27th AIM International Workshop

GHG Mitigation for India: Status and Way Forward

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India's NDCs (2005-2030)

1. To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation.
2. To adopt a climate friendly and a cleaner path than the one followed hitherto by others at corresponding level of economic development.

3. **To reduce the emissions intensity of its GDP by 33 to 35 per cent by 2030 from 2005 level.**

4. **To achieve about 40 per cent 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).**

5. **To create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030.**

6. To better adapt to climate change by enhancing investments in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management.
7. To mobilize domestic and new & additional funds from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap.
8. To build capacities, create domestic framework and international architecture for quick diffusion of cutting edge climate technology in India and for joint collaborative R&D for such future technologies.

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Development priority + India raising its NDC ambitions

	Measures	Pre-Paris	Post-Paris
Power	National Solar Mission Renewable Energy Retirement of Coal Plants T&D Losses reduction	20 GW by 2022 20 GW of Solar by 2022 No initiative No scheme was present	100 GW by 2022. 175 GW by 2022 and 450 GW by 2030. 170 thermal generation units retired by 2018. Ujwal Discom Assurance Yojana (UDAY) scheme, reduce losses to 15%.
Industry	Perform, Achieve and Trade (PAT)	PAT Cycle I (2012-13 to 2014-15) with 478 designated consumers (DCs) across 8 sectors	PAT Cycle II (2016-17 to 2018-19) with 621 designated consumers (DCs), across 11 sectors i.e. 3 new sectors (petroleum refinery, railways and DISCOM).
Transport	Electric Vehicle Ethanol Blended Program Metro Rail Freight Rail Road Construction Speed	No scheme was launched 5% Ethanol Blending Metro rail coverage is limited to 4-5 major cities of India. No scheme. ~11 km/per day	The number of electrified two-and three-wheelers has grown by more than 60% each year on average since 2015. 30:30 target 10% Ethanol Blending by 2022 and 20% by 2030 In 2020, over 650 km of metro rail was operational in 18 cities of India. Dedicated freight corridor: Increase freight rail share to 45% ~28 km/per day
Buildings	Standards and Labeling programme LPG Connection Green Buildings Buildings Energy Efficiency Programme	It covered sectors such as air conditioners, ceiling fans, refrigerators, TVs No scheme was launched No scheme was launched No scheme was launched	Currently, the programme covers 26 appliances of which 10 appliances are under the mandatory regime. As on December 2020, a total of 287.4 million households have LPG connections (including PMUY beneficiaries). Green building footprint was 7.61 billion sq.ft. with total number of 5918 green buildings as on October, 2020 Building energy efficiency projects completed in 10,344 buildings including Railway stations and Airports till May 2020.
Agriculture	Neem Coated urea application Energy Efficient Pump Programme	No production of neem coated urea Only 2209 pump sets have been replaced in pilot project at Solapur district.	Both imported and indigenously produced urea available in the country is neem coated since 2016. N2O emissions reduce by ~20% 74,136 pumps have been installed by EESL
Waste	Sanitation (Swachh Bharat Abhiyan)	No scheme was launched.	More than 6.2 million individual toilets and 0.59 million community and public toilets have been constructed.
Water	Micro-irrigation	Area covered under micro-irrigation was 7.73 million hectare till 2015.	Area covered under micro-irrigation was 8.7 million hectare till November 2019.

