DEEP DECARBONIZATION PATHWAYS

POLICY LESSONS ON DEEP DECARBONIZATION

in large emerging economies

INDIA

Garg A., Sudharmma Vishwanathan S., Chaturvedi R., Gupta D., Avashia V., and Patange O.

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The results presented in this report are outputs of the academic research conducted under the DDP BIICS project as per the contractual agreement. The academic work does not in any way represent our considered opinion for climate negotiations and also does not reflect the official policy or position of the Government of India.

WHY IS THIS REPORT SUBMITTED TO GST, AND WHAT TO EXPECT?

This report contains policy recommendations to realise national deep decarbonization pathways based on in-country scientific model-based analysis in four countries: Brazil, India, Indonesia and South Africa. This digest includes a description of deep decarbonization scenarios' main features, main synergies and trade-offs with country non-climate objectives, priority short-term policies and actions and key international enablers and accelerators of domestic transitions. Thus, it provides relevant information for the Mitigation, Finance flows and Means of Implementation & Cross-cutting thematic areas of the Global Stocktake (GST). Whereas the report does not provide a collective picture, bottom-up granular policy lessons from these four large emerging economies are essential input to assess the adequateness of the progress achieved and necessary action to keep the global long-term goals of the Paris Agreement within reach.

For each of these areas, we identify in the table below against which specific guiding questions, this report can provide relevant elements:

	In the DDP BIICS Policy Lessons Report you can find…
Mitigation	
2. What is the collective progress made towards achieving the long-term mitigation goal in Article 4.1 of the Paris Agreement, in the light of equity and the best available science?	Country assessments explored Current Policy Scenari-os (CPS) to understand the outcome of the current policy packages: main features and emission profiles can be found in Part I of each of the country chapters. Priority short-term policies and actions section in Part II discusses priorities based on a gap analysis be-tween CPS and Deep Decarbonisation scenarios (DDS).
3. What are the projected global GHG emissions and what actions are Parties undertaking to achieve a balance between anthropogenic emis-sions by sources and removals by sinks of GHGs, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty (Article 4.1 Paris Agree-ment, Decision 19/CMA.1, paragraph 36(b))?	The emission profiles of the DDS scenarios are in Part I of each of the country chapters. They represent a country-driven perspective of the national contribu-tion to the Paris Agree-ment global mitigation goal in the context of sustainable development. Projections explicit emissions by sources and removals by sinks.
Finance flows and Means of Implementation	
11. What are the barriers and challenges, including finance, technology development and transfer and capacity-building gaps, faced by developing coun-tries?	All country chapters put an emphasis on barriers and chal-lenges for realising the domestic transformations. This is namely covered in Part 2, including two specific sections on Investment patterns and Key international enablers and accel-erators of domestic transitions.
12. What is the collective progress made towards achieving the long-term vision on the importance of fully realizing technology development and transfer in order to improve resilience to climate change and to reduce greenhouse gas emissions referred in Article 10.1 of the Paris Agreement? What is the state of cooperative action on technology develop-ment and transfer?	This is best reflected under Key international enablers and accelerators of domestic transitions section in Part II for each of the country chapters. This digest focuses on the key enablers for the priority actions that have been identified to get onto the right path towards deep decarbonisation.
13. What progress been made on enhancing the ca-pacity of developing country Parties to imple-ment the Paris Agreement (Article 11.3 Paris Agreement)?	Progress on the enhancement of capacity is implicit in the assessment of the progress (as modelled in the CPS scenario) and the policy analysis of the gap that exists between current trends and the required level of action.

Cross-cutting

16. To achieve the purpose and long-term goals of the Paris Agreement (mitigation, adaptation, and finance flows and means of implementation, as well as loss and damage, response measures), in the light of equi-ty and the best available science, taking into account the contextual matters in the preambular paragraphs of the Paris Agreement: a. What are the good practices, barriers and chal-lenges for enhanced action? b. What is needed to make finance flows consistent with a pathway towards low GHG emissions and cli-mate-resilient development? c. What are the needs of developing countries related to the ambitious implementation of the Paris Agree-ment?	The DDP approach underlying this report's research is funda-mentally a country-driven exploration, back casting from the mid-century emission and socio-economic objectives to inform the short-term deci-sions within and across systems. Sectoral deep dives allow for an in-depth investigation of all levers, which are traditionally represented poorly in existing long-term roadmaps. Country-level lessons derive critical informa-tion for international discussion on overall progress, thus the entire report brings relevant evi-dence to this cross-cutting question.
17. What is needed to enhance national level action and support, as well as to enhance international co-operation for climate action, including in the short term?	The analyses underpinning this report have been de-signed under the premisses that scientific assess-ments should be seen less as an instrument to illus-trate transition pathways in a normative manner than as a way to determine the inclu-sive whole-of-society conversation that would be required to make the transition effective and acceptable in specific contexts. The gap between existing evidence and concrete ac-tion highlights that the carbon neutral transition is not only a matter of techno-economic feasibility but es-sentially a question of political economy and policy implementation. The report intends to bring clarity for each of the countries about the choices to be made in the transition, about the concrete policies and ac-tions that can be envisaged, about those who can be winners and those who may lose, and the measures adopted to manage the socio-economic costs of the transition. As a high-level digest, this is captured in Part 2 of the country chapters.

FOREWORD

Henri Waisman, Marta Torres Gunfaus, Anna Perez Catala, IDDRI.

The world has agreed to prevent the irreversible damages to human and natural ecosystems caused by anthropogenic global warming by limiting the rise of global temperature to well below 2°C and to pursue efforts to limit it to 1.5°C. To this, the Paris Agreement grounds this goal in terms of global emission trajectories and the need to embed them in the in the context of sustainable development and efforts to eradicate poverty. Subsequently science (IPCC SR1.5) further specifies that global neutrality concerning carbon dioxide specifically should happen between 2050 (for 1.5°C) and 2075 (for 2°C). It also points out the necessity of minding non-CO_2 forcers to maintain the global objective. To reach this scale of emission reductions, the scientific assessment concludes that rapid and far-reaching transformations, far beyond what has been observed in the past, are required in all components of the economic system, ie in energy, urban and infrastructure, industry and land and ecosystems. Such drastic transitions in turn require profound changes in technologies but also in social, economic, institutional and policy conditions. Science finally shows that the changes required by climate objectives can be compatible with broader sustainable development objectives if action is implemented without delay, is guided by strategic visions of transformations informing the design of well-designed policy packages and the cooperation among actors and is enabled by effective international cooperation. With these framework conditions at hand, countries are set to explore national pathways to explain how the rapid and far-reaching transitions required globally can happen in each country context.

