreages/producing properties in India, with partners chosen on a competitive basis. So far, they have been dis-interested in allowing sharing of stakes. This has to change and in national interest, our NOCs must enter into financial alliances that help bring technical advice as a partner rather than a contractor. This could make a significant dent on India's falling oil and gas production. (**Role of Government)**

- The NOCs have also been active globally in acquiring oil and gas acreages. This was expected to enhance the country's energy security as the reserves held by these companies could be harnessed in times of supply disruption. However, the track record has not been satisfactory. Against a target of annual production of 20 MMT of Oil plus Oil equivalent of Gas (O+OEG) from overseas properties fixed for 2017-18, the achievement has been only 14.98 MMT of O+OEG in 2019-20. Hardly any share of this comes to India physically. This takes away any energy security consideration in the overseas agenda. Moreover, the global markets are well supplied, and the need for assuring supplies is no longer urgent. The companies may now explore overseas opportunities only on commercial considerations and not as an energy security measure.

- India has been able to become a global Research & Development (R&D) and technology development centre in several sectors such as Information Technology (IT), telecom and such hi-tech sectors. Even for oil and gas, the global oil major Shell has one of its 3 global R&D centres located in India, from where leading solutions go out to their operations across the world. We should offer attractive terms to attract global technology providers to set up base in India, with whom our companies may collaborate to develop solutions relevant to the Indian geology.

7.10 Downstream

- The refinery sector is a fine example of policy success. It provides energy security and is a foreign exchange earner. India continues to have exportable surplus and on March 31, 2022, refining capacity was 23 % surplus over India's domestic needs (some imports like that of LPG may continue as it is not included in exports). Looking at demand growth at a CAGR of 3%, the existing capacity of 251 MMT and the announced expansions underway of 32.4 MMT, India's petroleum product needs until 2030 are taken care of. Now, going forward India has to also address its energy transition agenda which might hit refining. There may be a slowing of demand growth as various end uses including manufacturing get electrified, CGDs start supplying gas to erstwhile liquid fuel users, and there is generally a shift away from fossil fuels. While the government generally remains away from private investment decisions, however, the carbon emissions have to be reduced. Petroleum refining for exports lead to Scope 3 emissions. India will need to negotiate with countries that import petroleum products to acknowledge this emission in their emission reports. We also have to offset levies such as Carbon Border Adjustment Mechanism (CBAM) presently in discussion by imposing levies on the carbon-intensive export-oriented sectors rather than allow the European Union (EU) members to finance their energy transition via CBAM. The Government has to plan for closure and rehabilitation of those that may be affected in the long run by demand-induced closure of refineries. In light of this, the Government may take a considered view on limiting fiscal support to greenfield capacity that may come up only with an eye to export markets. There may even be a requirement of a carbon levy from an overarching policy perspective (**Environment management, Energy security and imports**).

- The new trend in India has been to encourage refineries whose product furnishings are more aligned towards the Petrochemicals sector rather than liquid fuels. This is a happy development. India's per capita consumption of several Petro-chemical products like plastic, polymers etc. is low and we are import dependent for most of these products. There is a dearth of crackers to meet the feedstock requirement of this sector. A close alliance between the two Ministries that deal with petroleum and Petro-chemical sectors could help in an orderly development of refineries that cater to both sectors. (**Governance**)

- India has adopted a major national programme, Ujjwala, to distribute LPG to all households. This has resulted in an increased demand for LPG. However, while the new refineries have exportable surplus of different products, India is domestically deficit in LPG for nearly 58.6% of our demand. Ideally this ought to be replaced by imported natural gas (LNG) as it would be a cleaner and cheaper option. Government would identify the dis-incentives that have resulted in this anomalous choice of furnish of products in refineries. It will examine the financial viability of LPG production and provide a similar viability outlook for LPG as what exists for diesel/petrol. (**Role of private sector**)

- In recent years, in keeping with the norms adopted by mainly the developed oil importing nations, India has invested heavily in creation of strategic storages. IEA requires its members to have 90 days of storage. While India has so far erected storage that might cater to 74 days of consumption, the question is often raised that it ought to add its storage capacity. We need to be cautious about the financing costs and diversion of capital from useful public investments into petroleum storages as well as cost of stored hydrocarbons. With rising demand, the need for storage may keep rising if we have a normative capacity in mind. There are several recent international and domestic developments that call for a fresh view on this issue. The geo-political situation in the Gulf from where we obtain most of our crude has eased. In the last one decade there hasn't been a single event that might have disrupted our crude supplies. Even Russia and other geographic regions such as North America have now emerged as oil exporters to India, diversifying our supply sources. It is high time that we stopped investing in strategic storages with domestic capital but encouraged commercial storages instead. India is a large oil market and will continue to be so, which gives us a vantage position in the oil market. We could require oil exporting global majors to set up storages in India and make it attractive by offering long term oil purchase contracts. If we do not insist on mandatory locking-in of capacities as strategic storage, these companies would be keen to establish commercial crude storages under FDI norms. As long as oil is stored in India, it anyway gives us comfort. Even the oil marketing companies (OMCs) may be required to maintain stocks for a defined length of time, and they may pass on this cost to the consumer on market pricing basis rather than the Government directly making investments into this business through its dedicated agency, Indian Strategic Petroleum Reserves Limited (ISPRL). (**Role of Government/Markets/private sector)**

- The ex-refinery price of refined products is insulated from retail prices. While refiners get international prices, the marketing companies do not. This area has been subject to periodic policy changes that have been driven by subsidy policy and international prices of products. Then there is the challenge of a differentiated approach towards private and public sector refineries. This is driven by the policy of under-pricing the products coming from public sector refineries, especially when crude prices rise. As the private sector is not included in the schema of subsidy distribution, it is given a different fiscal dispensation. Such an approach leads to distortion and uncertainty for the sector as a whole. The Government might migrate to a DBT based subsidy regime that would be efficient, focussed and could even be extended to private refiners. Then the need for a differentiated approach would not be there. (**Taxation, pricing, Role of private sector)**

- The major competitor of oil and gas in energy demand in Industry is coal. Unlike oil and gas, the price of domestic coal is insulated from international prices. This goes against the former which are largely imported fuels. The presence of the PSU behemoth, Coal India Limited (CIL), further queers the pitch. It has not revised its notified price for sale of thermal coal to the power sector in five years. If the country has to gradually march towards NZE, then the first step ought to be allowing the price of fuels to reflect market price. In that event, the competitiveness of less polluting fuels would rise. In the years to come, the externality angle arising from emissions etc. also needs to be adopted. The recent decision on setting up of carbon markets may gradually usher in the above environmental aspect. Price cues are a straightforward and efficient tool to help the move to clean energy.

- The Government has launched a successful program to blend petroleum products with domestically produced substitutes like ethanol, bio-diesel, Compressed bio-gas (CBG), methanol and DME. Second generation ethanol holds a lot of promise but has not taken off. This calls for a careful review and corrective action. This is expected to reduce crude imports, bring down the price of petroleum products and also enhance the income of farmers. Several of these drop-in fuels [methanol, glycol and Dimethyl Ether (DME)] could be derived from coal/lignite, which would support the Indian economy and energy security, too. There appears to be absence of a clear policy on technology/substitute choices in transport and cooking fuels. A long-term policy for blending of petrol, diesel and LPG with substitutes from various sources may be launched that will encourage investors to make long-term investment decisions.

- The impetus for natural gas along with the push for hydrogen has brought uncertainty to the future of liquid fuels. We discussed earlier that fuel substitution is very much likely in the transport and cooking sectors. Owing to multiple reasons, it may even be desirable. Looking to the great potential of these alternatives technologies/fuels to help India achieve its NZE target, they need a carefully crafted strategy. All this calls for an integrated approach especially because these alternatives sit in different Ministries. The Government may establish a monitoring mechanism in the NITI Aayog to coordinate steps towards a cleaner and energy secure solution. (**Governance**)

7.11 Natural gas

- Already acknowledged is the merit in transitioning from an oil-based economy to a gas based one. Allowing the markets to determine fuel choices is the best way to manage the challenge of energy transition. If subsidies were not to distort the markets, gas would be able to compete with petroleum products in all consumption sectors. Therefore, there are fuel economies that can be achieved with this shift. There is a large investment in infra to receive imported crude oil and deliver it across the length and breadth of the country via refineries. This calls for a calibrated response so that the latter is not rendered waste. Even oil companies may be supportive if their investments are not challenged. One way to do this is to divert the new demand for liquid fuels, and let natural gas cater to it through a slew of measures including price, availability and support from Oil Marketing Companies (OMCs). This calls for a policy statement from the Government.

- As is acknowledged, natural gas is a cleaner fuel than coal and even oil. However, as carbon pricing has so far not created an edge for cleaner fuels, adoption of the latter has largely been a result of action by courts/National Green Tribunal (NGT). If a phased mandate was provided through an enforcement mechanism, bigger industrial consumers or those that use coal may be asked to migrate to gas in the first phase. This will help roll-out the infrastructure, with the proviso that the smaller liquid fuels consumers are given a slightly longer time frame.

- Availability of domestic gas has not grown satisfactorily. While theoretically there should not be any difference between domestic and imported gas supply in a free market, but it is not the case in India due to costs, tariffs and statutory levies. There is a split in the market due to pricing differences between domestic gas and LNG. If there is a policy direction to drive gas consumption, then the end consumer price of gas needs to be competitive vis-à-vis oil. And a unified gas market is needed wherein the administrative provision of domestic gas being cheaper than imported gas also must be phased out. Therefore, with a recognition that the Indian gas story cannot be built around domestic gas, we ought to allow LNG imports to come in seamlessly and remove the price difference with domestic gas so that the market is a unified one. Perhaps a similar dispensation that is given to crude oil, needs to be extended to gas.

- The current coverage of gas trunk pipelines is just sufficient compared to the total gas supply. However, it may be short of requirement to support a quantum leap in supply. While some pipelines have high-capacity utilisation the same is not true for all. This anomaly needs to be fixed so that existing infra is well utilised. The present policy for erecting pipelines is one that lays all the throughput risk at the doorstep of the pipeline company. There is a need to de-risk the new pipeline developers. The PNGRB Act needs to facilitate this by a provision of Viability Gap Funding (VGF) where necessary. As regards the City Gas Distribution (CGD) network, the country has already seen great success. What is now needed is a roll-out of the grid as provided in the contracts signed with the successful bidders of CGD licensees. The allocation of cheap domestic gas for transport and cooking end-uses has not encouraged the cooking segment. While CNG demand has grown at a rapid rate, this segment can even absorb higher priced gas (LNG). This needs to be addressed by separate allocation for the two uses until the uniform gas pricing reforms discussed above are rolled out.

- The issue of exclusivity of city gas infra as well as their marketing rights has not been sorted out so far with legal wrangles. The exclusivity has denied the consumers benefits of competition that are available in liquid fuels. Moreover, when the Government is also providing cheap domestic gas without any pricing controls, the exclusivity of operations creates an undue advantage. Even price controls do not exist. If natural gas has to play a bigger role, then the marketing, infra and pricing decisions of CGD needs to be fair, equitable and efficient.

- If the consumers are to be assured of gas supply even when demand shoots up as might be the case when heating demand goes up in winter months, or when power demand for cooling goes up during summer months, there needs to be provision of a buffer in the supply infra. This calls for building gas storage on the lines of existing petroleum product storages at depots owned by OMCs. Depleted oil/gas fields of NOCs may be offered on a competitive basis to interested gas marketers for creation of commercial gas storages. This calls for a policy statement that supports gas storage. Even for pipelines connecting cities and areas, the PNGRB needs to ensure loop lines or connectivity from an alternate source.

- For gas demand to grow, demand side policies need to be set right. CGD appears to be the biggest driver. It has tied-up contractual commitments for CNG and PNG use with successful bidders. In the Industries, it is environmental triggers and technology that hold the key. As regards the Urea and Power sectors, there seem to be obstacles. In the first one, there is a finite demand. and cheap alternatives in the latter. The Government needs a comprehensive policy for demand growth and sector-specific interventions. The PNGRB is charged with the responsibility of licensing distribution and pipelines. It also ought to play a developmental role. It may undertake a policy review and recommend steps to the Government.

- In order to support the government's hydrogen agenda, depending on technical constraints a target of blending 10% to 20% of natural gas supply with hydrogen may be targeted for 2047. This will be helping in reduction of emission and increased fuel efficiency for CNG-fuelled vehicles. This will also avoid duplication of capex in laying of hydrogen pipelines. Before implementing the blending programme, trial runs/pilot programmes need to be undertaken to ensure the safety aspects of blending of hydrogen. However, clarity in statutes may be needed on jurisdiction over hydrogen transport. **(Environment & energy efficiency)**

- Natural gas flaring in the country is about 1.9 BCM per annum [**source: BP statistics, 2022**] which translates to 5.2 million metric standard cubic metre per day (MMSCMD). In case, this gas is utilized for power generation, it can produce about 1200 megawatt (MW) of electricity per day. The natural gas flaring in the oil & gas sector is there when natural gas is produced in association with crude oil and gas markets have variable demand. To manage such a situation, one option is to store the surplus produced gas in cascaded gas cylinders like used in CNG transportation which can be utilized effectively on a later date. **(Regulator and energy efficiency)**

- As regards distribution of liquid products, the OMCs have done a commendable job duly supported by a small but growing private retail network. Due to geo-political reasons, the global oil and gas markets have been in turmoil. Now, in the new normal conditions, the Government may take steps on pricing and fiscal levies such that there is true competition in the retail marketing space. Even the PNGRB ought to play its statutory role of promoting competition and good of consumers through efficiency in petroleum markets.

- If imported gas has to grow in the Indian gas market, there should be efficient and free access on a competitive basis at the LNG terminals. Importers should have 'open access' and be charged 'regulated tariff' at the LNG terminals. Adequate capacity rules out any monopoly conditions. On the contrary, regulation could help in higher capacity utilisation of the terminals and pipelines and ensure cost recovery. Regulation will also avoid diversion of capital in unwanted LNG terminal infrastructure, and sitting at the right places. Presently, the import of LNG is limited to little over half the LNG terminals capacity. **About 45 million metric tonne per**

annum (MMTPA) capacity of LNG Terminals are in operation, comprising 6 terminals. The under-construction LNG terminals are of about 22.5 MMTPA capacity. It needs to be ensured that there is a good match between capacity and demand. **(Government).**

- As a national gas grid evolves, there will be a need for an independent Transmission System Operator (TSO) for the same. The operator will be an entity on the lines of an independent electricity grid operator (ISO) that is under evolution. This will be essential to avoid duplication in infrastructure creation and ensuring gas availability throughout the country. The TSOs/ ISOs will ensure efficient utilization of gas infrastructure including LNG terminals acting in a fair and non-discriminatory manner to all the users. The right of changing the ISOs may also be provided to the end users of the pipeline like changing the mobile network operators.

7.12 Marketing

- OMCs have been a symbol of managerial success in the public sector. Making petroleum products available across the length and breadth of the country in an uninterrupted manner, is no small feat. Going forward, this segment of business is expected to undergo a sea-change. With CNG roll-out across the nation, liquid fuel demand will face a challenge. Rather than add the number of outlets mindlessly, there is an opportunity if the ROs also add CNG pumps in the same space. Even LNG is likely to be a fuel of choice for long distance freight and mass mobility. Similarly, electric mobility and hydrogen are also set to expand. Already the OMCs have become a part of this technology. The policy response ought to be evolving with the ROs as a provider of transportation fuel solutions. In order to have efficient marketing companies, one suggestion is to separate the marketing and refining arms of the oil companies. It is notable that the omnibus ROs, serving CNG and liquid fuel, may compete with the CGD licensees. Separation of integrated arms could promote privatisation as well. In the new era, refining may slow down but the marketing of fuel/electricity to mobility will keep growing with vibrancy in take-overs/mergers. Therefore, the Government may come out with a dispensation that the ROs do not work at cross-purpose with other transport solution providers but assimilate it in their business model.

- In the last few years, the Government policies have encouraged several private companies to enter the retailing space, albeit in a small way. Now, with multiple players, there ought to be no fear of cartelisation. The government has even exited the aviation sector. The government did send a right signal when it offered Bharat Petroleum Corporation Limited (BPCL) for privatisation. However, what the government can definitely do is to restrain the OMCs from aggressively expanding their network. They may now gradually allow the private companies to play a bigger role, with the rider that the business of OMCs is not poached in any way. This follows the maxim that the government need not be in business unless there are pressing reasons for the same.

- Reforms in the distribution, pricing, subsidy and infra roll-out for kerosene and LPG have been a huge success. Targeted subsidy and 100% clean cooking coverage has achieved multiple gains to the economy and society. In tandem, the 100% coverage of rural lighting has eliminated any role for subsidised kerosene. In any case, both these products are available for sale on commercial lines. The policy of targeted subsidy for identified LPG consumers ought to be extended so that the poor do not go back to dirty fuels.

- Pricing of petroleum products has been a complex issue. Not only does the subsidy issue contribute to this challenge, but even the public policy angle of affordability, profiteering and curbing monopoly tendency also weigh on the government's mind. India is not an exception, the Organisation for Economic Cooperation and Development (OECD) world resorted to interference in pricing and extended subsidies in recent times, too. While a geo-political event like the Russia-Ukraine war is difficult to anticipate, commodity cycles of high and low demand and supply impacting prices are known. Out of the four 'sensitive' petroleum products, now that kerosene subsidy is over, LPG subsidy is upfront from the government budget and petrol prices are generally market determined, it is only diesel that the government of the day gets concerned with. In the developed world diesel is more expensive than petrol due to higher emission factors, but this is not the case in India. It will be appropriate for the Government to come out with a medium-term policy statement on its approach to subsidy and pricing of diesel so that there are no uncertainties in any quarter.

- The PNGRB was established with the intention to provide a level playing field to the private sector who faced the challenge of competing with giants in the shape of OMCs. It was provided by law that the vast network of pipelines and storages etc will be made available to the new entrants on 'common carrier' basis. The report card of the Regulator so far on this parameter is not satisfactory. This needs to be sorted out so that the rights and obligations are settled by consultations and in a spirit of what the PNGRB Act enjoins, rather than through legal wrangles.

7.13 Conclusion:

Petroleum sector can play the role of a multiplier in many sectors of our economy. In this section we discussed those aspects of this sector, which have relevance to meeting the energy related objectives of our country. In the above process, there are several other impacts on our economy, which call for a balanced view in taking decisions. Oil sector taxation has a major role to play in bolstering up Union and State finances, including on sharing the rents. Fiscal levies also serve environmental objectives by serving as the proxy for congestion and air pollution in road transport. Our large energy imports (mainly of oil and gas) have anchored our economic relations with many countries, including the two superpowers. Our NOCs contribute a large share of the value of our capital market, and their re-organisation decisions have large implications on stock exchanges. Looking to the above, a robust inter-ministerial coordination mechanism could go a long way in advising the Petroleum Ministry in decision-making and implementing them, too.

Chapter 8: Electricity — The Road Ahead

8.1. Background

By 2047, the electricity sector will undergo a major transformation and the foundations of such a change will be set in the coming decade. This paper outlines the major steps to be taken in the future. The authors believe the policies and frameworks which shape the transition should be guided by the following principles for the electricity sector apart from the general principles of integrated energy policy:

- Consumer-centric approach to sector governance.
- 24x7, reliable, cost-competitive supply and quality service to be provided for all users of electricity.
- Accelerating and managing the supply mix shift from coal to non-fossil sources.
- Ensuring socially and environmentally responsible generation.
- Enhancing the financial viability of the sector.
- Achieving access and affordability goals.

This paper covers major developments at the Central and State levels across the electricity value chain. It does not discuss the generation of electricity by renewable sources, except in relation to DISCOM power procurement, grid substantial and progressive developments in the sector and major policy changes which have cem integration, large hydro power, and storage. In the past decade, there have beenented the foundation for future developments. These are covered in Box 3.

Box 3: Major achievements in the past decade

- By June 2024, India has installed 195 GW of renewable energy capacity (including large hydro).
- First country in the world to have a dedicated green energy market on a day-ahead and term-ahead basis. This would help DISCOMs and other obligated entities meet their renewable purchase mandates.
- National renewable purchase obligation target of 43% of consumption and 4% of Energy Storage Obligation.
- Specification of threshold for transmission based competitive bidding and various steps to encourage competitive bidding for transmission for ISTS and InSTS projects.
- 36 crore LEDs distributed since 2015 under the world's largest domestic lighting project, UJALA. India also has the world's largest streetlight replacement programme SNLP.
- Notification and vigorous implementation of the Late Payment Surcharge Rules, 2022 towards increasing payment discipline of DISCOMs.
- Notification of the Green Open Access Rules, 2022 which facilitates procurement of green energy via open access for consumers with contracted demand as low as 100kW.
- Between 2011 and 2021, about 5 crore households were electrified. This is comparable to providing electricity connections to all of Japan or Nigeria.
- Energy deficit has come down from 9% in 2013 to 0.5% in 2023. As per independent surveys, the availability of power in rural areas has gone up from an average of 12 hours in 2015-16 to 20.6 hours in the year 2020.

8.2 Industry Structure

Since 1992, the share of the private sector in generation has grown, especially in the renewables area. In the last two decades, the share of the private sector has grown from 11% to more than 50%. The table below shows the ownership of installed capacity for different sources of electricity.

Table 16: Installed Capacity (MW) in June 2024

Installed Capacity by Ownership (MW) in June 2024						
	Thermal	**Hydro**	**Nuclear**	**Renewables**	**Total**	**% of total**
State Sector	77880	27254		2537	107671	24%
Private Sector	86219	3931		143915	234065	52%
Central Sector	78898	15743	8180	1632	104453	23%
Total	**242997**	**46928**	**8180**	**148085**	**446190**	

Source:
https://cea.nic.in/wp-content/uploads/installed/2024/06/IC_June_2024_allocation_wise.pdf

Transmission was also the mainstay of the State sector and only later did the Central sector start to play a role. In the past decade, privately owned substation capacity has increased at the rate of 33% per annum and lines at the rate of 15%.

The growth of the Private sector has important implications for transparency, governance, regulation, and achieving the twin objectives of economic growth and sustainability.

Distribution remains the most crucial link in the power system and is still mainly in the State Sector, with a few Private sector islands – mostly those that were historically with the private sector (like CESC in Calcutta) but a few like Delhi and Odisha (privatization), Bhiwandi and Agra (Franchisees) are recent developments.

8.3 Generation

Although renewables have steadily increased in the last decade, non-fossil fuels account for only about 24% and thermal at about 76% of generation. The medium-term target was to reach 500 GW of non-fossil fuel-based electricity installed by 2030 and share in installed capacity going up from the present 40% to 50% by 2030. This year there has been a reassessment of this target of 500 GW of non-fossil fuel based installed capacity by 2030, and the date for achieving this number has been shifted to 2032 in view of the slower than anticipated progress of installing renewable capacity. However, the target to reach 50 % of installed capacity by 2030 is well on its way to being achieved; this figure having reached 45% on 31.3.2024. The slippage in the non-fossil fuel target has led to the target for coal being increased. In the NEP, a target of additional coal-based capacity of 50 GW for the period 2022-2032 had been set. Now, this has been increased to 80 GW. Correcting the energy mix to meet the sustainability goal in a cost optimal manner without compromising on the economic growth objective is the most difficult and important task in the generation space.

Dependence on coal will continue in the near future- and thus, it is critical that existing contracted capacity operates in a cost-optimal, efficient, and environmentally sustainable manner. The dependence on coal in the near future has been recognised in the Economic Survey this year. This is also implicitly recognised in the FM's budget speech this year as one of the priority areas mentioned there is fiscal support to an advanced ultra super critical thermal power plant to be developed by BHEL and NTPC.

A recent development has been that some states have issued tenders for a combined solar plus coal tender. Although the tender is one there are two contracts. This is not a good way of achieving the balance between solar and coal. The number of players who can qualify for both types of generation plants is limited and therefore, competition is adversely affected. It would be much better to have separate tenders for both types of generation plants. This would provide better competition and a much more robust price discovery.

Recommendations:

- Flexible operation of coal-based capacity must be increased. This has already been acknowledged and coal-based plants have been asked to take steps to operate at a minimum of 40% by 2030. This will need to be implemented.

- Reducing/ rationalising coal transport costs and discouraging load centre plants. Thus, all new thermal plants should be only at pit head. Exceptions can be made for Brownfield expansions if these are economically justified

- Timely payments to generators and implementation of the late payment surcharge rules need to be ensured. This has achieved some results this year and it needs to be pursued.

- Better utilisation of unutilised capacity and national level cost-economic dispatch through the use of DAM, RTM, SCED, PushP etc. There has to be a focus also on economic dispatch such that cost economic plants operate at higher PLFs in order to meet demand, which is recognised in the NEP.

- Exploring options for carbon capture to reduce climate change impact is also needed.

- GOI has issued a framework for the extension of PPAs after their expiry – this should be for a period of two years only, after which the plants should be allowed to sell their power on the exchange without pooling if the DISCOMS and Generators do not want to extend the PPAs.

- The GOI recognises the need for newly commissioned coal-based plants of about 80 GW in the period 2022-32. Capacity addition in the future must consider all cost-optimal technology options and India's needs to meet its growing demand, reliability requirements and energy security concerns.

- If the deployment of RE and storage does not take place at the required speed and scale, thermal projects should be added. In the interest of transparency and cost minimisation, all new thermal plants should be selected through competitive bidding under Section 63 of the Electricity Act, 2003. This competitive bidding should be separate for each type of generation and combined tenders for solar plus coal should be avoided. The Central government along with State governments would have to take the initiative and build consensus around these issues.

8.4 Transmission

Interconnecting and organising State grids into regional grids started in the 1960s. Over the years, these regional grids were connected, and by December 2013, all the grids were integrated to operationalise one synchronous national grid towards the idea of One Nation One Transmission Grid. Transmission congestion has also substantially reduced over time. The difference between constrained and unconstrained volumes was 17% for the power exchanges in 2012-13 which has reduced to 0.02% in 2022-23. Today, the cumulative power transfer capacity of the national grid is 1,18,740 MW.

To ensure promotion of investment and private sector participation in the transmission sector, steps need to be taken towards creating a level playing field and encouraging independent power transmission companies through competitive bidding. This has also been recommended by the Ministry of Power in 2021. In 2022, the apex court also upheld the need for competitive bidding by requiring all State commissions to fix the project outlay threshold above which competitive bidding should be undertaken in the state. Necessary institutional support in the form of dedicated agencies, model contracts and the fixation of investment threshold limits (in Rs. Crore) above which competitive bidding should be undertaken will enable this. There is also a need to bring some standardization and uniformity in transmission pricing, which is currently varied across States.

In December 2022, the Ministry of Power published a Transmission System Roadmap specifically for integrating 500 GW of non-fossil fuel based electricity installed capacity by the year 2030. In this background the following needs to be done.

Recommendations:

- In order to address the issue of transmission congestion and losses, the network infrastructure needs to be extended and upgraded with the latest available technology to make it stable and resilient.

- Data on transmission asset utilization should be put out in the public domain on a regular basis to aid better planning of new infrastructure.

- Transmission planning should focus on resilience against natural disasters and cyberattacks.

- India has nearly 3.36 million square km of sedimentary area and for expeditious exploration, the Government has been attracting public and private investment into Exploration & Production (E&P). To enable the above, good quality data has to be made available for E&P companies to identify prospects. One way of securing this objective without the Government undertaking data acquisition can be offering attractive terms of priority allotment of acreage to interested companies such as what used to be earlier the Reconnaissance /Prospecting Licenses in the mining sector. Large tracts of land can be offered particularly where data availability is scarce with a pre-emptive right to produce hydrocarbons, should the company find the area prospective after it has done exploration. As at this stage, the interested companies may only be asked to submit a minimum, time-bound exploratory programme; it would be a variant of the Open Acreage Licensing Policy (OALP) in which commitment for a definite revenue share is sought at the entry stage itself. This will be particularly helpful in Category III basins where no hydrocarbons have been discovered so far. The Government has already offered very attractive terms by doing away with revenue share in category II and III basins. This has still not yielded desired success and something more needs to be done, particularly for category III. As even category I basins have not seen much private sector enthusiasm, the same terms could be offered for it as well in a phased manner. In order to address the rent-sharing concerns across different categories of basins, the Government could have a differential royalty rate for different basins, with a higher rate for category 1.

- There are several global scale data companies who are in the business of acquiring seismic and other data and offering it to E&P companies. Their business model is centred around acquisition and sale of data to interested E&P companies. They have been active in India, too, under differing contractual conditions. In order to complete the appraisal of India's sedimentary basins within 5 years (2023-28), the Director General of Hydrocarbon (DGH) may promote multi-client speculative surveys at the expense of the former (and also from the RP licensees discussed above). The data companies who acquire the data by investing in this exercise will be entitled to recover their cost via sale of this data by hosting it on the National

Data Repository (NDR). As there is a risk perception for Category II basins, the Government may consider offering a subsidy for their investment, to be determined on a bidding basis. This policy would sit well with the Reconnaissance Permit (RP) regime recommended above. DGH may explore other options for completion of appraisal of Indian sedimentary basins within a fixed timeline of 5 years. (**Role of private sector**)

- A satisfactory development has been the launch of OALP. Looking at the headwinds being faced by fossil fuels, it is desirable that oil and gas reserves of the country be quickly discovered and brought to the nation's service. Oil and gas majors may not be interested in rank exploration acreages. This calls for India to look at mid-size and smaller companies to exploit our basins. These players are also active where discovery sizes are small as has been the case with Indian sedimentary basins. Any delay in prospecting the country's sedimentary basin may result in our resources remaining undiscovered. It is desirable that the entire area is awarded for exploration by 2028.

