MAJOR ECONOMIES AND CLIMATE CHANGE RESEARCH GROUP

INDIA

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EXECUTIVE SUMMARY

As a rising economy and growing contributor of greenhouse gas (GHG) emissions, India faces the challenge of maintaining growth while simultaneously trying to reduce its emissions or, at the very least, slow the rate of growth in emissions. In order to overcome institutional barriers to lowering the carbon intensity of development, the Twelfth Five Year Plan emphasizes India's need to pursue low carbon strategies for inclusive growth. This report outlines some of these existing strategies in the sectors we have identified as priorities for emissions reductions, these being energy production, energy efficiency, and transport. These particular sectors were selected keeping in mind their current contributions to GHG emissions, abatement potential, and future anticipated rate of growth.

ENERGY PRODUCTION AND EFFICIENCY

Coal is India's primary energy source, which is significant given that coal production in India has more than doubled in the last twenty years. India's National Action Plan on Climate Change (NAPCC) outlines strategies that include a shift to cleaner coal technologies and initiatives enabling the reception and uptake of renewable energy sources, like solar and wind.

India's vast population has driven its massive demand for electricity. Electricity is the main contributor within energy production and is also growing at a rapid pace, with 400 million Indians still to be connected to the grid. Inefficiencies in the current provision of electricity, primarily derived from coal, have led to high levels of GHG emissions in this sector. Improving efficiency standards and updating technology, both for coal and emerging renewable energy sources, will help reduce emissions from electricity production.

Key policy recommendations for the electricity sector include:

- Carbon capture and storage (CCS) for coal plants
- Expansion of nuclear power
- Continued expansion of policy instruments such as carbon trading and Renewable Purchase Obligations
- Expansion of solar and wind industries require greater incentives and a re-examination of domestic content requirement rules
- Land acquisition is another major barrier to expansion of renewables, and the recent law in this regard needs to be operationalized by working closely and winning the confidence of state governments and private sector

INDUSTRY

The industrial sector is a key contributor of GHG emissions, with iron and steel and cement industries being among the largest single sectors with mitigation potential. The main barriers to achieving mitigation in these sectors are technical and financial. Recommendations include:

- Advanced processes such as FINEX and DRI need to be incorporated into the steel industry to achieve the needed efficiency gains
- Institutionalizing recycling programs are also crucial

- Clinker substitutes ought to be explored in cement production.
- Both sub-sectors would greatly benefit from the introduction of CCS technologies, although CCS in the industrial sector is still largely in the pre-demonstration stage across the world

TRANSPORT

With the rapid urbanization experienced by India, transport is also a high-growth sector, with road dominating emissions. Road transport now contributes 87% of India's transport sector GHG emissions. India currently lacks the infrastructure for forms of mass transit that would relieve congestion caused by increased demand for some passenger vehicles and lower emissions. Additionally, implementation of India's fuel efficiency standards is not presently stringent enough to have a significant effect. Policy recommendations in this sector include:

- Vigorous implementation of emissions standards Bharat Standards III and IV
- Improved urban public transport, focusing on winning political support for lower-cost approaches such as Bus Rapid Transit (BRT) in cities
- Dedicated freight corridors along major routes
- Comprehensive re-examination of the flaws in the current public-private partnership (PPP) model in transport infrastructure to realize an optimal mix of participation

GENERAL BARRIERS AND RECOMMENDATIONS

India must overcome the following barriers in order to reduce emissions from energy production, curb demand for carbon intensive transport and increase energy efficiency:

- Political fragmentation and lack of cohesive strategies with specific targets
- Monopolies in energy markets
- Major financing gap to achieve a low-carbon economy
- Lack of state and domestic private sector capacity for implementation of existing policies
- Major land acquisition challenges
- Disinclination to sign international treaties that would commit India to emissions reductions that might prohibit economic growth

All recommendations made in this analysis fit within the overarching goal of strengthening technical and enforcement capacity for India's National Climate Action Plan:

- Use the NAPCC as a broad framework, but develop specific localized action plans
- Focus on co-benefits of climate change policies, such as energy security and public health
- Seek external funding through funding mechanisms like the Clean Development Mechanism for energy-production and efficiency related projects
- Instill capacity for negotiating well-monitored and structured public-private partnerships like the UNFCCCs Green Climate Fund or the U.S. State Department's U.S.-India Partnership, keeping in mind that PPP initiatives need to be carefully designed to avoid failure

RATIONALE

India is the second most populated country in the world and one of the fastest growing economies. In 2013, India was the ninth largest economy in the world, driven by a real GDP growth of more than 7% over the previous ten years. In part due to rapid industrialization, India is the third largest emitter of greenhouse gases (GHGs) globally, and emissions are expected to continue rising dramatically.[1] At the same time, however, India's per capita emissions are much lower than the global average. This dichotomy, the need to maintain growth while curbing emissions, presents a number of climate mitigation challenges.

India has primarily focused its strategy for climate change mitigation on activities that provide co-benefits for development. This approach is particularly salient in a democratic polity, as strategies that do not provide clear co-benefits for development will not receive voter backing. Clear links between reducing the carbon intensity of technology and savings to business will promote the uptake of emissions-reducing strategies like those defined under the National Action Plan on Climate Change (NAPCC) by business-oriented politicians like Narendra Modi.