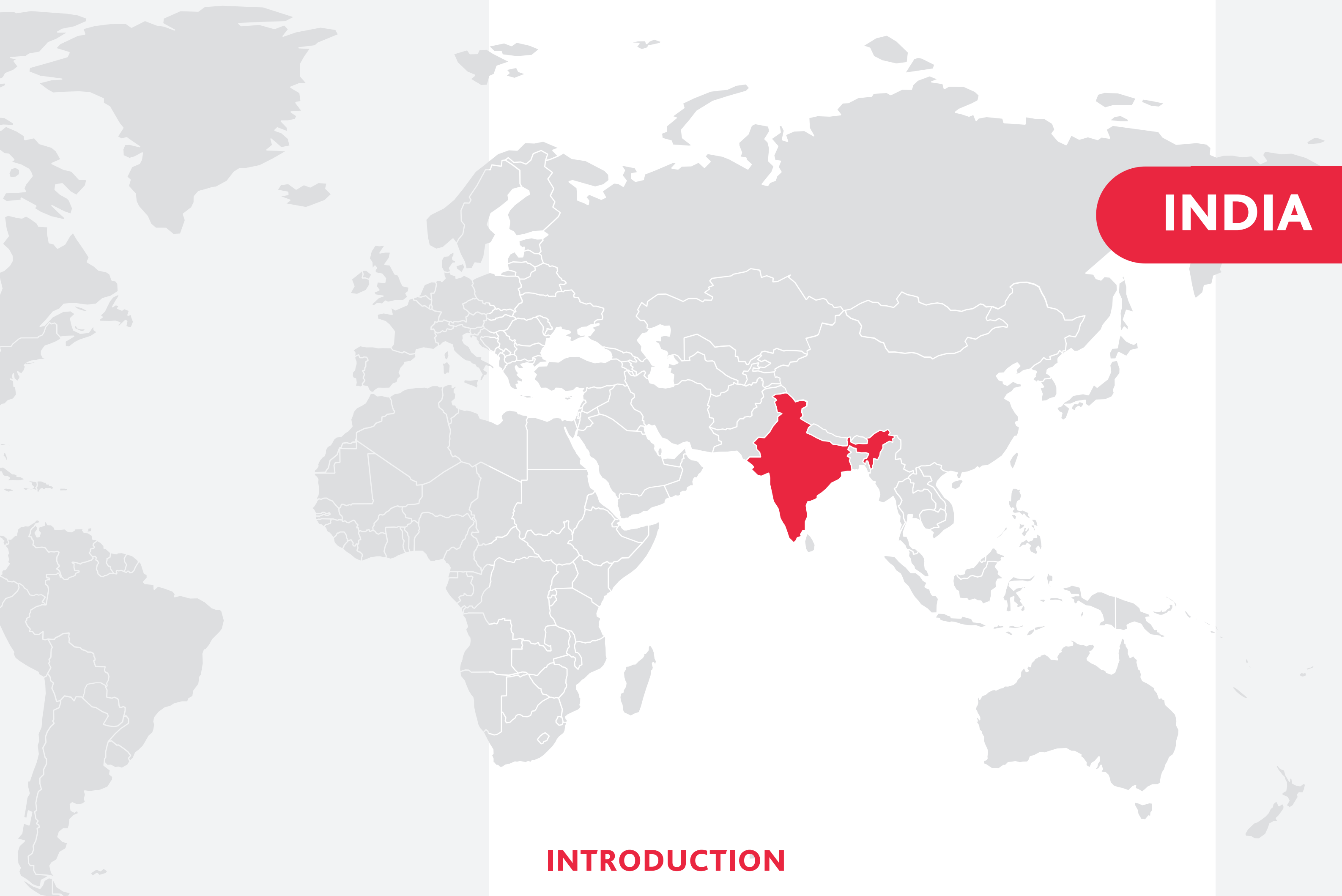
National deep decarbonisation of large emerging economies has been largely explored from a techno-economic perspective, resulting in viable sets of long-term pathways under a number of conditions. Existing analysis shows that the national transition can mostly been initiated using existing technologies and market instruments at low and often net negative financial cost and that, usually, these transformations can have associated large overall net economic benefits when external economic costs and benefits are factored in. However, similar to most parts of the world, most major necessary decarbonisation transformations are either not happening or happening at a slower pace. This gap between existing evidence and concrete action highlights that the carbon neutral transition is not only a matter of techno-economic feasibility but essentially a question of political economy. Actual implementation requires clarity about the choices to be made in the transition, about the concrete policies and actions that can be envisaged, about those who can winners and those who may loose and the measures adopted to manage the socio-economic costs of the transition. Scientific assessments should therefore be seen less as an instrument to decide transition pathways in a normative manner than as a way to inform the inclusive whole-of-society conversation that would be required to make the transition effective and acceptable.

The DDP community behind this report has committed to this vision of the role of scenario analysis in the public debate. The body of knowledge emerging from this community aims at ensuring that the features of the techno-economic deep decarbonisation transformations are contextualized in the diversity of country circumstances and described with sufficient details and granularity to inform decisions required to drive these transformations. Key challenges to date, which are critical to increase ambition and accelerate action, include: connecting the scenarios analysis and the diversity of policies and actions to implement in the real world; revealing the critical conditions that are outside the control of national authorities, where international cooperation must play a role; ensuring ownership of the insights emerging from the scenarios by a diversity of actors to empower them in the public debates.

The DDP approach underlying this report's research is established with these key challenges in mind. It is fundamentally a country-driven exploration, back casting from the mid-century emission and socio-economic objectives to inform the short-term decisions across systems. Sectoral deep dives allow for an in-depth investigation of all levers, opportunities and challenges suited to inform domestic stakeholder debate in highly complicated sectors, such as transport, industry, or agriculture/land-use, which are traditionally represented poorly in existing long-term roadmaps. The stakeholder engagement approach to the development of the scenarios and emanating policy insights is an essential mean for these scientific assessments to serve an action agenda.

This report presents a synthesis of the results of the assessment conducted in India. Part I describes the main features of the economy-wide Deep Decarbonization Scenario(s) (DDS), including a description of key national-scale socio-economic aspects and an explicit characterisation of the emission objective and trajectory. To realise the necessary changes to get on track to this path, a description of the Current Policy Scenario (CPS) is also presented, including a description of the main policies and actions considered. Scenario results include an in-depth description at sector level for the deep dives selected by each country. Part II focuses on key policy lessons, which can serve as direct inputs into policy conversation at the country level. It includes a description of the main synergies and trade-offs with country non-climate objectives, priority short-term policies and actions, with a focus on where shifts from current paths are critically required, investments patterns and key international enablers and accelerators of domestic transitions.

INDIA



INTRODUCTION

India, with the second largest population in the world, is the only large nation amongst the G20 countries on track to achieve its commitment to achieve the Paris goal of 2C (CAT, 2020) and in top 10 countries in the world in Climate Change Performance Index (CCPI) 2021, second year in a row.

India's Nationally Determined Contribution (NDC) submitted to the UNFCCC in 2016 has been formulated keeping in mind the developmental imperatives of the country (NDC 2015). It consists of eight different goals including three mitigation-centric quantifiable targets, namely:

1. To reduce the emissions intensity of its GDP by 33% to 35% by 2030 from 2005 level (**NDC- 3**);
2. To achieve about 40% cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 with the help of transfer of technology and low cost international finance including from Green Climate Fund (GCF). (**NDC- 4**); and
3. To create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030. (**NDC- 5**).

The other components of India's NDC pertain to the adoption of sustainable lifestyles based on traditional values of conservation and moderation, adaptation to climate change, clean economic development and environment- friendly technologies.

Development patterns supported by energy and sectoral policies seeking for accessibility, reliability and affordability have been the key drivers to India's historical emissions. Additionally, available resources (energy, water, land, critical minerals, labour) in the country and access to essential resources at global level in terms of quantity and prices also may enhance and/or aid to reduce emissions. In the past couple of decades, some of these policies have been endorsed by international commitments such as millennium development goals (MDGs) (2000-2015) and Sustainable Development Goals (SDGs) (2015-2030) in order to improve the nation's state of development and economy (SDG 2020).

In this study, we have attempted to **develop multiple pathways: a current policy scenario (CPS), which extrapolates trends of ongoing and planned policies until 2050,** and **two deep decarbonization scenarios (DDS), which propose alternative visions of transformations consistent with the Paris Agreement to inform short-term policies and the revision of the Indian NDC**. This report provides a summary of the scenario results and policy lessons emerging from the analysis.