- There is a wide variety of geological and geoscientific data types that are useful in making/developing hydrocarbons discoveries. The past several decades of exploration have yielded a large harvest of data held by public and private sector companies. This entire body of data ought to be made available to interested companies for better appreciation of the areas held by others who are yet to make discoveries. Complementing this is the proprietary data of existing operators. The latter have invested in data processing and software etc. to upgrade raw data leading to a good understanding of the sub-surface. There is every reason this proprietary data is brought into public domain after the lapse of a time-period so that it can be harnessed in national interest. This will also help in improved success rate in exploration of areas held by others in close proximity to discovered areas. Further, the Government will also harness this data by investing in better analytics and processing. DGH may publish the updated data analysis reports for 26 sedimentary basins in public domain so that there may be a higher uptake of greenfield projects. For this, DGH may need to upgrade its own technical capacity. (**Governance**)

- There is a need to review the existing New Exploration Licensing Policy (NELP) contracts signed over a period of 25 years since 1998. These contracts have tight provisions on timelines/cost recovery and other stipulations on development of discoveries and sharing of production. Despite announcement of a large number of discoveries in NELP fields, only few went on to be developed, rest having been surrendered due to a variety of reasons such as sub-optimal size of the finds, timeline issues and viability concerns. The Government may consider migrating these contracts from earlier profit-sharing contracts to a less onerous royalty regime (on similar lines to the new rent-sharing regime. This might enhance domestic oil and gas availability. Earlier, in the telecom sector, spectrum auction premia regime was migrated to revenue sharing. Therefore, the nation's interest in reducing import burden should be foremost and all efforts be made to find and produce hydrocarbons domestically. A comprehensive review needs to be done on how these discoveries could be converted into commercial prospects, by measures including pooling the infrastructure and reducing per unit cost of the hydrocarbons produced. The boundaries of the blocks could be re-configured and the pre-existing evacuation/processing infra of others could be considered for sharing. The surrendered discoveries may be offered to interested bidders via a separate focussed contractual framework. (**Revenue sharing)**

- From the achievements in oil and gas production, it does appear that the policy of bidding out marginal discoveries of National Oil Companies (NOCs) under Discovered Small Field (DSF) to interested E&P companies has not been a success so far. A review of the reasons behind poor success needs to be undertaken. In order to avoid mismatch between actual reserves and the prognostic ones, before offering DSF blocks, DGH should arrange for auditing of the reserves by an internationally reputed agency. An express identification of existing pipeline and processing facilities may be done with capped charges. Oil PSUs may be encouraged to participate in the DSF blocks subject to forming a joint venture / consortium with private companies. This would mitigate risk and also help develop vibrant private enterprises in this niche sector. The participating Interest (PI) transfer of the block should not be restricted and may be transferred at any time after award of the block. One problem with DSF has been poor access to capital. The FIs are reluctant to extend loan to the private bidders as they lack expertise to evaluate the reserves as collateral/future revenue streams, and also because the reserves are presently not allowed to be taken on the balance sheet of the E&P companies. The Government should clarify that for purpose of serving as a collateral, the reserves as certified by DGH may be allowed to be pledged just as other minerals are allowed in the case of mineral leases. This may help bring capital to the upstream sector while assuring the financiers. The conditionalities related to transfer of these contracts may also be made efficient so that the liabilities of the outgoing entity do not impede their transfer.

- The large number of E&P contracts with ever increasing numbers call for a strong institutional decision-making mechanism. Directorate General of Hydrocarbons (DGH) supports the Government in administration of contracts, monitoring, and regulatory functions, with no independent authority. The time is now right to transfer those upstream regulatory matters from the Government to an independent body. Petroleum and Natural Gas Regulatory Board (PNGRB) could be considered for such a role. Some example decision areas that could be entrusted to a Regulator are reserve declaration, revenue sharing, data disclosures, sharing of infra and cost approvals etc. DGH may become the technical arm of the Government in helping policy formulation. In due course of time, the sheer volume of work and record keeping will become too large for the Government to manage. The PNGRB Act could be amended to enable upstream work, which was the founding ambition when a regulatory mechanism was being considered for this sector. (**Role of a Regulator)**

- One way to achieve energy transition away from fossil fuels is to allow market prices to govern fuel choices. This calls for retail prices of petroleum products/gas to be determined freely at the marketplace. This will also lead to alignment of India's energy sector with the international one. Both the Government and corporates have to gradually fund energy transition which would become efficient by charging market prices that reflect the externality. This will help avoid future market shocks that might come with mandates imposed on a single entity to finance the transition, be it the refiners or upstream companies. Therefore, pricing of oil and gas ought to be on market principles, and the cost of energy transition be internalised. This will perhaps make fossil fuel prices cost reflective and may even help usher in clean energy on a free market basis through price cues. Wherever free markets do not exist, efforts must be made to provide conditions that mimic markets. And even subsidies in this sector ought to be focussed on identified vulnerable groups via Direct Benefit Transfer (DBT). (**Role of markets, Pricing, Subsidy**)

- Upstream infrastructure is often a challenge for E&P companies especially for smaller finds and for discoveries in offshore and difficult terrains. The Government will issue guidelines for mandatory sharing of surplus infra on the lines of 'common carrier' downstream infrastructure. This will help in quicker monetization of smaller discoveries and make infra investments financially viable, too. More than 160 hydrocarbon discoveries exist under the nomination and PSC regimes, which have not been put to production. Joint development of discoveries by multiple operators may also be encouraged. The Government may put a mechanism in place to help bring hydrocarbon discoveries into production through clubbing them or funding infra on user charge basis so that financing concerns may be taken care of. This has already been done by providing VGF for erecting trunk gas pipelines. (**Role of a Regulator**)

- National Oil Companies (NOCs) are producing 75.6% and 69% (2022), respectively of India's oil and gas production. Their salience has been unchanged over several decades despite the launch of several policies for entry into the private sector. But there is a higher expectation from them. It is a fact that International Oil Companies (IOCs) have developed large expertise by virtue of long experience of E&P activities over several geographies. ONGC, our premier NOC, has little success operating in deep-water. It has been able to bring only a small production from deep-water in the eastern offshore.

- While the Reserve to Production (R/P) ratios of most global oil majors is 10-12 years, that of ONGC has been static at above 30 years. Even the recovery factors have been around 30% from its most prolific Mumbai High whereas it is much higher in other oil and gas fields of the world. ONGC is partnering with several IOCs in different parts of the world including Russia, Vietnam, Brazil and elsewhere. Consortium approach is an accepted way globally. There is every reason that our NOCs should also attract financial collaboration in their acreages/producing properties in India, with partners chosen on a competitive basis. So far, they have been dis-interested in allowing sharing of stakes. This has to change and in national interest, our NOCs must enter into financial alliances that help bring technical advice as a partner rather than a contractor. This could make a significant dent on India's falling oil and gas production. (**Role of Government)**

- The NOCs have also been active globally in acquiring oil and gas acreages. This was expected to enhance the country's energy security as the reserves held by these companies could be harnessed in times of supply disruption. However, the track record has not been satisfactory. Against a target of annual production of 20 MMT of Oil plus Oil equivalent of Gas (O+OEG) from overseas properties fixed for 2017-18, the achievement has been only 14.98 MMT of O+OEG in 2019-20. Hardly any share of this comes to India physically. This takes away any energy security consideration in the overseas agenda. Moreover, the global markets are well supplied, and the need for assuring supplies is no longer urgent. The companies may now explore overseas opportunities only on commercial considerations and not as an energy security measure.

- India has been able to become a global Research & Development (R&D) and technology development centre in several sectors such as Information Technology (IT), telecom and such hi-tech sectors. Even for oil and gas, the global oil major Shell has one of its 3 global R&D centres located in India, from where leading solutions go out to their operations across the world. We should offer attractive terms to attract global technology providers to set up base in India, with whom our companies may collaborate to develop solutions relevant to the Indian geology.

8.5 Grid Operation

Initially, it was the Power grid that was operating the National Load Dispatch Centre (NLDC) and the Regional Load Dispatch Centre (RLDC). With the opening of the transmission component of the Power system to the private sector it was felt that the NLDC and RLDCs should be independent. Accordingly, POSOCO was set up in 2010, later renamed Grid Controller of India (GCI), which administers all these functions, including interstate transmission. With increase in market operations, cross border trade and inter-state transactions, the role of the GCI is critical and will grow in the future. State level LDCs also play a critical role in scheduling and dispatch within the state. With increase in non-DISCOM transactions, it is crucial that their autonomy be ensured.

The most important issue now is to ensure that the GCI is able to take advantage of the cheapest generation plants across the country. Currently, the GCI is operating the Security Constrained Economic Dispatch System (SCED). The pilot started in April 2019 and has resulted in significant savings. From the start of the pilot till February 2022, these savings were Rs 2070 crore – about Rs 2 crores per day. This comes from the capacity of the system to use the cheapest plants across the country.

Recommendations:

- The challenge is to expand the SCED to all generators, including State Generators over a period of time. This will lead to a reduction in costs and will also improve the reserves of the system to meet any unscheduled contingency.

- At all times, this should be done in a manner that protects the interests of the individual states and respects the Constitutional scheme. Encouraging cross border trade would also help in the utilisation of non-requisitioned capacity and managing demand-supply mismatches.

8.6 Distribution

Distribution is the focal point where the consumer meets the electricity system. Inefficiencies in the fuel supplying system and in the upstream sectors of the Electricity System show up in high tariffs.

Distribution is also the point where the ultimate financing of all generation and transmission happens. One of the major challenges is that the cost of supplying one unit of power is at about Rs. 8.48/unit and is growing at an average rate of 4.2% per annum. In order to keep this down it is important that generation and transmission costs are kept low – the most important step is to ensure competitive bidding in both generation and transmission to ensure that the distribution system is not overburdened.

In most states, tariffs are unable to rise commensurate with the increase in costs. Thus, although there is improvement in collection efficiency, billing efficiency and AT&C losses aggregate losses have continued to rise. According to the analysis of the Power Finance Corporation's annual report on DISCOMs for the period 2022-23, the losses which had reduced from Rs. 44614 crores in 2020-21 to Rs26,947 crores in 2021-22 have again risen to Rs. 57,223 crores in 2022-23 (Report released in April 2024). However, the indebtedness has increased along with a reduction in capital expenditure. This reveals dependence on borrowing to meet current liabilities. However, even if a DISCOM is able to increase efficiency and meet the annual losses, the build-up of cumulative losses is significant and would continue to burden the DISCOMs. As of 2022-23, these cumulative losses stood at Rs. 6.47 lakh crore and have been growing at a rate of 10% per annum since UDAY- the last power sector bailout in 2015. In some States[16] and some DISCOMs, costs are recovered – showing that it is possible to run a viable distribution system.

With high cost of supply and non-competitive tariffs, more and more consumers are opting for open access and captive options. This trend will only increase with the notification of the Green Open Access Rules, 2022 which reduces the eligibility limit to 100 kW from 1 MW for open access and has measures to ease procedural issues to availing such cost competitive options for consumers.

It would also help to get new generation capacity without long term Power Purchase Agreements with DISCOMs and make the electricity market a significant reality. To do this it would be worthwhile to examine the ways in which a proportion – say about 10% to start with - of the power sold from new generators is to be mandatorily sold outside the PPAs. This was mandated – at 15% - by the National Tariff Policy of 2006 but has not been implemented. Considerable interest has been shown towards introducing competition in distribution. International experience shows that this has produced limited success (see for example NREL 2017: An introduction to retail electricity choice in the USA). In the case of our country, where power demand is growing and the primary need is to ensure 24x7 power with high quality. Competition, (especially through multiple licensees operating in the same area of supply) in the cost-plus distribution segment is a secondary issue. It is more critical to ensure competition (through competitive bidding) across the value chain especially in generation, transmission to ensure competitive and efficient operations of the power sector.

Recommendations:

- For a developing country like India, ensuring high quality power is a must. It is more critical going forward, if we have to shift transport and cooking away from liquid fuels to electricity – which will progressively become less dependent upon fossil fuels. This is an important element of our strategy to reach net Zero by 2070. This investment in network development and system strengthening becomes critical.
  For example, the three DISCOMs in Gujarat namely MGVCL, DGVCL and UGVCL, the utility at Dadra and Nagar Haveli have no build-up of accumulated losses, regulatory assets or sustained revenue gaps. Given the primacy of distribution, what is required is to use every lever with the Central and State Governments– to push the DISCOMs into better management practices and agile, forward-looking planning/ investments. At the same time Regulators and Governments have to be pushed by strict financial controls to ensure that power supplied is billed and collected and where required subsidised without delay.

- Regulators must ensure power procurement whether for RE or coal is based on a detailed IRP exercise especially given future demand uncertainty.

- With impending technology and market structure changes, distribution network management and metering will be critical and early investments in capital and institutional capacities on this front is imperative.

- Given the wide variety of problems faced by different states in the distribution of electricity, national programmes can only achieve limited success if any. Deep analyses of each State with State specific solutions have to be found.

- There has been some success with reforming DISCOMS in the public sector and privatising DISCOMS. Some success has also been achieved in franchising part of the DISCOMS. All these models should be examined State by State and whatever is most appropriate for each state should be adopted. Financial incentives should be given for states which are able to show improvement.

8.7 Storage

With increasing integration of renewable energy into the grid, the challenges associated with variable RE generation can be addressed through grid-scale energy storage systems. There are several energy storage technologies, but the two most common storage systems are pumped storage projects hydro (PSP), accounting for nearly 90% of global electricity storage, and battery energy storage system (BESS). As per the electricity demand projections and installed capacity targets included in the NEP, the capacity of both PSP and BESS is likely to increase in 2026–2027 and 2031–2032 scenarios.

For pumped storage projects, although the guidelines provide for competitive bidding, the manner in which this will be done has not been spelt out. Some suggestions have been made to use Swiss Challenge – this should be examined and incorporated in the guidelines.

In order to provide the demand side push, GOI has notified the trajectory of Energy Storage Obligations (ESO) till 2030. While ESO can provide the demand push, concerted action from government as well as industry is needed to boost the deployment of grid-scale energy storage systems. Assuming availability of adequate renewable energy, compliance with ESOs and legal recognition of ESOs will remain a challenge unless favourable and supporting mechanisms are created at the level of States.

Although costs have been decreasing, storage technologies still need high upfront costs and can raise concerns about the economic viability of such projects. Viability Gap Funding (VGF) support for 4,000 MWh of BESS announced in the Union Budget 2023-24 is a welcome step in this direction. In a welcome step, the FM has in her budget speech in July 2024 recognised the importance of PSP and has promised a policy for promoting this form of storage.

Currently, storage is viewed in silos without taking into account the multiple value streams associated with storage, such as grid services, automobile charging. This value stacking can improve returns and therefore commercial viability. However, this would need research and policy attention on which revenue stream to prioritise when.

In addition to BESS and PSP, Concentrated Solar Power (CSP) investments can complement storage supply. Efforts to effectively incentivise procurement, investments and research is required.

Recommendations:

- Recognition of ESOs in the Electricity Act and CERC/SERC regulations is needed.
- The Ministry of Power must involve States in setting the ESO trajectory.
- Finance mechanisms like VGF are important for making storage commercially viable along with adoption of a multi-use approach (value stacking) towards energy storage.
- R&D efforts to explore and develop alternative technologies/chemistries for storage must continue.
- Guidelines for competitive bidding for Pumped Storage Projects should be laid down exploring the Swiss Challenge method.
- Promotion of CSP where cost-effective as a storage option should be explored.

8.8 Subsidies

The bulk of the subsidies paid in the power sector is to the DISCOMs for subsidising agricultural consumers and low consumption households. The problem is that at times there is delay in paying the subsidy to the DISCOMs by the state government, which increases working capital borrowing of DISCOMs or reduces investments in improving supply and service quality. There was a proposal to mandate that subsidies should be paid directly to the consumer through direct benefit transfer (DBT). This proposal was objected to by many states and has not been approved so far. There have been experiments with DBT– the problems associated with these experiments should be examined to find alternatives that can work.

Apart from subsidies there is also the problem of cross subsidies. Ideally tariffs should reflect cost of supply. However, agriculture and low consuming households are typically cross subsidised by other categories. This is only natural given the highly political nature of tariffs. The National Tariff Policy of 2006 and 2016 have provisions to limit the extent of cross subsidy to +/- 20%. These need to be implemented and the permitted cross subsidy brought down in the next Tariff Policy.

The major cross subsidy is in transmission. RE Projects and more recently new hydro power projects are given a waiver of ISTS charges for the PPA term for the newly commissioned project. The current dispensation ends in June 2025.This has been extended up to 2028 at progressively reduced rates. It has also been extended for offshore wind up to 2037-38 The major problem with this regime is that it has promoted concessions driven and highly inefficient location choices rather than those based on techno-economic viability. Waiver of transmission and other charges are in effect cross-subsidised by other users of the grid. If support for renewables is necessary it is better provided as a direct government subsidy rather than as a cross subsidy.

Recommendations:

- The current ISTS waiver scheme should be allowed to lapse in 2025 reversing the decision to extend it beyond 2025. This should be replaced by a generation-based subsidy to promote efficiency and cost minimisation.
- In general, cross subsidies should be avoided.
- The NTP provisions for cross subsidy should be implemented and the permitted cross subsidy brought down in future NTPs.

8.9 Roles of Government, Markets and Regulators

Government should ideally play the role of a facilitator, set up institutions and provide financial support where the market is weak or non-existent. It can be seen from the earlier sections that even today the role of the Government is much more than that. While the Government is withdrawing from the Generation and Transmission spaces, it is still dominant in the Distribution space. There are provisions in the Act for multiple licenses and therefore, competition in the Distribution space. However, these are fraught with dangers that the private sector will take only the high-end consumers and make the task of cross-subsidisation more difficult. The Act needs to be amended to provide adequate safeguards to check this.

This is especially important since it is the poor health of the DISCOMs that is preventing the growth of a vibrant electricity market. Currently less than 10% of the electricity supplied in the country is through exchanges. Neither is this number growing. This is because generators and financiers need the comfort of a long term PPAs. Therefore, anything that reduces the bankability of a generation project (such as poor DISCOM finances) has the potential to choke off future supply.

Recommendations:

- Regulators have been given a well-defined role in the scheme of managing the sector. It has been observed for many years now that the regulators are ceding space to the government. The blurring of roles must be checked. Regulation was introduced for certain good reasons, and for the Government to intrude into this space could upset the whole balance that has been brought into the system after the 2003 Act.
- Civil Society has to be vigilant and raise these issues and the consequences.
- Government to play the role of a facilitator and allow markets and regulators to function- wherever they can - so that the best decisions are taken.

8.10 Regulation

The Electricity sector has now 25 years of history. Its continuance over such a long period of time is a strong positive. However, this history also shows several problems that need rectification. Regulatory autonomy is one of the foundations of independent regulation, but this autonomy is inadequate in the electricity sector. In its composition and finances, ERCs are still directly and indirectly tied to the government. The CERC and SERC Funds are meant to provide financial autonomy to ERCs but not all States have these in place or have them free from government control. Effective autonomy in decision making can strengthen the overall autonomy and legitimacy of regulators as well as reduce the burden on governments. Another area, in which autonomy of SERCs is questioned, is with respect to the appointment of members and chairpersons. Human resource constraints and vacant positions are challenges faced by Regulatory Commissions as well as APTEL, which have functioned without chairpersons for extended periods of time. Recommendations on regulation are provided in the paper on Governance and Regulation being published as part of this series. One important point can be made here. One of the ways in which the growth of renewable power has been promoted is the setting out of targets for renewable purchase by DISCOMs. Now this has also been specified in the Energy Conservation Act by passing the State Regulators. This is not a healthy development. The Finance Minister's budget speech this year recognises the importance of state governments in the quest for economic development. In the spirit of this statement the GOI should reconsider this approach of trying to force the pace of change bypassing state governments and the regulators appointed by them. At the same time the challenges in implementing the RPO targets need to be carefully examined and suitable modifications made to the existing policies specially the monitoring and implementation mechanisms.

8.11 Financing

With the delinking of the generation projects in the 2003 Act, the responsibility of the financial community has increased manifold. Scrutiny by the financing agencies is expected to ensure that only financially viable projects are taken up.

The other area where the financing community can play a role is for tighter monitoring of DISCOMs so that they do not get financing unless they satisfy certain minimum conditions. Currently, the losses of the DISCOMs are being financed by default by some other entity – generators, fuel suppliers and such like. Recourse to central devolutions should be provided in case of such default. This will put pressure on the DISCOMs and their owners to improve their performance and ensure the financial viability of the system. However, the quantum of losses is high and it is unclear if central devolutions can absorb it.

Since coal-based generation plants would be needed to ensure electricity supply, a serious problem arises with regards to challenges in financing coal-based plants, which is linked to the problem of financing coal mining.

Just transition will result in substantial revenue and capital investments and measures are needed for financing such investments. Ideally, the cost of financing these additional investments should be shared equitably between ratepayers and taxpayers.

Recommendations:

- Recourse to central devolutions should be provided in case of default by DISCOMs in making payments to generators and fuel suppliers on the lines that is provided to RE projects.

- Strict limits on working capital borrowing should be applied and compliance should be monitored.

- RBI should provide guidance to Banks on minimum conditions needed for financing generation projects. Ensuring adequate electricity supply for all classes of consumers will need new coal-based generation plants – the NEP has suggested about 50 GW newly commissioned coal-based capacity till 2032. The financial community needs to be sensitised to these requirements and the consequences if new coal-based capacity is not financed.

8.12 Pricing

The starting point of electricity tariffs are generation prices. These also account for the bulk of the ultimate tariff to consumers. Over the years, transparency and efficiency has improved in pricing of generation through competitive bidding which has now become the norm. Hydro projects remain on the cost plus model. Geological uncertainty/surprise makes ex ante determination of costs difficult in hydro. Similarly, Transmission Tariffs are being progressively fixed through competitive bidding. Distribution tariffs are still set by a cost plus method and there does not seem much scope for competition to improve this since generation is the bulk of the tariff. If the health of the distribution sector improves a greater share of generation tariff for new projects can be set by the exchange which is both efficient and transparent.

Recommendations:

- To keep the prices to the consumers down, grid integration is necessary for wheeling cheaper power from any part of the country.

- This should be complemented by introducing Economic Despatch as quickly as is feasible.

- Pit Head plants should be promoted and load centre plants should not be allowed. Exceptions can be made for Brownfield expansions if these are economically justified

8.13 Transparency

With the growing role of the private sector competitive bidding has been extended to almost all segments – generation/transmission and distribution. The only segment remaining is hydro generation projects, which are still dominated by the public sector. It would be good if some method could be found to undertake competitive bidding here also. UPERC has directed UPPCL to undertake competitive bidding for hydro. Ministry of Power guidelines have suggested competitive bidding for pumped storage. However, the manner in which this will be done is not clear. This issue has been dealt with in the section on storage.

Tariff setting process is another area where transparency has improved. Thanks to competitive bidding, generation tariffs, which form the bulk of the retail tariff, is now fixed in a transparent manner. Even retail tariffs are now subject to greater scrutiny due to the elaborate tariff setting processes followed by the Regulatory Commissions. Thus, on transparency, there has been substantial progress over the last two decades.

Recommendations:

- Greater push and clarity for competitive bidding in hydropower and pumped storage is needed.
- Progress on transparency must be maintained by strengthening systems and regulatory institutions who have to ultimately approve tariffs even when they are fixed by a competitive bidding process.

8.14 Taxes and Electricity Duty

The electricity sector has enjoyed direct tax benefits in the past, such as income tax holidays in respect of profit, concessional corporate tax for electricity generating companies, and accelerated depreciation tax benefit. More recently, RE based power has been the recipient of such fiscal incentives. Such incentives create distortions in the economy. A striking example of this is the dispensation given to the Electricity Sector to claim depreciation on a Straight Line basis or Written Down Value. There is no reason why this should be given for the power sector alone nor how this will help the power sector. The sector has been a recipient of indirect tax benefits too in the form of customs duty exemptions and exemption from excise duty for certain goods when supplied to Mega Power Projects. However, such benefits have been difficult to administer and monitor. These should also be subsumed under the Performance Based incentive proposed.

Electricity Duty is levied by States on electricity consumption via entry 53 of the State List of Seventh Schedule of the Constitution, Electricity was exempted from sales tax and later VAT. However, Electricity has not been totally exempted from GST.

Recommendations:

- Any tax incentive/benefit should be routed transparently through the budget as a subsidy and linked to performance
- The entire area of taxes on the electricity sector needs to be examined in depth to understand if through a rationalisation of GST and Electricity Duty costs to consumers can be brought down.

8.15 Environmental Management

Although RE installed capacity in the country has increased, coal continues to dominate the energy mix and continues to attract attention due to environmental externalities associated with its extraction as well as its use in the power sector. The issues in the sourcing of coal, and environmental management of RE projects are discussed in literature and other papers of this series. Efficiency of coal-based power generation is linked to GHG emissions as plants with low efficiency have a more significant environmental footprint owing to higher consumption of coal and the release of other pollutants during the generation process. The Indian fleet is still one of the largest emitters of CO2 emissions and there is a scope for improving this efficiency further. Retirement of old and inefficient plants, complemented with the setting up of supercritical and ultra supercritical capacity has improved the overall efficiency of coal-based power generation in the country.

Ensuring emissions management and reducing the environmental impact of coal plants is even more critical if future capacity is to be pit-head as they will likely be concentrated in critically polluted areas.

Recommendations:

- Improvements in technology need to be accelerated at the level of R&D as well as deployment for improving the efficiency of Indian power plants.
- Retirement of inefficient plants should be on the basis of performance and not routinely linked to age.

Chapter 9: Renewable Energy Deployment under the Integrated Energy Policy

9.1 Background

The first applications of Renewable Energy Technologies (RET's) in India started in the 1970's and 80's with the Integrated Rural Energy Program (IREP). However, structured development of the sector started only in the 1990's, with the shift of focus to alternative sources of energy to reduce dependence on imported fossil fuels. Amongst the first steps was the creation of the Ministry of New Energy Sources (MNES) in 1992 (now known as the Ministry of New and Renewable Energy), followed by the introduction of Feed in Tariffs and Accelerated Depreciation by, primarily, the textile industry.

The first decade of the 21st century saw developments in biomass gasification, small hydro and the first solar plants. The launch of the National Solar Mission saw solar coming to the forefront of RE deployment and the focus shifting to competitive procurement of RE. As of today, the main technologies at the forefront of RE deployment include solar, and on-shore wind followed by small hydro, biomass, and waste-to-energy. As of 31st March 2023, India's installed Renewable Energy capacity stood at 178.79 GW and it contributed 16% of the country's power generation.

Looking ahead, RET's shall constitute most of the capacity addition in the Indian Power sector, slowly emerging as the predominant energy generation technology. The Government of India (GoI) aims to deploy 500 GW of Renewable Energy Capacity by 2032, which shall constitute 50% of the total power generation capacity in the country in 2030. By 2047, India aims for an installed capacity of 1000 MW and finally transitions to Net Zero by 2070.

These future targets set a very ambitious agenda for RE capacity addition, with India adding around 1000 GW or 40 GW annually over the next 25 years. As RET's scale up, they, along with other enabling technologies, will also have to address the demand from areas which hereto have relied on fossil fuels – transportation, cooking and thermal applications in industry (especially from high temperature applications). This would require the development of new technology options like Green Hydrogen (discussed later), Compressed Biogas/ Bio-CNG, Off-shore wind, micro/ pico-hydro, storage will play a critical role in the mainstreaming of RE technologies across new end uses.

The future transition of India's energy sector will see the convergence of energy end uses to 2 or 3 following options – electricity, hydrogen and natural (bio) gas. A large majority of electricity, green hydrogen and natural gas will be produced through Renewables. Renewable Energy Generation (as a % of the total generation) will grow by more than 5 folds between 2022 and 2047, creating the need for new technologies, policies, regulations, market structures and power systems management infrastructure. This chapter aims to identify some of the issues, challenges and opportunities that will come the way of the Renewable Energy Sector as it takes its place as the primary energy supplier in India between now and 2047.

9.2 Framework to Scale-up of RE Deployment in India

India aims to transition to a Net Zero future by 2070. To achieve this goal and create a framework for large scale deployment of carbon neutral renewable energy, India would need to undertake the following by 2047:

- **Demand Side**

1. Move to Time of Day or Demand based Tariffs.
2. Ensure at least 20% of the demand is programmable and flexible.

- **Utility scale RE**

1. Create a system with 80% dispatchable RE supply.
2. Meet 50% of the base load.
3. Ensure 10% dispatchable reserves to address variability of demand supply interface.

- **Distributed RE**

1. Transition to an energy system which has an average cost of supply (at consumer end) of INR 5/ kWh.
2. Ensure that most installations generate some form of onsite energy, with close to 75% of these being coupled with battery-storage systems.

3. Meet at least 10% of the demand met through onsite generation.

- **Transportation**

1. Transition to electric vehicles and green hydrogen by 2047.
2. Integration of electric infrastructure into the management of the grid with V2G and G2V operations.
3. Transition to rail for high volume high weight freight.

- **Industrial Heat**

1. A renewable heat purchase obligation of 100% for all industries operating in the low to mid temperature zones.
2. A 30% renewable heat purchase obligation for industries operating in high temperature zones.
3. Components aggregating to 75% by value of a project to be sourced locally.

   Considering the rapidly changing landscape and the need to move towards a carbon neutral future, this chapter intends to define an approach for:

1. General direction of RE deployment to meet the above requirements.
2. Create a diversified RE portfolio mix to meet the requirements from various demand sectors through the transition to Net Zero.
3. Identify areas of energy convergence.
4. Create flexibility in the systems to react to the change in the conditions and adapt.

Based on the above requirements, India needs to develop medium- and long-term roadmaps. Long term roadmaps would look at a 25-year horizon and would be broad in their outlook. Medium term roadmaps would define actions for the next 10 years and would be significantly detailed — detailed enough to undertake resource planning including evacuation planning, identification of new and innovative RE sources and land banks to be developed and brought to the market, availability of finance and local manufacturing to service these plans coupled with key policy and regulatory interventions required to make that happen.