In 2008 India developed its first comprehensive climate action plan, called the National Action Plan on Climate Change (NAPCC). The NAPCC is a comprehensive strategy for climate change adaptation and mitigation comprised of eight national missions – of which four focus on mitigation, three on adaptation, and one on increasing knowledge.[2] The Twelfth Five Year Plan recommended that these missions be reorganized and condensed into seven missions, which include the Jawaharlal Nehru National Solar Mission (JNNSM), the National Wind Energy Mission, the Energy Efficiency Mission, the Sustainable Habitat Mission, the Sustainable Agriculture Mission, the Mission on Sustainable Himalayan Eco-systems, and the National Mission for a Green India.[3] The goals outlined in these missions would allow India to make great strides towards emissions reductions; however many of the missions are still lacking concrete policy prescriptions and specifics on financing and implementation. Highlighting the potential of the NAPCC, while also noting its limitations, Dubash pointed out that "other than the co-benefits approach, there is no coherent strategy, either conceptual or in terms of overarching target setting, that ties together the missions."[4]

Beyond the missions in the NAPCC, India has older policies in place that, if strengthened, could help reduce emissions or slow their growth. These policies include incentives and subsidies for renewable energy use as well as many policies geared toward energy efficiency. The main recommendation for slowing emissions growth in India, across sectors, is to develop specific initiatives that are in line with the NAPCC missions, strengthen existing policies, and build capacity to facilitate their implementation.

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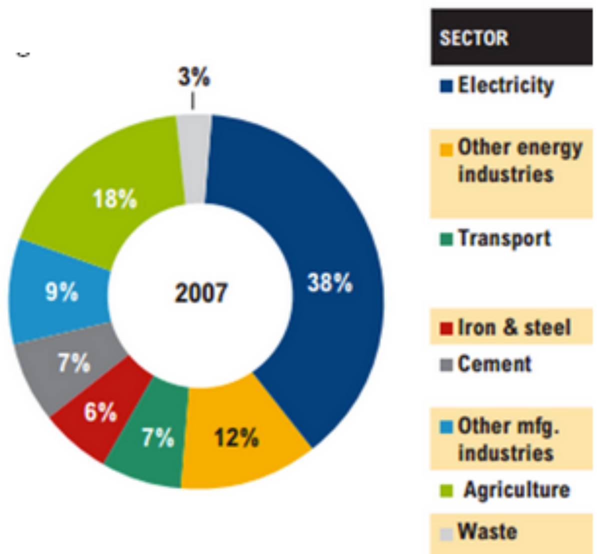
[1] Thaker and Leiserowitz, 2014.
[2] Planning Commission, 2012; Twelfth Five Year Plan, 2012, 222.
[3] WRI, 2014. The eight original missions were the Jawaharlal Nehru National Solar Mission (JNNSM), the National Mission for Enhanced Energy Efficiency, the National Mission on Sustainable Habitat, the National Water Mission, and the National Mission on Sustaining the Himalayan Ecosystem, the National Mission for a Green India, the National Mission for Sustainable Agriculture, and the National Mission on Strategic Knowledge for Climate Change.
[4] Dubash, 2012.

The sectors highlighted in this report are chosen based on overall contribution, rate of growth, and amenability to mitigation action. Electricity generation is clearly the most important among all these, with a 38% contribution to emissions in 2011 (figure 1). The industrial sector is also a major source of emissions, with 18% of the total, of which iron & steel and cement form the biggest single components. Although agriculture (18%) exceeds transportation (7%) in its net contributions, transportation is on a high-growth trajectory due to the rapid urbanization of India, while growth in agriculture is low. Agriculture also represents daunting challenges for mitigation action, given that most agricultural activity in India is informal and under the ownership of several hundred million small and medium farmers.

Figure 1: Emissions by Sector



Source: Indian Network for Climate Change Assessment (INCCA), 2010.

This report aims to highlight sectors with the greatest potential for emissions reductions and provide context for policy implementation in these areas. The report begins with an overview of the energy production, electricity and renewables, and transport sectors. Next it provides details on the current policy landscape and how existing plans can be strengthened in each sector. Finally, the report outlines potential political, market, cultural, financial, and technical barriers to implementation and offers recommendations for overcoming them.

SECTORS OF IMPORTANCE

ENERGY PRODUCTION

Overview

India's high order of sustained economic growth is placing enormous demand on its energy resources. Similarly, the drive for inclusive growth, rural electrification and improvement in well-being for the majority of the population will involve large increases in per capita energy consumption. In this sense energy production is critical in India's pursuit of sustained economic growth as well as improved human development

India is the fourth largest energy consumer in the world after the United States, China, and Russia. According to the "World Energy Outlook (WEO)" report, an annual publication by the International Energy Agency (IEA), "India is set to overtake China in the 2020s as the principal source of growth in global energy demand." Most of India's energy production growth is projected to be driven by coal, further adding to its GHG and particulate emissions. As the demand and consumption of energy increases in India, India's carbon emissions from the electricity sector are also expected to dramatically increase. This point is not lost on the Indian government. Since 2008, India has followed up on its National Action Plan on Climate Change (NAPCC) to varying degrees of success and the National Planning Commission has repeatedly stated that for India, "it is not a question of choosing among alternative domestic energy resources but exploiting all available domestic energy resources to the maximum as long as they are competitive."[5]

This section explores the role of India's energy production sector in reducing carbon emissions. It examines the energy related emissions by source, the main actors and institutions involved, possible mitigation measures and their associated barriers and recommendations to overcoming those.