PART 1: SCENARIO RESULTS

EMISSION PROFILES

Development has been and will remain a priority for India. The **current policy scenario (CPS) considers ongoing developmental policies** along with mitigation and adaptation strategies mentioned in the National Action Plan on Climate Change (NAPCC 2008) and Nationally Determined Contribution (INDC 2015). The CPS scenario extrapolates the ongoing policies till 2050. The deep decarbonization scenarios simulate ratcheting the ongoing policies with **DDS1 emphasizing on synchronizing development with deeper climate actions**, and **DDS2 ratcheting climate actions to move towards net zero emissions**. Both DDS1 and DDS2 scenarios focus on achieving development, however DDS2 prioritizes acceleration of climate actions thereby increasing mitigation costs in the near term. The implementation of policies and actions are at slower pace in DDS1 when compared to DDS2 in the short term.

The Indian CPS and DDS scenarios were observed to reduce the emission intensity of GDP by 41%-47% by 2030 when compared to 2005 levels. The emissions will reach 4.6 $GtCO_2$, 4.43 $GtCO_2$, and 4.24 $GtCO_2$ under CPS, DDS1 and DDS2 scenarios in 2030. The emissions will further reduce to 4.41 $GtCO_2$, 4.16 $GtCO_2$, and 3.9 $GtCO_2$ due to the addition of AFOLU as carbon sink under CPS, DDS1 and DDS2 scenarios (**Figure 1**). These pathways reiterate and solidify India's commitment above and beyond to achieve the Paris Agreement goals.

India is projected to require a carbon budget of around 136-142 $GtCO_2$ under CPS scenario (including LULUCF) for the 2020-2050 period. Under DDS scenarios, the estimate ranges between 86 and 114 $GtCO_2$ (including LULUCF), a reduction by 36.7% and 23.5% respectively when compared to CPS scenarios. The cumulative fossil and land-use-change CO_2emissions from 1850 through 2019 is ~ 1,800 $GtCO_2$ for fossil emissions and ~775 $GtCO_2$ for land-use change, for a total of ~2,390 ± 240 $GtCO_2$ (AR6 WGI SPM, page 38). India's historical cumulative emissions of the global cumulative emissions is less than just 5% from 1850 to 2019. Based on remaining carbon budget from 2020 for 2°C global warming limit (~ 900-2,300 $GtCO_2$) (AR6 WGI SPM), India's future carbon budget share ranges between 5.9%-15% in CPS scenario and 3.7%-11.6% in DDS scenarios. **Table 1** presents the implications of policies implemented on NDC and Paris Agreement across CPS and DDS scenarios.

Figure 1. CO_2e emissions including LULUCF

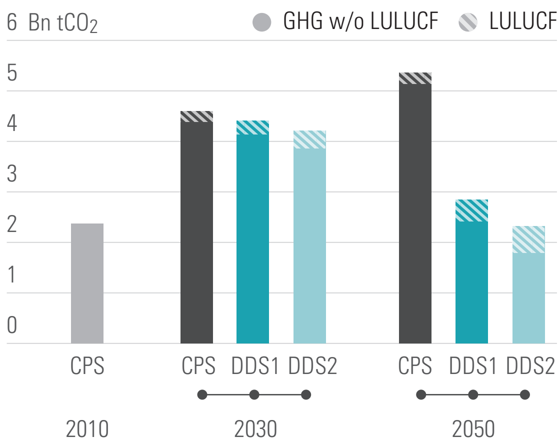


Table 1. NDC Indicator Goals across CPS and DDS scenarios

Indicator	CPS	DDS1	DDS2
NDC Goal 3 (Reducing GHG/GDP by 33-35% of 2005 level by 2030)	41%	44%	47%
NDC Goal 4 (Increasing non-fossil based generation capacity to 40% by 2030)	55%	59%	63%
NDC Goal 5 (Addition of carbon sink by 2.5 to 3 Bt by 2030)	2 Bt CO_2	3.17 Bt CO_2	3.89 Bt CO_2
Impact on Paris Agreement (Cumulative CO_2 emissions including agriculture non-CO_2) during 2020 and 2050) (*Including LULUCF*)	142 Bt CO_2e *136 Bt CO_2e*	114 Bt CO_2e *104 Bt CO_2e*	98 Bt CO_2e *86 Bt CO_2e*

SOCIO-ECONOMIC IMPLICATIONS

India has the second largest human population in the world with more than 1.35 billion people with 64% of the population in the 15-59 age group (WB 2018). A significant section of its large population depends on climate-sensitive sectors such as agriculture, fisheries and forestry for livelihood. India's population is expected to peak at 1.7 billion in 2060 (UN 2015). India is also one of the largest emerging economies in the world with average GDP growth rate from 1980–2014 observed to be about 6.2%; however, per capita GDP in India is still lower than global average. According to World Bank data, India's per capita GDP (nominal) in 2017 was $1,939 (only 3% of that of the United States and 22% of China's per capita GDP) (WB 2018). Still, it ranks sixth globally in terms of its GDP**. It is rapidly moving towards becoming a middle income economy with population projected to overtake China by 2025, and urbanization exceeding 50% by 2050** (UN 2019).

Transformational and resilient structural changes are required to reduce energy intensities and carbon intensities. The average growth rate of CO_2 emissions between 2005 and 2015 of 7.2% per year is the result of the following annual growth rates: population 1.8%, GDP/capita 4.9%, energy-intensity of GDP is -3.2% and carbon-intensity of energy 3.7%. GDP/capita, carbon intensity and population growth were the main drivers of the increase in Indian carbon emissions during 2005 and 2015 (**Figure 3**).

For CPS scenario, declining carbon and energy intensities are unable to offset income effects and population growth and, hence, carbon emissions are projected to rise. For DDS scenarios, the reduction in carbon intensity of energy supply of DDS1 is higher between 2030 and 2050, while for DDS2 is higher between 2015 and 2030. Similarly, decline of energy intensity in DDS1 is higher between 2030 and 2050 (-4%), while for DDS2 the decline is about -5% from 2015 to 2050. For DDS1 scenario, the reduction is due to i) the decarbonization of electricity and ii) a shift among fossil fuels towards the less carbon intensive fuels in industry and transport sector after 2030. For DDS2 scenario, i) the phased decarbonization of electricity from 2015, ii) a reduced share of fossil fuels after 2030, and iii) the use of bioenergy with carbon capture, utilization and storage (BECCUS) selected oil and industry sector.

The decline in energy intensities is due to combination of technical change (towards more efficient equipment, infrastructure and technologies) and structural changes in the Indian energy system. For example, in the power sector technical advancement includes improvement in energy efficiency through a) retiring old power plants, b) increasing plant load factor, c) shifting to less carbon intensive technologies, d) shifting to renewable sources, e) reducing transmission and distribution (T&D) losses and so on. Amongst these changes, integration of renewables in centralized power grid requires structural changes of the infrastructure, while the addition of prosumers