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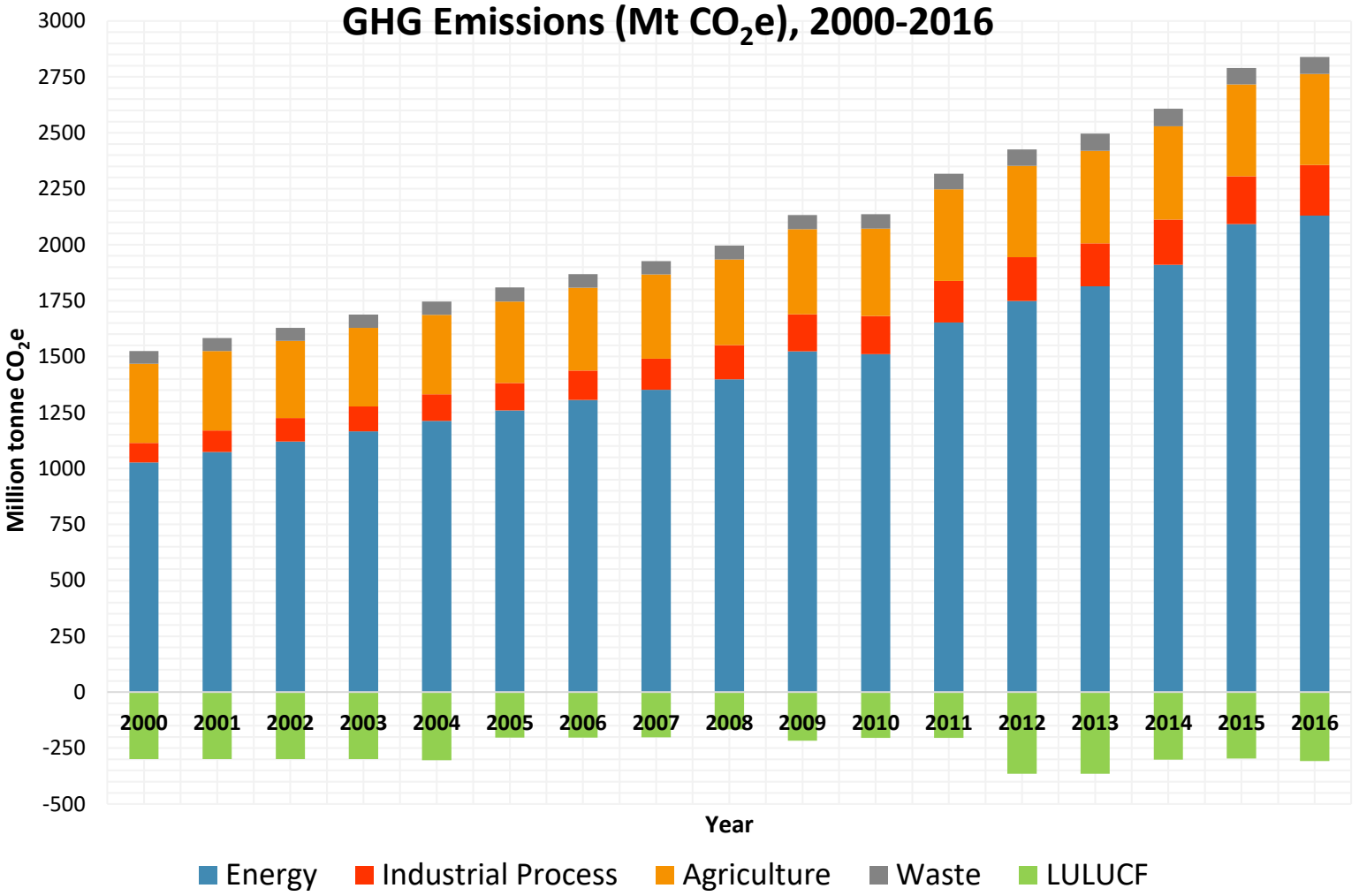