Planning of electricity generation and consumption is centred around thermal. RE has considered a minor stakeholder in thermal-centric planning. To meet the ambition of Net Zero Carbon, this paradigm needs to change. RE should be considered as the centre of planning for generation and consumption. New role for thermal would be complementing RE till better generation and balancing technologies are commercially available. Subsequently thermal can be phased out to be completely replaced by RE to the maximum extent practically possible. This transition would take decades. However, the paradigm shift needs to happen now and the transition needs to start immediately. While the transition roadmap is clear to most stakeholders, as is the point where the industry needs to be, there is still debate on the key challenges that need to be addressed by policymakers to make the transition happen.

9.3 Opportunities and Challenges for RE Scale Up to 2047

9.3.1 Renewable Energy Resource Potential in India

Opportunity: India is blessed with significant Renewable Energy resources. The biggest sources of Renewable Energy are solar, wind, hydro, bioenergy, and waste to energy. Solar and onshore wind potential has been mapped adequately well and has been used for many years now for commercial deployment. The potential for other technologies has also been mapped adequately. However, these technologies couldn't see scale-up. Adequate technical and commercial potential exists in India to meet the projected RE deployment of ~1200 GW by 2047. There is a scope for improvement in resource mapping and re-estimating the potential with the improvements in the existing technologies and upcoming technologies.

Recommendations:

- Sites with best potential that can be tapped have been tapped with the prevailing latest technologies. Technologies have improved since then increasing the generation potential of the sites. For example, deploying wind turbines with increased hub heights and solar modules with higher efficiency can increase the generation at least by 20%. By redeveloping these sites, the infrastructure can be utilized more efficiently. To enable this, the Government of India needs to put in place a repowering strategy in place. This strategy would also define the periodicity of repowering compensation mechanisms for old projects, methodology for deploying new equipment on sites etc. This strategy should address the wind, solar, hydro and bio-energy sector.

- Significant RE potential exists in hydro (ranging from large hydro to micro hydro, bioenergy, wind, especially small wind and offshore wind. Instead of defining the overall technical potential, the Government of India can focus on mapping commercially exploitable potential every decade.

9.3.2 Independent Power Producers

Opportunity: Since its inception, RE deployment has been conceptualized as Independent Power Producers (IPP) driven. Competition has been another cornerstone of REdeployment. The experience has been good. This has led to a fall in RE tariffs, innovation in technology and commercial solutions, tapping of international markets for finances and internal capacity. Role of Government institutions has been power procurement, providing transmission and facilitating the project development activities like land acquisition.

Recommendations:

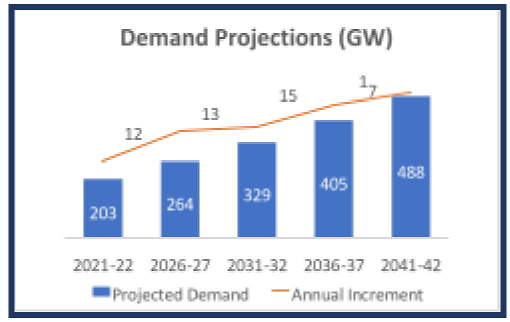
- Going forward, IPPs will continue to play a central role in RE deployment. Government institutions should continue to focus on supporting IPPs. However, the support should be realigned to develop an ecosystem for the evolving power sector with RE as the backbone. Different aspects of the ecosystem are discussed in detail in subsequent sections.

- Tariff-based competitive bidding has worked successfully in scaling up RE and developing new energy supply solutions. Going forward this approach will lead to the identification and commercialisation of commercially viable new technologies. The Government should focus on R&D in line with the need of the IPPs to develop new solutions.

- One of the major hurdles for scaling up RE is delays in the signing of the PPAs and sometimes cancellation of the same. DISCOMs have signed long-term thermal PPAs. New RE PPAs will only add up the existing thermal PPAs increasing the cost of energy without adding any benefits to DISCOMs. Increasing demand is helpful to address this situation. DISCOMs would need support in transitioning this phase without increasing their cost and cost of energy to the consumers.

9.3.3 Increasing demand for energy

Opportunity: According to the IEA, India will drive the largest increase in demand for energy (3% annually) over the decade. India's per capita electricity consumption (1255 kWh in 2021-22, a third of the global average) is set to rise with universal electricity access and large- scale electrification of industry and transport. CEA projects demand to increase to 488 GW by 2042.



Recommendations:

- Demand is set to increase between 12 to 17 GW per annum. To meet this demand through renewables (solar and wind), an annual addition of 40 GW to 60 GW would be required. Considering the shorter gestation period for RE projects, RE is more suitable to scale up to meet the increasing load. Thermal can be used to meet the current demand. RE can be deployed to meet the upcoming demand. Gradually thermal assets can be transitioned to provide flexibility to the grid to complement RE. As the thermal assets run out of their life, they can be replaced with the prevailing state-of-the-art RE-based energy supply solutions.

9.3.4 Shifting from Thermal Focused Planning to RE-Focused Planning

Integrating higher proportions of RE by adding storage to time-shift wind or solar to meet the demand throughout the day. At the same time, the demand patterns for the states vary from each other based on the local climate, demographic profile, and economic activity. Going forward demand patterns are likely to change with increasing economic activities, convergence of non-electrical demand to electrical demand, energy efficiency and demand side management. Considering the infirm generation of RE, RE-based energy solutions need to be designed as per the demand pattern.

Recommendation:

- RE deployment should move away from the plain vanilla solar or wind projects deployment. Instead, the focus should be on the development of service offerings that have a portfolio of RE and Storage projects that mirror the daily and seasonal demand curves. Capacity planning needs to be undertaken considering these requirements. New and emerging power procurement models like Round the Clock Power need to be pioneered. Further, innovation in introducing new service offerings needs to be encouraged.

- To meet the balancing and time-shifting demand for plain vanilla RE capacity already commissioned and support upcoming projects, there is a need to bring in standalone grid-based services like Energy Storage, demand-shifting programs, EVs and Green Hydrogen.
- Accurate demand estimation (understanding the time of day peaks and off-peaks) across the seasons and changing demand patterns across years is critical for improved RE planning. The DISCOMs need to carry out a detailed assessment of the demand patterns to ensure optimal investments in RE solutions.

9.3.5 RE Integration with the Grid

The Challenge: As India moves towards 100 per cent Renewables, integration of highly variable RE resources will be the biggest challenge facing the Indian Power grid. When the percentage of variable RE in the grid crosses 15%, variability challenges start impacting the operation of the grid. These challenges need to be addressed through diversification of RE generation, improved transmission and distribution planning, and the creation of a robust ancillary services market that includes sufficient storage to name a few. RE integration needs high visibility of generation resources, adaptive demand projections, flexible operations, and the availability of high ramp-rate assets. Policymakers and regulators would need to plan the management of the system along with RE capacity addition to smoothen the uptake of RE by the grid. Proactive RE integration will require work on several parallel workstreams:

1. Diversification of RE generation: Diversification of RE resources, from very heavy reliance on onshore wind and solar to new technologies like offshore wind, small hydro, bioenergy for power generation is critical if India is to optimally meet its varying energy and power demand.
2. RE Resource Maps: RE resource/land mapping to understand where the next set of RE projects would be developed. Developing and updating these resource maps on a five-year basis will be critical for all system optimization efforts undertaken downstream of this. This resource mapping/land mapping exercise should be led by the CEA with participation of state power departments.
3. Power System Design: Based on the inputs from RE resource and land mapping, design of RE evacuation systems like green energy corridors, timely capacity addition of the ISTS system, especially timing the readiness of the Grid to be able to evacuate the RE power coming online, simulation of energy flow in the system with

daily, seasonally, and annually varying demand. This exercise will have to be undertaken every 2 to 3 years and would be best undertaken by POSOCO in partnership with the RLDCs and SLDCs.

4. Creation of System Balancing Assets: Grid based assets like Transmission and Distribution Battery Energy Storage, Pumped Hydro based storage etc. would need to be created not only for time shifting generation from RE surplus hours to demand intensive hours, but these assets would also be tasked with ensuring grid stability through frequency and voltage support, ramp up support etc. Planning for the deployment of these assets would have to be undertaken concurrently by POSOCO working with SECI and the Load Dispatch Centers.

5. New Generation Technologies – New and upcoming technologies with a potential for commercialization need to be integrated into the plans.

9.3.6 Commercialization of New RE Technologies

The Challenge: Wind and Solar have certain limitations like infirmity in generation and lower land efficiency. These limitations, currently, are not restricting the scaling up of these technologies or becoming the biggest supplier. However, these limitations can be a hurdle for net carbon zero. New technologies need to be explored to (1) complement solar and wind and (2) takeover the lead as solar and wind cannot scale up anymore. Solar and wind are the cheapest among the RE technologies. However, there can be other RE resources and technologies that can be cheaper than solar and wind. New technologies need to be explored from this angle as well.

Recommendation:

- **Industrial Heat**

  An ecosystem to encourage innovation needs to be developed:

1. New RE technologies with high potential need to be identified and initial development activities like R&D, piloting and early commercialization need to be funded through grants, subsidies, and feed-in-tariffs.

2. Innovation in the private sector needs to be encouraged through development of Innovation Hubs (IIT Chennai’s innovation hub is a good example), Public Private Partnerships between PSU’s, Technical Universities and start-ups need to be encouraged.

3. Energy and Climate Innovation Funds need to be designed and deployed for use by startups in the climate and clean energy arena to provide the initial start-up capital for prototyping and market testing.
4. Development of resource maps for new emerging technologies, along with use cases and pilot demonstrations need to be encouraged by state PSUs.
5. Technology transfer and collaborations with laboratories, universities and corporations need to be facilitated.

- For scaling up, an ecosystem needs to be developed. The ecosystem includes supply chains, skilling, developing infrastructure like land banks and transmission, technology transfer and collaborations.
- Often missed in the R&D eco-system in India is involvement of the Industry and their needs. This pushes industry to rely on whatever is available in the market. The R&D eco-system should involve Industry and allocate a part of resources in finding viable solutions as per the Industry's needs.

9.3.7 Renewable Energy for Transport

The energy demand from Transport makes up around a fifth of the energy consumption in the country. This demand is primarily met through fossil fuels (close to 95%). The country aims to transition to 100 percent electric mobility by 2047. The roadmap for energy transition from 2023 to 2047 will require graduated movement of transport from gasoline-based fuels to a combination of electric, CNG and blended biofuels. India has already set a target of 20 percent bio-ethanol blend in gasoline by 2025.

9.3.8 Bioethanol Blending for Transport

The Opportunity: Blending bioethanol into gasoline (over and above 20%) will reduce GHG emissions and enhance energy security by reducing the import of gasoline. Targeting higher blends of bioethanol in gasoline, starting 2030 and going right up to 2045, will also require commiserate investments in the production of feedstock and fuel flex vehicles.

Recommendations:

- To transition to higher blends of bioethanol, there is a need to facilitate promotion of production of 1st generation biofuel feedstocks and transition to 2nd generation bio-fuel feedstocks. **Higher blends of Bioethanol and creation of vehicle standards for higher blends:** India needs to enhance its target for bioethanol blending to 30 percent by 2035 and 40 percent by 2044. Simultaneously the country would need to facilitate development of vehicle stocks which can use higher blends of bioethanol. This would require the development of standards for retrofitting of old engines and development of new flex fuel engines.

- **Enhanced production of first-generation feedstock:** To meet higher blending requirements, a commiserate increase in feedstock availability would be required. As rice and sugarcane are water intensive crops, there is a need to encourage production of maize for bio-ethanol production through dedicated and targeted programs. A variety of incentives like Minimum Support Price for Maize and creation of maize intensification zones can be taken up. Moving forward, the Government of India also needs to define a policy for "Energy as a Crop" as there are significant opportunities for farmer income enhancement through energy-based crops.

- **Transition to second generation biofuels**: Second generation biofuels have huge value addition as they utilize agri-waste, have higher yields and consequently lower cost and would allow the mainstreaming of biofuels. Technological barriers make 2nd generation biofuels commercially unviable at present. India needs to fast-track the development of second generation biofuels through the launch of a "Dedicated Technology Mission" on the lines of DARPA with a clear roadmap for commercialization of the technology.

9.3.9 Compressed Biogas for Transportation

The Opportunity: The Government of India (GoI) aims to more than double the proportion of natural gas in India's energy mix by 2030 through development of carbon neutral options like compressed biogas (CBG). GoI, under the SATAT scheme, targets production of 15 MTPA of CBG through 5000 CBG plants by 2023-24. India's realizable potential of CBG is around 22 MTPA. Harnessing this potential could lead to the replacement of imported Natural Gas in transport and cooking. India would do well to completely exploit its potential for CBG by the end of this decade. GoI has already laid down the procurement process with purchase prices. The key challenge lies around financing the initial set of CBG plants to establish credibility of the technology with financers.

Recommendations:

- To address financing issues, the Government of India needs to create a CBG Guarantee Fund and a CBG Insurance scheme to provide comfort to lenders and investors. This fund and insurance schemes would slowly lose relevance as the first few hundred plants get commissioned, post which financing will start happening based on the merit of the projects. To facilitate CBG production further, GOI can work with state governments to launch bio-waste procurement programs, which can use existing infrastructure like FCI's to collect and sell biowaste to CBG developers, reducing feedstock risks in the process.

9.3.10 Decentralized Renewable Energy for Transport

The Opportunity: The integration of Distributed Renewable Energy (DRE) with Electric Vehicles (EV's) offers significant opportunities for grid stabilization and low cost of EV charging. The challenge lies in creating the framework for integration of EV's and DRE with the grid and allowing the use of DRE and EV's for grid support and stabilization.

Recommendations:

- The Power Regulator needs to allow deployment of DRE (Small Solar and Wind) systems with a capacity higher than the connected load of the facility to facilitate low-cost EV charging. At the same time, DRE projects and EV's need to participate in the ancillary services market and provide support to the grid. For this to occur, value streams need to be defined and monetized. At the same time, standards and technical protocols need to be defined for V2G energy transfer and support. The Government of India can promote utilization of DRE and EV's for grid support through the notification of a Virtual Power Plant Policy. The Government of India also needs to define a V2G scheme which includes interconnection standards and protocols.

9.3.11 Decentralized Renewable Energy

Opportunity: With the advent of Time of Day (ToD) Tariffs, reduction in the cost of onsite energy storage and greater penetration of Electric Vehicles, decentralized RE, with zero cost of transmission and distribution will emerge as one of the most economical sources of power. Onsite RE +storage is expected to achieve grid parity between 2030-35. At the same time, onsite wind generation can also be deployed in areas where the wind profile is strong. As wind speed and solar radiation often supplement each other, solar and wind onsite working in tandem will provide an excellent resource for the grid. Onsite wind and solar will allow consumers to become more energy-independent and provide more flexibility to meet their own demands. Till such a time that RE+Storage achieves grid parity, policymakers and regulators will have to provide certain incentives (like upfront subsidies, special ToD tariffs for small generators) to keep investments in the sector alive.

Recommendations:

With the advent of EVs, the demand for electricity is expected to rise substantially. Encouraging onsite generation can help address this demand through:

- Unrestricted access to the grid.
- A standardized interconnection procedure.
- Time of day tariffs and time of day energy credits for onsite generation.
- No system sizing limits if the consumer is able to consume onsite energy on their own.
- Grid to Vehicle and Vehicle to Grid energy flow for onsite RE systems.

9.3.12 Captive Biogas Plants.

Opportunity: Development of biogas plants may not be the most attractive in congested city environments, but they have a huge potential for application in suburban and rural India. While the gas generated in these plants can be used for cooking and heating purposes, another more important role can be played by these plants, especially bigger plants – that is providing grid support during variable RE generation. These plants can become important components of the ancillary services market or virtual power plants and support the grid in its operations.

Recommendations:

- Regulators and policymakers would do well to define cases where these plants can provide grid support and develop incentive schemes for some of the initial plants being deployed. Policy makers would also do well to work with technology suppliers to create customized modular products that are available to users, regulators and distribution companies would need to define interconnection standards, procedures, and guidelines while banks and FI’s would need to be trained in lending for these projects/ products.

9.3.13 Onsite Wind

Opportunity: Onsite wind generation has the potential to pick up in areas where the wind profile is strong. As wind speed and solar radiation often supplement each other, solar and wind onsite working in tandem will provide an excellent resource for the grid. They will also allow consumers to become more energy independent and provide more flexibility to meet their own demand.

Recommendation:

- Policy makers and regulators need to provide the same access to onsite wind as they do to solar rooftops. During the initial stages of the technology's deployment on the ground, policymakers should also provide viability gap funding or generation-based incentives to allow uptake and smoothen the initial deployment of technology.

9.3.14 Micro and Pico Hydro.

Opportunity: India is blessed with mountain ranges in the north, southeast and southwest of the country with an extensive network of riverine systems whose potential is still to be tapped through small user based captive plants with export potential to the grid. These plug and play (micro and pico hydro plants) can be developed by communities, individual households, businesses, and institutions in the same manner in which solar rooftop plants are there in cities.

Recommendation:

- Policy makers need to work with technology suppliers to create plug and play products for users. Regulators and distribution companies need to define interconnection standards, procedures, and guidelines while banks and FI's would need to build capacity for lending to these projects/ products. However, the biggest initiative required would be the development of a market for these products in the mountainous regions of the country.

9.3.15 Renewable Energy for Heat in Industry

The Opportunity: Heat accounts for around two-thirds of all primary energy demand in India. Most of this comes from biomass, coal, diesel, and gas. Although solar thermal, geothermal and biomass have the potential to provide heat to support industrial processes, their application in India is still very low.

Recommendations:

- Create a sustainable heat policy that mandates the wider use of renewable resources for heat provision - compressed biogas, solar thermal and biomass-based heat. This policy would create heat obligations, requiring all industries to meet a certain share of heat demand through renewable sources. At the same time, create a pull for biomass pellets by mandating that a certain percentage of energy for the firing of boilers and furnaces in industry come from biomass pellets.

- Availability of feedstock is the biggest challenge for use of biomass by industry and thermal plants. While feedstock availability exists, limited agencies aggregate feedstock and make these available at fixed prices to bioenergy and thermal plants. Creating a market for aggregation and trade of biomass is critical and can be initially undertaken using established procurement chains like food grains and milk.

- Availability of financing to the solar thermal and bio-energy sectors continues to be a challenge due to perceived risks around technology and availability of feedstock. To facilitate financing and create a pull for funding in this sector, a risk mitigation framework is required. This will initially have to be put together by the Government of India in the form of dedicated lines of credit for these projects, first loss guarantees for financiers, and creation of dedicated training programs for FI's on bio-energy project financing.

9.3.16 Financing Renewables

The Challenge: Access to long tenure financing is a significant challenge for Renewable Energy Projects due to their high upfront cost and long-life cycle. Very few institutions in India provide long term financing (12 to 15 years) as of now.

Recommendations:

- PFC, IREDA, SBI, PNB, L&T Finance and REC are some of the banks and Financial Institutions providing long-term financing to the RE sector. However, given the expected uptake in RE financing in the future, other FI's and banks also need to up their game. Green financing/ climate positive investing should be made mandatory for all banks and FI's where a certain portion of their funding should go to funding RE projects.

The Challenge: Distributed Renewable Energy project financing is still a challenge due to the following challenges – perceived credit risk of customers, high transaction costs and limited capacity of FI's staff to process such loans.

Recommendations:

- To address credit risk for FI's, the Government, through PSU banks/ FI's can create a credit guarantee, which will lead to a marginal increase in the cost of funds but will enhance the flow of funds to the sector. Banks and FI's will also benefit from the experience of funding these projects, allowing them to better understand the market and design bespoke products suiting different market segments. Higher volumes will also reduce transaction costs. The IBA needs to make DRE financing training compulsory for 30% of the staff of all FI's operating at the retail level.

The Challenge: Cost reduction will be the main driver of RE uptake in the future, especially in the retail sector. The Distributed Renewable Energy market will see significant innovation, with the entry of several start-ups. However, most of these start-ups will perish in the valley of death unless project financing is made available to them to first develop prototypes and second do pilot testing on the ground. However, these are high risk investment areas where very few funds/ investors operate.

Recommendations:

- The government needs to work with the public sector, multilateral and bilateral agencies to develop customized Innovation Funds which will be funded through grant capital from the government or DF's and which will be patient catalytic capital.

9.3.17 Institutional Structure

Challenge: Electricity being a concurrent subject, both the Central Government and State Governments have jurisdiction over the sector. However, the MoP/ state power departments have jurisdiction over the management of the grid, the regulators, and the load dispatch centers. While the spirit of federalism demands that the concurrent status be maintained, certain structures need to be put in place and processes streamlined to improve RE project development and distribution.

Different ministries like the Ministry of Power, Ministry of New and Renewable Energy, Ministry of Railways and Ministry of Road Transportation and Highways are involved in the deployment of RE for various applications. These ministries need to interact and coordinate in taking up and implementing the RE mandate.

Recommendation:
A joint coordination committee comprising the senior management of the involved Ministries needs to be set up for planning, implementation, and coordination purposes. The key areas which this coordination committee needs to address include:

- Development of Transmission and Evacuation infrastructure: Wind and solar have about 612 months while the development of evacuation infrastructure takes anywhere between 3-5 years depending on issues such as line length and Right of Way (ROW) issues. MNRE, MoP, FoR and the CEA need to work together as a part of the overall planning framework and identify most attractive zones for RE Hybrid and RTC Project deployment in the future. This needs to be undertaken under the medium-term planning framework.

- Development of Joint RE Roadmaps for States: States need to develop robust RE roadmaps for medium term planning (10 years). Most states lack the capacity and the resources to undertake the development of such roadmaps. Appropriate Central Agencies need to step in and support State Governments to jointly develop these roadmaps and assess the readiness, strategies, resources and capacity of the states to implement these roadmaps.
- Creation of Cost of and Value of RE: Although RE resources are the cheapest on a stand-alone basis, critics of RE deployment sight the high cost of integration that comes with stand-alone RE. MNRE, in partnership with MoP and the states need to undertake an annual assessment of the cost of and value of RE at different levels (stand-alone solar/ wind, solar rooftop, RE hybrids, RTC etc) and determine the cost of and value of RE for appropriate decision making.

Challenge: As highlighted above, the current power sector is thermal centric while the future of the power sector shall be RE centric. This would need reviewing of the technical aspects and the business of power generation and consumption including policy and regulatory regime.

Recommendation:
- Government should form a high level inter ministerial committee to review the current power sector and identify the needs of the transitioning to RE centric power

sector. All stakeholders including State Governments regulators, IPPs, DISCOMs etc need to be involved.

- Basis the need, the Government can take up a mission to transform the power sector from thermal centric to RE centric in 10 years.

9.3.18 Taxation for Energy sector:

Tax regime on energy and energy projects is complex and frequently changing, sometimes causing disruptions due to sudden and frequent changes. The taxation regime also makes it difficult to understand the true cost of energy and how each source of energy compares to others. Few of the energy sources viz., petroleum and coal has been a major source of revenue for the Governments. RE becoming a major supplier can potentially reduce the revenue to the Governments.

Recommendation:

- Tax regime can be revised to bring uniformity in taxation on energy. For example, bringing energy under GST.

Chapter 10: Nuclear Energy

10.1 Introduction

Nuclear power potentially has an important role in a clean energy transition. Nuclear power is not an eternal source like the sun and wind. However, it has several[1] positives. Nuclear can provide large baseload and stable power to the grid. It can also supply high temperature heat for sustainable hydrogen production, and low temperature heat for desalination as well as heating buildings and homes. A nuclear plant has low fuel cost, a long operating life (twice as long as solar and wind power plants), needs far less land, and comparatively negligible amount of scarce critical materials. There are more than 400 reactors operating globally, with a cumulative installed capacity of about 360 GW[2]. Thus, there is considerable experience with the technology over the last several decades. In many countries, such as Belgium and France, nuclear accounts for more than 50% of the electricity generation. In other countries, such as the US, UK, Russia, and South Korea, its share is about 20% or more. Thus, it is an important energy source in several leading countries.

Yet, there are several challenges with nuclear power, and even the OECD world with long experience of this source of power is divided in its future outlook. The high capital cost and long gestation period make these projects economically challenging. While there have been only two major nuclear disasters in recorded history – Chernobyl (1986) and Fukushima (2011), however, these have heightened deep rooted public concerns about the safety of nuclear power. Germany has decided to phase out nuclear power, while the UK is supportive of new nuclear power plants. Spain and Switzerland have discontinued building new reactors. Japan called to reduce its nuclear power capacity. Finally, there are concerns about nuclear waste disposal.

In India, nuclear-installed capacity is about 7 GW, contributing to 3% of the overall electricity generation. The Department of Atomic Energy (DAE) has ambitious targets. However, even after several decades, the installed capacity is modest. This chapter attempts to explore future Indian nuclear power scenarios considering its advantages and challenges.

10.2 Brief history of the Indian nuclear power program

India has modest uranium deposits. These were initially estimated at about 61,000 tons, though recent discoveries have raised this number to about 3,82,675 tons. Indian uranium ore is of poor grade. However, India has rich thorium reserves; about 25% of the world's total deposits. Thorium has the potential to meet India's future power requirements for the foreseeable future, for which the technology is yet to be established. However, thorium is not a fissile material and must be converted to a fissile isotope U^{233} so that it can be utilized in the nuclear reactor.

Thus, India's nuclear power program was conceived as consisting of three stages for achieving long-term energy security. This consisted of the following components –

1. **1st Stage:** Build Pressurized Heavy Water Reactors (PHWR) using natural uranium. The 1st stage program involved reprocessing the spent fuel to recover highly fissile Pu^{239}.
2. **2nd Stage:** This involves developing Fast Breeder Reactors (FBR) using mixed oxide fuel consisting of Pu^{239} (recovered from 1st stage) and natural uranium. In these reactors, Pu^{239} generates energy through fission, and the U^{238} present in natural uranium gets converted to Pu^{239} through a series of nuclear reactions. Thus, an FBR "breeds" more plutonium than it consumes. This surplus plutonium can be used to develop more reactors and significantly expand the nuclear power capacity. There is also a possibility to introduce thorium as a "blanket" in the FBR so that it is converted to U^{233} for future use.
3. **3rd stage:** This consists of large-scale utilization of naturally occurring thorium in breeder reactors mixed with U^{233}.

It has long been expected that the three-stage nuclear power program would lead to a large nuclear power capacity, which can sustain India's energy needs for centuries. The stage 2 has not been established successfully and efforts are on at Kalpakkam.

It is also pertinent to point out that following the nuclear tests in Pokhran in 1974 and later in 1998, India was restricted from importing nuclear fuel, technology, and equipment. Thus, the Indian nuclear power program was totally indigenous and with budgetary and resource constraints. Due to the constraints on uranium mining, the nuclear reactors were starved of uranium supply, and they operated at low plant load factors generating less energy against its potential.

In this background, the India – US agreement for cooperation in civilian nuclear power was a landmark step. It allowed India access to international markets and import nuclear fuel, equipment, and technologies for civilian use. It was expected that this deal would provide a much-needed fillip to the Indian nuclear program and enable it to expand rapidly. India began importing uranium and the existing reactors are operating at almost full capacity since then.

10.3 Nuclear power projections

The Integrated Energy Policy document (Strategy for growth of Electricity in India, DAE) prepared by the Planning Commission estimated nuclear power capacity as per **Table 18**. This consisted of a combination of PHWR, LWR, and FBR. It is noteworthy that these projections were taken prior to the signing of the Indo – US nuclear deal. Clearly, these are very ambitious numbers and even the pessimistic scenario for 2030 eludes achievement by leaps and bounds.

Table 18: Nuclear Power Installed Capacity

Year	Pessimistic (GW)	Optimistic (GW)
2030	48	63
2040	104	131
2050	208	275

Following the Indo-US agreement, Prime Minister Manmohan Singh stated that the Indian nuclear power program could generate up to 470 GW by 2050 following the three-stage program. There were estimates that India could produce 500 GW of nuclear power for at least 400 years using India's economically extractable thorium reserves.

The recent projections have been relatively modest.
Table 19 shows the targets as per the recent draft National Electricity Plan.

Table 19. Nuclear Power Capacity Addition

Year	Nuclear (GW)
2022-27	7
2027-32	8
2022-32	15

10.3.1 Present Situation

At present, India has 22 operating nuclear power reactors, with an installed capacity of 6,780 MW (Table 20). This is from a combination of first stage technology - Pressurized Heavy Water Reactors (PHWR), Pressurized Water Reactors (PWRs), and Boiling Water Reactors (BWRs). Nuclear power generation is about 47 Terawatt hours and accounts for 3% of India's total electricity generation.

Table 20 Nuclear Energy Capacity of India

Type of Reactors	Capacity (MW)	No.
PHWR	4460	18
PWR	2000	2
BWR	320	2
Total	**6780**	**22**

In addition, there are 8 reactors of 6800 MW capacity under construction, the details of which are mentioned in the table below:

Table 21 Under-Construction Reactors in India

Type of Reactors	Capacity (MW)	No.
PHWR	2800	4
LWR	4000	4

Total	**6800**	**8**

Bharatiya Nabhikiya Nigam Limited (BHAVINI) is currently commissioning a 500 MWe Prototype Fast Breeder Reactor (PFBR) at Kalpakkam, Tamil Nadu. The construction began in 2004 with a target to commence commercial operation in 2011 but the project has been facing various delays and is still not commissioned even after 2 decades since the expected target. This is the first FBR and a successful demonstration is expected to pave the way for large-scale capacity addition using FBRs as envisaged in the three-stage program.