India's Energy Mix

Fuel combustion in electricity generation, solid fuel manufacturing, petroleum refining, transport, residential and commercial activities, agriculture and fisheries are all sources of emissions from energy production. Energy production also includes the fugitive emissions due to coal mining and handling of oil and natural gas.

India's largest energy source is coal, which accounted for 43.5% of the total energy supply in 2011, followed by biofuels and waste (24.7%), petroleum (22.1%), natural gas (6.7%), hydropower (1.5%) and nuclear (1.2%).[6]

India's emissions patterns are increasingly driven by migration to India's urban centers. With the adoption of the New Economic Policy in 1991, India's population has increasingly moved to cities. This urbanization has not only led to a steady increase in energy demand but also altered the energy mix, away from traditional biomass and increasingly in favor of coal and peat. While

[5] Gambhir, 2012.
[6] US EIA, 2013.

the amount of energy generated by renewables such as solar, hydropower, wind and other sources has increased by 30% between 1990 and 2010, the IEA estimates that the consumption of fossil fuels has increased significantly: "Coal, oil and natural gas use has risen by 180%, 164% and 400% respectively in the same period."[7]

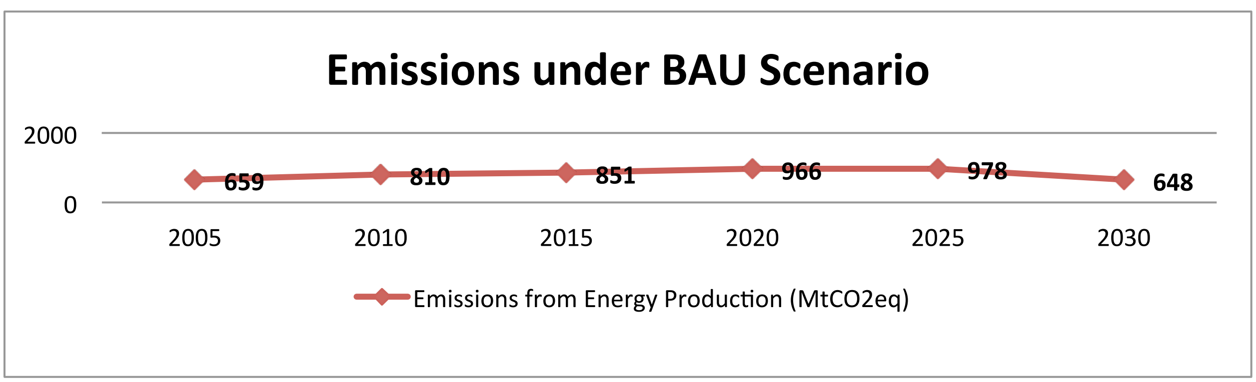
While the sources of emissions from energy production are variegated, electricity production stands as the primary driver of India's energy related emissions (figure 1). As a result, this section focuses on GHG emissions from the electricity sector.

India's electricity sector is the fastest growing area of energy demand, increasing from 23% to 38% of total energy consumption between 1990 and 2009."[8] According to a projection in the Twelfth Plan Document of the Planning Commission, India is set to produce 669.6 million tons of oil equivalent (MTOE) by 2016-17 and 844 MTOE by 2021-22 domestically.[9] This will meet around "71 per cent and 69 per cent of expected energy consumption, with the balance to be met from imports, projected to be about 267.8 MTOE by 2016-17 and 375.6 MTOE by 2021-22."[10]

Emissions & Potential Mitigation Strategies

In 2007, electricity production alone was responsible for 38% of GHG emissions while other energy related industries like oil refinement and coal production together accounted for 12% of total emissions.[11] Coal is the dominant fuel for electricity generation (figure 2), and is expected to remain dominant for the foreseeable future. Given the growing demand of electricity and anticipated fuel mix under the Business as Usual Scenario, emissions will likely continue to grow steadily for at least another decade. According to the McKinsey & Company's Climate Desk Tool, emissions from the energy production sector will grow to 966 $MtCO_2eq$ by 2020 and taper off to 648 $MtCO_2eq$ in 2030 (figure 3).

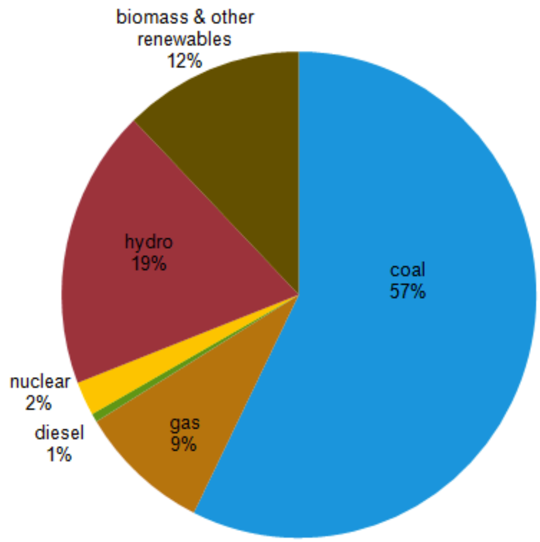
Figure 2: India Installed Power Capacity



Source: EIA, 2014

[7] Pahuja et al., 2014.
[8] US EIA, 2013.
[9] Government of India, Central Statistics Office, 2013.
[10] Ibid.
[11] Indian Network for Climate Change Assessment (INCCA), 2010.