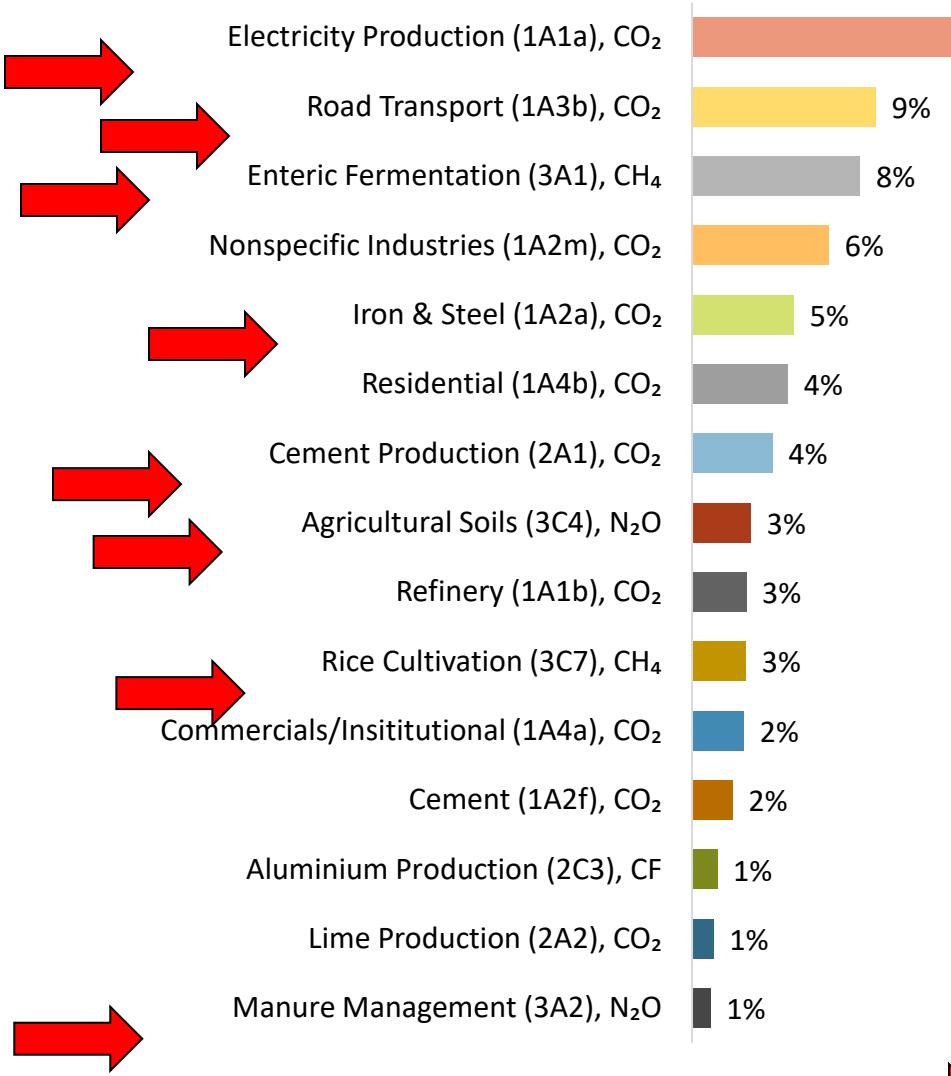
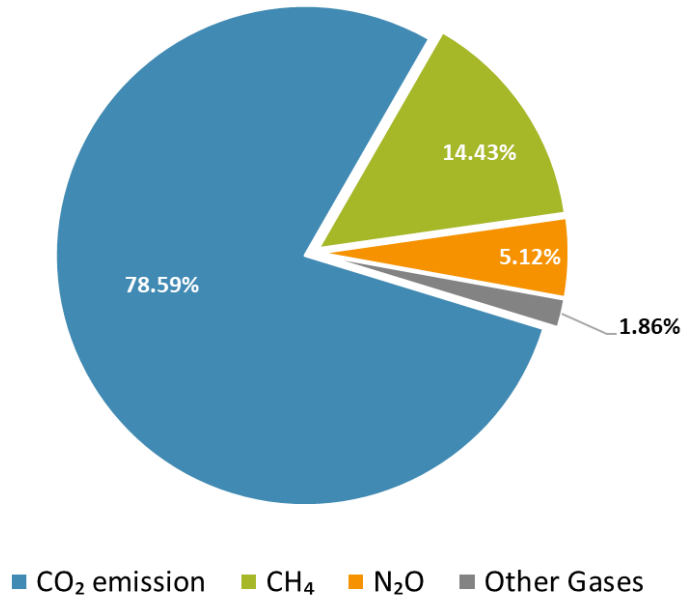
Sector wise GHG Emission (Mt CO_2e)