Figure 2. Urban population, Rural population and GDP per capita

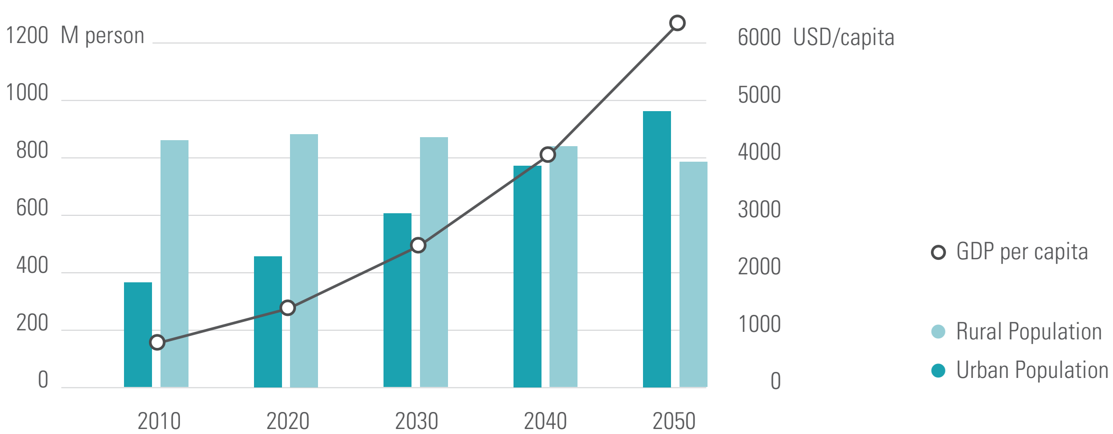
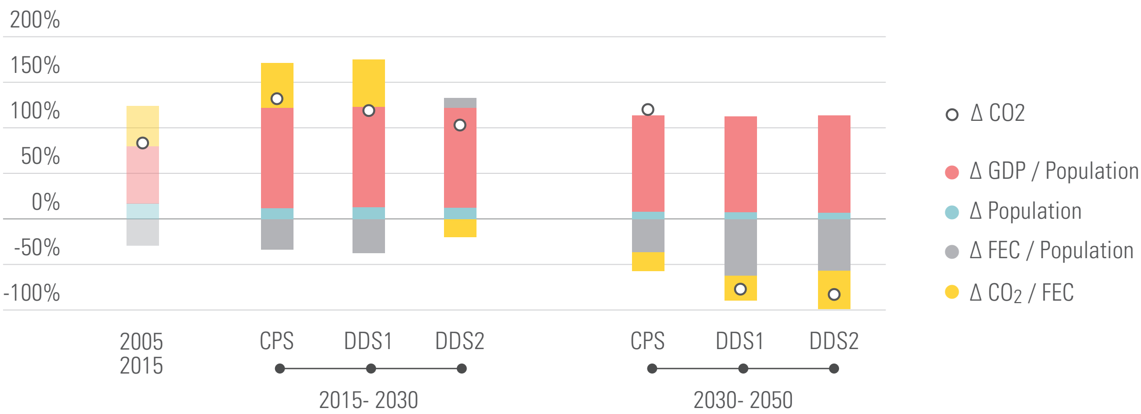


Figure 3. Decomposition of Indian energy-related CO_2 emission changes for historical (baseline, 2005-2015) and future time-frame (2015-2030, 2030-2050) compared to baseline



(providers as well as consumers) also requires change in tariffs, and subsidy policies at national, subnational and local level.

SECTORAL DEEP DIVES

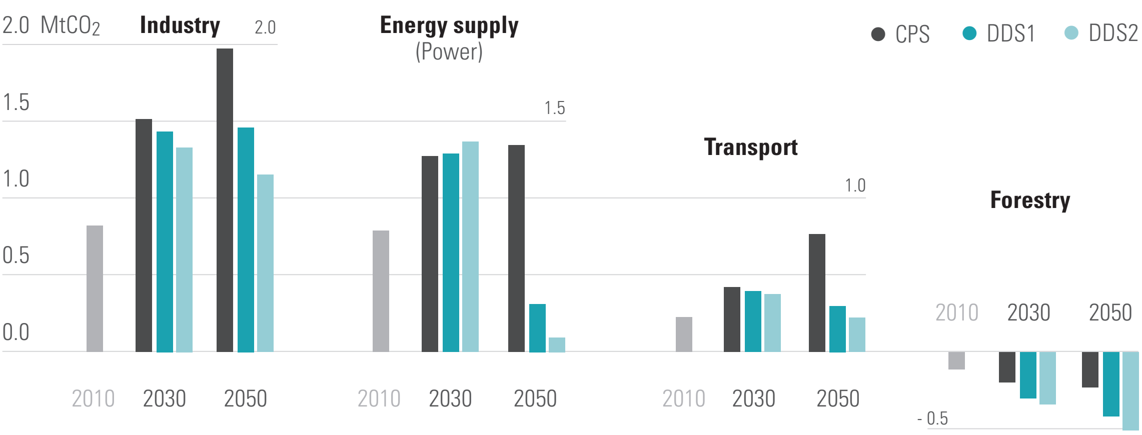
Decarbonization across all sectors will play an essential role in short, medium and long term. In 2016, electricity production constituted 40% of total GHG emissions followed by industry sector (18.7%), agriculture (14%) and transport (13%); whereas LULUCF removed 15% of country carbon dioxide emissions. For India, **power sector is the largest contributor to emission reductions followed by transport, industry and forestry sector in CPS scenarios** (Figure 4).

Power

Decarbonization of electricity sector is essential to move towards carbon-neutral India in DDS scenarios, as it subsequently impacts end-use sectors (transport, industry and building). Currently, India has the fourth largest wind capacity and the fifth largest solar generation capacity in the world.

Electricity generation will increase by four times in 2050 when compared to 2010. The share of fossil-fuel based generation capacity has declined from 66% in 2006 to 61% in 2020. A considerable shift is being observed towards non-fossil fuel-based generation due to increase in renewable generation capacity target from 100 GW in 2010 (to be achieved by

Figure 4. Sectoral CO_2e emissions (million tonnes)



2020) to 175 GW in 2015 (to be achieved by 2022) to 450 GW in 2019 (to be achieved by 2030). In DDS scenarios, a major decrease in CO_2 emissions is observed due to a shift towards nuclear, renewables with storage (due to ambitious targets) and large hydro, energy efficient capacity, and improvement T&D losses. The shift to alternative sources will result in the increase of coal and gas stranded assets by 2030s and 2040s in DDS2 and DDS1 scenarios respectively. The average carbon intensity of electricity of 721 gCO_2 per KWh (2010) reduces to 372 gCO_2 per KWh in 2050 under CPS scenarios, to 107 gCO_2 per KWh and 77 gCO_2 per KWh under DDS1 and DDS2 scenarios respectively.

Industry

Industry is second largest contributor to India's economy. The emission shares increase to about 36%, 51% and 50% in CPS, DDS1 and DDS2 scenarios respectively in 2050. The increase in share is due to coal, natural gas used for fuel combustion and emissions from industrial processes especially in the steel and cement industry. This is due to drastic reduction of carbon emissions in power sector. Overall, decoupling of industrial activity is observed due to a drastic decrease in carbon intensity of energy intensive industry. Emissions can be decreased in select 'heavy industries' through a combination of material efficiency, energy efficiency, product substitution, demand reduction and installation of carbon, capture and storage (CCS) units.

Light industry (including non-specific industries) contributed to almost 45% of the emission share in 2016. The share of light industries increases to 49%, 44% in CPS, DDS1 and decreases to 36% in DDS2 in 2050. It is observed that unlike power, it is difficult to abate overall emissions in both energy intensive and light industries with ratcheting the current energy efficient policies and shift to natural gas, and electricity.

Transport

Modal shift is key to decarbonization of the transport sector and subsequent foreign exchange savings. Indian Railways is the largest network in the world and is projected to account for 40% of the total global share of rail activity by 2050. The modal share in freight is projected to increase from 27% to 45% in 2030. India also has the second largest road network in the world. DDS1 and DDS2 scenarios assume a modal shift towards rail. Till 2030, road is assumed to be the dominant transport mode in both scenarios holding a share of 53% and 50% for DDS2 and DDS1 respectively. However, by 2050, rail transport will be the preferred mode in DDS2 and DDS1 scenarios with a modal share of 51% and 49% respectively. The DDS1 scenario reduces the fossil fuel demand by 68% in 2050 compared to 2012, thus leading to foreign exchange savings of 5.8 trillion US$.