Figure 3: Emissions under BAU Scenario

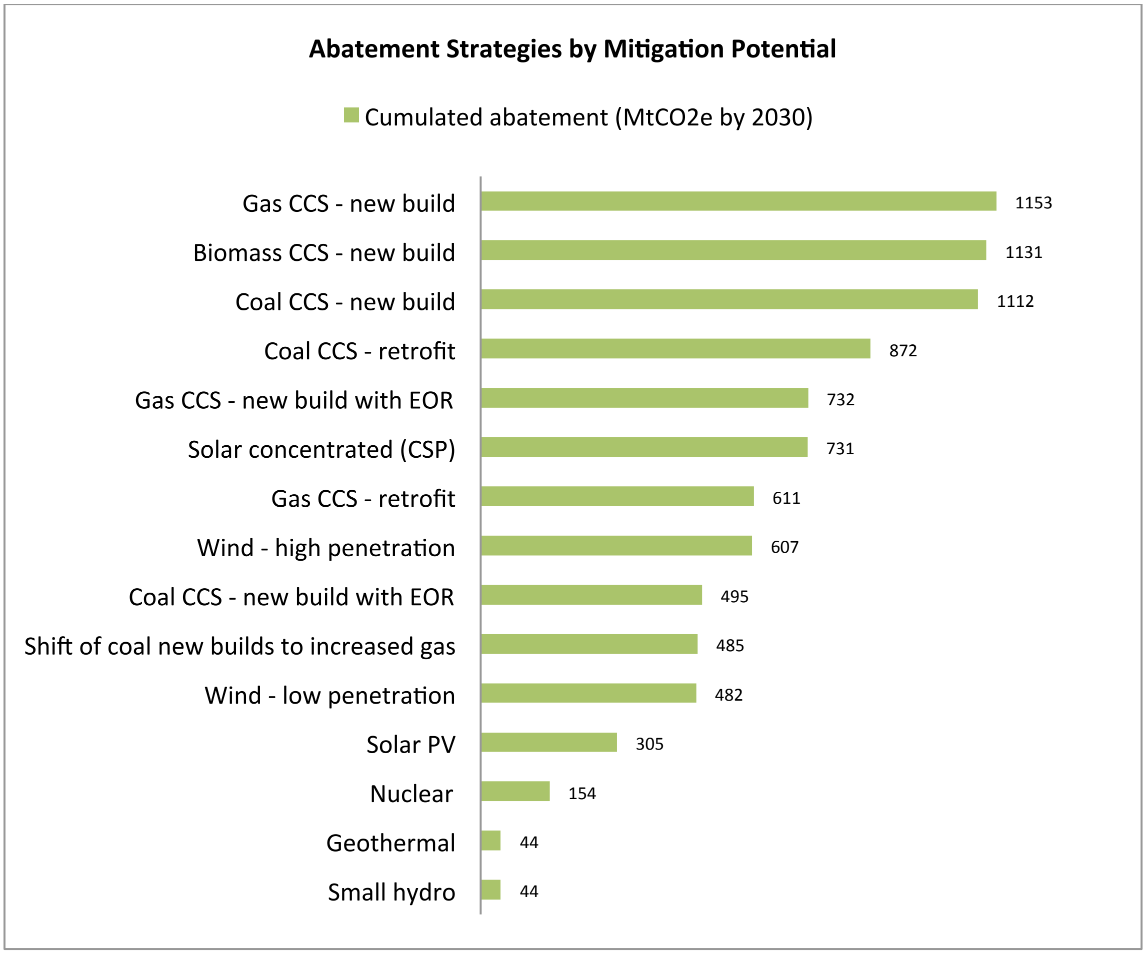


Source: McKinsey Climate Desk, 2014

In order to alter the emissions trajectory and reduce India's emissions from the power sector, a number of mitigation strategies can be adopted. Some involve shifting the energy mix while others require the introduction of more efficient technology into the energy production sector. The McKinsey and Company Climate Desk Tool outlines some of the potential abatement strategies that can be adopted by India's power sector. These strategies are discussed in their relevant *sources* section, along with the barriers that inhibit their implementation and recommendations to overcome those barriers. The following charts give a snapshot of the full technical emissions reduction potential of these abatement strategies along with the expected costs.

Due to the current and future dominance of coal in India's fuel mix for electricity generation, power plants with carbon capture storage (CCS) facilities, especially those built recently, have the greatest potential in terms of reducing CO_2 related emissions (figure 4).