Source: India's BUR-3 (MOEFCC 2021)

Category-Gas wise GHG Emission (2016)

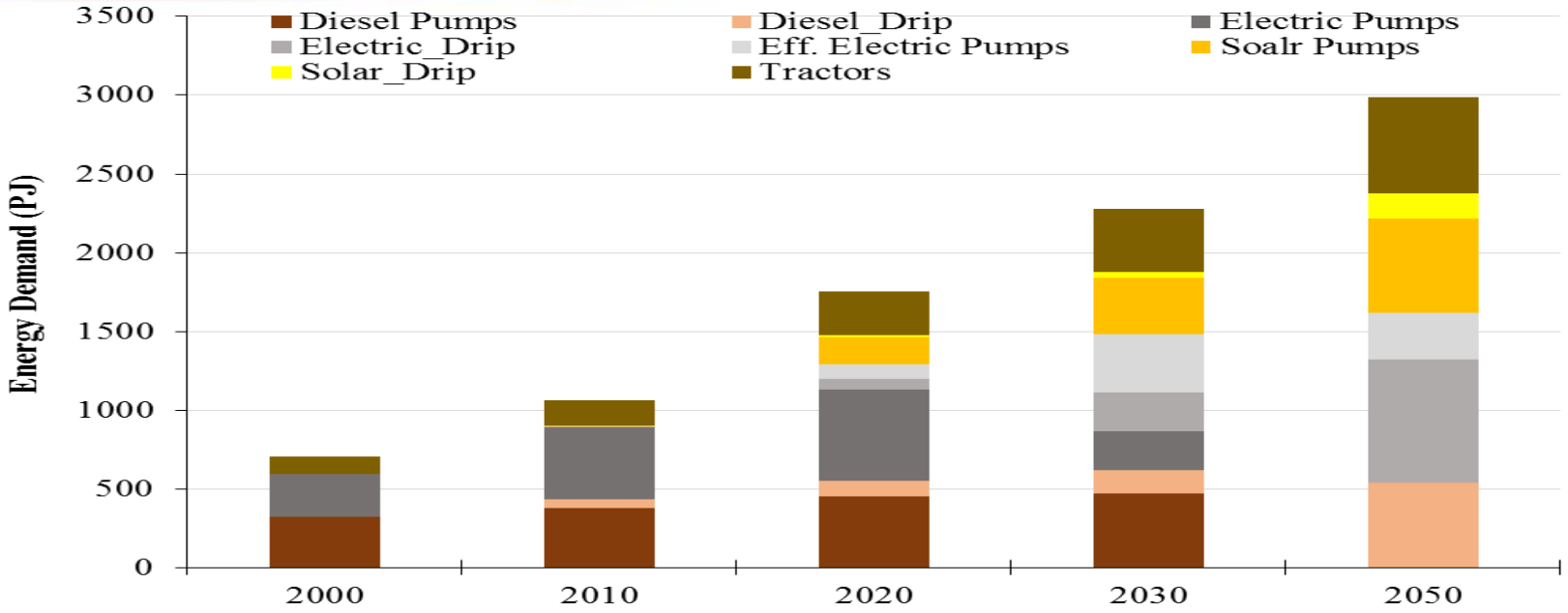




Difficult and challenging to abate

Source: India's BUR-3 (MOEFCC 2021)

Aggressive Net Zero? 2060-2065



Source: Work in progress. Under Embargo. Please do not cite.

	Cumulative CO_2 Budget (Billion ton)	CO_2/capita at 2050 (ton)
NDC	147	2.7
Current Policy (with LULUCF)	136 (125)	2.4 (2.2)
Synchronizing development and Net-zero (with LULUCF)	116 (100)	1.3 (1.01)
Aggressive Push for Net-Zero (with LULUCF)	104 (87)	1.2 (< 1.0)

Reference: Vishwanathan and Garg (2020), India's BUR (2021)

Thank You

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India has been raising its ambition (1)

	Sector	Measures	Pre-Paris	Post-Paris
1	Cross-sectoral, Power	National Solar Mission	20 GW by 2022.	100 GW by 2022.
2	Cross-sectoral, Power	Renewable Energy	20 GW of Solar by 2022.	175 GW by 2022 and 450 GW by 2030.
3	Power	Retirement of Coal Plants	No such intitative	A total of 170 old thermal generation units having a higher heat rate and a cumulative capacity of 10.64 GW, have been retired till March 2018.
4	Power	T&D Losses reduction	No scheme was present	Under Ujwal Discom Assurance Yojana (UDAY) scheme, it is targeted to reduce Aggregate Technical & Commercial (AT&C) losses to 15 per cent by 2018-19. Emission reductions of 7.99 MtCO2 for 2015 and 6.07 MtCO2 for 2016 achieved.
5	Industry	Perform, Achieve and Trade (PAT)	PAT Cycle I (2012-13 to 2014-15) with 478 designated consumers (DCs), resulted in total savings of approximately 13.28 Mtoe and avoided emissions of 31 Mt-CO2. It covered 8 sectors i.e. Aluminium, cement, chlor-alkali, fertilizer, Iron & steel, Pulp & paper, textile, thermal power plant, etc.	PAT Cycle II (2016-17 to 2018-19) with 621 designated consumers (DCs) which resulted in total savings of approximately 13.28 Mtoe, translating into 61.34 Mt-CO2 of avoided emissions. It covered total 11 sectors i.e. 8 sectors of PAT cycle I & 3 new sectors (petroleum refinery, railways and DISCOM). BEE has rolled out six PAT cycles till 31st March, 2020, with a total of 1073 DCs covering 13 sectors. It is projected that total energy savings of about 26 Mtoe translating into avoiding of about 70 million tonnes of CO2 will be achieved by March 2023.

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India has been raising its ambition (2)

	Sector	Measures	Pre-Paris	Post-Paris
6	Buildings	Electricity Saving through Household Appliances	No flagship scheme was present.	As on November 2020, more than 366.85 million LED bulbs, 7.207 million LED tube lights, and 2.340 million energy efficient fans were distributed by EESL across India under the UJALA scheme, which has led to cumulative emission reduction of 180.08 MtCO2 from 2014-15 to November 2020.
7	Buildings	LED Street Light Coverage	No scheme was launched.	Under the Street Lighting National Programme (SLNP), more than 11.25 million LED street lights have been installed until September 2020. The programme has led to a cumulative energy savings of 18.071 billion units and emission reduction of 14.82 MtCO2 from 2015-16 to 2019-20.
8	Buildings	LPG Connection	No scheme was launched.	As on december 2020, a total of 287.4 million households have LPG connections (including PMUY beneficiaries).
9	Buildings	Buildings Energy Efficiency Programme	No scheme was present	Building energy efficiency projects completed in 10,344 buildings including Railway stations and Airports till May 2020. It has led to a cumulative emission reduction of 0.36 MtCO2.
10	Buildings	Green Buildings	Green building footprint was 3.11 billion sq.ft. with total number of 3247 green buildings as on September 30, 2015	Green building footprint was 7.61 billion sq.ft. with total number of 5918 green buildings as on October, 2020
11	Cross-sectoral	Standards and Labeling programme	It covered sectors such as air conditioners, ceiling fans, refrigerators, colour TVs	Currently, the programme covers 26 appliances of which 10 appliances are under the mandatory regime. Overall energy savings of 301 billion units from 2007 to 2018, the equivalent avoided generation is approximately 74 GW during this period. The energy saving achieved under the scheme in the year 2018-19 amounts to 55.7 billion units translating to an abatement of 45.67 MtCO2e emissions.