Additionally, Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP) Unit 1&2 (2*700 MWe PHWRs) is expected to be implemented by 2028. Land availability, MoEF clearance, consent from AERB, excavation, ground improvement and casting of foundation piles are completed. Regulatory clearances for the casting of the building raft, tendering, and progressive installation of various equipment and components are in progress.

Along with this, ten 700 MWe PHWRs in fleet mode having administrative approval and financial sanction by the government, are expected to be completed by 2031. Preparatory activities such as land acquisition, environment clearance, equipment procurement, are in progress.

If we assume that all the under-construction and planned reactors are successfully completed as per schedule, the total installed nuclear capacity is expected to reach 22 GW by 2031. This is still much lower than what was expected. Nuclear power will still be a relatively small contributor to India's rapidly growing electricity needs.

Clearly, so far nuclear power has not lived up to the high expectations. At the same time, India's energy needs are rapidly growing and there is an urgent need to meet the energy demand with fossil-free sources. Considering the above, the key questions are:

1. What are realistic nuclear power projections for 2030, 2040, and 2050?
2. When will India accomplish the capacities estimated as per three-stage power programs, in particular thorium utilization?
3. How does nuclear power compare with other energy sources such as solar and wind?

Analysis

The answer to the above depends on a few crucial factors such as the cost of nuclear power as compared with other sources, public acceptance, safety and nuclear waste disposal, and nuclear liability legislation. It is also important to consider the future of a three stage program. This section discusses these issues in some detail.

10.4 Cost of Electricity

The cost of electricity is a crucial factor in planning the electricity mix. India being a developing nation, the capital cost and operating cost of each energy source are two critical decisive factors for its integration into the mix. An energy source should not burden the economy with a high cost.

The capital cost and levelized cost of electricity (LCOE) are usually estimated to categorize energy sources as cheap or expensive.

Nuclear energy has the highest capital cost among all sources. As per Central Electricity Authority (CEA) optimal generation capacity report, PHWRs have a capital cost of around 11.7 Crores/MW, whereas LWR's capex ranges around 19 Crores/MW[10].

The under-construction reactors, Kudankulam 3 & 4 PWR project (2x1000MW) has a sanctioned cost of Rs. 39,849 Crore, and Kudankulam 5 & 6 PWR project (2x1000MW) has a sanctioned cost of Rs. 49,621 Crores. On the other hand, Rajasthan's RAPP 7&8 PHWR plant (2X700 MW) has a sanctioned cost of Rs. 12,320 Crores, and the Kakrapar KAPP 3 & 4 (2X700 MW) plant will cost Rs. 11,459 Crores. It is evident from the above figures that domestic PHWRs are cheaper than imported PWRs. The availability of supplier credit becomes important as India cannot afford to fund such expensive power projects.

This raises the big fundamental question of whether our country should go for more imported reactors that are not economically feasible or should utilize domestic resources for expanding the PHWRs in the country?

Even though the capital cost of nuclear power is high, its generation cost is reasonable. The nuclear power plants of India have been supplying power at Rs 2 to Rs 3.50 per kWh. The oldest nuclear plant, Tarapur has been supplying the least cost of power at Rs 1/kWh. While the capital cost of the indigenous PHWRs is lower than the imported LWRs, the fueling cost of imported reactors is less than the indigenous reactors. It is difficult to accurately estimate the cost for all reactors as it is dependent on factors like location, capacity, technology, and plant-specific requirements.

It is pertinent to compare the cost of nuclear energy with other sources of energy. The cost of renewable sources, especially solar, has significantly reduced in the last few years. The cost of energy storage technologies, such as batteries is also rapidly declining. In terms of Levelized Cost, Nuclear energy has the highest LCOE among all energy sources, mainly because of its high capital cost and the long gestation period of new nuclear power plants. Solar and wind, on the other hand, have attracted tenders of electricity prices less than Rs. 3 per kWh in 2017-18. However, as renewable energy is intermittent in nature, we should consider energy storage for a fair comparison. The levelized cost of co-located battery storage (1MW/4MWh BESS) could reach Rs. 4.70 per kWh by 2025 and Rs. 3.81 per kWh by 2030. Nuclear has another advantage over renewables as its PLF is much higher than solar and wind, for the same installed capacity, the actual electricity generation from a nuclear plant is more than three times that of a solar plant.

The above analysis suggests that it is prudent to continue with the building of indigenous PHWRs. However, the plans for LWRs should be retained as an option with careful consideration of the costs and economic viability.

10.5 Uranium Availability

Recent reports from the Atomic Minerals Directorate indicate that India has more than 300,000 tons of uranium. It can support a mix of several PHWRs and a few LWRs. A single PHWR of 700 MWe capacity would require about 6,000 tons over its operating life. Current uranium resources can then support about 50 such reactors (35 GW generation capacity). Improved fuel design could extend its life in the reactor, suggesting a possible doubling of energy extraction from the same fuel. But there is no restriction in importing Uranium for use in reactors under IAEA safeguards. The residual content of uranium and plutonium in it serves as fuel for FBRs and Light Water Reactors (LWR) without need for further mining of uranium. However, adequate capacity in the country for uranium enrichment to feed the LWRs is essential for an indigenous LWR program. LWR installed capacity of 10 GW will require 150 tons of Low Enriched Uranium (LEU). To produce 150 tons LEU per year, an enrichment plant with a sufficiently large capacity (1 million SWU) will need to be set up in time.

10.6 Public Acceptance

Nuclear energy has often attracted attention because of the public's concern for the safety and security of reactors, especially for a country like India that has a dense population. The debate around safety is highly polarized. Proponents of nuclear power argue that nuclear power is among the safest sources of energy when measured as the number of deaths per unit of electricity generated [16]. However, the critics dismiss these claims. Their argument is that a large-scale nuclear accident can cause severe and irreparable damage to the neighboring regions for decades. The memories of the Chernobyl and Fukushima nuclear accidents are still fresh in the public mind.

Therefore, there have been multiple instances where people protested the construction of planned nuclear plants. The movement against Kudankulam and Jaitapur plants are the two highest public resistance movements. In 1989, a mass rally gathered to protest the construction of the Kudankulam plant. Their main concern was the potential release of radioactive contaminants, loss of biodiversity and livelihoods, and the presence of an earthquake zone. The movement which became dormant in the following years, was again expedited post Fukushima nuclear disaster in 2011. This even led to major law and order problems in the region. The Jaitapur nuclear plant was supposed to be the largest nuclear plant in India with a 9900 MW capacity.

People's perception is extremely crucial when it comes to nuclear energy. Public engagement is vital for the expansion of the nuclear power program. For India to achieve large nuclear capacity, it will need to identify several new nuclear sites. As per Atomic Energy Regulation Board (AERB), nuclear plants require an exclusion zone of 1.5 km around the plant. Also, nuclear plants need to be close to water bodies to meet their large cooling water needs. Therefore, in a densely populated country such as India, it may not be easy and straightforward to identify these new sites. Sites for new nuclear power plants could conflict with local land use needs. There will also be concerns about the safety of nuclear power plants. Land acquisition is already an emotive issue in India, and nuclear power plants trigger yet higher reactions.

DAE will have to find innovative ways to communicate with the public and address their safety concerns. Some specific suggestions to build public acceptance include:

- Action should be taken to implement recommendations on the Nuclear Safety Regulatory Authority (NSRA) Bill, first introduced in Parliament in 2012. Its objective was to ensure greater independence from DAE to the Authority. NSRA was to replace AERB.

- For every new project, there is a Safety Review Committee for every new Project. It would be good to include outside experts for taking external views and consultation.

- Enhancing public outreach through interactions with local teachers, students, community leaders, media personnel etc. These should be aimed at an honest appraisal of nuclear science and nuclear power technology focusing on its safety aspects.

- Making people in the neighbourhood of NPPs direct partners in its benefits. This can be achieved through significantly increased, public centric developmental activities under Corporate Social Responsibility. Such activities should start right after the site selection or even earlier.

- Comments on nuclear power from scientific and engineering communities outside DAE are few but do appear from time to time, providing an independent view. A forum for discussions on these at a level that the public understands might help.

- Greater transparency on the part of AERB would be helpful. This could be done by publishing the bases for safety clearances given at every stage of a project in non-technical languages. The website of AERB could also provide for public comments and responses.

10.7 Nuclear Liability Legislation

When the Indo-US nuclear agreement was inked, it was expected that major international nuclear companies would come forward to partner in building large, advanced nuclear power plants in India. However, this has not happened even after 15 years of the agreement, except for 1000 MWe VVERs being built with Russian cooperation at Kudankulam in Tamil Nadu. A major sticking point is the civil nuclear liability law.

International laws for civil nuclear liability are designed to ensure that the victims receive fair compensation as soon as possible and the liability. The laws also lay out who will be held responsible for the accident. The Convention on Supplementary Compensation (CSC) 1997 is the internationally accepted legislation to prescribe a minimum compensation amount. India is a signatory to the CSC and the Parliament ratified this in 2016. Further, India enacted the Civil Liability for Nuclear Damage Act (CLNDA) in 2010. The main objective of this Act was to ensure speedy compensation to the victims of the nuclear accident[18]. CLNDA provides for strict and no-fault liability on the operator of the nuclear plant. The operator will be held responsible for the accident regardless of any fault on its part. This is in accordance with the provisions of CSC. Therefore, they decided to hold the operator solely responsible. It was also important to affix a single point of responsibility so as not to cause harassment to the victims to secure compensation from various equipment suppliers.

However, the Indian CLNDA includes clauses to also hold the equipment suppliers responsible for an accident. Section 17 (b) of CLNDA states that the operator of the plant after paying their share of compensation for damage in accordance with the Act, shall have the right of recourse where the "nuclear incident has resulted as a consequence of an act of supplier or his employee, which includes the supply of equipment or material with patent or latent defects or substandard services". Thus, this allows the operator to sue the equipment suppliers responsible and exposes the suppliers to risk.

The suppliers of nuclear equipment (domestic as well as international) are wary of these clauses as it exposes them to potentially very high risk and unlimited liability.

This has been a major sticking point with some nuclear equipment suppliers. However, some progress has been made in this direction. When US President Obama visited India in 2015, the differences were ironed out sufficiently to enable US vendors to supply reactors to India. The US accepted India's proposal to set up an insurance pool to cover Rs 1500 Crores to compensate suppliers if necessary. A clear definition of "supplier" was provided. Despite the above facilitation, not a single project has been announced so far.

With France, the issue is not nuclear liability, but the high cost of power from reactors France has offered to supply. The proposal submitted by France in 2021 is still under consideration.

10.8 Small and Modular Reactors (SMRs)

Much is being said of the usefulness of Small Modular Reactors (SMRs) for India as a means of rapid additions to nuclear power contribution. The capacities of SMRs are typically less than 300 MW. A recent publication of the International Atomic Energy

Agency provides information on ongoing R&D for 6 types of SMRs from 14 countries. Of the 70 reactors listed, most are at the stage of conceptual design and basic design. Very few have prospects for realization in the next few years.

SMRs can be built at lower capital investment and reach completion from the first pour of concrete to grid connection in 2-3 years. For additions to be significant, 300 MWe plants of LWR designs would be the appropriate choice. In the absence of an indigenous program for their development, import of a few is being proposed. The leading vendors are American firms who have received safety clearances for their design.

Over the past decade and more, proposals for import of large LWRs by India from US and France have not reached fruition on account of issues ranging from cost, fuel supply, right to recycle spent fuel, civil nuclear liability and the like. It is not clear if SMR imports will succeed now.

It will take some time to finalize and get safety clearances to build a prototype before they can be built in numbers. There is yet no estimate of the size of the contribution that SMRs could make in coming years. In view of their smaller rating, it would be preferable to focus on Indian Standardized design of an SMR suiting our requirements.

10.9 Three Stage Program

As explained in the earlier section, India's planners conceived of the Three Stage Program for the eventual utilization of Thorium to achieve long-term energy security. It was projected that India could achieve at least 500 GW of nuclear power if this plan is implemented with commitment.

However, the progress so far has been slow. It is important to realize that Thorium is not a fissile material, instead, it is a fertile material. Large-scale use of Thorium can commence only after there is a sufficient supply of Plutonium (Pu^{239}). As mentioned earlier, plutonium is recovered from the spent fuel of thermonuclear reactors (PHWRs). This is utilized in Fast Breeder Reactors (FBR), which can breed more fuel than they consume. Thus, India will have to develop many FBRs to generate enough Pu required to initiate the Thorium program.

As of now, India is developing a 500 MW Prototype Fast Breeder Reactor (PFBR), which is yet to be commissioned. The completion and commissioning of this reactor has been significantly delayed. As the Indian nuclear program is shrouded in secrecy, there is little knowledge in the public domain of the reasons for this inordinate delay. Once successful, subsequently, there are plans to build four more such reactors. The experience gained from building and operating the PFBR will provide information on the technical and economic viability of building more such reactors.

Given the above, it will take a considerable time for large-scale utilization of Thorium. This has also been admitted by DAE in Parliament. DAE mentioned that Thorium usage will take “a few decades”.

Hence, it is unreasonable to expect many FBR or Thorium based plants by 2050. These plants could play a role in the latter part of the century, if at all. Therefore, given India’s urgent need for clean energy and climate goals, it will be prudent to rely on conventional thermal reactors in the next 2 – 3 decades.

10.10 Nuclear Projections

The above analysis provides pointers to the nuclear power capacity that can be expected by 2050. Several modelling studies have projected the capacity of various energy sources for the coming decades. These studies have considered the least cost optimization to arrive at a future energy mix. In general, these studies project a large expansion in non-fossil sources. Utility-scale solar tops the list with over 1000 GW by 2050. Wind energy capacity is projected to grow to 300 – 400 GW. As against this, nuclear energy remains relatively small with a capacity range of 39 – 68 GW by 2050.

Thus, it appears that nuclear power will remain a small contributor to India’s future energy requirements. Though looking at its proven merits of being a reliable, base load source with significantly lower per MWh land requirement, it may play a much larger role provided focused efforts are initiated without any more hesitation. This may be possible by adopting well-coordinated multiple implementation pathways. Even this modest growth by a factor of 6 – 10 times from the present installed base of 7 GW by the year 2050 may appear ambitious to some, considering the history of delays in nuclear power plants. But it is definitely doable; and recognizing the inevitability the government appears to be actively pushing for nuclear power and has a good pipeline of plants in the construction and approval phase. The above reasoning makes it difficult to write-off the nuclear agenda and will remain as an energy option.

Table 22: Installed capacity of Nuclear

Study	Installed Capacity by 2050
	Nuclear
LBNL	39
IRADE	60
CEEW	68

10.11 Summary and Policy Recommendations

Nuclear, being the oldest clean energy-producing technology, has good potential in achieving energy security and climate goals. It provides baseload power and can help manage the intermittent generation of renewable energy. It is also a clean source of energy and vital to meet the long-term climate goals. Given India's large energy requirements, the country is not in a condition to ignore any source of energy. At the same time, there are several challenges with nuclear pertaining to economics, safety, and public acceptance. These need to be understood and addressed.

Here are some specific policy recommendations:

- India should pursue the nuclear power program with determination and commitment. However, it is important to be realistic about what it can do in the 2050 timeframe. From the above analysis, it appears that nuclear will continue to remain a modest contributor to India's energy mix at least till 2050.

- We should continue with the indigenous program for PHWRs given their demonstrated credentials of economic viability, safety, and reliability. The LWR program needs a rethink and serious discussions to assess its economic viability. It is not prudent to burden the Indian energy sector with a very high-cost energy source.

- It needs to be carefully modelled whether during the lag currently being seen with nuclear growth, might the renewable power (wind and solar) plus battery solutions grow to a level wherein the role of nuclear becomes a smaller one.

- As India has already invested huge amounts of research in FBR & Thorium utilization stages, these programs should continue, but with time bound implementation and deliverables. Hopefully, this could lead to thorium utilization as envisaged in the third stage of the nuclear power program in the latter part of this century.

- Steps should be taken to generate more transparency in civilian nuclear power programs by enhanced information sharing and integrating public opinion in decision making. Institutionalized mechanisms should be evolved for seeking and addressing concerns and suggestions from experts outside the establishment. This will help build public trust. For instance, AERB should be separated from DAE to ensure independence of the regulator. Various other ways should also be explored to generate public acceptability as mentioned in the text.

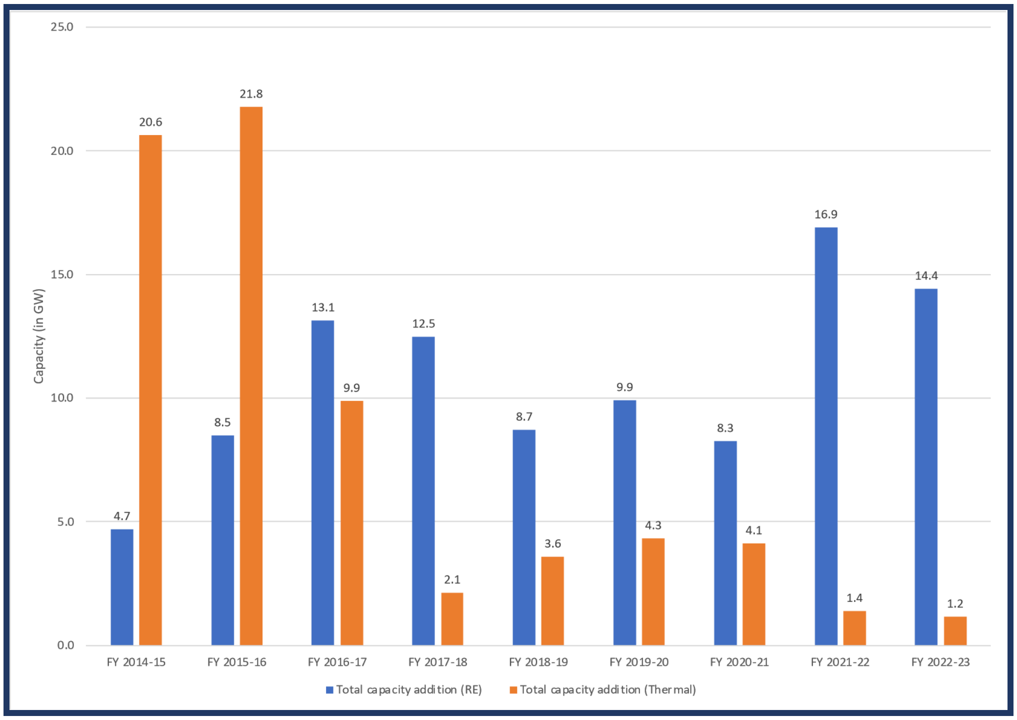
Chapter 11: Green Hydrogen

11.1 Introduction

India relies on fossil fuels to meet much of its primary energy demand with coal accounting for 45 percent, followed by 25 percent from petroleum, 20 percent from traditional biomass, six percent from natural gas, three percent from RE (including hydro) and one percent from nuclear (IEA, 2023). To fulfil this demand, India imports 85 percent of its crude oil, a quarter of its coal requirement (MoC, 2023) and half of its natural gas demand (PPAC, 2022). This exposes the country to dual vulnerabilities of geopolitical risks and a widening fiscal deficit.

The dependence on imported fossil fuels also adds to India's emission inventory**.** Energy consuming sectors (power, industry, transport, and buildings), which rely heavily on fossil fuels for either their feedstock or energy needs, contribute to three quarters of the annual GHG emission of 2.7 gigatons CO_2e in India (Mukherjee & Chatterjee, 2022).

India, nonetheless, is incorporating abundant, available, and affordable renewable resources to power its economic activities and meet its national development objectives (figure 14). Augmenting "Renewable Energy (RE)"in the power sector, through accelerated policy efforts, will help reduce emissions in sectors which can be electrified such as road transport, low temperature industrial processes and space conditioning. Several industrial processes, such as steelmaking, hydrocracking in oil refining, fertilizer production, inter alia are however considered hard-to-abate as they require fuels with high energy density or use carbon as a feedstock and are thus inconducive for electrification.



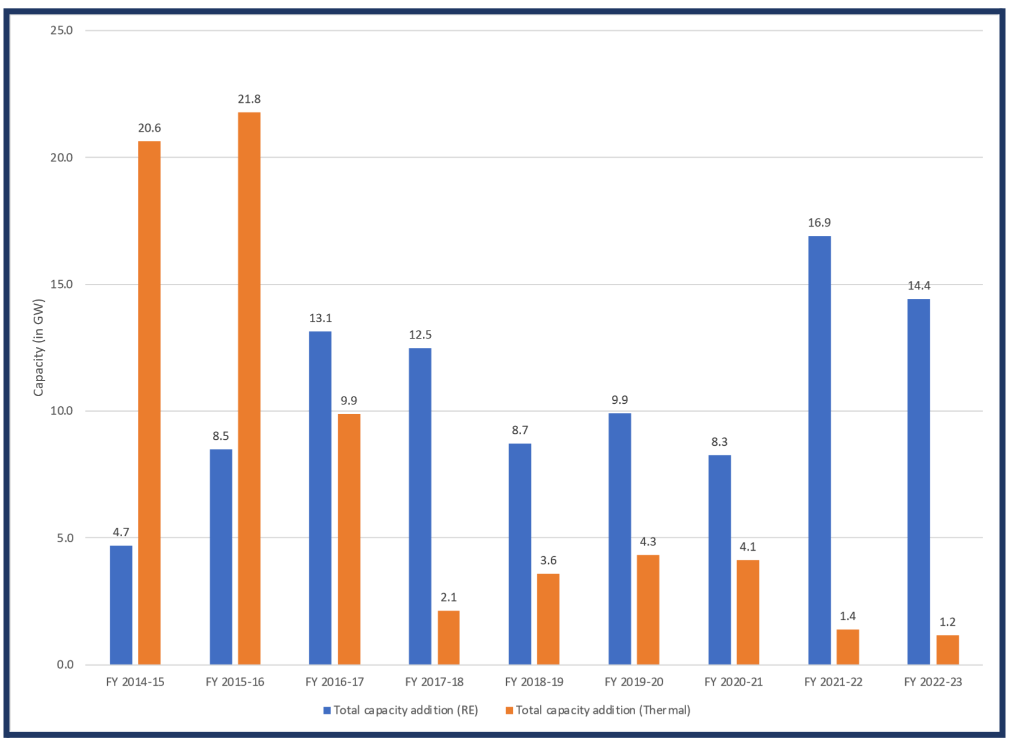


Figure 17: Capacity additions in RE vis-a-vis thermal in installed power capacity. [Source: CEA]

11.2 Hydrogen – A Clean Molecule

To tackle emissions from these hard-to-abate industries, reduce exposure from price volatility of imported fuels and minimize energy security risks, a domestically produced low carbon molecule would be required**.** Hydrogen fulfils that role as it is versatile, reactive, storable, transportable, and clean burning.

Traditionally, hydrogen as a fuel and industrial feedstock, either in its molecular form or in a form where it is bound within a molecule, fulfills multiple roles along the industrial value chain. India's industry – chemical and refining, are currently the largest producer and consumer of hydrogen in India. They cumulatively produced and consumed approximately 6 million tons in 2021 which was 6.4 percent of the global production – 94 million tonnes (Mt), equivalent to about 2.5 percent of global final energy consumption.

Hydrogen has conventionally been produced from unabated fossil fuels through processes such as Steam Methane Reforming (SMR), and coal gasification which have a high emission intensity. Low emission hydrogen, on the other hand, is produced commercially from:

a. Water electrolysis utilizing renewable energy or nuclear energy as an energy source.

b. Gasification of coal or biomass while incorporating Carbon Capture and Storage (CCS) and SMR utilizing natural gas as a feedstock while also incorporating CCS. These various production pathways have been color coded to represent original energy source, production method and associated emissions (figure 15).

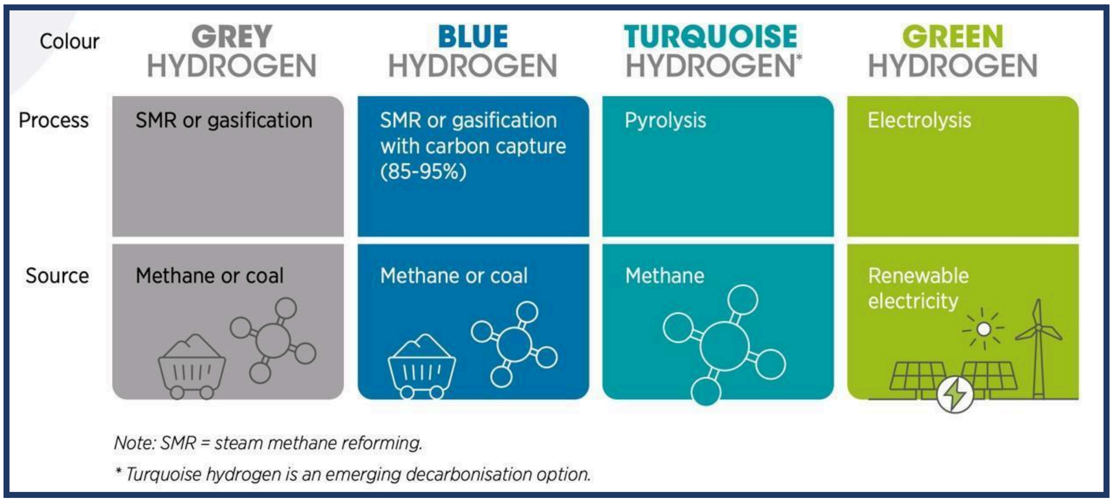


Figure 18: Hydrogen production pathways

Source: (Droege, 2023) (IRENA, 2021)

The biggest value proposition of hydrogen is in decarbonizing the hard-to-abate sectors, which can only be accrued if cleaner production methods are used (table 1). Producing low carbon hydrogen, defined either as ‘blue or green’ at the scales required will however be challenging. Much is to be done to make this market a reality for India. Government and industry alike have acknowledged that low carbon hydrogen could lead to significant positive impacts. In the former, the drivers are national economy, emissions, and energy security. For the latter it is a significant opportunity, and the private sector has started to respond to the potential demand for green hydrogen production both domestically and globally.

Table 23: Emission intensity and resource efficiency of various production pathways

Process	Emission intensity	Carbon capture (CCS)	Feedstock		Water	Electricity	Classification
	tCO2 per tH2	tCO2 per tH2	t per tH2	Type	t per tH2	MWh/tH2	Colour
SMR	9.0	0.0	3.4	Natural Gas	6.64		Grey hydrogen
ATR	9.0	0.0	3.8	Natural Gas	25.27		Grey hydrogen
Coal Gasification	19.2	0.0	11.4	Coal	12.17	1.36	Brown hydrogen
SMR with CCS	1.0	8.6	3.7	Natural Gas	4.68		Blue hydrogen
ATR with CCS	0.6	9.8	3.8	Natural Gas	25.27		Blue hydrogen
Coal Gasification with CCS	1.5	17.7	11.4	Coal	12.17	1.36	Blue hydrogen
Electrolysis using ALK/PEM	0.0	0.0			10	53	Green Hydrogen

Recent trends and analysis indicate that, driven by technology advancements, reduction in costs of renewable energy and electrolyzers and aggressive national strategies by some of the major economies, Green Hydrogen is likely to become cost-competitive in applications across industry, mobility, and other sectors within a short span (IRENA, 2020) (Raj, et al., 2022). It is already cheaper than producing blue hydrogen from natural gas with CCS and is likely to achieve cost parity with blue hydrogen produced through coal gasification with carbon capture and storage (figure 16) within this decade.

Coal gasification and SMR units with CCS are dominated by big industrial set-ups, characterized by large upfront investments and long lifetimes. Any future investment, to avoid stranded assets, therefore should be viewed from a long-term lens, in which case investments on green hydrogen projects come out as most favourable.

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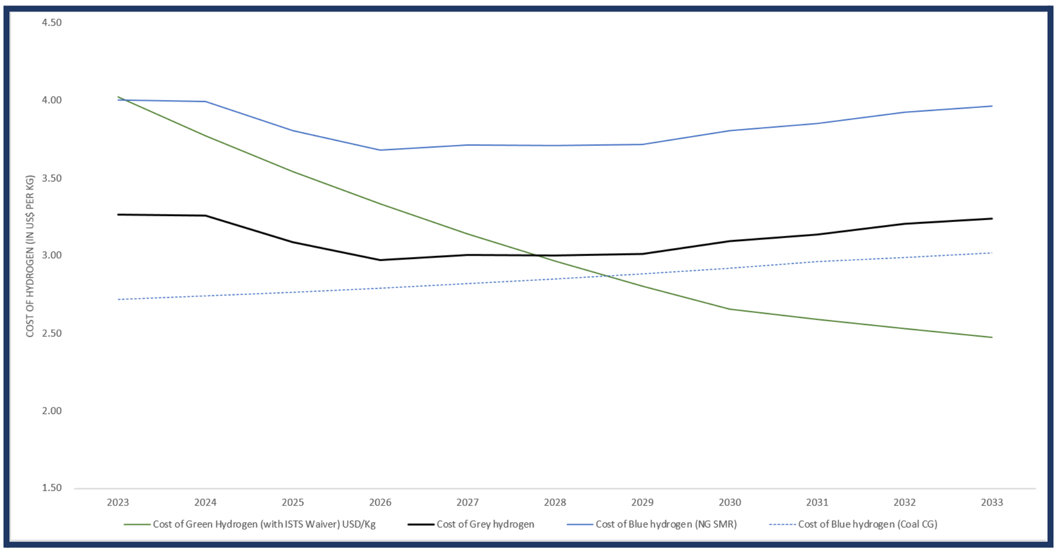

Figure19: Levelized cost of hydrogen from large projects

Source: (IRENA, 2021) (Argus, 2023) (IRENA, 2020) (Mukherjee & Chatterjee, 2022) (PPAC, 2022)

11.3 National Green Hydrogen Mission

The Government of India (GOI), recognizing the critical role of green hydrogen, announced the National Green Hydrogen Mission (NGHM) in January 2023, with a total budget of US$ 2.4 billion to bridge the viability cost gap of green hydrogen and its derivatives vis-à-vis their alternatives (such as grey hydrogen) and to promote clean energy investments in green hydrogen value chain. The NGHM's objective is to provide a comprehensive action plan to establish a conducive green hydrogen ecosystem and catalyze large-scale green hydrogen investments for domestic consumption and to eventually position India as a global hub for production, usage, and export of green hydrogen and its derivatives. Green hydrogen represents a major transformation in the fuel mix which will require interventions both on the supply and the demand side.