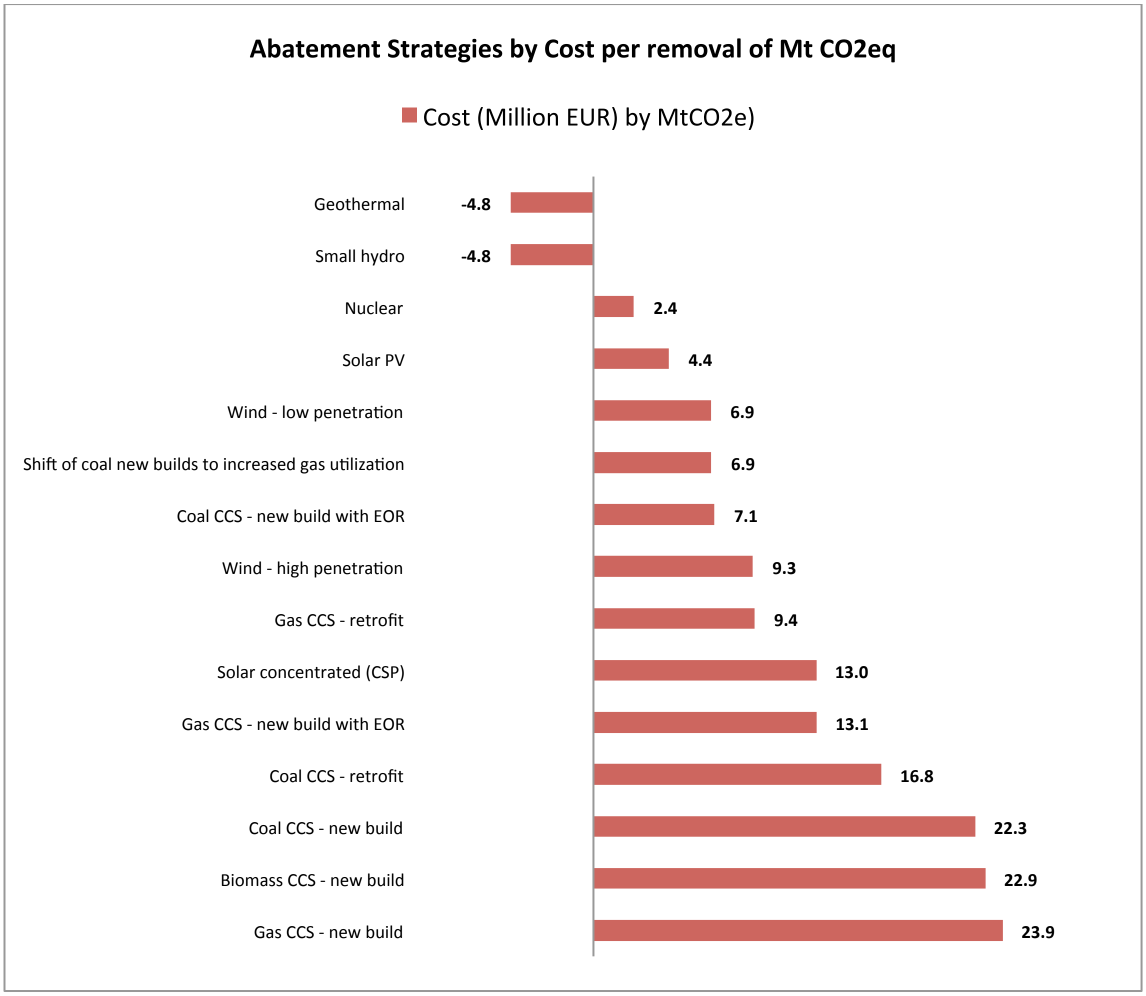
Figure 4: Abatement Strategies by Mitigation Potential



Source: McKinsey Climate Desk, 2014

However, CCS is expensive and requires specific technical expertise. This translates into the CCS related strategies being relatively more expensive in terms of Euro/ton of CO_2 emissions compared to renewables (figure 5).

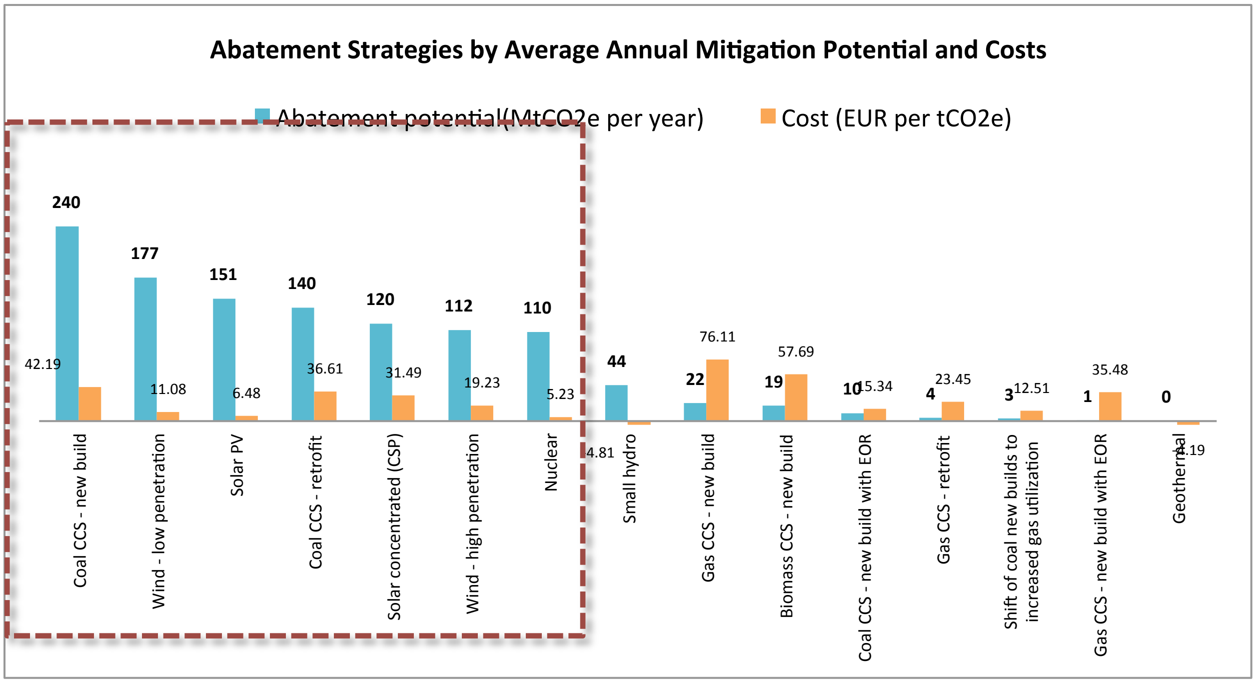
Figure 5: Abatement Strategies by Cost per Removal of Mt CO2e