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India has been raising its ambition (3)

	Sector	Measures	Pre-Paris	Post-Paris
12	Transport	Electric Vehicle	No scheme was launched.	The number of electrified two-and three-wheelers has grown by more than 60% each year on average since 2015, and there were 1.8 million such vehicles in 2019.
13	Transport	Ethanol Blended Program	5% Ethanol Blending	10% Ethanol Blending by 2022 and 20% by 2030.
14	Transport	Metro Rail	Metro rail coverage is limited to 4-5 major cities of India.	In 2020, over 650 km of metro rail was operational in 18 cities of India.
15	Transport	Road Contruction Speed	~11 km/per day	~28 km/per day
16	Transport	Bus Rapid Transit Projects	operational in 8 cities	
17	Waste	Sanitation (Swachh Bharat Abhiyan)	No scheme was launched.	More than 6.2 million individual toilets and 0.59 million community and public toilets have been constructed. As on December 2020, under the mission, 4,340 cities have been declared ODF, while 100 per cent door-to-door waste collection has been achieved in over 83,434 wards.
18	Agriculture	Neem Coated urea application in agriculture	No production of neem coated urea.	Both imported and indigenously produced urea available in the country is neem coated since 2016. Total mitigation of 7.529 MtCO2 was achieved in 2017-18 and 2018-19, with a total production of 47.99 million tonnes.
19	Agriculture	Energy Efficient Pump Programme (Agriculture Demand Side Management)	Only 2209 pump sets have been replaced in pilot project at Solapur district.	74,136 pumps have been EESL has installed which has resulted in estimated energy savings of 191 million kWh per year with avoided peak demand of 35 MW, GHG emission reduction of 0.14 MtCO2 per year and estimated annual monetary savings of INR 960 million in consumer electricity bills.
20	Agriculture, Water	Micro-irrigation	Area covered under micro-irrigation was 7.73 million hactare till 2015.	Area covered under micro-irrigation was 8.7 million hactare till November 2019.

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SDG implications of water-energy transitions in India

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LETTER

SDG implications of water-energy system transitions in India, for NDC, 2 °C, and well below 2 °C scenarios

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Supplementary material for this article is available online

Abstract

India needs to address the immediate concerns of water supply and demand, due to its increasing population, rapid urbanization, and growing industrialization. Additionally, the changing climate will influence water resources, which will subsequently impact the overall sectoral end-use demand patterns. In this study, we have integrated a water module with the existing bottom-up, techno-economic Asia–Pacific Integrated Model/End-use energy system model for India to estimate the future water demand in major end-use sectors under business-as-usual (BAU), nationally determined contribution (NDC), and low-carbon futures (2 °C and 'well below 2 °C') up to 2050. We also simulate the effects of water constraints on major sectors under different climate-change regimes. Our results show that water-intensive end-use sectors, specifically agriculture and power, will face major impacts under water-constrained scenarios. Over the period between 2020 and 2050, policy measures taken under the NDC scenario can cumulatively save up to 14^{6} billion cubic metres (bcm) of water, while low-carbon scenarios can save 20–21 bcm of water between 2020 and 2050, compared with BAU. In a water-constrained future, NDC and low-carbon futures can save 28–30 bcm of water. There is a need to increase the current water supply by 200–400 bcm. The marginal cost of installing dry cooling systems in the power sector is considerably higher than the cost and benefits of installing micro-irrigation systems with solar PV. Integrated policy coherence is required to achieve sustainable development goals, e.g., NDC and Paris Agreement goals, in both water and energy sectors. Concurrently, regulatory and economic instruments will play an essential role in improving resource-use efficiency at a systemic level, to reduce the overall water demand.

Journal: ***Environmental Research Letters (2021)***
Type: *India specific*
Research: SDG-NDC linkages, Water-Energy Transitions

Key Insights:

- The need to increase the water supply (in the non-water-constrained scenarios)
- Stranded coal assets (in the water-constrained scenarios)
- Impacts on system costs and future investments
- SDG-NDC linkages: Implementing NDC policies will result in the achievement of targets under SDG7, SDG11, SDG12, SDG13, and SDG15[25]. However, this may put stress on water resources (SDG6) without WUE measures. Achieving SDG targets can help India to meet resource-use efficiency goals, in addition to the NDC and Paris Agreement goals (as these targets are a subset of SDG13).