The transport sector accounts for 13.3% of total energy CO_2 emissions with road transport dominating the mix with 90.1% share of total transport emissions. In road transport, almost 2/3rd gasoline consumption is by two- and three-wheelers. They have to be therefore targeted first for conversion to EVs. In the baseline year, fossil fuel-based vehicles hold the highest share in the freight sector for service demand procurement. However, with the ongoing policy and schemes, EVs are expected to increase over the years gaining dominance by 2050. In the LCV category, EVs will hold a share of 57% and 56% for DDS2 and DDS1 scenarios respectively. For the rigid HCVs, the share will be 56% and 55% in DDS2 and DDS1 respectively. However, for the articulated HCVs, EVs will not be the most preferred vehicle due to high cost constituting a share of 44% and 40% in DDS2 and DDS1 respectively.

The overall emissions in the sector will reduce by about 60% in DDS2 compared to CPS in 2030 and by about 85% in 2050. The emission reduction of 8.8 $BtCO_2$ can be achieved for the 2013-2050 from passenger transport, and freight transport contributes 5.6 $BtCO_2$ emission reduction in DDS2 scenario. Actions taken towards improving the urban transit infrastructure, implementing the projects related to metro rail and efficient technologies lead to a 16% emission reduction in the transport sector in 2050 compared to that in 2013. Freight transport by dedicated freight corridors and setting up of multimodal logistic parks contributes 8.4% reduction in transport sector emissions. Apart from this, adoption of biofuel blending and higher efficiency of vehicles and shift towards electric vehicles lead to a reduction of 6.9% and 26.7%. Shift towards electric vehicles makes the highest contribution to the emission reduction amounting 42%.

Introduction and scaling up of hydrogen as a fuel will require investment in R&D, technology transfer and financial investment. Fossil fuels dominate the energy share: accounting for 84% of total fuel consumption of the transport sector in CPS in 2050. However, there is a significant reduction, amounting to a 68% decrease in 2050 compared to baseline in the fossil fuel share under DDS2 scenario. In DDS1 and DDS2 scenario, hydrogen gains interest in the transport sector as an alternative fuel technology by 2050 with 4.37% and 6.34% share respectively. Interestingly, there is a sharp shift towards electrification with the share of electricity reaching 97% by 2050 in the DDS2 from the insignificant share of 1.6% in 2012.

Agriculture, Forestry, and Land use

Agriculture contributed to ~14% of national annual GHG in 2016. In contrast to energy systems where CO_2 is the main GHG emission, methane and nitrous oxide are the main emissions from agriculture sector. The emissions from the agriculture sector reduces from 574 $MtCO_2e$ in CPS, to 462 $MtCO_2e$ and 312 $MtCO_2e$ in 2050.

Landuse, Landuse change and Forestry (LULUCF) removed around ~15% of GHG emissions in 2016. The forest area comprises little more than one fifth of (20%) of its geographic area, more than 50% of its population depends on agriculture. Despite its large population density, India is largely successful in keeping deforestation at bay; however, it limits the increase of forest area for climate change mitigation and sustainable development. In this context, we argue that agro-forestry or trees on farmer's lands present a unique opportunity for growth of green cover and climate change mitigation for the South Asian countries by the 2050s and beyond. In CPS, carbon sequestration in Indian forests will increase from about 115 $MtCO_2e$ to 231 $MtCO_2e$ per year from 2015 to 2050. In DDS1 and DDS2 scenarios, it increases to 420 and 510 $MtCO_2e$ in 2050. Major mitigation opportunities come from planting of trees outside forests (ToF), expansion of forests (afforestation & reforestation), densification of existing forests in that order respectively.

Indian soils are generally poor in soil carbon content, hence increasing soil carbon in croplands presents a win-win scenario for improving yields and food security as well as for carbon dioxide removal. Soil carbon improvements are considered *via* two pathways, one being plantation of Trees outside Forests (ToFs) or expansion of agro-forestry on additional 15 Mha till 2050 (today ToF area in India stands at 10 Mha)–so that total ToF area in India increases to 25 Mha. This increment in soil carbon is rather straight-forward and associated with less uncertainty (up to 15-20 $MtCO_2$ per year in 2050). Another pathway being no tillage, nutrient recycling, and mauring on other croplands. This presents an additional 45-50 $MtCO_2$/yr of mitigation opportunity in 2050. However, this soil carbon increment is associated with larger uncertainty. Soil carbon monitoring and accounting is better positioned in India today with the initiation of the Soil Health Card Scheme (https://www.soilhealth.dac.gov.in) by the Central Govt. in 2015.

PART 2: KEY POLICY LESSONS

India's current NDC have been consistent with on-going development and economic policies. Under the Energy Conservation Act of 2001, India has been on the mission to make its energy systems technical and fuel efficient. The National Action Plan on Climate Change (2008) and Nationally Determined Contribution (2015) have played an active role not only in enhancing this mission but also playing a crucial role in reducing overall carbon emissions.

Feasibility of deep decarbonization scenarios is dependent on various factors, the most important of which being incremental mitigation targets, technologies (CCUS, hydrogen, nuclear, coal to other chemicals, smart grid, transformational urban planning), **socio-economic-political considerations, and financial support commitments** (domestic and international).

PRIORITY SHORT-TERM POLICIES AND ACTIONS

Coal

Coal currently is the backbone of India's energy systems. India is the second largest coal consumer of coal in the world. Coal consists of 56% of India's energy supply (2018), 72% of power supply (2020) and 54% of generation capacity share (2020). The deep decarbonization scenarios estimate phasing out of coal to be one of the primary drivers of emission reduction to move towards 1.5C Paris compatible pathways and carbon neutrality around 2080s. This move will need socio-economic and structural transformation leading to transitioning to cleaner sources of energy in power and industry and other end-use sectors. This will both induce clean air and better human health, and simultaneously impact employment and associated sources of revenues of coal mining districts, states (~35-45% revenue) and railways (~40% revenue).

Policies and actions by government, largest public sector undertakings and private firms have already committed to Paris climate goals and carbon neutral targets. For example: Coal India Limited, India's largest PSU plans to become net-zero by this decade. India will still need at least a minimum of 200 Mt of coking and non-coking coal imports due to domestic demand-supply gaps, even if the central government retains the suggested zero-import policy for steam coal. However, off late coal mine e-auctions have not attracted players for over 50% mines put on the block. This could be an indicator that coal mining under current circumstances and environment is not considered attractive.

Stranded assets in the form coal investments already made (e.g. plants, mines, transport) could increase as consequences of selected alternate pathways. Coal value chains directly and indirectly impact about 20 million plus people in India. It is a source of revenue for eastern and south-central states. **Coal transitions will impact locality, states, regions and people at social, political and economic level if implemented in a haphazard manner.** India is aware that it will require multiple discussions and due diligence to adhere to the just transition principles to transform the entire coal value chain especially its coal mining sector. There needs to be a long-term vision (30-50 years) and mission in place to explore the transition towards alternative and lucrative sources of employment for unskilled and skilled labour, in addition to diversification to alternative lucrative businesses and revenue for cities, states, private firms and Indian railways. Simultaneously, the entire Indian fossil-fuelled energy infrastructure needs to be transformed to non-fossil fuel based, resource efficient, environment friendly, affordable, sustainable and accessible energy systems. Acts, Missions, policies and programmes need to be developed which not only support the processes for these transformation through policies and investments but also explore traditional, hybrid, innovative and radical modes of implementation at various temporal and geographical scales.