Source: McKinsey Climate Desk, 2014

As India's energy mix changes, the relative abatement potential and the cost of these strategies will also change. Figure 6 highlights the average annual abatement cost of mitigation strategies along with the expected annual cost. This is perhaps a better method of comparing mitigation strategies as it highlights the average mitigation potential and costs over time. Moreover, it better matches India's energy security concerns, the NAPCC's institutional framework, and allows for a better idea of annual budgeting costs.

Figure 6: Abatement Strategies by Average Annual Mitigation Potential, Costs



Source: McKinsey Climate Desk, 2014

The top seven abatement strategies according to annual abatement potential include the new the installation or retrofitting of coal power plants with CCS technology, expansion of solar photovoltaic and wind (high and low penetration) power as well as growth in nuclear power capacity. Since each of these strategies face specific technical, institutional, financial and market barriers, they are discussed in the following sections.

BARRIERS: COAL DEPENDENCE AND TRANSITION TO LOW-CARBON GENERATION TECHNOLOGIES

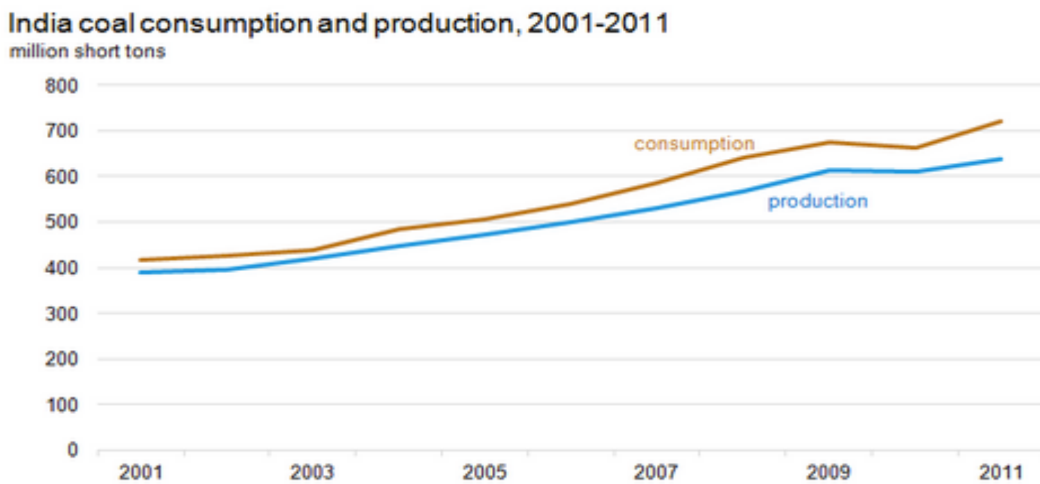
As discussed earlier, coal is India's primary source of energy. India's dependence on coal is a function of available resources and existing infrastructure. The country has the fifth largest coal reserves in the world and is a major importer in the global energy market. According to India's Central Statistics Office (CSO), 54% of the total installed electricity generation capacity is coal based and 67% of the capacity planned added during the Eleventh Five Year Plan period 2007-12, was coal based. These numbers are even higher when generation is considered, with nearly 80% of generation in the Twelfth Plan (2012-2017) slated to come from coal-based power.[12]

The CSO's annual energy statistics report predicts that the demand for coal will reach 980 MT during the Twelfth Five Year Plan period, and India will be able to accommodate 795 MT in

[12] Government of India, Central Statistics Office, 2013.

2016-17 through domestic production. While imports are expected to bridge the demand gap (imports have increased by 13% since 2001),[13] domestic coal production will also need to grow at an average rate of 8%, compared to the 4.6% stated in the Eleventh Five Year Plan.[14]

Figure 1: India Coal Consumption and Production, 2001-2011



Source: EIA, 2013

According to an August 2011 study by Prayas Energy Group, India has 590,000 megawatts (MW) of projects in the pipeline. Table 1 provides information on 572 proposed projects representing 614 MW of capacity and an estimated 3.63 billion tons of annual carbon dioxide emissions. [15]

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[13] US EIA, 2013.
[14] Government of India, Central Statistics Office, 2013.
[15] Prayas Energy Group, 2011.

Table 1: Production Centers in India

Status	#of Plants	Capacity (MW)	Annual tons of CO_2
Planning	128	154,582	914,148,740
Early development	113	155,262	918,173,014
Advanced development	47	53,340	315,436,801
Construction	98	82,765	489,447,447
Newly commissioned (since 1/1/2010)	112	56,815	335,986,911
Deferred	27	45,230	267,476,687
Cancelled	21	30,420	179,894,778
Unconfirmed	20	24,685	145,979,704
Uncertain	6	11,260	66,588,271
Total	572	614,359	3,633,132,353

Source: Government of India, Central Statistics Office, 2013

Out of the 572 proposed power plants, only a very small percentage were categorized as supercritical and ultra-supercritical generation technology. Plants employing high-efficiency and low-emission technology (HELE) technology can significantly reduce emissions. However, the age of existing plants makes retro fitting difficult and the cost of new HELE plants makes investments in them unattractive. Similarly, while India's 12th Five Year Plan highlights plan to invest in Carbon Capture and Storage (CCS) related technologies progress has been very slow due to technical and financial barriers.