The NGHM, by 2030, is expected to result in:

(a) Producing 5 million tons of green hydrogen per annum
(b) Catalysing 125 GW of additional RE
(c) Leveraging US$100 billion of investments
(d) Creating more than 600,000 new jobs
(e) Avoiding 50 million tons of annual GHG emissions and
(f) Reducing the dependency on imported fossil fuels by US$12.5 billion

The NGHM will also support India's goal of becoming a leader in electrolyzer technology and manufacturing.

The NGHM has identified city gas distribution (CGD), oil refining, fertilizers, ammonia production, heavy commercial vehicles and long-haul operations, steelmaking, maritime shipping, and exports of green hydrogen and its derivatives as the key demand sectors. Green hydrogen and its derivatives can be utilized in these sectors either to:

(a) Fulfill a drop-in demand, for example in sectors such as ammonia which already utilizes grey hydrogen and replacing it with green would help its decarbonization.

(b) Blended with existing fuels to substitute a share of polluting fuels which India currently imports such as in case of HCNG which substitutes a portion of imported natural gas with hydrogen to be utilized in transport sector and,

© Replace incumbent and emission intensive technology/process with clean processes utilizing green hydrogen such as replacing Blast Furnace (BF) based process of steelmaking that uses imported coking coal with hydrogen based Direct Reduction of Iron (H2DRI).

Recommendations:

GOI has already signalled an ambition to achieve net-zero by 2070 hence enunciating the need for hard-to-abate sectors to decarbonize. The ecosystem, however, needs to minimize obstruction to future hydrogen projects by harmonizing standards and removing regulatory barriers, enhance confidence of equipment manufacturers and producers to invest in plants by creating conducive investment mechanisms, establish stringent sectoral emission norms that provides incentives to both producers and end-users, and establish a domestic marketplace for hydrogen-ready equipment at both ends of the value chain – production and consumption.

Producing hydrogen at the scales required under NGHM would require the following supply side interventions:

- **Full Load Hours:**
  Full Load hours (FLH) defined as the number of hours the electrolyzer would have taken to consume the amount of energy current consumed over a period (typically one year), had it been operating at full capacity, in relation to the electrolyzer plate capacity availability of RE for electrolyzer. FLH can be increased based on the firmness and dispatchability of renewable electricity. A combination of solar, wind, energy storage and banking through Round-The-Clock (RTC) can significantly increase the FLH, which in turn is an important driver towards minimizing the levelized cost associated with production of green hydrogen, at least in the initial years when CAPEX of electrolyzers are high. Contemporary research indicates that oversized RE (or derated capacity of electrolyzer) through a combination of onshore wind and solar in India, without any energy storage, can deliver high-capacity utilization factors (CUF) with low levels of curtailment and low tariffs.

- **Managing Offtake Risks:**
  The merchant market for green hydrogen has not matured like wind or solar in India and given its current unfavorable economics, off takers show limited voluntary

purchase interest. Further, duration of contracts is also a factor, with developers (green hydrogen producers) preferring long term contracts while off takers favor short-term contracts. The European Union is utilizing risk mitigation instruments such as a contract for difference (CfD) scheme that aims to close the market price gap between renewable green hydrogen and its fossil-derived grey counterpart. Similar measures, such as payment security mechanism, penalty clauses in contracts to mitigate supplier default, inter alia which protect the interests of green hydrogen producers need to be introduced in the near and medium term in India.

- **Pilot Projects:**
  Given the nascency of the sector, pilot projects will be critical to boost investor confidence and ensure learnings for green hydrogen producers and consumers alike. GoI has announced pilot projects in shipping, long-haul mobility, and low carbon steel projects. These need to be extended to other sectors such as fertilizers and to be primed for success should be co-located with major demand centres such as major freight corridors in case of mobility. Further to enable upscaling of lessons, the learnings need to be collated and disseminated through a centralized platform with extensive engagement of industry.

- **Enhance Competencies in Domestic Manufacturing:**
  Given the global shortage of electrolyzer supply and high lead times, domestic electrolyzer manufacturing capabilities are essential to kickstart GH adoption. Most electrolyzer manufacturing facilities are currently located outside India and any hydrogen produced soon is expected to be based on imported electrolyzers. There is therefore an increased emphasis on domestic electrolyzer manufacturing capacities, to reduce dependence on imports for the future hydrogen ecosystem, provide supply surety and reduce costs. A focus on domestic electrolyzer manufacturing could guard the upcoming green hydrogen economy against potential global demand-supply imbalances, help reduce GH costs, and attenuate domestic job creation possibilities. Incentives must be provided for developing domestic electrolyzer manufacturing capabilities and hydrogen storage facilities. The incentives provided for manufacturing should provide a revenue stream for producers, increase competition, build capacities and experience in the short term. The incentives, such as Production Linked Incentives (PLI) being outlined should be front heavy with clear sunset clauses. This would not only ensure private investments but also ensure cost reductions. The development of domestic

manufacturing competencies would also provide fillip to MSMEs which are slated to play a big role in the supply of Balance-of-Plant (BOP) components of electrolyzers.

- **Incentives:**
  In the short term, it is imperative to adopt a front heavy green hydrogen incentive scheme that defines the detailed incentives, specifies the eligibility criteria and eligible recipients, outlines the competitive selection process, and appoints the implementing agency which will manage the incentive scheme. This can be geared up to initially achieve cost parity of green hydrogen and its derivatives through cost buy downs such that a market can be instituted with appropriate supply and demand. The initial incentives announced as a direct subsidy for green hydrogen, however, may be modest compared to the current requirements, as they are available for a period of three years and when viewed in levelized terms contribute to a cost buy down within the range of US$ 0.1 – US$ 0.2 per kilogram, while the cost differential with competing alternative (grey hydrogen) is almost US$ 2.0 per kg.

11.4 Scaling Hydrogen Demand through Policy

Reaching a delivered hydrogen cost of where it is cost competitive with contemporary alternatives such as natural gas and coal will require massive scale-up in demand. The more promising use cases in industry are only funded with one-off grants for demonstration projects. For the industry to scale up, demand needs to be supported with comprehensive policy coordinated across government. The demand side interventions need to include:

- **Emissions Penalty:**
  An important tool to help accelerate the switch to low carbon technologies is the introduction of a penalty on CO2 emissions. This could be in the form of regulations limiting emissions from certain processes or end-uses, or through the imposition of a carbon tax. Introducing an emissions penalty would help level the playing field between green hydrogen and grey hydrogen sooner than relying on prevailing trends. This could stimulate the industry in the short term, helping India keep abreast of clean energy technologies by further supporting deployment. Such a policy measure is being undertaken by the EU in the form of a carbon border adjustment mechanism (CBAM), which ensures that domestic industry does not get

penalized and is put at a competitive disadvantage vis-à-vis 'dirty' imports from other countries, which do not pay such a tax.

- **Mandates and Obligations:**
  Alongside punitive measures to restrict emissions from certain processes or end-uses, it would also be beneficial to support products produced with low carbon hydrogen through green product standards. This would allow consumers to differentiate between products made using environmentally sustainable methods, versus polluting. Further, depending on the cost competitiveness, appropriate mandates for industries with drop in demand (such as oil refining and fertilizer) can be notified. This is likely to activate the domestic demand and can be undertaken through adoption of a regulation on green hydrogen obligations that mandates appropriate industries to replace a minimum share of grey hydrogen with green hydrogen in their operations.

- **Green Procurement Mandates:**
  A switchover to green steel in case of infrastructure projects would raise overall costs by merely 0.15%. Considering the slight premium, the government can promote Green Public Procurement (GPP), described as a range of policies that ensure environmental considerations are included in the procurement process of the national and state governments. It is one of the most effective policy measures to drive important early demand for highly polluting sectors such as low emission cement, concrete and steel.

- **Storage and Transportation Logistics:**
  Hydrogen's low density and volatility makes it considerably harder to store and transport than fossil fuels. For hydrogen to replace fossil fuels, significant transport and storage infrastructure would need to be built. Transporting and storing hydrogen in large quantities will be one of the most significant challenges for a future hydrogen economy. Pipelines represent the lowest landed cost structures both under long distance and short distance considerations. However, currently, there are no large-scale hydrogen pipelines carrying 100% hydrogen (without blending with natural gas) in India. Transportation of hydrogen via the pipeline route is contingent on national and third-party infrastructural development efforts. The availability of pipeline and storage infrastructure across the country could ease the development of a green hydrogen ecosystem and deliver green hydrogen to

industries at low costs. The government of India would need to create policy and regulatory mechanisms enabling the development of green hydrogen pipelines and governmental green hydrogen storage facilities. Large-scale hydrogen production and transportation of green hydrogen, in the long run, would not be achieved in the absence of a national green hydrogen pipeline network. The policy would need dedicated efforts in R&D, funding, and commercialization to be implemented properly and deliver results.

- **Development of Hydrogen Hubs**:
  Incentives and mandates should also be supplemented with geographical assessments such as by creating a geospatial map capturing all aspects of the hydrogen economy to identify potential clusters around existing factories, transmission infrastructure, and renewable hubs. Industrial clusters have been a common strategy across many of the hydrogen roadmaps being developed, for example in the European Union. Industrial clusters or hydrogen hubs can help coordinate and concentrate support to advance green hydrogen adoption. Providing incentives and support to priority regions while creating green hydrogen procurement quotas for industries located in these clusters can solve demand and supply, as well as alleviate finance constraints to accelerate deployment.

- **Bulk Procurement:** The government can provide financial certainty to early adopters through investment facilitation measures like demand aggregation, such as undertaken for the solar sector by promoting a central institution like SECI. This demand aggregation would enable economies of scale, increase competition, drive down prices, ensure quality control and improve access to information.

11.5 Building a Hydrogen Ecosystem

Development of a hydrogen ecosystem, however, requires a systems approach which needs to activate the entire value chain, and hence requires work on several parallel issues.

- **Standards:**
  Hydrogen is a flammable gas and for widespread adoption it is imperative to reduce the biggest environmental risks to ensure safe production, transportation, and utilization of green hydrogen. It is therefore essential to adopt a national green hydrogen regulation framework that establishes safety standards for (a) green

hydrogen production; (b) green hydrogen transportation and storage; and (c) green hydrogen utilization in the mobility sector. Clearer plans, policies and standards are required to address the potential environmental and ecological impacts that may also arise from the expected large scale sector development. Medium and long-term policy actions will be needed to manage impacts, including indirect and cumulative impacts, arising out of green hydrogen production, transportation and storage and utilization, including setting up production facilities that might require desalinated water given the shortage of freshwater and consequent propensity to locate in and around the ecologically sensitive coasts and wetlands.

- **Guarantees of Origin (GO):**
  A robust framework can facilitate the trading of hydrogen as a commodity on national and international markets. Currently, India does not have such a framework in place and there are numerous issues and open questions to be addressed. First, the national certification processes must align with the international markets. Second, only a few voluntary certification schemes are functional and even these are not effectively monitored and evaluated. Third, the responsibility matrix of all the stakeholders is not clearly defined. There is an urgent need to develop certification standards and processes that infuse confidence among the stakeholders. GO may follow either a cradle-to-grave approach or a well-to-gate approach. This, however, would be dependent on the ease of monitoring, reporting and verification (MRV), and it is strongly recommended that the government needs to undertake wide stakeholder consultations before finalizing an approach. Adoption of green hydrogen standards that define what is eligible for consideration as "green" hydrogen is imperative to be competitive.

- **Skilling:**
  It is recommended that India starts putting in place partnerships for investments in long-term skilling. While the Government of India, through the Ministry of Skill Development and Entrepreneurship has already begun initiatives targeting engineers and researchers so they can understand the basics of green hydrogen production, detailed programs educating engineers and technicians on design, engineering, operations and maintenance, and storage and transportation, still need to be designed and implemented. On-ground training on safe handling of hydrogen supply and end-use systems also need to be created and implemented, as do training on how to use seawater/wastewater for electrolysis, if fresh water is

not available. This would require upstream collaborations with institutes of national repute and others working in the green hydrogen space and would need to be thought of and planned for, urgently.

- **Carbon Market:**
  A national carbon market is essential for carbon pricing signals to provide a level playing field between clean energy and fossil fuels as the carbon markets factors in the associated externalities. Carbon pricing will result in earlier cost parity of green hydrogen and fossil fuels. The amendment to the Energy Conservation Act, 2001 provides the legal framework and empowers the central government to specify carbon trading schemes and issue carbon credit certificates to registered entities. This is a significant step toward the launch of a national carbon market in India. In addition, the amended Act also provides the legal basis for the government to specify a minimum share of consumption of non-fossil fuel by designated consumers, which include industries such as steel, cement, textiles, chemicals, and petrochemicals; the transport sector including Railways; and commercial buildings, as specified in the schedule. This will not only increase RE penetration, but also allow the government to mandate green hydrogen obligations for designated consumers in specific industries.

- **Principle of Additionality:**
  India, while working towards its ambition of producing 5 MMT of green hydrogen per annum by 2030 also has other development goals. This includes decarbonizing its electric grid, climate proofing its natural resources and providing a sustainable development model for its citizens. To ensure that green hydrogen does not compete for resources such as renewable energy and water, India would need to imbibe the principle of additionality – that all inputs required for green hydrogen production are additional in nature and do not divert resources from other important uses such as electrification in case of renewable energy and irrigation/drinking water needs in case of water. In case of latter, though it has a minor impact on overall levelized cost of hydrogen it is imperative that the siting of any green hydrogen production centers be such that it does not contribute to any additional stress on the available water resources i.e., areas with over-exploited water resources should be strictly avoided and wherever possible demineralization of abundant surface water (such as oceans) should be preferred with adherence to strict waste disposal regulations.

INTEGRATED ISSUES

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Chapter 12: Governance And Regulation For An Integrated Energy Policy

12.1 Background

This paper is part of a series of papers that together can help in the formulation of an Integrated Energy Policy (IEP) for India. It assumes that there is an integrated energy policy for the country with principles and policies laid down to guide central and state governments, regulators and the private sector.

India's economic growth needs a reliable, secure and sustainable access to energy. With increasing urbanisation, growing demand for infrastructure and technology, a robust energy sector is essential. Besides economic importance, the energy sector is intrinsically linked to society and environment. The Minister of Finance in her Union Budget Speech for 2024-2025 identified 'energy security' as one of the priority areas for the budget and announced that the Government would formulate a policy on 'appropriate energy transition pathways that balances the imperatives of employment, growth and environmental sustainability'.

Traditionally, the various components of the energy sector such as power, coal, oil and gas, atomic energy, renewable energy, end use sectors such as transport, industry, have all been dealt with by separate institutions at the level of Centre and States. There is a need to develop synergy across these institutions and areas towards a comprehensive and integrated policy for the energy sector in India. This policy brief discusses overarching issues in governance and regulation in the energy sector and makes recommendations to address these issues and challenges. These recommendations are for the overall architecture of the sector to enable and implement an IEP. The brief contains both short-term and long-term action points to strengthen the governance and regulation of the energy sector in India.

12.2 Governance Structure of the Energy Sector

The present system of management of the Energy Sector in the Government of India (GOI) is one in which the individual ministries – Power, New and Renewable Energy, Coal, Atomic Energy, and Petroleum & Natural Gas – deal with their respective domains. The Ministry of Environment, Forest and Climate Change (MOEFCC) deals with the issues concerning environmental impacts and climate change across these Ministries. There are also ad hoc committees set up from time to time to deal with specific issues. The erstwhile Planning Commission and now the NITI Aayog do deal with cross-cutting issues. These are the two bodies that have dealt with the issue of an integrated energy policy in the past. However, there is no institution at present that deals with these intertwined issues of energy policy on a continuous basis. An Integrated Energy Policy (IEP) will need a dedicated and continued body to implement the policy and ensure that principles enumerated here are fully complied with. There may also be cases where a deviation from these principles may be justifiably sought. This body will have to take a look at these requests and get them approved. The last attempt to create such a body was the Advisory Board on Energy which was wound up in 1988. It used to be located in the Cabinet Secretariat. However, as the name implies it was only an advisory body with no executive responsibilities.

12.2.1 Proposed reform in GOI

Design and implementation of a national IEP would need a full-fledged administrative set up with powers to issue orders and ensure implementation by the line departments in GOI. It would also have to liaise with the State Governments and obtain their cooperation. Therefore, as a starting point the draft IEP will have to be placed and discussed before a body such as the Governing Council of the NITI Aayog to ensure a buy-in from the States. There are many crucial aspects of the IEP that will need to be implemented by the States - Power and renewable energy, Electric Vehicles, Electric cooking, Solar Heating and Cooking as well as Hydrogen will require the support of the State Governments. Development of energy resources - oil and gas, and coal also require the support of the State Governments. The initiative for this will have to be coordinated at the GOI since the major energy ministries are located here and since climate change related goals are the primary responsibility of GOI. It will have responsibility for all the energy supply ministries and also other ministries that may have a role in implementing the IEP. The MOEFCC will have an increasingly important role to play as Energy Policy is going to be dominated by environmental concerns, notably our international climate goals and targets as envisaged in the NDCs communicated to the UNFCCC. Therefore, the permanent Secretariat of the IEP is most suited to be housed in some part of the GOI, with a mechanism for inter-ministerial and inter-department coordination where Centre-State as well as Inter-State concerns can be addressed.

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One obvious candidate for an Energy Policy Secretariat is the NITI Aayog, but the other possibilities could be the Cabinet Secretariat, which was the implementing agency for the Advisory Board on Energy and the Prime Minister's Office itself with the Secretariat reporting to the PM. The administrative issues relating to housing this new agency and defining its role and scope could be examined by the GOI in consultation with State Governments, relevant government agencies and other stakeholders in the energy sector. The Secretariat could be supervised by 2-3 dedicated eminent persons in the field of energy.

The other alternative is to combine most, if not all, the Energy Ministries into one Energy Ministry. The IEP Secretariat can then be located here. This is the practice in some parts of the world – in the US there is only one Energy Department; In the UK the Energy Department has been given the responsibility of Climate Change. While these global examples are no doubt one possibility but given the historical background in India, such an amalgamation of all Energy ministries does not seem to be an immediate possibility. Thus, such an option seems less likely to be accepted and implemented, at least in the near future. Therefore, it would be better to have a coordination mechanism to start with and then assess the need and modalities of this merger of all Energy Ministries later.

12.2.2 Proposed reform in State Governments

In addition to the proposed reorganization at the Government of India, there is a need at the State Government level also for similar coordination of energy policy and dovetailing it with the environmental policies required for achieving our national goals. State Government policies will also have to be in line with the decisions of the IEP implementing Agency. For example, the policies on RPOs (Renewable Purchase Obligations) will need to be harmonised at the National and State levels. While the ultimate responsibility lies with the State Electricity Regulatory Commissions the national imperatives will have to be married with the State level constraints and requirements. Similarly, the effort to wean away the transport sector from fossil fuels towards cleaner alternatives would depend highly on state government policies for the same in the sphere of public transport, road registration and taxation policies, encouraging recharging infrastructure and such like They can also take the initiative in suggesting new policies for the country. For this they will also have to create a similar body that can coordinate actions across different departments in the State Government. In some ways this may be easier in the States since they have only one Energy Department. This nodal point in the State can then coordinate with the corresponding agency in GOI. Involvement of States is going to be important in the energy sector as resource rich States are dependent on resources, especially fossil based resources, for revenue. State level coordination is needed as other sectors in which initiatives are taken or needed at the level of States need to be aligned with the overall IEP goals and principles.

With the focal points established in both the Centre and the States, the next issue is the organization of the IEP Secretariat and its reporting design. It should also place progress reports before a Standing Sub-Committee of the NITI Aayog's Governing Council. This Sub Committee will have representation from all the concerned departments from GOI and State governments. At each meeting of the GC there could be a dedicated session on IEP discussing the progress, problems and policy. The reforms at the level of Centre and States have to be made upholding the principles of cooperative and competitive federalism. In the recent past, some of the actions of GOI seem to be a departure from these principles. However, the statements of the Finance Minister in the budget speech for FY 24-25 are a welcome reaffirmation of these principles.

12.2.3 Cross Cutting Issues

With the growing emphasis on environmental concerns dominating the discourse on energy policy, the role of science and technology (S&T) is also becoming more important. With the importance of coal in our energy landscape in the near future, efforts are needed for mitigating the impact of coal on the environment. Such efforts need R&D and S&T interventions during the entire life cycle, from extraction to utilisation of coal in power generation. Further, local environmental issues also need attention, irrespective of the source of energy generation. Taking a leaf from the Ministry of Petroleum and Natural Gas (MOPNG), the other energy ministries should also look at establishing S&T Centres. In order to coordinate R&D done and supported by such Centres, there should be a Standing Committee serviced by the IEP Secretariat. The objective should be to find solutions and disseminate them for implementation and deployment.

At present, the mandate of the Bureau of Energy Efficiency (BEE) has been expanded to go beyond promotion of energy efficiency in electricity to developing a carbon market in India. In the long run, there should be a stand-alone exchange and regulation for the carbon market. Until then, BEE could take the responsibility of the same as is being currently done with some coordinating mechanism cutting across Ministries.

The IEP secretariat proposed here will be based on the foundation of Inter-Ministerial and Centre-State coordination. The primary objective of the secretariat would be to implement the objectives of India's Energy Policy in an integrated manner which takes into account all the sectoral aspects as well as cross cutting issues. The nature of the body should not be restricted to advisory and be that of an implementing and oversight agency instead. The secretariat should not be an ad hoc body and be institutionalized and continuous in its existence and functioning. The process of creation and functioning of this secretariat should uphold tenets of good governance and ensure transparency, public participation and regular flow of information.

Recommendations:

- The GOI must establish a Permanent Secretariat of the IEP which would implement the objectives of IEP and liaise with the line ministries and departments of GOI and the State Governments.

- The administrative set up of such a Secretariat should be finalised by the government in consultation with all the relevant stakeholders. Some of the options for hosting this Secretariat include NITI Aayog, Advisory Board on Energy of the Cabinet Secretariat, or the Prime Minister's Office.
- Alternatively, a longer-term suggestion, which can be considered after due consultation, is to merge most if not all energy related ministries into one Ministry of Energy. The IEP Secretariat can then be located here
- State level action and coordination should be at the core of IEP. States may be grouped according to regions and the coordination can be steered by the Secretariat.
- Energy needs to be mainstreamed and have dedicated sessions at all the Meetings of the Governing Council of the NITI Aayog.
- All the Energy ministries should establish Science and Technology Centres, similar to that in MOPNG, to coordinate research and disseminate the results for implementation and deployment. This could be supported by a Standing Committee of the proposed IEP Secretariat.
- Merge activities of BEE and PCRA into one dedicated agency for energy efficiency and reduction of carbon footprint.

12.3 Regulation in the Energy Sector

One of the notable features of post liberalisation reforms in the 1990s was the establishment of independent regulatory authorities (IRA). As in several other developing countries, IRAs in India were introduced in the electricity sector, along with unbundling and privatisation of the sector. Odisha was the first State to introduce an independent electricity regulatory commission in 1996 under the Orissa Electricity Reform (OER) Act, 1995. Although not in the form of IRA, regulatory changes were introduced in other energy domains too, e.g., in upstream oil and gas. After the initial years of learning the IRAs were restructured in the Electricity and telecom sectors. Now the standard template is to have a regulatory body headed by a non-judicial member and an appellate body headed by a judicial member.

12.3.1 Overview of the Present Regulatory Structure in the Energy Sector

Electricity has one of the most elaborate regulatory frameworks in India. Power sector reforms culminated into constitution of IRAs in the form of State Electricity

Regulatory Commissions (SERC) and Central Electricity Regulatory Commission (CERC), constituted initially under the Electricity Regulatory Commissions Act, 1998 (which gave the states the option to have a regulator) and later made mandatory under the Electricity Act of 2003. The experience in this sector has been discussed in some detail in the paper on Electricity already published.

As the upstream oil and gas sector was opening up to private investments in early 1990s, Directorate General of Hydrocarbons (DGH) was established in 1993, 'to promote sound management of the Indian petroleum and natural gas resources having a balanced regard for the environment, safety, technological and economic aspects of the petroleum activity'. The main regulatory agency governing the downstream oil and gas sector is the Petroleum and Natural Gas Regulatory Board (PNGRB), a statutory body constituted under the PNGRB Act 2006. While the Act envisaged PNGRB to regulate a number of aspects such as refining, processing, storage, transportation, distribution, marketing and sale of downstream products, the Board's mandate has been rather limited and important regulatory functions, such as tariffs, are kept out of the purview of PNGRB.

After around five decades of nationalisation in the coal sector, mining laws have been amended to open up coal mining to the private sector. However, unlike electricity and petroleum, an independent regulator or a specialised technical body has not been established. The Ministry of Coal has continued to regulate the sector through the Nominated Authority, who is a serving official of the ministry, and the Coal Controller's Organisation. The Nominated Authority is responsible for the auction process and allotment of coal blocks and operationalization of auctioned or allotted mines, and the Coal Controller is the Commissioner of payments.

The atomic energy space was governed by internal and ad-hoc committees for many years until the Atomic Energy Regulatory Board (AERB), a subordinate authority of the Department of Atomic Energy (DAE), was created under the Atomic Energy Act in 1983. Unlike an IRA, AERB gets its regulatory powers as delegated to it by the Central Government. While involved in the rulemaking process, and a competent authority for safety aspects, AERB does not enjoy rule making powers.

12.3.2 Experience of IRAs in the Energy Sector

Different domains and sources of energy in India have had different trajectories and experience with regulation. In some cases, there is a detailed, multilevel and comprehensive independent regulatory framework (CERC and SERCs in electricity), while in others the IRA is limited to only a specific set of activities of the sector (PNGRB in downstream oil and gas sector). Certain government bodies and departments under the nodal Ministries also perform regulatory functions (Coal, DGH and AERB). Thus, the energy sector has been regulated by a mix of government departments, technical and administrative regulators in the absence of a single overarching Independent Energy Regulator.

It has been more than 25 years since IRAs were introduced in the electricity sector and there have been both advantages and disadvantages of the model. Despite their perceived shortcomings IRAs have continued at Central and State levels. IRAs are believed to be enhancing regulatory efficiency, independent of interest groups, and not bound by obligations of the government. This makes IRA better placed to provide a level playing field to public and private entities towards the development of the sector and public interest in general. However, regulators, while expected to be independent from the government, are not completely disconnected from the political economy of the sector. Some of the disadvantages or challenges that have been noted in the experience with IRAs are discussed below.

Despite years of existence of delegated as well as independent statutory authorities, regulatory capacity has been seen as a cause of worry across sectors in India. Subject matter knowledge is essential to regulate any sector and many IRAs struggle with inadequate staff, vacant expert member positions or inability to hire the best candidates. While lack of capacity and experience has been common in the energy sector, some regulators like SEBI have performed somewhat better in comparison to building a pool of their own expert staff over time**.** Given the technical nature of decisions in the energy sector, the government needs to invest in and institutionalise capacity enhancement of regulatory institutions, while keeping the process de-politicised**.** Regulatory design at times has shown a lack of clearly aligned objectives horizontally and vertically. This calls for greater coordination in different regulatory agencies.

Autonomy of regulatory structures must be preserved at multiple levels in keeping them immune from influence of various stakeholders in their decision making processes. This is more challenging in the energy sector due to the presence of government entities in the industry. Organisational and operational autonomy, along with financial autonomy, is crucial to provide the regulators the freedom to appoint personnel independent of the industry or government. However, examples where permissions from government needed to recruit staff, requirement to match salaries to government-scale, or remuneration being paid by companies, have been noted in SERCs as well as PNGRB. The dependence on the executive is even more pronounced in the case of regulatory agencies created under the administrative and budgetary control of the Ministry/department, for example DGH or AERB.

It is imperative to recognise and address the difference between de jure and de facto autonomy. Laws and regulations prescribing autonomy in constitution, operational and financial matters may not always materialise in de facto autonomy of regulators. An exception however is AERB, where de facto independence and legitimacy has been greater than de jure where despite lacking rule making powers, it is recognised as an expert and independent body.

A dilemma emanating from autonomy of regulatory institutions is the extent of such autonomy or independence raising the question of regulating the regulators. While being immune from influence and being independent is essential, it should not translate into being isolated. Accountability ensures legitimacy of regulatory institutions and processes. Accountability can be internalised in regulatory governance as – (i) vertical or top-down accountability, whereby regulatory agencies are accountable to the parliament and/or government, and; (ii) bottom up accountability where regulatory agencies are accountable to not just legislature, executive and courts, but to all stakeholders and public.

Actions of regulatory institutions need checks and balances as they are not subject to the election loop of a democratic process. These checks and balances operate at a formal and institutional level where actions are subject to oversight by legislature, through parliamentary committees, questions, etc. and by courts or specialised tribunals, e.g., APTEL. However, such regulatory oversight can hold a regulator accountable mainly for its actions, and not omission. Public scrutiny is important in the latter, where accountability of regulators is ensured through consultative processes involving industry and other stakeholders, including civil society.

- **International Experience of IRAs**

  Reviewing the experience of different jurisdictions with regulation of the energy sector is an extensive exercise and this paper does not attempt to do that. However, it flags certain characteristics from the energy sector that are common in countries around the world.