Power

Deep decarbonization in India hinges on the power sector moving from a carbon intensity

of about 0.8 tCO_2/MWh to a range between 0.1 to 0.3 tCO_2/MWh. Decarbonization of transport, building, agriculture and to a certain extent industry is significantly dependant on the shifting from fossil fuels (coal, diesel, petrol) towards decarbonized electricity and other alternative sources of energy.

Early action in the current decade may avoid long-term carbon-intensive lock-ins, however will also result in stranded (coal, gas) infrastructure, labour and regions. Actions include shifting to gas economy (as transition fuel), increased nuclear (for shift in base load) and large hydro (water and siltation challenges). Each of these options need to be available during the course of transitions in the next three decades. Policy support (regulatory, economic instruments) is required to promote R&D in technology, markets and capacity building for renewables, battery storage, grid integration and grid flexibility. Stranded assets in the form coal and gas based power plants will increase as a consequence of selected deep decarbonization pathways. Power sector in India is consciously diversifying to add renewables in its portfolio and actively addressing the implementation challenges of grid flexibility and integration at pilot level. In the short term, the challenges that need to be addressed include fuel availability (gas), production, storage (hydrogen, renewables), capital intensive (nuclear, large hydro), costs (storage battery), resource availability (critical minerals, land) and waste (nuclear, battery). Nuclear energy could help replace coal as base load for national power grid, thus, supporting very deep decarbonization leading to even net-zero. Therefore, domestic nuclear sector needs international support to make India a part of nuclear supplier group (NSG). Technology transfer and financial support should be provided.

Industry

Industry will be one of the 'difficult to abate' sectors' in India. Mitigation action implemented by large plants in energy intensive industries need support policies from the government like Perform, Achieve and Trade (PAT) schemes to achieve deeper decarbonization. Additionally, light industries and MSMEs will represent a large share of residual emissions in 2050, hence will require innovative finance and technologies to move towards carbon-neutrality. Emissions from coal demand can be reduced by installation of appropriate carbon capture, utilization and storage (CCUS) technologies at select locations and certain activities. It is too early for enhanced coal bed methane (ECBM); no storage feasibility studies have been conducted leading to high geological uncertainty. Enhance oil recovery (EOR) (but not necessarily with CO_2) is currently preferred by oil and gas industry to increase production of near saturating fields. CO_2 utilization for EOR could be an industry level probability but through select demonstration projects. Research shows that **CCUS could be an essential component of Indian energy policy going forward with around 780 Mt mitigation potential each year at under US$60/t-$CO_2$ and around one bt at US$75/t-$CO_2$**.

The use of hydrogen appears to be cost-effective only in chemicals industry in the short term. It is not yet a feasible option for steel industry in India. The Government of India has established a national mission on hydrogen wherein considerable R&D and promotion of hydrogen is included. The Indian industry is also investing heaviliy in green hydrogen. Enhanced nuclear could also facilitate hydrogen economy penetration. **There is a high probability that a part of the 450 GW renewable target could be used to produce green hydrogen**. Technological development and investment across the entire value chain for production, transport and storage of green hydrogen is required. The amount of electricity and water required may become a possible barrier for development and scaling-up of green hydrogen.

Our study indicates a significant amount of emissions from MSMEs based industries. Hence, **there is a need to facilitate the provision of cheaper finance through global financial institutions for climate change actions especially for MSMEs that employ over 110 million people in India**.

Transport

Electric vehicles, fuel efficient technologies in all modes, bioenergy and multi-modal logistics will play a crucial role in decarbonizing the transport sector. Interventions in urban transport such as urban transit infrastructure, metro rail projects and green mobility technologies along with the behavioural shift towards clean, convenient and affordable transport options contribute to emission reduction in the sector. The behavioral shift will be triggered through short-term interventions such as the provision of safe, accessible and affordable public transport services, and involving all stakeholders including the private sector in the transport infrastructure planning; for example the Business Development Units can be set up along the railway infrastructure.

Sustainable transport options include multimodal logistic along the dedicated freight corridors in addition to fuel efficiency improvement, move towards biofuels and electrification. Intensive electrification requires significant investments in the technology development, battery production and charging infrastructure.

The electricity sector must also move towards carbon neutrality in order for the transport sector to achieve the same. India's transport sector needs an overhaul with optimal modal mix, intermodal integration and first mile/last mile connectivity. Short-term actions to achieve this include introduction of uniform regulations across modes which are currently headed by disparate departments, increasing the capacity of railways having high levels of capacity utilization presently, and higher investment in metro projects and public transport services. The biofuels policy offers the opportunity to initiate bioethanol-based BECCUS which is one of the most economical technologies for CCUS. The captured CO_2 could also be utilized for EOR and further studied to inform the policy debate on negative emission technologies. Introduction and scaling-up of hydrogen as a fuel will require investment in R&D, technology transfer and financial investment.

AFOLU

Agro-forestry (Trees outside Forests, ToF) presents one of the largest mitigation potential in India's LULUCF sector till 2050 (132 $MtCO_2$ per year in 2050 under the DDS2 scenario). It can also help India achieving its long-term national goal of bringing 33% of its geographic area under forest and tree cover. Afforestation and reforestation especially reforesting degraded forestlands present one of largest mitigation opportunities for India till 2050 (196 $MtCO_2$ per year in 2050 under DDS2 scenario). Densification of existing forests too presents a significant mitigation opportunity for India in the LULUCF sector.

Indian soils are generally poor in soil carbon content; increasing soil carbon in croplands presents a win-win scenario for improving yields and food security as well as for climate change mitigation. Soil carbon improvements through the plantation of trees ourtside forests and via no tillage, nutrient recycling, maturing, on other croplands provides addtional sink of about 60-70 $MtCO_2$/yr. However, this part is associated with larger uncertainty. There is a need to launch soil carbon enrichment mission for croplands; soil health card scheme could provide an excellent baseline for this mission.

Agriculture is another hard-to-abate sector that needs specific attention from policymakers for not only mitigation actions but also from an impact, resilience building and climate change adaptation perspective. Almost 70% of the population in India depends on agricultural income. Hence, the extensive practices of cultivation and livestock rearing would remain. The penetration of neem-coated urea and nano- fertilizers are expected to have N_2O mitigation (~50%). Cross breeding programmes as well as systemic efforts to promote cattle feed options that help mitigation of CH_4 emissions from enteric fermentation need to be stressed upon. Promotion of manure management systems and technologies would support mitigation efforts from livestock rearing. Management of rice watering schedule helps reduce CH_4 emissions e.g. alternate wet and dry irrigation rather than continuous flooding reduced the methane production.

SYNERGIES AND TRADE-OFFS WITH NON-CLIMATE OBJECTIVES

India is committed to achieve its SDG and NDC goals by 2030. The Indian government stresses on meeting both development goals and climate targets. The current study integrates water, energy and carbon systems to model SDG-NDC linkages. Implementing NDC policies will result in the achievement of targets under SDG3, SDG6, SDG7, SDG8, SDG9, SDG11, SDG13 and SDG15. On the other hand, achieving the SDG targets can help accomplish resource-use efficiency goals in addition to NDC and Paris Agreement goals (as these targets are a subset of SDG13.

SDG13, SDG7, SDG15 are highly synergistic with NDC. SGD 3 and SDG6 will be subsequently impacted as we achieve the current NDC. At the same time, SDG16 (peace, justice, strong institutions) and SDG17 (global cooperation) are required to attain both SDGs and NDC. Sub-targets under SDG1, SDG2, SDG6, SDG8, SDG9, SDG11, SDG12, SDG15 are the drivers that have been used to model India's energy-economy-environment systems in this study. SDG4 (education and awareness especially pertaining to environment) impacts the achievement of all the SDGs as well as NDC. More work is required to capture the impact of SDG5 (gender equality), SDG10 (reduced inequalities), and SDG14 (life below water) on the current NDC. **Table 2** presents synergies and trade-offs with non-climate objectives.