TECHNICAL, FINANCIAL, POLITICAL, MARKET AND OTHER BARRIERS

Carbon Capture and Sequestration (CCS)

CCS technologies are relevant to both coal and gas powered plants. CCS equipped power plants can capture or scrub emissions in three ways. In *pre-combustion* capture, producers partially oxidize the fossil fuels and can separate out component gases, such as carbon monoxide, carbon dioxide, and hydrogen. This enables carbon capture before the process of combustion and the generation of electricity. In *post-combustion* capture, the carbon dioxide within the flue gases that the combustion process releases is captured and stored. The final method is *oxy-fuel combustion* where producers burn fuel in an environment of pure oxygen, rather than normal air. The resultant carbon dioxide can be stored after processing the flue gases through cooling chambers. Each of these methods has its own drawbacks and limitations, and there is no question that each of these will require significant investment to come to fruition as a viable technology for reducing greenhouse gas emissions. All ultimately require underground disposal in geologic formations which is another technical as well as an environmental barrier.[16]

[16] China Paper, MECCS, 2014.

Current CCS related R&D activities in India occur under the Department of Science and Technology (DST). The DST launched National Program on Carbon Sequestration (NPCS) Research in 2007, with a view to competing with other countries in this area with respect to both pure/applied research and industrial applications. Currently, the government through the Institute of Reservoir Studies is carrying out pilot projects for CO_2 capture in Gujrat. However, there are a number of technical reasons why CCS will not be a major mitigation strategy in the short to medium term.

In terms of technical barriers, the Indian government is unlikely to invest in scaling up CCS adoption until a degree of confidence in the technology has been gained via large scale deployment internationally.[17] Currently, the technology is in the demonstration phase. Another technical barrier is the lack of lack of accurate geological storage site. This data is critical because the location, capacity, permeability, and other characteristics of the sinks must be known before any capture technology can be installed in power plants. Lastly, the fact that capture technologies are not standard for sources and scales makes R&D even more difficult as this requires different retrofitting technologies and configurations for different plants.

The issue of CCS drastically increasing the cost of electricity while reducing net power output is often cited as being one of the biggest financial barriers to acceptability of CCS in India. The capital costs of CCS adoption is estimated to be 30 to 40% higher than traditional coal power plants.[18] Given that the India is still waiting for large scale demonstrations of the technology elsewhere, the high capital costs makes it even difficult to invest in. Additionally, CCS deployment is held to run counter to India's ambitious goals for greater electrification, especially given the country's present electricity deficit and projected energy demands.

In terms of institutional barriers, there is no clarity on how CCS retrofitting on existing plants will influence the Terms of Reference for the plant. Similarly, the adoption of CCS will require both technical transfers and international finance from agencies such as the World Bank, the Asian Development Bank, etc. These financing agencies will likely demand higher governance requirements in terms of monitoring, measuring and verification. To fulfill these requirements, India will have to fundamentally reform how the power sector is regulated and managed. Moreover, CCS technology is often considered to be a "non-productive expenditure" within the bureaucracy as it does not fit in the overall goal of meeting the Millennium Development Goals.[19]

<u>High Efficiency Low Emissions (HELE) and Other Technologies</u>

The adoption of HELE technologies for coal plants can serve as a medium term emissions reduction strategy and an intermediary solution between existing installed capacity and CCS technology. India's Technology Action Plan 2009 (developed with Japan) acknowledges that HELE technology can address both electricity demand and global emissions simultaneously. While these technologies exist and are being adopted in India, the development and large scale

[17] TERI, 2013.
[18] Dadhich, 2007.
[19] Ibid.

deployment of HELE coal technologies in India is impeded by a number of barriers.

From a technical perspective, insufficient Information, varying qualities of coal and the lack of local operations and maintenance capacity is a barrier to adoption. India's coal has high ash content (approximately 40%), low calorific value (approximately 2400–3300 kcal/kg) and low volatile matter.[20] The gasification of these high ash-content coals, gas cleanup, and low-calorific value of syngas present challenges, yet to be resolved, for the adoption of IGCC or other HELE coal technologies in general. Moreover, component erosion due to high ash content reduces the availability and reliability of power stations - a common problem in India already. Similarly, the lack of adequate operation and maintenance (O&M) standards, practices, and tools presents a technical capacity challenge in the adoption of these technologies. These O&M standards and practices differ depending on the type of the plant (subcritical, supercritical, ultra-supercritical, etc). This is the reason why the actual operational efficiency of subcritical technology, in many cases across the world is far below the designed efficiency due to inadequate O&M. As a result, increasing efficiency will require much more than the installation of plants.[21]