In countries with a strong federalism, the regulatory functions are distributed between Central/Federal level and State levels. In the United States of America, the Federal Energy Regulatory Commission (FERC), an independent agency under the Department of Energy, is responsible for regulation of various aspects of interstate transmission of electricity, oil and natural gas. States have their own public utilities commissions, which govern retail sale of electricity in their territories. State level Commissions or Departments are responsible for the domestic on land oil and gas industry. Similarly, Canada Energy Regulator (CER) is responsible for export and inter-province transmission of electricity. Provinces have their own Regulators or Boards for electricity, and oil and gas resources. In Germany, the Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway (Bundesnetzagentur) is responsible for regulation of transmission and distribution networks. Smaller intra-state electricity networks fall under the purview of State Regulators.

In terms of scope, most regulators have electricity and oil & gas networks within their domain. The above-mentioned regulators, as well as Office of Gas and Electricity Markets (Ofgem) in the United Kingdom are examples of the same. Oil and gas in some jurisdictions are also dealt with separately, for example, National Petroleum Agency in Brazil or the Norwegian Petroleum Directorate in Norway. Coal in most cases is dealt by the agencies dealing with other minerals. Safety aspects of atomic energy are also governed by dedicated agencies in most countries around the world, e.g., U.S. Nuclear Regulatory Commission, French Nuclear Safety Authority, or the UK's Office for Nuclear Regulation.

12.3.3 The Road Ahead

Introducing New Regulatory Institutions

The most important question is whether India needs an independent statutory regulator for the IEP. At present, India has a full-fledged regulatory system in the power sector, no independent regulator in the coal sector and a partial regulator for oil and gas. Going forward, India could benefit from independent statutory regulators for coal, oil and gas. Alternatively, India could have a single multi sectoral regulator, established with technical and market-based experience. In the case of the transport sector, a number of technology choices are available and emerging in the sector to reduce dependence on fossils. At present, these different technologies are scattered across ministries and departments with varying mandates and priorities. To govern mobility in a holistic manner that can include various technologies without inter-fuel hostility requires an inter-agency coordination mechanism or a dedicated Regulator for Mobility.

Recommendations:

- IRAs for Coal, Mobility and Oil and Gas need to be established quickly.
- Even with sectoral regulators, an Inter-agency coordination mechanism is needed to bridge the gaps between various ministries, state governments, regulators and relevant agencies.
- A single Energy Regulator governing various sources of energy, including upstream and downstream aspects, in the long run.

Improving and Reforming Existing Regulation

Till the time new regulatory institutions are introduced, existing regulatory arrangements have to be strengthened towards removing the lacunae highlighted here and in the individual sectoral chapters. In the light of the preceding discussion and principles of regulatory governance, following recommendations need urgent consideration.

Recommendations:

- There is a need to strengthen coordination amongst different agencies and regulatory bodies governing energy sectors and cross cutting areas.
- Vacant positions at Regulatory agencies and Appellate tribunals must be filled and incentives must be provided to attract suitable candidates.
- Sustained efforts are needed for enhancing the technical capacity of regulatory authorities. One of the ways this could be done is to establish a National Institute for Regulatory Research and Practice cutting across all Regulators- both at the Centre and the States.
- Ensuring transparency and mandatory consultation mandated by law at every level of decision making and implementation of regulatory decisions is imperative for strengthening accountability of regulators. At the same time, autonomy of regulators has to be balanced with accountability.
- Autonomy in affairs of the regulatory agencies, especially in matters of personnel and finances is essential for impartial and de-politicised discharge of functions.

- Alternative dispute resolution forums should be considered to reduce enormous delays in adjudication of disputes in sectors like electricity.

- Expertise to design and implement flexible and dynamic regulations equipped to uncertainties and variabilities in the energy sector in a transparent manner is needed.

- The regulatory agencies should make use of technology to improve its functioning and use open data to share information with the public.

Interim arrangements where the Government is the Regulator

In many areas (like Coal) the nodal ministry performs the regulatory functions. These areas do need a regulatory body but it is unlikely that this will happen soon. One of the ways in which these needs can be addressed is through constituting a standing committee of independent professionals (located in the concerned Ministry or, as in the case of something like mobility which cuts across Ministries, it could be located in one of the major Ministries) who would review draft decisions and give advice, that is then put out in public domain. Such an arrangement should be mandated by law by inserting provisions in the relevant Act of the sector. However, this should be only an interim arrangement till the time an independent regulatory authority is constituted.

Recommendation:

- An interim standing committee of independent professionals must be constituted to review draft decisions and give advice in areas where the Government is the Regulator. Such advice should be put in the public domain.

Chapter 13: Technology Innovation through Research & Development

13.1. Background

"The concept of energy transition revolves around 5 aspects:
(1) Renewable Energy Access, (2) Low Carbon Emission, (3) Enabling Sustainable Development Goals (SDGs), (4) Innovation, technology, and data, (5) Finance and investment."

Developing energy-efficient and renewable energy technologies is the core element of the energy transition. To achieve this we need favorable economics, ubiquitous resources, scalable technology, and significant socio-economic benefits to underpin such a transition. Renewable energy can supply two-thirds of the total global energy demand along with a reduction of the greenhouse gas emissions that are needed to be achieved by 2050. The energy transition is urgently needed to meet the objectives of limiting average global surface temperature increase below 2° Celsius. A transition excluding the use of fossil fuels to low-carbon solutions will play an essential role, as energy-related carbon dioxide (CO_2) emissions represent two-thirds of all greenhouse gases (GHG) This energy transition will be enabled by technological innovation, notably in the field of renewable energy, green hydrogen production and carbon dioxide sequestration and developing energy efficient industrial technologies.

This transition for India brings out the aspect of energy independence, security, economic development, energy access, clean air, and climate change. The 27 trillion $ economy by 2050 and the energy demands juxtaposed with the net zero pathway make this equation quite a complex one. However, to achieve these objectives in the stipulated time, we need to have an action plan. Which can be as below or beyond.

13.2 Green Hydrogen Production, Storage, and Transformation

Hydrogen is crucial for the circular economy. However, green hydrogen production is at a nascent stage. The National Green Hydrogen Mission Program launched by the GoI would facilitate research and commercial-scale hydrogen production. Such mission programs should bring researchers working in academia and industry to a single platform to exchange ideas and resolve challenges. The DST and PSA should act as a catalyst to bridge the gaps to facilitate research and commercialization between academia and industries. Such mission programs can have small sections working at different levels for rapid goal achievement. Because green hydrogen production has different ways to achieve and is a multifaceted problem like green hydrogen production, hydrogen storage, and transportation.

13.3 Strategies for Optimisation

To overcome the limited specialized workforce and high operational costs the following measures can be undertaken:

- Instead of buying foreign technologies, more emphasis should be given to national and international collaborations to facilitate translational research and to reduce the cost of production as any technology can become people's technology when it is affordable and accessible. To achieve this more energy research centers in partnership with industries should be established.

- Any mission project becomes successful when a large number of human resources are allowed to contribute at various levels. This would also help to facilitate employment in the energy research sector and later they can become an integral part of relevant industry sectors. Thus, training, and empowering human resources should also be considered.

13.4 Carbon dioxide capture and conversion for circular economy

To reduce carbon emissions, the carbon dioxide-centric circular economy should not be ignored. Carbon dioxide is also a precious feedstock for many commercial processes and hence carbon capture and carbon utilization should be prioritized. Therefore, relevant mission programs can be launched to capture and convert carbon dioxide to methanol and other significant commercial products. The use of methanol for transportation should be encouraged and industries should be incentivized for developing the relevant technologies to recycle carbon dioxide like the use of methanol fuel cells in transportation, carbon dioxide as feedstock in polymers production, etc.

13.5 Strengthening and Expanding Existing Technologies

Tidal energy, wind energy, solar, grid energy solar, and thermal energy have been emerging as the better source of renewable energy for heat application, hybrid renewable generation etc. Funding should be provided for research and development in this sector to maximize the output and expand its applications and utility by minimizing the limitations.

13.6 Battery and Fuel Cell Research For Energy Storage And Conversion

Whether it is tidal energy, wind energy, solar, or grid energy the most important issue is the storage, conversion, and transportation of this energy. Therefore, battery research for expanding the capacity and deliverables of existing technologies and developing more sustainable and economical batteries comprising sodium, potassium, etc. should be encouraged at academic research institutes and industries by providing sufficient funding, infrastructure, and opportunities to collaborate at national and international levels. Fuel cell research is also equally important for instant and optimum energy conversions to reduce carbon emissions. Lithium recycling should be prioritized for sustainability.

13.7 Bioeconomy and Carbon-Neutral Biofuel Combustion

Biofuel is one of the important constituents of the present sustainable energy source. Public (farmers) involvement to accelerate crop production is necessary. However, focused efforts are necessary to educate and incentivize farmers, industries, and researchers working in this sector. More research is needed to make biofuel combustion carbon neutral.

13.8 Electricity and Renewables

Given the need for integration of higher levels of variable renewables into the grid, themes, where increased research focus will be needed in the future, are:

1. Storage technologies such as concentrated solar thermal with pilot/demonstration projects (this was mentioned in the earlier IEP but somehow with the focus on Solar PV, this has taken a back seat. We think that CSP has a future in India, and it can be mentioned).
2. Recycling and end-of-life disposal of batteries.
3. Digitalization and block-chain technology.
4. Making thermal machines more flexible with minimum cost implications.
5. Study of system inertia with increasing penetration of VRE.
6. Use of microgrids to provide ancillary services to the grid.

7. Super-efficient air conditioning technologies (given that cooling is seen as one of the fastest-growing demand drivers for electricity worldwide)

Fostering the use of clean energy technologies to the maximum possible extent in hard-to-abate sectors like steel, chemicals & petrochemicals, cement, etc. These would include research on technologies like hydrogen-based direct reduction of iron, Molten Oxide electrolysis (MOE), kiln electrification, use of new cement chemistries and composite cements, carbon capture and storage, new materials, and metallurgies compatible with the new technologies, other options for electrification of thermal processes in industries, etc. Developing waste-to-energy technologies delivering affordable power, also focussing on agro waste, municipal solid waste, and agro-industry waste (biodegradable waste such as fruits pulp, and vegetable food waste) to convert into biohydrogen through thermochemical and biochemical pathways to produce biohydrogen, biofuels ethanol and methanol and aviation fuels, transport fuel etc.

13.9 Developing Sustainable Industrial Technologies

Many conventional industrial processes (ex. ammonia synthesis from nitrogen) are not sustainable at all. These processes consume a lot of energy, and natural resources and emit excessive amounts of carbon dioxide and other greenhouse gases. If we want to be a carbon-zero nation then we also need to focus on the bring technological revolution and equip industries (pharma, polymer, fertilizer, oil, metal, etc) with more sustainable and economic technologies to achieve this basic research in science and engineering should be facilitated by offering joint projects and encouraging and incentivizing industries for upgrading to the sustainable processes.

Developing sustainable cooling technologies for industries, air conditioners, etc. should also be the thrust area of the research.

Additionally, it may be emphasized that the absorption of new technologies must take place as part of a wider process of technological capacity building within the country. Improving firms' capacity to absorb new technologies (their 'absorptive capacity') is essential to enabling firms to take full advantage of new low-carbon technologies. Recipient firms must take a strategic approach to acquiring knowledge and expertise as part of the transition process. Aspects related to this can perhaps be also added to the text appropriately.

13.10 Monitoring GHG Emissions by Industries

Monitoring and measuring carbon dioxide emissions at the sources is important to keep a check on them. Investment in R & D related to carbon dioxide sequestration projects should be made mandatory for the industries emitting excess carbon dioxide. The industries that keep a check on carbon dioxide or other GHG should be incentivized/awarded.

13.11 Burning of Agricultural Waste

The relevant technologies should be made available to farmers so that instead of burning agricultural waste, they can use it to make organic fertilizers and other products.

13.12 Carbon Neutrality Awareness Campaigns

Carbon neutrality awareness programs should be arranged at schools, colleges, universities, etc .

13.13 Role of DST and PSA

- To encourage the participation of public and private academic institutes, startups, and industries in the R & D, necessary funding should be provided through DST, PSA, and along with subsidies and rebates in taxes. This is important in the case of R&D as many feel that India is not investing enough in this sector.

- Training, capacity building, and knowledge exchange is gaining focus and India is now supporting newer centers of excellence in this regard. Many of these centers are coming up in technical institutions like IITs etc. However, we have to involve startups, state universities, and private universities to do it at a larger scale by providing financial support through DST. DST and PSA can act as nodal funding agencies to connect academic research and startups with relevant industries.

- The role of the private sector and even CSOs in promoting R&D and innovation is crucial in commercialization. There should be a common platform to exchange innovation and experiences to facilitate collaboration through sharing of knowledge, technologies, and experts. The participating industries should be incentivized.

- The DST/PSA should initiate dedicated research centers to perform high-end translational research to provide immediate solutions to pressing issues.
- In particular, with the National Research Foundation (NRF) being set up, it may be critical that NRF plays a role in enabling renewable energy sector research with appropriate funding, facilitating exchanges among the necessary stakeholders. NRF combines all funding bodies and hence can play a critical role in harnessing energy research. Overall research expenditure is still well below 1 percent of GDP. NRF should take care of this keeping in view similar investments in developed countries. Out of this expenditure, critical investments must be done in energy research. This will help in meeting future demands. Centers of Excellence on this may be set up in different institutions so that the development of India can be speeded up. In certain sectors, the Government's help and promotion has outperformed. For example, the area of clean air with the help of pollution control boards can be cited. Several technical centers, knowledge centers, etc have helped these sectors. Similar efforts must be made in a big way in energy research.

Private partnerships in providing funding for the above-mentioned thrust areas should be identified and encouraged. A separate task force should be constituted to mentor, monitor, and measure the mission programs for each of the above categories.

13.14 Role of Government

India should initiate national innovation programs (NIP) to accelerate research and development in green hydrogen production, hydrogen storage and mobility, fuel cell technology, carbon capture and conversion, zero carbon emission, and clean energy partnership programs to achieve carbon neutrality by 2070.

Recommendations: While this draft discusses the critical research needed in the area with an emphasis on the renewable sector, it is important to view it as a part of the Integrated Energy Policy (IEP). A viable energy policy cutting across diversity in demands of energy in various sectors across the country must be made. One can identify specific needs of renewable energy across the country and a quantitative assessment of the needs of different renewable energies (as specified) with the help of IEP.

In the current scenario, India's spending on Innovation R&D research and development (R&D) is among the lowest in the world. The India Innovation Index 2021 has found that the overall spending on R&D by India has been relatively low across the country. This was reflected in the overall share of gross expenditure on R&D (GERD) as a percentage of GDP, at about 0.7%. which is much lower than developed countries like the United States (2.9%), Sweden (3.2%), and Israel (4.5%). The government's investment in research and development should be increased to 1.4 % at least and then every year 0.15 % to 0.25% for the next 10 years to maintain it like other developed nations. An announcement to establish a National Research Foundation (NRF) was made in 2019. The NRF will support peer reviewed R&D of all types and across all disciplines including interdisciplinary and social science research, to significantly strengthen India's research and innovation potential. Finally, this was approved on June 28, 2023, the modalities of the NRF have been laid down and it provides an NRF outlay of Rs 50,000 crore over five years (2023-28). The approved Bill will pave the way to establish NRF that will seed, grow, and promote Research and Development (R&D) and foster a culture of research and innovation throughout India's universities, colleges, research institutions, and R&D laboratories. The NRF should provide major funding to R and D in the field of renewable energy and allied areas of research by establishing more centers of excellence and national knowledge network centers at institutes of eminence (IoE), CSIR labs, and reputed private universities engaged in energy transition. There should be dedicated centers contributing to energy demand management and public education on energy transition. The government should provide subsidies/incentives to the institutes and industries participating in the energy transition research and levy taxes on the industries which emit heavy carbon and are not ready to incorporate green technologies to reduce carbon foot printing.

Chapter 14: Energy and Air Pollution

14.1 Background

As per the International Energy Agency (2021), unregulated and inefficient energy production and usage is responsible for 85% of global particulate matter (PM) emissions, and nearly all of sulphur oxides (SOx) and nitrogen oxides (NOx) emissions. By some estimates, high exposure to unhealthy PM concentrations has reduced the lifespan of Indians by 6-9 years and caused premature deaths of 1.7 million Indians. Notably, a major component of PM is black carbon, which increases atmospheric warming, and aerosol formation. These two mechanisms, depending on their magnitude, together contribute towards climate change. Hence, there is a clear nexus between our energy choices (both production and usage), PM pollution, and climate change.

This chapter recognizes the benefits of tackling these issues in an integrated manner (IPCC 2013). The cost saving estimates of this integrated approach are in the range of USD 2 – 196 per tonne of CO_2 emitted. With this integrated approach in context, this chapter forecasts the impact of the recommendations made in the previous chapters on achieving reductions in climate change, through reducing air pollution.

While dealing with air pollution, our main concern is with the PM. Due to its small size, it can get deposited in our lungs and bloodstream, and cause lung cancer, stroke, and heart disease. Notably, PM is not only a primary pollutant but is also formed during the transport of gaseous pollutants (such as CO, SOx, NOx) in the atmosphere, through complex chemical reactions.

Much of air pollution news in India comes from the Indo-Gangetic Plains (IGP), where the annual average $PM_{2.5}$ levels are 3-6 times the CPCB standards, and 15-20 times the WHO standards. Contrary to belief, air pollution isn't just located near energy demand or consumption centres. Recent analysis has revealed that in winters, even rural areas in the IGP are exposed to alarming levels of polluted air. An expanded and more representative air quality monitoring network would be essential to understand the levels of air pollution in nonurban areas.

Through this chapter, this Policy acknowledges the linkages between the choices of our fuels, the regulatory mechanisms for abating emissions, and their impact on public health. All of the recommendations in the previous chapters have kept the public health angle in perspective. Hence, this Policy is confident of providing cleaner air to all citizens, despite the forecasted increases in our energy demand,

and supply. However, given our continued reliance on coal, and increasing market competition in the supply sector, some interventions would be prudent.

In this context, across the key energy activities (industry and electricity generation, transport, and biomass cooking), this Policy aims to:

1. Decrease the emissions intensity of air pollutants and greenhouse gases,
2. Increase the energy efficiency of key sectors, and
3. Reduce the energy demand in key sectors through appropriate design interventions. Sectoral interventions to achieve the second and third objectives have been covered in detail in previous chapters, and hence, this chapter will mainly focus on the first objective.

This Policy recognises the importance of abating non-energy sources of air pollution (such as road dust, construction and demolition dust, burning of agro residue); while not covering them in this chapter.

This Policy acknowledges the contributions of NCAP in city-based actions for tackling air pollution. However, there has been a realisation that cities falling within the same airshed need to abate their emissions together, to improve air quality. Different airsheds may have different meteorology, thus requiring a study of the permissible emission loads in respective airsheds. Differences in these permissible limits will not only influence regulatory standards, but also in starting new pilots of emission trading schemes (ETS), and eventually a future National Emissions Trading Market.

In this context, this Policy also discusses the need for a more effective regulator, with adequate resources and staff to implement the polluters pay principle. While giving its recommendations, this Policy also incorporates best global practices and principles.

14.2 Sectoral Interventions

The key energy sectors can be classified as point sources (which are stationary), line sources (mostly transport), and households (through use of biomass for cooking). This section deals with each of these sectors, and their abatement measures.

14.2.1 Addressing point sources

In India, point sources (industry and electricity generation) cumulatively account for about 40% of primary PM emissions, 50% of NOx emissions, and 45% of SOx emissions. Much of this owes to the predominance of coal in our energy mix. All this while, India's per-capita energy consumption is only at 35% of the world average, growing from 20% of world average in 2000.

Point sources (including power plants) are currently regulated through the provisions of the Air Act, 1981 and the Environmental Protection Act, 1986. The 1986 Act empowers the central government to notify emission norms for specific industries (such as cement, brick kilns, thermal power plants etc), industrial processes or operations,

Under the Air Act, emissions from point sources are specifically regulated at the establishment phase (through consent management) and operational phase (through monitoring and inspections). Consent is granted if units fulfil certain conditions to mitigate the impact on the environment (such as height of emission stacks). In case the consent conditions / Board's directions are violated, the Boards have the powers of unit closure, and criminal prosecution.

This section deals with: (i) point sources, and their abatement measures (in addition/repetition to earlier chapters), and (ii) some key enablers for abating point sources (such as OCEMS, Emissions Trading etc).

14.2.2 Electricity Generation

Between 2012-13 and 2021-22, the electricity generated in the country increased by more than 55%. As per the National Electricity Plan, this is likely to further increase from 1492 billion units in 2021-22 to 2025 billion units in 2026-27. Through these years, the share of coal-based power has decreased from 80% in 2012-13 to 75% in 2021-22. In 2026-27, this is expected to decrease to 60%.

Combustion of coal leads to SOx, NOx, CO, and primary particulate matter (PM) emissions into the air. As per some studies, up to 80% of the PM emissions from coal-based power plants are secondary in nature, meaning they are formed from NOx and SOx emissions (Cropper et al, 2021). Notably, many of the non-attainment cities under the National Clean Air Programme are in proximity of coal-based power plants.

Without emissions intensity reduction in electricity generation, the advantage of electrification of demand sectors will remain limited to 'emissions shifting' and not actual improvements in public health outcomes.

In addition, & reinforcement of the suggestions made in the previous chapters for abating emissions from electricity generation, this Policy recommends:

1. Developing a phased roadmap for making nuclear power the 'base load', considering permission of foreign investment, and an expert-led review of India's civil nuclear liability law.

2. Ensuring competitive bidding for electricity generation, transmission, and distribution

3. Fast-tracking deployment of deploying suitable pollution control equipment (such as Flue Gas Desulfurization) to reduce pollutant emissions

4. Taxing the power produced by new coal-based power plants on the basis of respiratory and healthcare costs in the nearby 'local airshed (20-40 km in all directions)'. This will need an expert independent committee with public health experts and environmental economists and doctors.

14.2.3 Industry

Recent studies have indicated that levels of pollution in India have risen faster than the increase in economic activity. This has happened while services, and not manufacturing, have been the primary driver of growth. In other words, the increase in air pollution has been disproportionately more than the increase in manufacturing activity (especially when compared to China).

Similar to electricity generation, industrial emissions arise from the type of fuel being used, industrial process, and the pollution control equipment being used. Different industrial processes emit different loads of pollutants (SOx, NOx, PM) into the atmosphere. However, generally, certain industries are seen to be the most polluting such as iron and steel, aluminium, pulp and paper, thermal power plants etc. While these are large installations, this sector is quite heterogeneous, consisting of more than 6.3 crore MSMEs.

In addition, & reinforcement of the suggestions made in the previous chapters for abating emissions from industry, this Policy recommends:

1. Developing strategic international partnerships to: (i) encourage trade of clean industrial inputs (such as cement and steel), and (ii) deny market access to polluting industrial inputs (such as steel and cement) which are undercutting cleaner produced domestic inputs.

2. Leveraging the First Movers Coalition to launch challenge competitions for suppliers to large enterprises to provide breakthrough technologies in hard to abate sectors.

3. Developing a roadmap for industries running in unapproved areas to be regulated together at cluster level, latest by 2025. The State Pollution Control Board may regulate the cluster for the merged off-gases and flue gas streams from the industrial activities of the cluster as a whole, by offering a mix of financial and non-financial incentives (such as longer consent periods).

Key Enablers for Point Sources

- Strengthening Measuring, Monitoring, Reporting and Verifying (MMRV) of OCEMS data.
- The CPCB has mandated the installation of OCEMS data in 17 categories of industrial units (such as power plants, aluminium, zinc, copper plants; cement plants; iron and steel plants). This allows emission stacks to be monitored remotely. Currently, this data is neither available in public domain, and can neither be used for legal purposes. As the OCEMS system collects data in hostile environments (with high temperatures and fast air flows), quality assurance, certification, testing, and calibration of the equipment is a prerequisite for regulatory purposes.
- This Policy recommends using OCEMS data for regulatory and legal purposes. To enable this, this Policy recommends expediting the ongoing certification and testing process for OCEMS by CSIR-National Physical Laboratory. As a complementary measure, this Policy also recommends capacity building of technical staff at the Pollution Control Boards to understand the ways in which OCEMS may produce inaccurate values.
- After standardisation has been achieved, this Policy recommends making the OCEMS data available in public domain, as a public good. This may be supported by amending respective legislations suitably. Transparency of OCEMS data is a prerequisite to encourage industries to invest in energy efficiency and pollution abatement technology.

14.2.4 Leveraging OCEMS data for Emission Load Linked Mechanisms

In the context of air pollution abatement, the pollution load emitted by a source is of relevance. Accurate concentration and flow rate data from OCEMS can help accurately determine the emission load of a given point source. The total emission load is directly related to the time of operation, the total fuel used, combustion efficiency, and other indicators. Pollutant concentrations alone are not directly related to the above parameters.

Credible emission load data can enable emission load linked taxation, or even cap-and-trade and type Emission Trading Schemes. This Policy recommends airshed level regulatory bodies to be responsible for setting emission load linked taxes (or environmental charges) or emission caps, keeping in mind trends of past air quality.

The pilot of the emissions trading scheme in Surat promises good results. However, further understanding of scaling up this scheme to different types of industries in different airsheds, needs to be studied. More importantly, corresponding investments in OCEMS MMRV need to be made to enable this.

Unification of CPCB and State Pollution Control Boards (SPCBs) into one central entity, with airshed, state, and regional offices.

An expansion in workload, lack of adequate staff, and reliance on manual inspections have meant that Pollution Boards have been ineffective at ensuring deterrence. Further, a lack of government funding has meant that Pollution Boards focus most of their efforts on their single largest source of revenue – consent fees from the very units they ought to regulate. The absence of penal provisions in the Air Act has meant that Pollution Boards have had to rely on criminal prosecution, unit closures, and consent management to abate industrial emissions

Not only are these steps resource and time intensive, they are unable to abate or compensate for the damage done in a reasonable period of time. To resolve this, this Policy recommends:

1. Existing SPCBs to be subsumed into the CPCB, with funding etc transferred directly to the central government. This Policy recommends a public consultation, especially with legal experts, air pollution experts, and retired members of the higher judiciary in this regard.
2. Unifying existing State level engineering and scientific cadres into the new central entity

3. Amending the Air Act to allow inflation-adjusted and deviation-adjusted penalties to be imposed on industries. In tandem with other legislation, this can serve as the basis for emission load linked taxation / emissions trading
4. Identifying airsheds and establishing airshed level offices / committees for standard setting, guidance, high resolution air quality monitoring and knowledge (discussed below).
5. Including private experts from domains of environment, public health, production and process engineering, policy in its functioning

14.2.5 Introducing Airshed Level Regulation

Under the NCAP (including the 15th Finance Commission Million Plus City grants), significant fiscal resources have been directed at city-centric mitigation efforts. The programme envisages to achieve reductions up to 40% or achievement of National Ambient Air Quality Standards (which are notified by the CPCB) for PM_{10} concentrations by 2025-26.

The program directly grants funds to urban local bodies and SPCBs/PCCs, which become performance linked in the later stages of the programme. This Policy appreciates the distinction made for Million-Plus-Cities (MPC) by the 15th Finance Commission and recommends the continuity of both NCAP and MPC grants in successive Finance Commission years.

However, for reasons related to capacity deficit, lack of planning, and staff crunches, the programme (even though strongly linked to incentives) has failed to deliver improvements in air quality. One of the reasons is that many sources of air pollution in a city are outside city limits. Adjacent cities, especially in upwind directions have an implication on downwind cities.

These cities are likely to fall within the same airshed, and hence allow better forecasting of weather patterns – an important determinant of pollution levels. This Policy recommends the identification/notification of airsheds within the country, and establishment of airshed level regulatory bodies / committees, through suitable routes.

This Policy acknowledges the existence of CAQM as India's first airshed level entity on air quality, and its wide-ranging directions to abate different sectors – both energy (such as industrial and vehicular emissions) and non-energy (road dust and construction dust). Inspite of the existence of CAM, this Policy remains open to trying other routes for airshed level entities.

With due consideration to airshed level nuances, the airshed level regulator can be a focal point for knowledge, standard-setting (for legal processes such as consent management, inspections), guidance, technical training and capacity building, and reviewing emission load linked taxation and emission caps. To enable high-resolution airshed monitoring, a network of representative high-resolution super-sites can be leveraged. This will help provide background context to city specific source apportionment studies.

14.2.6 Transport & Mobility

Between 2012-13 and 2021-22, the total no. of registered vehicles in India doubled from 17 crore to 34 crore. Since 2000, the annual distance travelled per capita has more than doubled from 1,500 km to 4,000 km.

This Policy acknowledges the earlier recommendations on:

1. Encouraging non-motorised transport (walking and cycling),
2. Integrated transport system planning (especially public transport),
3. Decreasing private vehicle trips through congestion pricing parking charges,
4. Linking motor vehicle taxes with their per capita emissions ,
5. Changing the modal share of railways vis-à-vis trucks in freight movement,
6. Increasing fuel efficiency (CAFÉ norms) and decreasing emissions intensity (BS norms) of existing vehicles, and
7. Phasing in hydrogen/electric powered vehicles in public and private fleets.

In addition to these earlier recommendations, this Policy recommends an accelerated phase-out of all BS-I / BS-II auto-rickshaws, two-wheelers, and trucks. To achieve this, this Policy recommends offering a combination of scrapping incentives & tapering financing assistance to purchase new vehicles over the next 3 years. These incentives should decrease each year, over the next 3 years. This Policy supports financial assistance in the form of subsidies on interest, or interest subvention.

Further, this Policy recommends no further registration of BS-III vehicles and BS-IV vehicles (except for vehicles in national security & emergency service operations) after 2026.