Deep decarbonization will result in ratcheting up the mitigation actions (SDG13), with higher share of renewables and increased energy efficiency (SDG7), in addition to increased afforestation, reforestation (SDG15). The scenario will require innovation in industry (SDG9), transit-oriented, sustainable cities (SDG11), through responsible production and consumption (SDG12). Water efficient technologies in agriculture (SDG6) and dry cooling systems in power sector need to be installed simultaneously. The immediate impact from non-fossil fuelled energy systems will be clean air (SDG3). Like NDC, decarbonized pathways will require stronger institutions (SDG16) with bilateral and multilateral international cooperation (SDG17).

As a developing country, India will be a) urbanized and b) a significant section of the society with transition from low to middle income and middle to high income society. Hence, the **achievement of SDGs will be a work in progress to improve the standard and quality of life at both household and individual level**. Deep decarbonization scenario (DDS1) aligns

Table 2: Synergies and tradeoffs with climate and non-climate objectives

SDG	Power	Industry	Transport	Agriculture	Forestry	Comments
13 Climate action	High synergy / Model analysis	High synergy / Model analysis	High synergy / Model analysis	High synergy / Model analysis	High synergy / Model analysis	High. The synergies will be cross-sectoral. As stated earlier, India's NDC integrates climate change mitigation and adaptation measures into its national policies, strategies and planning.
7 Affordable and clean energy	High synergy / Model analysis	High synergy / Model analysis	High synergy / Model analysis	High synergy / Model analysis	Neutral / Model analysis	High. SDG sub-targets complement the NDC goals for renewables and energy efficiency.
15 Life on land	Neutral / Not analyzed in this project	Neutral / Not analyzed in this project	Neutral / Not analyzed in this project	High synergy / Model analysis	High synergy / Model analysis	High. SDG sub-targets complement and are synergistic with NDC goals in agriculture and forestry sector.
3 Good health and well-being	High synergy / Not analyzed in this project	High synergy / Not analyzed in this project	High synergy / Not analyzed in this project	High synergy / Not analyzed in this project	High synergy / Not analyzed in this project	High. Achievement of NDC targets will lead to improve local air quality.
16 Peace, justice and strong institutions	High synergy	High synergy	High synergy	High synergy	High synergy	High. String insitutions are required for timely implementation of policy instruments.
17 Partnerships for the goals	High synergy	High synergy	High synergy	High synergy	High synergy	High. Majority of the technological solutions (EV, hydrogen, CCUS) require strong international collaboration.
8 Decent work and economic growth	Moderate synergy / Out of model analysis	Moderate synergy / Out of model analysis	Moderate synergy / Out of model analysis	Moderate synergy / Out of model analysis	Moderate synergy / Out of model analysis	Moderate.
9 Industry, innovation and infrastructure	Moderate synergy / Out of model analysis	Moderate synergy / Out of model analysis	Moderate synergy / Out of model analysis	Moderate synergy / Out of model analysis	Moderate synergy / Out of model analysis	Moderate.
11 Sustainable cities and communities	Moderate synergy / Not analyzed in this project	Neutral / Not analyzed in this project	Moderate synergy / Not analyzed in this project	Moderate synergy / Not analyzed in this project	Moderate synergy / Not analyzed in this project	Moderate.
12 Responsible consumption and production	Moderate synergy / Out of model analysis	Moderate synergy / Out of model analysis	Moderate synergy / Out of model analysis	Moderate synergy / Out of model analysis	Moderate synergy / Out of model analysis	Moderate.
6 Clean water and sanitation	Moderate synergy / Model analysis	Moderate synergy / Model analysis	Moderate synergy / Model analysis	Moderate synergy / Model analysis	Neutral	Moderate.

- High synergy
- Moderate synergy
- Neutral
- Moderate tradeoff
- High tradeoff

- Model analysis
- Out of model analysis
- Not analyzed in this project
- Not applicable

with the Sustainable Development Goals and development policies to address issues of energy security and air pollution. **Table 3** presents the extension of SDG goals to 2050.

INVESTMENT PATTERNS

India puts in about USD 100 billion each year for climate adaptation and ring-fencing its population and systems. This is likely to touch USD 360 billion by 2030. In accordance to Article 9 (paragraph 3) of the Paris Agreement, the developed countries need to provide financial assistance to developing countries of USD 100 billion annually till 2025, and much more beyond 2025 to the green climate for both mitigation and adaptation actions. For developing countries to enhance their mitigation commitments, additional financial flow would be required from developed countries. The CPS scenario for India may require an investment of around US$ 120 billion per year during 2020-2030 (Total ~ US$ 1.2 trillion). The 2C and well below 2C is projected to be US$ 160 – 270 billion per year during 2020-2030 (Total ~ US$ 2.1 trillion). Net-zero by 2050 will require US$ 160 – 260 billion per year during 2020-2040 (Total ~ US$ 4.2 trillion), while net-zero by 2065 will require US$ 120 – 140 billion per year during 2020-2045 (Total ~ US$ 3.3 trillion).

Green finance, innovative finance, internal carbon pricing, risk sharing instruments and carbon markets will play a crucial role for the implementation of DDS scenarios. Policies will need to be implemented in an integrated manner across ministries and sectors. (EV: Power, Transport, Solar PV: Power, Industry, Agriculture, Building, Hydrogen). At the same time, public and private institutions need to a) de-risk investments to mobilize finance at scale for technologies and strategies that aim at mitigation, adaptation and sustainable development actions; and b) mainstream the climate risks and opportunities into decision making.

Enhanced commitments by large industrial houses along with government push/facilitation could be deciding factors. The central government needs to signal and encourage the industry (large, MSMEs) to include ambitious mitigation actions in

Table 3: SDG indicators across scenarios in 2050

SDG	Indicator	CPS	DDS1	DDS2
7 AFFORDABLE AND CLEAN ENERGY	7.1 Percentage of households electrified	As of 2019, all villages have been officially electrified. However, there are at least 10-15 million households left to be electrified. So, all scenarios assume that all households are electrified by 2025.		
	7.1 Percentage of household with cleaning cooking fuel	100% by 2035	100% by 2030	100% by 2025
	7.2 Renewable share in total energy mix (% of GW)	55%	59%	63%
	7.3 Energy intensity in terms of primary energy and GDP	7.2	4.9	3.5
8 DECENT WORK AND ECONOMIC GROWTH	8.4 Percentage Renewable share in total final energy mix	55% by 2050	59% by 2050	63% by 2050
	8.4 Per capita fossil fuel consumption (in GJ/capita/year)	45.3 by 2050	31.1 by 2050	22.3 by 2050
13 CLIMATE ACTION	13.2 Pre 2020 action achievement of pre 2020 goals as per country priority	In terms of emission pathways, India has achieved its commitment to Copenhagen Accord 2009.		
	13.2 Achievement of NDC goals post 2020	In terms of emission pathways, India is the only country on track to move towards a global 2C world. All scenarios NDC (conditional, unconditional) goals before 2030. Forest sector NDC achievement is in-built in the CPS as well as all the three other scenarios.		
15 LIFE ON LAND	15.1 Forest area as proportion of land area	25.5%	32%	33%
	15.2. Area of trees outside forests	10 Mha	25 Mha	25 Mha
	15.3 Increase in Forest area in 2050 compared to 2015	6 Mha	8 Mha	13 Mha
	15.4 Percentage of degraded area restored (Bonn Challenge)	We assume Bonn Challenge has been achieve in CPS scenario. India originally pledged to restore 21 Mha over the period 2014 to 2030. It planned to restore 13 Mha over 2014 to 2020 and another 8 Mha from 2020 to 2030.		
	15.5: Restoration of soil carbon	Cropland soil carbon remains low	Cropland soil carbon increases by 2 MgC/ha	Cropland soil carbon increases by 3 MgC/ha

their short-term and long-term strategies through tax rebates and similar economic instruments to make them competitive in the short term. Domestic manufacturing should be strongly encouraged for solar PVs, batteries, and hydrogen technologies.