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Energy system transformation to meet NDC, 2°C and well below 2°C targets for India

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Energy system transformation to meet NDC, 2 °C, and well below 2 °C targets for India

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Abstract
India's commitment to Paris Climate Change Agreement through its Nationally Determined Contribution (NDC) will require the energy system to gradually move away from fossil fuels. The current energy system is witnessing a transformation to achieve these through renewable energy targets and enhanced energy efficiency (EE) actions in all sectors. More stringent global GHG mitigation targets of 2 °C and well below 2 °C regimes would impose further challenges and uncertainties for the Indian energy systems. This paper provides a quantitative assessment using bottom-up optimization model (AIM/Enduse) to assess these until 2050 for meeting carbon mitigation commitments while achieving the national sustainable development goals. Energy transformation trajectories under five scenarios synchronized with climate mitigation regimes are explored—Business As Usual scenario (BAU), NDC scenario, 2 °C scenarios (early and late actions), and well below 2 °C scenario. The key results from the study include (a) coal-based power plants older than 30 years under NDC and older than 20 years for deeper CO_2 mitigation will be stranded before their lifetime, (b) increase in renewables of up to 225–280 GW by 2050 will require battery storage with improved integrated smart grid infrastructure, (c) growth in nuclear to 27–32 GW by 2050 is dependent on nuclear supply availability, (d) gradual shift towards electrification in industry, building, and transport sectors, and (e) installation of CCS technologies in power and industry sectors. Cumulative investments of up to 6–8 trillion USD (approximately) will be required during 2015–2030 to implement the actions required to transform the current energy systems in India.

Saritha S. Vishwanathan started working at NIES since November 1, 2019.

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Springer

Journal: ***Climatic Change (2020)***
Type: *India specific*
Research: Transformations, Investment

Key Insights

- Coal-based power plants older than 30 years under NDC and older than 20 years for deeper CO2 mitigation will be stranded before their lifetime
- Increase in renewables of up to 225–280 GW by 2050 will require battery storage with improved integrated smart grid infrastructure
- Growth in nuclear to 27–32 GW by 2050 is dependent on nuclear supply availability
- Gradual shift towards electrification in industry, building, and transport sectors
- Installation of CCS technologies in power and industry sectors
- Cumulative investments of up to 6–8 trillion USD (approximately) will be required during 2015–2030 to implement the actions required to transform the current energy systems in India.

Indian Institute of Management, Ahmedabad, India

Low carbon and high growth can co-exist

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journal homepage: www.elsevier.com/locate/worlddev

Achieving sustainable development in India along low carbon pathways: Macroeconomic assessment

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ABSTRACT

Achieving fast and inclusive economic growth concurrently with greenhouse gases (GHG) emission control could have wide-ranging implications for the Indian economy, predominantly fuelled by fossil energies. India faces high income inequality with the bottom 50% of its population owning only 2% of total national wealth. Other developmental challenges include 304 million people living in poverty, 269 million without access to electricity, 92 million without access to safe drinking water, and around 2 million homeless. Despite such challenges, India has committed to reduce the GHG emission intensity of its GDP 33–35% below its 2005 level by 2030, including via turning 40% of its power-generation capacity away from fossil sources. To explore the macroeconomic consequences of achieving development along low-carbon pathways, we use a hybrid modelling architecture that combines the strengths of the AIM/Enduse bottom-up model of Indian energy systems and the IMACLIM top-down economy-wide model of India. This hybrid architecture stands upon an original dataset that reconciles national accounting, energy balance and energy price statistics. With this tool, we demonstrate that low-carbon scenarios can accommodate yearly economic growth of 5.8% from 2013 to 2050 i.e. perform close to if not slightly higher than our business-as-usual scenario, despite high investment costs. This result partly stems from improvement of the Indian trade balance via substantial reduction of large fossil fuel imports. Additionally, it is the consequence of significant shifts of sectoral activity and household consumption towards low-carbon products and services of higher value-added. These transitions would require policies to reconcile the conflicting interests of entrenched businesses in retreating sectors like coal and oil, and the emerging low-carbon sectors and technologies such as renewables, smart grids, electric vehicles, modern biomass energy, solar cooking, carbon capture and storage, etc.