14.2.7 Vehicle Emissions Monitoring

Both CAFÉ norms and Bharat Stage standards force vehicle manufacturers to increase fuel efficiency and reduce tailpipe emissions respectively, at the pre-road stage. However, as vehicles age, vehicles lose efficiency and pollute more. In this context, this Policy supports the enforcement of Real Driving Emissions (RDE) regulations, which entered into force from April 1, 2023. The RDE regulations bring on-road emissions within their scope. Currently, the RDE emission limits are higher than that for laboratory testing, due to inaccuracy in emission measurement. Anticipating increasing accuracy in measurement methods, this Policy strongly recommends eliminating relaxations in on-road emission standards (vs laboratory levels) by 2027**.**

Vehicle fleet monitoring is crucial for market surveillance. Open-path and extractive remote sensing have emerged as potential alternatives for on-road emissions monitoring. Recognising the in-efficiency of the PUC system, this Policy recommends investment in further development, and deployment of remote-sensing technology**.** The remote sensing data can be used in maintaining emission inventories, informing regulatory compliance, and nudging consumer choices.

14.2.8 Household (Biomass Burning for Cooking)

Cooking is one of the primary uses of energy. Latest NFHS-5 data suggests that as of 2021, 90% urban households (81% in 2015-16) and 43% rural households (24% in 2015-16) had access to clean cooking fuels. In 2019, household air pollution caused by using polluting cooking fuels (such as biomass) contributed to one-third of deaths attributable to air pollution in India.

Being a case of energy poverty, this Policy acknowledges the need for a stack of clean cooking fuel options to meet the needs of different households. For households with on-grid electrical connections, electrical cooking solutions must be rapidly scaled up. For households without grid connectivity, solar based induction stoves (such as Surya Nutan) can be delivered.

This Policy acknowledges the Piped Natural Gas (PNG) as a clean cooking fuel. However, given India’s dependence on gas imports, it may serve as an intermediate or transitory fuel for more households which can afford so. This Policy recommends expansion of the domestic PNG network, while simultaneously promoting electric cooking options from an energy security perspective.

For the most vulnerable sections who are likely to continue using biomass, this Policy recommends the development of emission free biomass cookstoves, to reduce the exposure of household members to highly polluting emissions.

14.3 Enhancing Air Quality Monitoring

Monitoring the levels of criteria pollutants is fundamental to determining the success of abatement measures. To this end, this Policy recommends continued strengthening the Air Quality Monitoring Network, by establishing more Continuous Ambient Air Quality Monitoring Stations, especially in areas which are representative of large industries and transportation hubs. The Policy also recommends exploring possible uses of low-cost sensors for nonregulatory and citizen engagement purposes.

14.3.1 NCAP 2.0 – Incentivising Technology Breakthroughs

Over the long term, this Policy recommends the expansion of the NCAP from being only city abatement focussed to also being technology focussed. To this end, this Policy recommends leveraging NCAP funds, and even CSR funds, to buy or patent technologies that demonstrate efficiency gains/emissions reduction, especially in hard to abate sectors**.**

This Policy welcomes the National Missions on Hydrogen, Advanced Cell Chemistry as crucial first steps in this regard.

14.4 Conclusion

In summary, this Policy's recommendations, both from the demand side and supply side, will ensure a decoupling of India's energy sector and its carbon and pollution footprint. In other words, the choices made in this Policy will be able to effectively deliver on India's energy security, in tandem with our net zero and public health goals.

Chapter 15: Carbon Pricing

15.1 Introduction

Carbon pricing is an established policy instrument that can reduce the cost of emissions reductions, promote low carbon investments and shift sectors away from fossil-intensive technology lock-in. It can drive green capital markets by providing a strong price signal to investors. It also delivers a potential mechanism for the government to raise revenues through taxes (in case of carbon tax) or via auction of allocations and/or through taxing the proceeds (in case of an Emissions Trading System). This could become a vital fiscal source for governments that depend on fossil fuel tax revenues, as they progressively advance towards net zero emissions. Carbon pricing can be implemented through a carbon tax, which prices the emissions, or by implementing a carbon market that sets a limit on the emissions and allows regulated entities to trade, thus creating a price for carbon. As of 2022, 23.17 per cent of global emissions were covered by carbon pricing, of which, 17.55 per cent are in the form of carbon markets.

Replacing fossil fuels with renewable energy for electricity generation, switching from internal combustion engine (ICE) vehicles to electric vehicles (EV) and use of energy efficient appliances in residences and businesses can address about 55 percent of current annual carbon emissions in India. The remaining 45 percent of emissions come from hard-to-abate sectors such as heavy industries, agriculture, and livestock. Switching to renewables and greater adoption of energy efficient practices can reduce emissions by 15 – 20 per cent by 2050. Appropriate carbon pricing along with renewables, energy efficiency and hydrogen will be critical to reducing emissions by 65 per cent by 2050.

However, an effective strategy for a successful transition to a net zero economy while achieving India's developmental goals would require an understanding of all dimensions of the challenge. Given this context, the rest of the chapter looks at whether India needs carbon pricing, which carbon pricing instrument – carbon tax, emission trading scheme (ETS) or a combination - is more appropriate given India's climate and development objectives, what design considerations should be kept in mind while developing and implementing such instruments, and finally the potential impact of those instruments on growth, jobs, and industrial competitiveness.

15.2 Does India need a Carbon Pricing Mechanism?

Achieving India's net zero target will require a structural shift in the economy necessitating large scale reallocation of resources from carbon-intensive to clean technologies and production processes, besides sizable additional investments during the next few decades. It is estimated that meeting India's energy transition goals will require investments to the tune of US$160 billion per year between now and 2030 and a cumulative investment of US$ 3.5 trillion from 2020 till 2050. A focus on carbon pricing in India is also necessary in the context of border adjustment mechanisms such as the Carbon Border Adjustment Mechanism (CBAM) of the European Union (EU) and foreign pollution fee (under discussion) in the USA. Carbon pricing, therefore, must play a prominent role in incentivising low carbon activities and penalising carbon-intensive activities, within a larger policy framework.

15.2.1 Carbon Market

Recognizing the importance of carbon pricing, the Government of India notified the Carbon Credit Trading Scheme (CCTS), 2023 on 28th June 2023. With this scheme, India enters the league of nations with a domestic carbon market. Obligated entities under the Indian CCTS will receive carbon intensity targets as opposed to, for e.g., the European Union's Emission Trading Scheme (EU ETS) that functions on absolute allocations. Key functionaries within Indian CCTS are:

1. Administrator: Bureau of Energy Efficiency (BEE)
2. National Steering Committee (includes BEE, several ministries, state government representatives, experts etc.)
3. Registry: The Grid Controller of India (POSOCO)
4. Regulator: Central Electricity Regulatory Commission (CERC)
5. Technical Committee (includes BEE, experts, etc.)
6. Accredited Carbon Verification Agencies
7. Trading Platform: Power exchanges

CCTS 2023 will be a compliance-based scheme in which the Ministry of Power (MoP) will decide the sectors and the obligated entities to be covered under the compliance mechanism based on the recommendation of the Bureau of Energy

Efficiency (BEE). MoP, after duly considering the recommendations of BEE and National Steering Committee, shall recommend the notification of greenhouse gases emission intensity targets to the Ministry of Environment, Forest and Climate Change (MoEFCC) for notification under the Environment Protection Act, 1986. The obligated entities shall be issued carbon credit certificates for their achievement in reducing the GHG emissions intensity beyond the target set for such obligated entities, based on the recommendation of the National Steering Committee. The obligated entities that do not achieve their targeted reduction in GHG emissions intensity shall meet shortfall by purchasing carbon credits certificates from Indian carbon market (Ministry of Power, 2023).[6] It is expected that sectors such as cement, iron and steel, pulp and paper, fertiliser, chlor-alkali, and petrochemicals, will be initially included under the Carbon Credit Trading Scheme.

India’s experience with Market Mechanisms for Climate and Clean energy

There are two market-based mechanisms currently working in India to promote adoption of clean energy and energy efficiency. These are the perform and trade (PAT) scheme and renewable energy certificates (REC) mechanism. The PAT scheme was designed to tap into the energy efficiency potential in energy intensive industry units. Till 2019, PAT covered 13 sectors covering 956 designated consumers (DC). In 2023, additional sectors were included under the PAT scheme. Energy savings accrued by the DCs were converted into energy saving certificates (ESCerts) and traded through the national electricity trading platforms - India Energy Exchange Limited (IEX) and Power Exchange of India Limited (PXIL). During the first cycle of PAT (2012–2013 to 2014–2015), the market fluctuated over the trading period with price of ESCerts varying between INR 200 per ESCert to INR 1200 per ESCert. Experts identified two major challenges with the PAT scheme; first, it could not provide a consistent price signal to attract additional investments, since the certificates were issued ex-post and second, the targets were not sufficiently stringent and could be easily achieved.

Renewable purchase obligation (RPO) is a mechanism by which obligated entities are mandated to buy a firm ratio of the total consumption of power from renewable energy sources such as solar, wind, etc. RPO has been notified by more than 30 states and union territories which allows obligated entities to purchase renewable energy certificates (REC) for RPO compliance. Electricity generated by a renewable energy generator has two components – electricity and environmental attributes. The environmental attributes can be exchanged in the form of RECs. The REC mechanism successfully registered, issued, and traded RECs on the designated power exchanges. However, lack of compliance by the obligated entities created a huge inventory of RECs. Since the last decade or so, the floor price has become the market clearing price for both solar and non-solar RECs. To address the concern related to non-compliance by obligated entities, few state electricity regulatory commissions have started to exercise the penal provisions under RPO regulation.

15.2.2 Carbon Tax:

India does not have an explicit carbon tax specifically imposed on fuels such as petrol and diesel. These petroleum products are, however, subject to substantial excise duty import duty and value added tax (VAT). According to India’s Long-Term Low-Carbon Development Strategy document launched during COP27, the excise duty and VAT amounts to an effective carbon tax, which is higher than many developed countries. The total contribution of the petroleum sector to the exchequer in 2021-22 stood at around 3.3 per cent of India’s gross domestic product (GDP) (RBI, 2023).

Clean Energy Cess

In 2010 India introduced a clean energy cess on coal at the rate of Rs. 50 per tonne. The proceeds were earmarked for the newly created National Clean Energy Fund (NCEF) with the objective of financing research and development in clean energy technology projects. In 2017, the clean energy cess was replaced by the Goods and Services Tax (GST) compensation cess of Rs. 400 per tonne on coal production, which was meant to bridge the revenue shortfall of states owing to the implementation of GST.

It is estimated that 54.7 percent of greenhouse gas (GHG) emissions in India are subject to a positive net effective carbon rate (NECR). The NECR in India is highest in the road transport sector and zero or negative in other sectors such as agriculture, industry, and buildings (OECD, 2021).

Recommendation: Irrespective of whether it's a carbon tax or an ETS, carbon pricing in India should be aimed at:

- Reducing the costs of India's energy transition and meeting its climate goals.
- Mobilizing domestic and international finance needed for an energy transition.
- De-risking investments in low-carbon technologies. This has to be carefully aligned with India's overall climate transition, keeping equity and justice at the centre.
- Becoming a market leader in the international landscape for key low-carbon technologies as well as business models and technical know-how.
- Financing renewable energy, electric vehicles, green hydrogen, energy storage and other clean technologies.
- Aligning with the international regime for carbon pricing in the context of trade, with due consideration given to the principle of Common but Differentiated Responsibilities and Respective Capabilities (CBDR-RC).
- Building public awareness and engagement about the role of carbon pricing within a larger policy mix to facilitate a people-centric climate and energy transition.

15.2.3 Carbon Tax or Carbon Market: Which One is More Suitable for India?

Many similarities exist between carbon taxes and carbon market or Emissions Trading System (ETS). Both provide a direct financial incentive for mitigating emissions by putting a price on carbon. Both work on the principle of polluter pays – carbon tax is levied on usage of fossil fuel whereas in the case of carbon with auctioned allowance and cap and trade, polluters are required to pay for emissions they do not reduce. While both carbon taxes and carbon markets help mitigate the cost of low carbon transition for a company or economy, there are several differences. One fundamental difference in approach is, the carbon market regulates the maximum quantity of emission while carbon tax fixes the price. In an ideal world, carbon tax provides a more balanced signal to investors and often brings the additional benefit of raising significant fiscal revenue. Unlike the carbon market, taxes are not exposed to market uncertainties and the carbon price holds good regardless of other climate and energy policies. As taxes generate additional revenue, it is potentially a better choice when governments intend to accelerate mitigation action by providing multiple incentives. On the other hand, in a well-structured market with sufficient number of market players, emission trading can provide economic efficiency gains by promoting investment in emission reduction in companies or infrastructure with lowest cost of GHG mitigation. Carbon taxes also have the advantage of not requiring a trading infrastructure, making them relatively easy to administer. This aspect can make them less of a strain on government capacities than ETS. However, in practice, introducing a new tax which may impact price, jobs, and competitiveness in the short run is a difficult political conversation.

A study by the International Monetary Fund estimates that a US$ 25 per tonne carbon tax for India will reduce emissions by about 25 percent by 2030. Achieving India's target of net zero by 2070, however, would require a carbon tax that may have to rise linearly (beginning 2020) to US$ 117 per tonne of carbon dioxide by 2050. Global experience with carbon pricing instruments suggests that carbon taxes are more effective, but comparatively less used, whereas non-tax risk mitigation measures such as the ETS, feebates, and regulations are less effective and therefore should be used as a complement to carbon taxes.

Scenario analysis conducted as part of the RBI report on currency and Finance (2023) estimates that a carbon tax of US$ 25 per tonne (US$ 50 per tonne in the second scenario) can reduce carbon emissions by 25 per cent (36 per cent) compared with the baseline scenario of "business as usual" projected by 2030 by the IMF (2019). A combination of other policies such as ETS, feebate, and regulatory measures could reduce emissions by an additional 93 per cent of the reduction achieved through carbon taxes. Use of green hydrogen in hard-to-abate industry sub-sectors could reduce emissions even further.

Recommendations:

India's current measures for climate mitigation include a mix of efficiency standards, renewable energy targets, taxes, subsidies, and regulations. Given India's multipronged policy approach to achieving the updated NDCs and the net zero by 2070 target, the following carbon pricing measures are recommended:

- Given that use of fossil fuels is already taxed in India, carbon taxes should be included in GST, Central Excise and State VAT, without altering the rate of taxation in the near term.
- Receipts from carbon taxes should be credited to a separate ring-fenced fund and a part of the receipts should be invested in clean energy projects supporting India's net zero transition.
- A carbon market should be used as a complementary policy without significantly altering the existing carbon taxes or subsidies. The primary goal of the carbon market should be accelerating decarbonization in industries through technology innovation.
- Taxes and trading price don't necessarily have to be the same as they will be two separate mechanisms, implying that policy makers could maintain some sense of control over equity and distributional impacts.

15.3 Design of Carbon Taxes

Recommendations:

Given India's current climate mitigation policy landscape and existing taxes on fuels, the following recommendations are made.

Phase wise implementation:

- Carbon tax should be introduced gradually over several years starting with a lower tax rate and gradually increasing it. This gives businesses and individuals time to adjust and adopt clean technologies.

- Most studies (Varun et al., 2021, Nikit Abhyankar et al., 2022)[16] suggest that India's dependence on coal as a source of energy would continue in the short to medium term. Therefore, it is recommended that coal should continue to be subject to GST and an additional carbon tax linked to the quantum of carbon emissions from coal should be introduced. While doing so, the government can decide on how non tax revenues from coal, such as freight charges by railways, is repurposed. Now that the statutory commitment period of five years under the GST Compensation Act of 2017 is over, the need of the hour is to repurpose and rename the compensation cess on tobacco, coal and fossil-fuelled transportation, as a carbon tax[17].

- Government is encouraged to pass on the real cost of electricity to consumers. Experience from diesel subsidy reforms indicate that market linked diesel pricing policy provided more growth to the economy than the earlier pricing policy with heavy subsidy on diesel[18]. The Indian economy was able to absorb the second and third order price shocks if any due to removal of diesel subsidy. We envisage a similar future for electricity price rationalisation.

- Carbon tax rates, once decided, should not be changed frequently and should only be increased gradually.

- Impact of carbon tax on the economy and emission reduction should be monitored and reported. This will help in policy adjustment and ensure the effectiveness of the tax.

Revenue Recycling:

Revenue generated from carbon tax must be recycled back to the economy in a manner that promotes green growth and addresses any distributional impacts due to the incidence of the tax. Revenue recycling will promote climate actions without increasing the overall tax burden on businesses and common citizens.

- The receipts should be ring fenced.

- A part of the revenue generated from carbon tax should be used to address distributional impacts on vulnerable households, farmers and businesses. The revenue generated from carbon tax should be used for implementing climate adaptation measures to minimise the impact of climate change on vulnerable communities.

- A part of the revenue generated from carbon tax should be used for additional investment in research and development of clean technologies and renewable energy sources. By fostering innovation, the economy can become more resilient, sustainable, and competitive.

Bringing uniformity:

Carbon tax should be applied to all fuels that are already taxed (both GST and outside of GST). To bring uniformity, we must also consider the impact of non-tax charges levied on fossil fuel. For example, Indian Railways charges coal freight disproportionately to subsidise passenger transport.

- Carbon tax should be applied within the existing legislative framework of the GST. The tax should be additional to the GST, and the rate for each fuel should be determined based on carbon emissions and calibrated to protect the government revenues.

- The social cost of carbon approach as well as the abatement approach suggest that the current tax burden on petroleum products is already quite high. It is therefore recommended that the carbon tax on petroleum products should be included under GST subject to a uniform GST rate with an additional non-creditable carbon tax (Shakti & EY, 2018) while carbon tax on coal should be gradually increased over time[19].

- In case states do not support the levy of carbon tax under the GST, the carbon tax can be levied by the centre and the states outside the GST, as per current practice.

Upstream vs downstream:

Point of levy of carbon taxes should be upstream since it will be administratively easier and can be done using existing tax laws. To nudge consumer behaviour change, carbon tax can be levied downstream. For example, higher tax on vehicles with lower fuel efficiency and/or higher carbon emissions.

Sectoral Strategies:

Rate of carbon tax for different sectors must be levied based on their emissions intensity and ability to adapt. Exemptions or lower tax rates can be proposed for sectors which are critical for the economy but harder to abate.

Balanced Approach:

A balance between climate objectives and economic consideration is required to ensure that the policy achieves its intended objective with minimum unintended consequences for business and individuals. New carbon taxes must be designed through a consultative process and using econometric models.

15.4 Design of Carbon Market

Recommendations:

Based on the recent development in this sector, following recommendations are made:

Maintaining Liquidity, Trading, Price and Stability:

Market management principles must be enforced to maintain 'liquidity', 'trading', 'stability' and 'price management'. This can be achieved by:

- Setting ambitious but appropriate targets.
- A "market management" function should be conceptualized during the early phases of the Indian carbon market. The markets management entity should purchase, bank and trade surplus credit in the next cycles ensuring price stability.
- If there is a market deficit, credits from the international market can be permitted (which are allowed to sell for limited windows). Similarly, outward flow of credits (limited window) from sectors permitted to export (eligible and non-NDC sectors) can be restricted to ensure market stability. These measures are needed in the early phases of the Indian carbon market.
- To generate liquidity to finance innovative measures and ambitious projects, the feasibility of limited, and selective futures contracts, monthly/quarterly settlements may be explored.
- In future when energy and non-energy sectors are part of the crediting scheme, all credits should be easily transferable across all market participants.

- Encourage public NetZero pledges and commitment from high emitters and allow these entities to meet a certain percentage (for e.g., 10-15%) of their voluntary obligations from CCTS.

Creation of a Secondary Carbon Market:
Secondary carbon markets can be distinguished from the primary carbon market through its ability to facilitate trading of emission allowances (or units) among a diverse set of market participants. For example, under EU ETS, after the allocations are put into circulation by companies, they can be traded. Any individual or company with an account in the EU registry can buy and sell EU allocations (EUA). India may allow the creation of a secondary market only after the market attains maturity.

Carbon Credits as Financial Instrument:
Classifying carbon credits as financial instruments brings them under the preview of financial market rules. This can further stabilise the carbon market by ensuring robustness and transparency. For example, EU ETS emission allowances are classified as financial instruments by Markets in Financial Instruments Directive (MiFID) and Regulation (MiFIR).

Linking Domestic Carbon Crediting Mechanism and Global ETS:
Linking a domestic carbon crediting mechanism with a global ETS can help streamline efforts to address climate change and promote international cooperation. Linkage with International Carbon Markets will ensure that if the carbon intensity (as proposed in the NDC) is on track to be over-achieved, the surplus credits do not flood the domestic carbon market. This will help in stabilising the prices and continue to drive the effort to exceed climate targets and ambition.

Here are some steps that can be taken to establish such a linkage:

1. Maintain high quality of credits and establish a robust monitoring, reporting and verification (MRV) mechanism.

2. Identify existing global or regional ETS that India can join or create new global or regional ETS along with like-minded countries.

3. Coordinate with international partners to harmonise emission reduction or removal methodologies. Establish common standards and protocols to

ensure transparency, accuracy, and consistency in calculating carbon credits across different jurisdictions.

4. Equivalency criteria has to be developed for carbon credits generated through domestic mechanisms and those traded in the global ETS. This may involve setting benchmarks or conversion factors to ensure the comparability of credits.

Supply of High-Quality Emissions Reduction:

Though demand for carbon credits is expected to rise in future, ensuring supply of high-quality carbon credits is often difficult in practice.

- Establish additionality and crediting baseline. There are existing mechanisms such as the Carbon Credit Quality Initiative (CCQI)[21] which can be used to assess the quality of additionality and the credit baseline.

- Create safeguards to avoid carbon leakage, carbon intensive technology lock-in, negative impact on other environmental indicators such as biodiversity, and perverse incentives. The need for a safeguard mechanism has been established by several crediting programs and standards such as Clean Development Mechanism (CDM), Verified Carbon Standard (VCS), Verified Carbon Standard (VERRA), Gold Standard, Australian Carbon Credit Units (ACCU), EU ETS etc.

Qualifying criteria for Obligated or Voluntary Buyers:

While ensuring supply quality, there must be qualifying criteria for entities who are purchasing these credits to offset their own emissions. Carbon credits must not become a tool for delaying emission reduction within the buyer’s own emission or across its value chain.

15.5 Impact Of Carbon Pricing On Price, Jobs, And Competitiveness

A review of the existing literature suggests that there is no conclusive evidence on the negative impact of carbon pricing on price, jobs and competitiveness. However, it is recommended that a cautious approach should be adopted while implementing a carbon pricing mechanism or negotiating cross border carbon tax.

According to Carbon Pricing Leadership Coalition’s Executive Briefing, 2016, carbon pricing is not a determinant factor influencing a company’s performance. The paper draws data from the United Kingdom's production census which did not detect negative effects on economic performance because of the introduction of the Climate Change Levy (an energy tax). A paper on British Columbia's carbon tax reform found limited impacts on industrial competitiveness. A small but statistically significant annual increase of 0.74 percent in jobs over the period of 2007 – 2013 was witnessed.

Another paper demonstrated how a global uniform carbon price could simply shift the onus of solving the climate change problem to developing countries. The study demonstrates how a global uniform carbon price can negatively impact the price of products such as metal, fuel, and textile manufactured in newly industrialised Asian economies such as China, India, and Indonesia. For example, the price of Indian metal, fuel and textile will increase by 15%, 8% and 7% respectively due to implementation of a global carbon price of US $50, whereas economies with least carbon intensive supply and production chain such as the USA, Europe and Brazil will incur limited price increase. The price increase negatively impacts competitiveness and jobs under pressure. About 3% and 2% jobs will be under pressure in India and China respectively due to implementation of a global uniform carbon price. As impacted sectors employ a large majority of low and medium skilled workforce, they are expected to witness the largest relative changes. For example, low skilled workforce will be under pressure in China while the medium-skilled workforce would be most severely affected in India.

15.6 Conclusion

As stated in the earlier section of the paper, options for a carbon tax should be explored along with development of a domestic carbon market. The biggest advantage of carbon tax is its ability to raise fiscal revenues which can be used not only for building future low carbon infrastructure but also for revenue recycling to mitigate some of the welfare impacts of carbon pricing.

There are different ways to utilize tax proceeds to improve economic outcomes. For example, the UK and France provided a lump sum dividend to households. While this can improve progressivity, it may reduce income and employment by disincentivizing the unemployed to engage in work search. Another alternative could be a corporate tax rate cut, which may increase productivity and output, but lead to a likely reduction of progressivity (RBI, 2023).

For India, it is recommended that there be a reduction in income tax to reduce any potential adverse impact of carbon pricing. Finland also used this as its preferred policy tool, since it improves progressivity, income, and employment Further, the tax proceeds should be used to promote a people-centric climate and energy transition, for example, by investing in human capital and adaptation measures to address the impact of climate change on vulnerable communities.

INDIA VISION @ 2047:

INDIA VISION @ 2047:
Chapter 16: India Vision 2047 -Low Carbon Growth Pathway

16.1 Background

India demonstrated climate leadership and sustainable practices while contributing little to global warming: Contrary to fossil-led growth witnessed in developed economies, India's development is largely low-carbon and inclusive. India's contribution to cumulative global GreenHouse Gas (GHG) emissions by 2021 is only 57.1 Gt, accounting for less than 4% despite having 18% share of the world population. On the contrary, the United States accounts for 24%, the EU accounts for 16.8%, and China accounts for 14.3% in the global cumulative emissions. India's per-capita GHG emissions at 2.8 tons in 2021 is less than half of the world average of 6.9 tons, less than 1/3rd of China and 1/6th of per-capita emissions observed in the United States. India's installed capacity of renewable energy stands at 42% of the total installed capacity and is the third highest in the world. India has provided electricity access to 100% of the households and provided LPG access to ~96% (320 million) million households.

Despite minimal contribution to global emission, India has unleashed its climate ambitions clearly with the announcement of Nationally Determined Contributions (NDC) and submission of "Long-Term Low Carbon Development Strategy" laying down the path for achieving the "Panchamrit" goals announced by the Hon'ble Prime Minister at COP-26.

16.2 India Vision 2047 - Call to Amritkaal

India has challenged itself to become a developed nation by 2047 and this development must not come at the cost of climate or health, be people-centric, sustainable, equitable and justifiable. While moving towards its developmental path India must be conscious of its net zero commitments, thereby every possible attempt shall be made to decouple growth and emissions. The key to which is:

- Reducing Ensuring energy efficiency and conservation at all levels.
- Promoting demand electrification and increasing share of renewable energy.
- Reducing the energy demand gap between rural and urban by embarking upon a people-centric approach.

As India embarks on a developmental path to meet the aspirations of a growing economy, its per capita primary energy consumption will increase considerably. India's per-capita primary energy consumption in 2022 stands at 7,118 kWh compared to 31,032 kWh in China, 40,561 kWh in Germany and 77,472 kWh in the United States. Energy needs, therefore, will grow from such a low base to meet the development deficit and aspirations of a growing economy. However, the energy service needs will be met in an efficient manner that will yield a much lower per capita demand while delivering the same quality of life standard, equivalent to that of developed nations.

By assuming constant growth rate during 2023-47 with real GDP growth of 7%, inflation of 4% and exchange rate depreciation of 2%, we find that India's GNI will reach $ 27.4 trillion USD by 2047 and per-capita GNI will reach $17,212 USD by 2047 which comfortably puts India in High income bracket, as per World Bank definition.

India's developmental needs and aspirations on one hand and its vulnerability to climate impact on the other, warrant for integrated energy planning. Energy is the key source of GHG emissions and is the most significant lever for economic and social development. Therefore, estimating the right energy transition pathway is important for India's sustainable growth.

India Vision 2047, a call to "AmritKaal", is an aspirational vision envisioned should the policy recommendations highlighted in the "Approach to the IIEP" be adopted. The authors carefully crafted the demand and supply choices, inserted into the India Energy Security Scenarios (IESS) 2047 pathways calculator, as developed by NITI Aayog, and generated a unique pathway named as the Integrated Energy Policy (IEP) 2047 Pathway.

The aim of IEP 2047 pathway is to analyze and respond to the key transitional challenges by considering energy at affordable prices, ensuring adequate per capita consumption, improving access to clean cooking energy, ensuring universal coverage of electricity and low emission and security of supply thereby leading to indomitable growth and prosperity in a climate and environmentally responsible manner. The idea is also to capture the preponderance of renewable technologies, storage solutions, smart grids, green hydrogen and many other emerging technologies along with the responsible consumer behaviour as outlined in the

Mission LiFE. There is also a recognition that fossil-based capacities will grow in the short run, and there may be stranded capacity in 2047. This is meant to assure that energy needs of the country do not wait for clean energy solutions to grow to scale and are cost effective. The IEP pathway also showcases a set of potential implications of the energy choices on India's energy security, emissions, growth, grid stability etc. These potential implications guide the policymakers in making an informed choice.

16.3 Universal and Equitable Access to Modern Energy

The foremost objective of the IEP 2047 is to eradicate energy poverty and make modern energy available to all citizens, at an affordable price. In 2047, the hundredth year since Independence, every Indian must have access to all forms of modern energy as per his/her choice and in desired volumes. In the IEP scenario the total energy demand in the country is expected to double in the next 25 years. This will also translate into an increase in per capita energy consumption from 0.43 toe in 2022 to 0.74 TOE by 2047, while per capita electricity consumption increases from 906.6 kWh in 2021 to 3375 kWh in 2047 (IESS estimate). Adoption of environment conscious lifestyles leads to moderate increase of per capita energy as well as electricity consumption and is still below the world average. The demand would be much higher if efficient choices are not made, especially for the likely new demand in the next 25 years. The share of electricity (a relatively modern energy) in overall energy demand is going to increase from 18.3% in 2022 to 39.3% in 2047. This is a high level of electrification and will support an efficient energy system allowing a high level of penetration of renewable energy. The projected primary energy supply at approximately 2.3% CAGR over 2022-47, is expected to meet the energy requirement for a decent quality of life for every Indian. Robust energy markets will enable the spread of infrastructure to make energy available across the country.