KEY INTERNATIONAL ENABLERS AND ACCELERATORS OF DOMESTIC TRANSITIONS

India will not be net zero by 2050 under all scenarios. For the world to be net zero by 2050, the developed countries therefore need to have ambitious plans to be net-negative energy systems. Additionally, more work is required on the management of carbon sinks (natural and geo-engineered). We need to **involve multi-national/trans-national businesses and industry** in climate change discussions and actions (for technology transfer, financial investment and capacity building).

International support and facilitation is required to create a vibrant carbon market in India, and link it with other carbon markets around the world. This will enhance economic efficiency of GHG mitigation all over the world. The Paris agreement Article 6 covering Internationally Transferred Mitigation Options (ITMOs) could also be a relevant mechanism for this. **Some of the top Indian businesses have committed to become net zero and internalize carbon price gradually**, but it must be an international consolidated expression by large businesses.

It is evident that the future of coal in each scenario hinges on the developments in power sector in the coming decades. It is also observed that the industry sector will also become more efficient, however it will still be hard to abate emissions due to coal and industrial processes without significant investments in alternative technologies.

Deep decarbonization in India and the move towards carbon neutrality hinges primarily on the power sector. End-use sectoral deep decarbonization especially transport, building and industry is significantly dependent on shifting to electricity. Decarbonized electricity decreases the overall emissions by 1-1.3 Bt CO_2 in 2050 in DDS1 and DDS2, when compared to CPS. Future of coal use and mitigating climate change are closely interconnected, and more so for coal-dependent economies like **China, India, USA, Germany, Russia, Japan, South Africa, South Korea, Poland, Australia, Turkey and Indonesia, which together account for over 88% of global coal extraction and use per year. Coal is a global concern, therefore the solution to phasing out of coal should also be global.** Individual coal-dependent countries, especially developing countries, would be concerned with their energy security and economic-social-political compulsions. These countries may continue with coal until provided with international support through clean technology transfers, financial investments and associated capacity building to move towards a decarbonized economy.

India ranks third in crude oil import netting around 4,544 bpd as of December 2018. It imports from Iraq, Saudi Arabia, Venezuela and Nigeria. Imports from African countries such as Angola, Cameroon and Chad decreased by 18% of total energy consumption due to high international prices. Oil consumption share in the energy fuel mix was around 29% in 2017. **Our study projects a decrease in oil demand after 2030 due to a shift towards electric vehicles (2W, 3W, 4W, buses, Metro, Train). Pricing of oil impacts pricing of natural gas (Henri Hub, NBP, Japanese market).** Natural gas makes up only 6% of energy consumption in 2017, however imports for the liquefied natural gas (LNG) increased 9.7% year-on-year. India currently imports around half its gas, largely from Qatar, the US, Australia and Russia. CPS and DDS1 scenarios rely on natural gas for base load. Hence, pricing of oil and natural gas (energy commodities) will also be an important market mechanism to transition towards a low-carbon/carbon neutral society.

Developed countries and India will need to collaborate for incentivising solar (power, building), wind (power), BECCUS (power, industry, agriculture), and green hydrogen fuel transformation (industry, transport) technologies in the next 2-3 decades. There is a need to create a common technology development pool (battery storage, grid integration, electric vehicles, CO_2 capture utilization and storage (CCUS), hydrogen, advanced bioenergy and nuclear power) in which industrialized and developing countries are equal partners. These technologies are required to upscale DDS scenarios for even earlier net zero by India. South-South collaboration is also possible between India, other developing and least developing countries especially in South East Asia and Africa for solar and bioenergy.

The Indian Ministry of science and technology currently supports three bi-national science and technology (S&T) centres which are independent entities established under inter-governmental bilateral agreements with France, USA and Germany. Presently India has bilateral S&T cooperation agreements with 83 countries. During recent years the cooperation has strengthened significantly with Australia, Canada, EU, France, Germany, Israel, Japan, Russia, UK and USA. Nature of access to technology development, production and manufacture depends on ownership of technology and the financial mechanism in which the technology is transferred. The types of mechanisms include trade, FDI, JV, licensing agreement, strategic acquisitions and alliances, overseas R&D, joint R&D and local innovation. For example, moving towards a hydrogen fueled economy will become viable only through international support, even as the source of hydrogen (blue or green) will be highly debated for the coming decade.

DDP

The DDP is an initiative of the Institute for Sustainable Development and International Relations (IDDRI). It aims to demonstrate how countries can transform their economies by 2050 to achieve global net zero emissions and national development priorities, consistently with the Paris Agreement.. The DDP initiative is a collaboration of leading research teams currently covering 36 countries. It originated as the Deep Decarbonization Pathways Project (DDPP), which analysed the deep decarbonization of energy systems in 16 countries prior to COP21 (deepdecarbonization.org). Analyses are carried out at the national scale, by national research teams. These analyses adopt a long-term time horizon to 2050 to reveal the necessary short-term conditions and actions to reach carbon neutrality in national contexts. They help governments and non-state actors make choices and contribute to in-country expertise and international scientific knowledge. The aim is to help governments and non-state actors make choices that put economies and societies on track to reach a carbon neutral world by the second half of the century. Finally, national research teams openly share their methods, modelling tools, data and the results of their analyses to share knowledge between partners in a very collaborative manner and to facilitate engagement with sectoral experts and decision-makers.
www.ddpinitiative.org

IIM AHMEDABAD

The establishment of the Indian Institute of Management Ahmedabad (IIMA) aims to continue to be recognized as a premier global management school operating at the frontiers of management education and practice while creating a progressive and sustainable impact on society. IIMA supports its vision by placing emphasis on a high-performance work environment, supported by a culture of autonomy, creativity and collaboration amongst its faculty members, staff and students. As the Institute engages in its objectives, it will ensure that its research and teaching activities continue to address diverse areas which are of concern to varied sections of society.
The Public Systems Group (PSG) at IIMA is an interdisciplinary group with a focus on the generation and dissemination of knowledge concerning the public sphere, the performance and management of public systems, the formulation and implementation of public policies, their societal determinants as well as consequences. In the field of Energy and Environment, policy research is carried out in close interaction with various ministries of the Government of India, industry associations and international organizations. Some prominent areas of research include climate finance, energy businesses, corporate accounting of greenhouse gases, energy and environment modeling, water-energy nexus, preparing businesses, state and central government for climate change mitigation and adaptation challenges.

https://www.iima.ac.in

IDDRI

The Institute for Sustainable Development and International Relations (IDDRI) is an independent, not-for-profit policy research institute based in Paris. Its objective is to identify the conditions and propose tools to put sustainable development at the heart of international relations and public and private policies. IDDRI is also a multi-stakeholder dialogue platform and supports stakeholders in global governance debates on the major issues of common interest, such as actions to mitigate climate change, protect biodiversity, strengthen food security, and to manage urbanisation. The institute also participates in work to build development trajectories that are compatible with national priorities and the sustainable development goals.

www.iddri.org