1. Introduction

The developing Indian economy faces multiple challenges echoing key dimensions of the Sustainable Development Goals (SDGs) of the United Nations. It thus counts around 269 million people living

mate commitments outlined in India's Nationally Determined Contribution (NDC) under the Paris agreement of the United Nations Framework Convention on Climate Change (UNFCCC) envision development along low-carbon emission pathways. India's enormous developmental needs therefore have to be balanced with

Journal: ***World Development***
Type: *India specific*

Research: Hybrid IMACLIM, Macroeconomic assessment

Key Insights

- Deep decarbonisation (2 degree C target) along with high growth can be achieved simultaneously for Indian economy

- Low carbon pathways lead to lower trade balance deficit and foreign debt remains under control

- Energy-efficiency improvements are pivotal but that might lead to increase in the capital intensity of the productive sectors

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Looking under the hood: A comparison of techno-economic assumptions across national and global integrated assessment models (IAMs)

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Looking under the hood: A comparison of techno-economic assumptions across national and global integrated assessment models

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ABSTRACT

Integrated assessment models are extensively used in the analysis of climate change mitigation and are informing national decision makers as well as contribute to international scientific assessments. This paper conducts a comprehensive review of techno-economic assumptions in the electricity sector among fifteen different global and national integrated assessment models. Particular focus is given to six major economies in the world: Brazil, China, the EU, India, Japan and the US. The comparison reveals that techno-economic characteristics are quite different across integrated assessment models, both for the base year and future years. It is, however, important to recognize that techno-economic assessments from the literature exhibit an equally large range of parameters as the integrated assessment models reviewed. Beyond numerical differences, the representation of technologies also differs among models, which needs to be taken into account when comparing numerical parameters. While desirable, it seems difficult to fully harmonize techno-economic parameters across a broader range of models due to structural differences in the representation of technology. Therefore, making techno-economic parameters available in the future, together with of the technology representation as well as the exact

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Journal: ***Energy***
Type: *Consortium (Global and national models)*

Research: IAMs, Techno-economic assumptions

Key Insights

- Comprehensive review of techno-economic assumptions in the electricity sector among 15 different global and national integrated assessment models
- Representation of technologies differs among models, which needs to be taken into account when comparing numerical parameters.
- Difficult to fully harmonize techno-economic parameters across a broader range of models due to structural differences in the representation of technology.

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Reducing stranded assets through early action in the Indian power sector

Environmental Research Letters

LETTER

Reducing stranded assets through early action in the Indian power sector

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Abstract

Cost-effective achievement of the Paris Agreement's long-term goals requires the unanimous phase-out of coal power generation by mid-century. However, continued investments in coal power plants will make this transition difficult. India is one of the major countries with significant under construction and planned increase in coal power capacity. To ascertain the likelihood and consequences of the continued expansion of coal power for India's future mitigation options, we use harmonised scenario results from national and global models along with projections from various government reports. Both these approaches estimate that coal capacity is expected to increase until 2030, along with rapid developments in wind and solar power. However, coal capacity stranding of the order of 133–237 GW needs to occur after 2030 if India were to pursue an ambitious climate policy in line with a well-below 2 °C target. Earlier policy strengthening starting after 2020 can reduce stranded assets (14–159 GW) but brings with it political economy and renewable expansion challenges. We conclude that a policy limiting coal plants to those under construction combined with higher solar targets could be politically feasible, prevent significant stranded capacity, and allow higher mitigation ambition in the future.

1. Introduction

The foremost step to reach the goals of the Paris Agreement is rapid electricity sector decarbonisation, leading eventually to a zero-emission energy supply system by mid-century (Rogelj *et al* 2018, p. 129). This implies that the current global coal capacity of about 2015 GW, representing 6700 coal units and 30% of world emissions (IEA 2018, Coal Swarm 2019), must drop down to zero in roughly 30 years. However, up until 2018, the total coal power capacity continued to increase, even though at a decelerating pace (Shearer *et al* 2019) and were the single largest contributor to the growth of energy-related emissions in 2018 (IEA 2018). This trend might not change soon. First, because around the world, there are still 235 GW of plants under construction (India's and China's share is 15% and 55% respectively), and another 338 GW under various stages of planning (India's and China's share being 17% and 21% respectively) (Coal Swarm 2019). Second, the operating plants in India and China,

Journal: ***Environmental Research Letters***
Type: *India specific*
Research: Power sector, energy, emissions

Key Insights

- Harmonized scenario results from national and global models along with projections from various government reports
- Both these approaches estimate that coal capacity is expected to increase until 2030, along with rapid developments in wind and solar power
- Coal capacity will be stranded in the order of 133–237 GW after 2030 if India were to pursue an ambitious climate policy in line with a well-below 2◦C target
- Earlier policy strengthening starting after 2020 can reduce stranded assets (14–159 GW) but brings with it political economy and renewable expansion challenges

Comparing transformation pathways across different regions and countries

Climatic Change
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Comparing transformation pathways across major economies