Increased urbanization and rural transformation in the IEP scenario by and large will remove the developmental distance between the rural and urban areas. Therefore, there will be little difference in energy consumption levels. 57% of rural households who rely on traditional biomass for cooking in rural areas will shift to clean fuels by 2047 while in urban areas, 100% access to clean fuels will be achieved much earlier, by 2030. Electricity based cooking will also gain traction with 15% households in rural and 20% households in urban areas shifting to electricity by

2047. The IEP scenario also promotes climate resilient buildings and climate conscious lifestyles in both rural and urban areas. As the building space will nearly double during this period, adoption of ECBC codes will account for a large reduction in energy demand from the default case. Per-capita residential energy demand in rural areas increases at a faster rate of 4.5% CAGR compared to 4.3% CAGR in urban areas during 2020-47.

16.4 Energy Security

The International Energy Agency (IEA) defines energy security as “uninterrupted availability of energy sources at an affordable price”. (Why not use the IEP, 2008 for this definition?) The various dimensions of energy security in the Indian context include reducing and diversifying energy imports, ensuring stable and affordable energy prices and a reliable supply of energy.

India had imported 87.7% of crude oil, 47.5% of natural gas and 27.9% of non-coking coal in 2022. With greater thrust towards adoption of clean and green fuels, India’s consumption of fossil fuels will not see greater increase despite doubling of energy demand. India’s import dependency on crude oil falls to 75% and non-coking coal to 6% in 2047. With greater thrust on green grid and clean fuels, **the share of clean energy is expected to increase from 16% in 2022 to 41% in 2047 (of total primary energy)** driven by a conducive ecosystem for growth of renewables and clean fuels. It is notable that the conversion losses being lower in the case of clean energy, the volume of PES gets moderated in comparison to a fossil-denominated supply. The ability to meet developmental aspirations while balancing energy security and climate commitments is no means a small achievement for the most populous nation in the world.

Nevertheless, higher level of RE utilization exposes us to different types of vulnerability i.e., concentrated supply chain in critical minerals and metals required for RE. Currently, critical mineral extraction is heavily dominated in the hands of few nations, notably, Graphite (China, 79%), Cobalt (DRC, 70%), rare earths (China, 60%) and Lithium (Australia, 55%). The level of concentration is even higher for processing with China dominating across the board. **It is imperative for the country to build in strong capabilities in the form of diversified import basket of countries and strong domestic manufacturing to avoid shifting from fuel**

dependency to material/mineral dependency. Government of India's Production Linked Incentive scheme along with push for exploration and excavation of domestic reserves of critical minerals thus need greater attention.

16.5 Affordable Energy

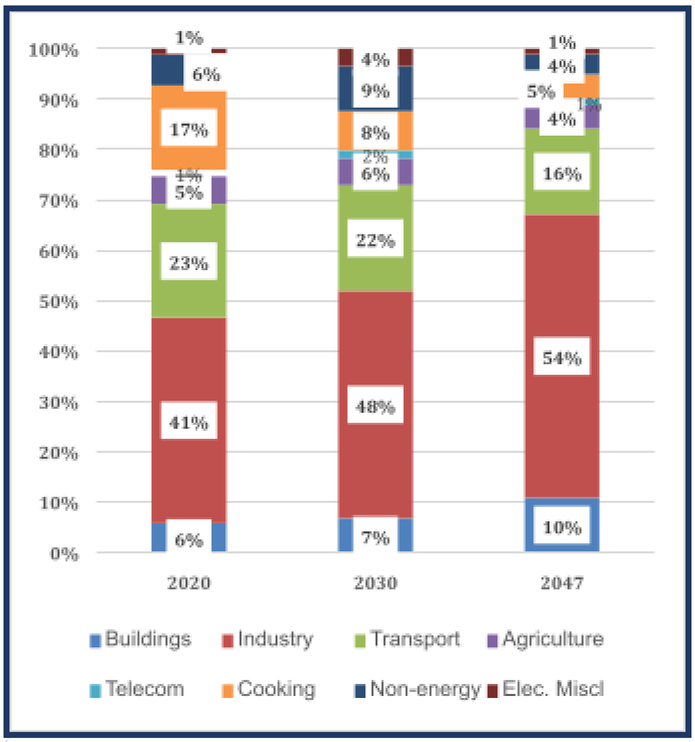
The electricity tariffs in India are kept at a stable low by the Government, even during the Ukraine Russia conflict. The residential electricity tariffs in India are around $ 0.07/KWh compared to $0.52/KWh in Germany and $0.18/KWh in the United States, to meet the developmental aspirations of a growing economy. Further, access to clean cooking fuels for the poor population is subsidized for the vulnerable sections of the society through government programmes. But having said that going forward, the pricing, subsidy and affordability aspects of energy supply will undergo the most dramatic change of all. The country will have transitioned to direct benefit transfer (DBT) making it possible for the vulnerable sections to exercise choice in procuring their preferred source of energy in an efficient manner. Also, **installation of rooftop solar, smart meters, energy efficient appliances will lead to emergence of prosumers**. This will further promote markets and competition, which will become the norm in the larger context. The IEP scenario reveals that the transition to cleaner energy by 2047, will be a cheaper pathway with estimated total energy system cost at $ 229 Billion USD per year than the BAU scenario wherein the estimated total energy system cost is $ 253 Billion USD per year. (We can take a view whether we need to get into capex/opex related outputs in the IESS. There can be both sets of views) However, energy system cost is capital intensive in IEP compared to BAU scenario due to high CAPEX and low OPEX nature of investment requirement for RE. Share of renewable energy crossing 65% by 2030 (in capacity terms) indicates that the Indian energy market is much less vulnerable to the international energy price volatility with reduction in import dependency of fossil fuels. Hence, competitive markets, combined with a higher share of cheaper renewable sources, demand electrification and efficient subsidy delivery mechanism, will make energy affordable.

16.6 Emerging Trends in Energy Sector

16.6.1 Growing Energy Demand:

Energy demand is expected to double by 2047 with a CAGR of 2.6% to meet the rising aspirations of people. This would be lower than what has been witnessed during the last decade (2012-22). Notably, the building sector sees the highest growth rate in energy demand at 4.8% followed by Industry at 3.7% during 2020-47. Interestingly, cooking exhibits a negative growth rate due to factors such as:

a) Adoption of clean and modern fuels especially with phasing out of traditional biomass in the cooking sector.
b) Improvements in energy efficiency.



The inefficient combustion of biomass was leading to high energy supply and less delivered useful energy. Agriculture and Transport sector see moderate growth in energy demand due to greater penetration of clean fuels and shift to non-motorized and public transport especially in passenger transport sector and modal shift from road to rail in freight transport (See Table-1 of Annex-3). The share of industry increases from 41% in 2020 to 54% in 2047 driven by the growing role of the manufacturing sector while the transport sector share drops from 23% in 2020 to 16% due to shift to clean energy sources and higher share of public transport. The share of buildings improves from 6% in 2020 to 10% in 2047 due to improved living standards. [Figure. 20]

16.6.2 Change in Energy Mix with Shift towards Clean Energy:

As a result of a shift towards clean energy, energy efficiency and demand management measures, the share of non-fossil in the total primary energy supply improves from 16% in 2022 to 41% in 2047 (Figure-21). India's coal demand will remain the same - an increase from 388 Mtoe in 2020 to 405 Mtoe in 2047. Due to this increase in the share of non-fossil fuels in the energy mix and in terms of percentage share in total energy supply, coal's share falls from 48% in 2020 to 27% by 2047 (See Table-A2 of Annex-3).

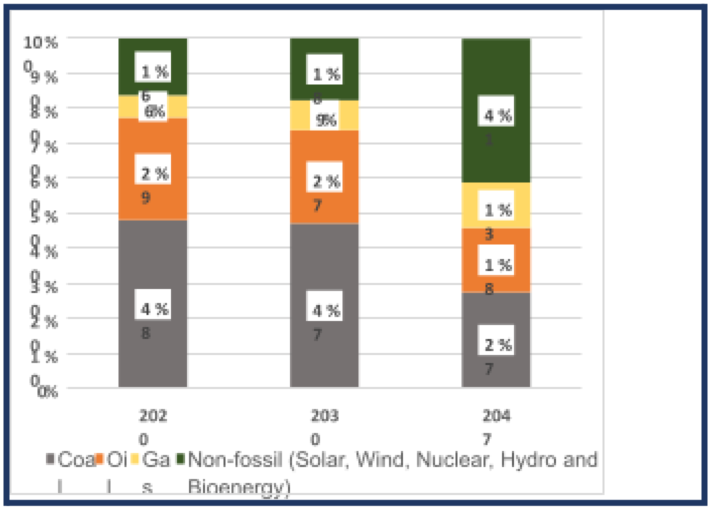


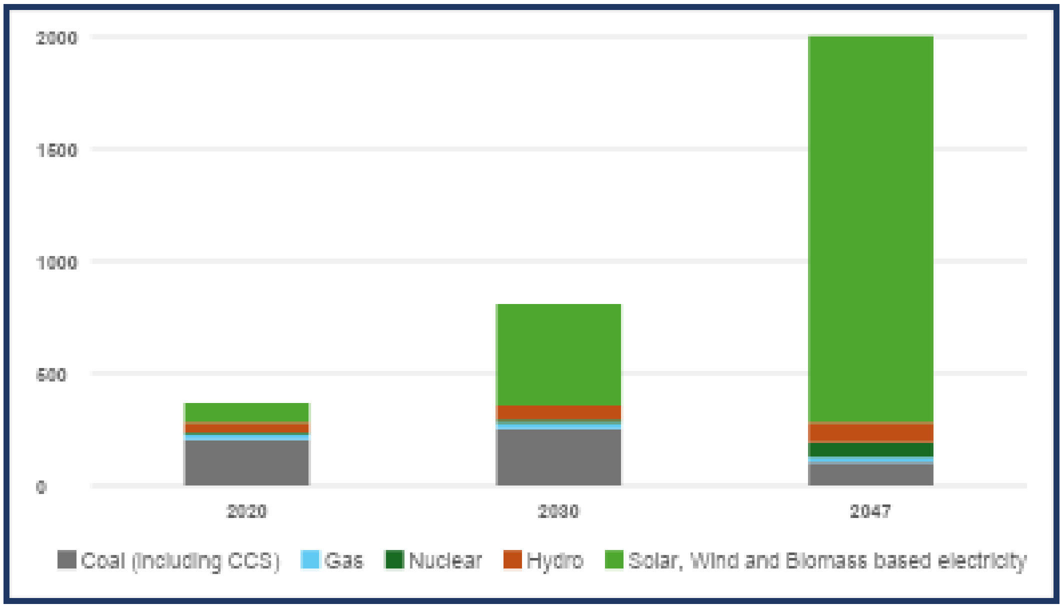
Figure 21: Primary Energy Mix

Energy elasticity to GDP declines from 0.23 MJ/INR in 2020 to 0.08 MJ/INR in 2047 indicating the adoption of environment conscious lifestyles. India's per-capita primary energy supply will increase from 0.6 toe in 2022 to 0.93 toe (IEP) by 2047, which is still below the world average.

16.6.3 Greening of Electricity Grid:

With rising developmental aspirations leading to increased energy demand which concomitantly is met through electricity, we observe that India's installed capacity will increase by 5 times over 2022 levels (Figure-22). India's installed capacity of non-fossil stands at 44% in the total installed capacity (Aug 2023) and is expected to reach 94% by 2047 (See Table-A3 of Annex-3). The increase is primarily driven by a conducive ecosystem for renewable energy, which is now the cheapest source of supply, even without climate change constraints or carbon pricing. On the other hand, the share of coal-based capacity will decline, signifying a move away from traditional fossil resources. **These end-of-life coal plants could be well**

re-purposed for either building storage solutions, mega RE facilities or even smaller nuclear plants.



In terms of electricity generation from grid, solar and wind capacity together account for a significant majority, comprising around 76% of the overall electricity generation in 2047 (See Table-A 4 of Annex-3). This indicates a remarkable shift towards harnessing clean and sustainable energy sources, furthering India's commitment to a greener and more environment-friendly power generation system. The IEP scenario also estimated a total storage requirement of around 2 TWh by 2047 to cater around ~4600 TWh of RE power generation in the country by 2047.

16.6.4 Decline in Overall Import Dependency:

India's overall import dependency falls from 41% in 2020 to 29% in 2047 indicating that India will become less reliant on external sources to meet its energy demands. However, gas import dependency increases from 57% in 2020 to 61% in 2047 due to increased demand for gas products such as PNG in Cooking, use of gas in industries such as fertilizer, refineries and LNG in heavy transport. This offers an opportunity to decarbonize via electric cooking and green hydrogen. The increased demand for coking coal in the steel sector, especially from imports, means an increase in coking coal import dependency from 53% in 2020 to 73% in 2047. This also calls for process changes. Oil and Non-coking coal see greater decline in import dependency.

16.7 Energy Infrastructure of India

Enhanced energy supply will require a large expansion in energy infrastructure along the entire value chain during the next 25 years. Just as the country has built its optic fiber backbone across the country along with the gas pipelines and electric transmission lines, the new infrastructure will support enhancement of clean energy supply and utilization. IOT based applications will further minimize the communication time and cost for smart use of such technologies. LNG terminals, city gas distribution grids, strategic and commercial oil and gas storages, renewable energy projects (both grid connected and rooftop) will have sprung up to deliver energy to all parts of India. India has the advantage of offering a new market, for which the latest technology will be the norm in infrastructure creation. It is acknowledged that it is more cost effective to adopt the latest technology when building new rather than retrofitting. The advent of new technology and cost reduction in storage options (battery among others), will facilitate exploitation of the abundant renewable resource.

IEP recognizes the need for greening the electricity grid and pushes for almost 94% of the installed capacity of grid from non-fossil sources by 2047 and 89% in terms of overall electricity generation with solar and wind accounting for dominant share. Such mega scale RE penetration in the energy system of India is expected to change the sector structurally and characteristically as well. Battery energy storage costs at 10 Rs per kWh in 2023 are prohibitively expensive. Therefore, coal will be an important source of base-load energy for India in the short run, which will ensure security, affordability and balance.

To match high economic growth along with lower emissions and cost, use of natural gas shall be a good option for India as a transitional fuel. Given the low emissions factor of gas along with the benefits of having proven low-cost technology, a gas-based energy system in the country will usher in multidimensional benefits. Natural gas supply is expected to increase by 3.5 times by 2047 to meet the demands of the gas-based economy. India’s various offshore exploration schemes and plans will play a crucial role in this regard. Gas imports via LNG are also likely especially in the light of large un-utilised capacity in our LNG receiving terminals.

Nuclear energy is appearing to be a swing technology for India. Higher utilization of the same can bring a cost effective, energy efficient and stable supply system with reduced emissions. However, technology comes with its own risks and coverage costs, details of which are highlighted in the Nuclear Chapter.

Nevertheless, SMR technology (especially 300 MWe capacity) is a bright star with a potential to repurpose coal based TPP in the future. India's indigenous PWHR technology is also expected to receive a boost due to opening up of the sector.

The local endowment of energy resources will influence the energy mix in nearby markets as witnessed in the north and north-east, where hydel power may play an important role. India's north-east is central to its vision of an integrated South Asian electricity grid wherein the electricity will be traded across nations of Bhutan, Nepal, Bangladesh, Sri Lanka and Myanmar. International Solar Alliance (ISA), with more than 120 member countries co-founded by India and France, is playing a major role in shaping the establishment of **One Sun One World One Grid (OSOWOG) alliance**. The coastal south and west India being renewable rich and close to the oil/gas rich West Asia, will witness a more significant role of fuels such as LNG, Green Hydrogen and its derivatives.

16.8 Climate & Environmental Impact

16.8.1 GHG Emissions:

Despite significant economic development (real GDP increasing at a 7% p.a rate) and corresponding increase in energy consumption, India's energy emission intensity to GDP will fall by 78% from 17.1 kg CO_2 eq. per 1000 INR in 2020 to 3.74 CO_2 eq. per 1000 INR in 2047. Further, India's energy-related GHG emissions grow at a marginal rate of 0.2% between 2020 and 2047. As a result, India's overall GHG emissions will reach around 4 Gt by 2047, still below the world average ?? of 4.7 Gt in 2022, and may see emissions peaking much before 2040. IEP shows that per capita GHG emissions will reduce from 2.4 tons per person in 2020 to 2.5 tons per person by 2047. With huge expected increase in energy needs largely met from clean sources, India will additionally utilize ~110 Gt by 2047, well within India's fair share of 89-458 Gt (1.5^{o}C scenario) and 241-609 Gt (2^{o}C scenario).

16.8.2 Land and Water Requirements:

IEP is also rationalizing the resource utilization of India to meet the necessary target of energy supply and demand. To achieve ~2000 GW of installed capacity by 2047 India needs around 2.06 million Ha of land and 9.4 Billion Cubic Meter (BCM) of water. Some word on feasibility of this?

16.9 Conclusion

The IEP scenario envisions that India's energy needs will double by 2047 as it meets the rising aspirations of people and emerges as a developed economy. This supply will meet the energy demand parameters of a developed country in an efficient and sustainable manner. Indian economy guided by Hon'ble Prime Minister's vision of Amritkaal, however adopts an environmentally friendly green growth strategies as evident in the results where such massive increase in energy demand comes with decline in energy supply elasticity of GDP by 65% between 2020-47 without compromising the people's quality of life.

The present energy market structure will undergo a paradigm shift in the future driven by green growth strategies. As the share of electricity in overall demand is likely to increase, we will see the emergence of large integrated energy players with both forward and backward linkages, as evident today, wherein power producers are also increasingly participating in commercial mining of coal. The role of markets will be strengthened wherein energy will be freely traded, and competition will usher benefits to the customers.

Demand will drive the future of energy in India, unlike the past. Rapid demand electrification (from 18.3% to 39.3%) in the next 25 years will ensure green growth in buildings, industry and the transport sector. On the supply side, installed capacity increases more than 5 times, with the share of non-fossil accounting for almost 94%, and in line with the vision of the Indian power sector. However, such a large grid based on RE requires a huge storage capacity of 2 TWh in 2047 with various energy storage solutions such as a battery storage, pumped hydro etc playing a crucial role in maintaining stability and reliability of the grid.

The role of clean fuels such as Green Hydrogen and its derivatives, and Biofuels lead to a strong increase in the share of clean energy in total primary energy supply from 18% in 2022 to 41% by 2047. Such massive increase in clean energy leads to reduction in India's emission intensity to GDP by more than 80% over 2005 levels. India's growth predominantly will be low carbon in nature with its requirement for carbon space being within its global fair share. The IEP scenario ensures adequate per capita consumption, improves access to clean cooking energy and dominance of clean fuels thereby leading to indomitable growth and prosperity as envisaged by Mission LiFE which advocates for sustainable energy production and consumption.

Annex-1: IEP scenario – Approach and Assumptions

India Vision 2047 is a call to "AmritKaal", an aspirational vision, envisioned should the policy recommendations highlighted in the "Approach to the IIEP" be adopted. The authors carefully crafted the choices across each of energy demand and supply options, inserted that into the India Energy Security Scenarios (IESS) 2047 pathways calculator (version 3.0), as developed by NITI Aayog, and generated a unique pathway named as the Integrated Energy Policy (IEP) Pathway. The IEP pathway showcases the impact of India Vision on energy security, emissions, growth, grid stability, land usage etc.

How does the IEP scenario get generated?

The IEP scenario for 2047 is not the original modelling work of ACPET. This is a scenario developed by ACPET using the IESS 2047 Tool, and that, too, in consultation with experts from NITI Aayog to develop an aspirational energy and environment pathway for India. The IEP pathway took learnings from NITI's Net Zero Economy (NZE) Pathway and inputs from the chapters under the Approach to IIEP. The team used the Version 3 of IESS 2047 pathways calculator for developing the IEP scenario. For more info visit - India Energy Security Scenarios, 2047 (iess2047.gov.in)

Does IEP tie down ACPET to the projections?

No, in-fact the beauty of IESS is that it gives millions of different pathways to choose from. The projected pathway is achievable by following the policy approach in the document, and the energy scenario in 2047 may be different if the approach is not followed. The idea here is not to tie down to a specific number or a scenario, instead to facilitate an informed debate wherein the views of a wider set of stakeholders are captured for the policy-making process. The ACPET team in consultation with NITI attempted to develop an IEP pathway to visualize a people centric, collaborative, transparent and integrated approach for energy and environment policy making. We hope that the IEP scenario could become one of the example pathways within the IESS model.

Key Assumptions:

The scenario is therefore more focused towards implementation of LiFE concept which is a more people-centric behavioral approach towards attainment of NZE by 2070. The purpose of this scenario is also to determine a pathway which can provide access to modern energy to all by 2047 followed by providing a cleaner environment to society by reducing GHG emissions from fossil fuel burning, while keeping the developmental goals in mind. Major assumptions for this scenario are described below:

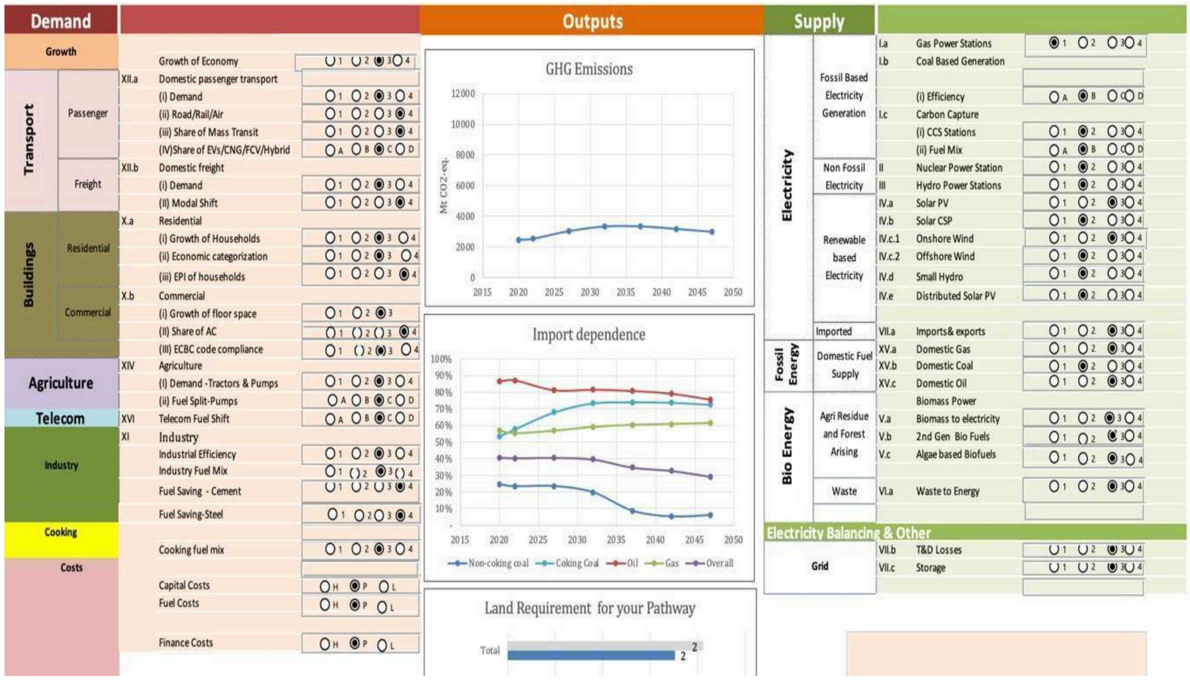
Parameter	Units	2020	2022	2027	2032	2037	2042	2047
GDP Growth rate	**%**	Real GDP is assumed to grow at constant 7% CAGR during 2022-47						
Inflation	**%**	4% inflation till 2047 (RBI monetary policy mandate is to maintain inflation within 4%-6% range)						
Exchange rate depreciation	**%**	Exchange rate depreciation of 2% is assumed in relation with USD.						
Sectoral share of GDP	**%**	Share of Industry is assumed to improve due to various Aatmanirbhar Bharat initiatives from 27.2% (2022) to 34.5% (2047) Share of Services is assumed to improve marginally from 54.4% (2022) to 58.7% (2047) • Share of Agriculture is assumed to decline from 18.4% (2022) to 6.8% (2047)						
Population	Millions	1349	1375	1436	1490	1535	1569	1592
Urbanization	%	35%	36.2%	39.1%	42.1%	45.1%	48.0%	51%
Household Size - Urban	No. of people	4.20	4.14	4.00	3.85	3.70	3.56	3.41
Household Size - Rural	No. of people	4.50	4.45	4.32	4.19	4.07	3.94	3.81

Annex-2: IEP Scenario Choices

The IEP scenario is built on the inputs/recommendations from the Approach to IIEP report, it considers the following:

- Adopting the principles of universal access to energy, secured energy supply, and equitable distribution of modern clean energy in an affordable manner.
- Acknowledge the role of energy efficiency as the foremost important strategy in decarbonization of energy demand.
- Acknowledging the importance of demand side management where people's behavior change is prioritized through promoting environmentally responsible behavior in terms of preference for non-motorized transport, mass transit systems such as rail/metro train services over privatized/personal transport systems. The choices also recognize that India will be able to achieve its EV commitments.
- The choices recognize that increasing the share of railways for freight transport is much more efficient with Indian Railways electrifying its 100% tracks and aiming to achieve net zero by 2030.
- The choices recognize that energy demand in residential buildings will increase due to construction of new houses and improvement in living standards as people's income increases, however, energy demand increase will also see highest efficiency improvements with people adopting efficient building code in construction and five-star rated appliances.
- Energy demand in commercial buildings will be deterministic on assuming greater penetration of climate resilient buildings (through adoption of Energy Conservation Building Code-ECBC), highly efficient energy appliances, use of nature-based cooling and adoption of 4R principles.
- The cooking sector choices are guided by the factors such as elimination of traditional biomass, increasing the penetration of PNG and Electric based cooking in both rural and urban areas. With higher use of PNG in urban areas, LPG can be diverted in providing access to clean cooking fuels for rural populations.
- Acknowledge the role of Green Hydrogen in decarbonizing Hard-to-Abate sectors such as Steel, Refineries and Fertilizer and pushing for a low carbon and highly efficient industrial system especially in steel and cement sectors. Electrification of industrial energy demand is also crucial in decarbonizing the industrial sector.

- Agriculture demand choices assume greater penetration of clean fuels and improvement in energy efficiency.
- The supply side choices acknowledge that India's electricity system has to be decarbonized with greater thrust towards renewable technologies and energy storage. Within renewables, choices allow for optimistic growth in ground-mounted solar and on-shore wind as these technologies are already cost competitive in the Indian context.
- Conservative growth is assumed for technologies such as Offshore wind, Concentrated Solar Power (CSP) and Carbon Capture Storage (CCS) as these technologies are not yet commercially competitive.
- Large legacy issues led to selection of conservative growth strategy for growth in Distributed Solar, Hydro and Nuclear technologies. The slow growth in these technologies due to long leads in their commissioning will allow competing technologies to grow.
- Due to poor economic viability of gas-based power plants which largely depend on imported gas (and availability of cheaper coal-based power), the scenario assumes no addition in gas power capacity in the future.
- Greater thrust on promotion of bio-energy which include biomass-based power, 1G/2G biofuels and waste to energy. However, in these choices we have not considered whether diversion of land for energy production will affect food prices and food security.
- The choices also call for enhanced domestic production of oil and gas so as to enable to reduce India's import dependency and be on the path of achieving energy independence by 2047.



Annex-3: Result Tables

Table A1: Final energy demand by sector

Sector	Units	2020	2030	2047	CAGR
Buildings	Mtoe	34	56	123	4.8%
Industry	Mtoe	238	367	637	3.7%
Transport	Mtoe	133	172	193	1.4%
Agriculture	Mtoe	32	43	53	1.9%
Telecom	Mtoe	8	13	15	2.5%
Cooking	Mtoe	99	64	54	-2.2%
Non-energy	Mtoe	35	73	45	0.9%
Elec. Miscl	Mtoe	7	28	12	2.2%
Total Demand	Mtoe	586	772	1176	2.6%

Table A2: Primary energy mix under IEP

Fuel Type		2020		2030		2047
	Mtoe	%	Mtoe	%	Mtoe	%
Coal	388	48%	502	47%	405	27%
Oil	238	29%	285	27%	272	18%
Gas	52	6%	91	9%	191	13%
Solar	5	1%	50	5%	226	15%
Wind	6	1%	26	2%	146	10%
Nuclear	13	2%	34	3%	138	9%
Hydro	14	2%	17	2%	26	2%
Others: Biomass, Agricultural Waste	94	12%	62	6%	74	5%
Total	810	100%	1067	100%	1479	100%

Table A3: Electricity capacity mix

Fuel Type (in GW)		2020		2030		2047
Coal	205	55%	252.3	31%	89.2	4%
Coal CCS	0	0%	2.3	0%	15.0	1%
Gas	25	7%	25	3%	25	1%
Nuclear	7	2%	16	2%	64.5	3%
Solar	32	9%	320	39%		62%
Wind	38	10%	119	15%	453.2	23%
Other Renewables	17	5%	13.2	2%	25.9	1%
Total	370.0	100%	810.2	100%	2,001.7	100%

Table 4: Electricity Generation (TWh)

		2020		2030		2047
Coal	897	70%	1148	51%	240	5%
Coal CCS	0	0%	11	0%	74	1%
Gas	48	4%	51	2%	55	1%
Nuclear	42	3%	111	5%	444	9%
Hydro	165	13%	200	9%	301	6%
Solar	55	4%	425	19%	2172	44%
Wind	65	5%	269	12%	1623	33%
Other Renewables	15	1%	26	1%	71	1%
Total	1285	100%	2241	100%	4979	100%

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