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Abstract
This paper explores the consequences of different policy assumptions and the derivation of globally consistent, national low-carbon development pathways for the seven largest greenhouse gas (GHG)–emitting countries (EU28 as a bloc) in the world, covering approximately 70% of global CO_2 emissions, in line with their contributions to limiting global average temperature increase to well below 2 °C as compared with pre-industrial levels. We introduce the methodology for developing these pathways by initially discussing the process by which global integrated assessment model (IAM) teams interacted and derived boundary conditions in the form of carbon budgets for the different countries. Carbon budgets so derived for the 2011–2050 period were then used in eleven different national energy-economy models and IAMs for producing low-carbon pathways for the seven countries in line with a well below 2 °C world up to 2050. We present a comparative assessment of the resulting pathways and of the challenges and opportunities associated with them. Our results indicate quite different mitigation pathways for the different countries, shown by the way emission reductions are split between different sectors of their economies and technological alternatives.

Keywords Climate change mitigation · Paris agreement · Carbon budgets · National transformation pathways · National energy-economy models · Integrated assessment models

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Journal: ***Climatic Change***
Type: *Consortium (Global and national models)*
Research: IAMs, national pathways

Key Insights

- Explores the consequences of different policy assumptions and the derivation of globally consistent, national low-carbon development pathways for the seven largest greenhouse gas (GHG)–emitting countries (EU28 as a bloc) in the world, covering approximately 70% of global CO2 emissions

- Methodology : Carbon budgets from global models for the 2011–2050 period were then used in eleven different national energy-economy models and IAMs for producing low-carbon pathways for the seven countries in line with a well below 2 °C world up to 2050

- A comparative assessment of the resulting pathways and of the challenges and opportunities associated with them

- Results indicate quite different mitigation pathways for the different countries, shown by the way emission reductions are split between different sectors of their economies and technological alternatives.

Low carbon transitions are not cheap

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RESEARCH ARTICLE

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Macroeconomic assessment of India's development and mitigation pathways

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ABSTRACT

Although a rapidly growing economy, India faces many challenges, including in meeting the Sustainable Development Goals of the United Nations. Moreover, post-2020 climate actions outlined in India's Nationally Determined Contribution (NDC) under the Paris Agreement envision development along low-carbon emission pathways. With coal providing almost three-quarters of Indian electricity, achieving such targets will have wide-ranging implications for economic activity. Assessing such implications is the focus of our research. To do so, we use a hybrid modelling architecture that combines the strengths of the AIM/Enduse bottom-up model of energy systems and the IMACLIM top-down economy-wide model. This hybrid architecture rests upon an original dataset that brings together national accounting, energy balance and energy price data. We analyse four scenarios ranging to mid-century: business-as-usual (BAU), 2°C, sustainable 2°C and 1.5°C. Our 2°C pathway proves compatible with economic growth close to the 6% yearly rate of BAU from 2012 to 2050, at the cost of reduced household consumption but with significant positive impact on foreign debt accumulation. The latter impact stems from improvement of the trade balance, whose current large deficit is the primary cause of high fossil fuel imports. Further mitigation effort backing our 1.5°C scenario shows slightly higher annual GDP growth, thereby revealing potential synergies between deep environmental performance and economic growth. Structural change assumptions common to our scenarios significantly transform the activity shares of sectors. The envisioned transition will require appropriate policies, notably to manage the conflicting interests of entrenched players in traditional sectors like coal and oil, and the emerging players of the low-carbon economy.

Key policy insights

- Low carbon pathways are compatible with Indian growth despite their high investment costs
- Moving away from fossil fuel-based energy systems would result in foreign exchange savings to the tune of $1 trillion from 2012 to 2050 for oil imports.
- Achieving deep decarbonization in India requires higher mobilized capital in renewables and energy efficiency enhancements.
- Phasing out fossil fuels would, however, require careful balancing of interests between conventional and emerging sector players through just transitions.

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India; energy-economy model; sustainable development; 2°C; 1.5°C; climate policy

Introduction

Since economic liberalization in 1991, India's GDP has been growing at an annual rate of 7% to 8%. Part of this growth stems from structural change, which saw the Indian economy turn from agriculture in the 1970s, to services and industry, which contributed 53% and 31% of GDP respectively in 2017 (Economic Survey, 2018). This

Journal: ***Climate Policy***
Type: *India specific*
Research: Hybrid IMACLIM, Macroeconomic assessment, Low carbon transitions

Key Insights

- A stringent 1.5DEG scenario with India's carbon budget cut by two-thirds compared to BAU results in a slightly higher GDP and lower foreign debt

- Shifting away from fossil fuel based energy systems results in foreign exchange savings of 1 trillion USD from just oil imports over 2012-2050

- Low carbon growth is contingent on the availability of transformative technologies and the necessary capital for deploying them

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