In terms of financial and institutional barriers, the lack of appropriate price, financial, legal, and regulatory frameworks inhibit the adoption of such technologies. The most important issue is perhaps that of intellectual property rights as most HELE coal technologies belong to private companies. The dissemination of the HELE manufacturing and operations "know-how" occurs primarily through commercial transactions between private technology companies and utility companies in host countries. India's policy however is to require companies contracted to develop supercritical units to hand over all technologies to the Indian company operating the plant. In India's case, the absence of an enabling environment for technology dissemination can hinder the adoption of advanced technologies. India's regulatory system is advanced in some areas and archaic, unnecessary and counterproductive in others. Given that much of India's coal production and distribution is state operated, revamping regulations can benefit from the small number of players involved. However, the government involvement and existing regulatory framework can also influence price signals (subsidies, long term contracts for input, etc.) and reduce the financial incentives to transfer new technologies. Financing HELE technologies is also difficult through the Clean Development Mechanism as the process is lengthy and uncertain.[22]

RECOMMENDATIONS

Carbon Capture and Sequestration (CCS)

In order to realize the long term potential for CCS, the government of India can consider adopting the following strategies:

- *Knowledge building and capacity development of policy makers and regulators. The* National Program on Carbon Sequestration (NPCS) must contain a more systematic and

[20] Major Economies Forum on Energy and Climate Change, 2012.
[21] Ibid.
[22] Major Economies Forum on Energy and Climate Change, 2012.

sustained research component aimed at informing India's policy makers of the potential benefits and risks of adopting CCS technologies.[23]

- *Capacity development for storage site assessment, development, operation and monitoring and verification.* The lack of information on potential storage sites is one of the biggest hurdles to CCS deployment in India. There are two main ways this issue can be addressed. First, Indian geologists can be trained in advanced assessment techniques specific to CCS outputs. Second, India's coal and environmental protection agencies can have greater involved in site assessments in other countries in order to develop customized regulatory frameworks. Similarly, as CCS technology is still in the demonstration phase, India's research networks need to increase its international collaboration and involvement to facilitate knowledge and technology transfers.[24]

- *Capacity development of financial institutions*. Since the norms and practices of CSS technologies differ from those applied for normal power plants and industries, India's financial sector will need greater technical capacity to conduct financial evaluation of CCS projects. The government and regulatory agencies can kick start this process by informing Indian financial institutions about global practices and helping them to adapt these to Indian requirements.

High Efficiency, Low Emissions Coal-Fired Power Generation (HELE)

The adoption of HELE and other related efficiency related technologies is driven by the country's 13th Five Year Plan. To accelerate the shift towards more energy efficient and environmentally friendlier plants, the following strategies can be explored:

- *Identifying research and development priorities*. Different countries require different HELE coal technologies relative to their economic, regulatory, and technical and resource needs. India can maximize its return on investments and ensure successful large scale adaption by identifying priority technologies at the early stage. India is currently involved in R&D efforts on IGCC technology suitable for Indian coal and is also prioritizing the adoption of larger (660/800 megawatt [MW]) thermal units based on supercritical technology in capacity addition programs. India's energy policy planning, energy finance sector and regulatory framework must also align with these priorities as well.[25]

- *Developing regulatory & financial incentives.* Instituting efficiency and emissions related regulatory incentives can provide private utilities the opportunity of benefitting from high cost HELE technologies. The Central Electricity Regulatory has already adopted a national level tariff mechanism to promote energy efficiency. Similar incentives, perhaps even specific ones for HELE plants can improve financial viability in the short and medium runs and attract greater private sector finance. The government should continue to leverage and support public-private partnerships to in order to effectively identify HELE coal technologies and design appropriate policies and measures. The

[23] Ibid.
[24] Ibid.
[25] Major Economies Forum on Energy and Climate Change, 2012.

private sector's involvement will be critical in achieving the government's long term goal of indigenous manufacturing.

- *Investing in capacity development.* Developing effective capacities in areas such as operations and management (O&M) is as important as installing HELE technology. Here, there is greater scope for coordinated action on the international front. Currently, there is no internationally agreed upon mechanism or framework to confirm or promote the progress of technology development that each country or region has achieved. While training missions, exchange programs and capacity building initiatives through IO's such as the World Bank will be important, India can lobby for and support the development of an international technology transfer mechanism under the UNFCCC. Debates on this topic have been intense but inconclusive. The creation of an international technology transfer mechanism under the UNFCCC can act as an institutional platform for navigating IP right issues and improving public-private partnerships for technology transfers.[26]

<u>Other Policy Recommendations</u>

- *Reform taxation policy*. Currently, the Government of India imposes a tax of Rs 100 per mt on the consumption of coal, both domestic and imported. This is effectively a carbon tax and the revenues are used to fund the National Clean Energy Fund. While this tax has provided $524 million[27] for the National Clean Energy Fund, it does not significantly influence the consumption of coal or alter the power mix. As a result, experts at the World Bank working on the environmental and health costs of coal-related particulate emissions advocate for a higher level of taxation.[28]

- *Tax particulate matter emissions.* An alternative to the existing flat tax on coal use can be to tax particulate matter emissions (PM). A PM tax PM10 level (where particulate matter is less than or equal to 10 microns or less in diameter) can significantly reduce particulate levels and carbon emissions without hurting the Indian economy. According to their report titled "Diagnostic Assessment of Select Environmental Challenges in India," a 30% particulate emission reduction would lower GDP about $97 billion, or only a net of 0.7%, representing a very small impact on growth annual growth rates.[29]

- *Explore short term low cost options to reduce particulate emissions*. Removing contaminants before combustion or "washing coal" can be an effective low-cost option to significantly reduce emissions from power plants and decrease environmental costs.[30] This process "not only reduces the ash content of coal, but also improves its heating value and removes small amounts of other substances, such as sulfur and hazardous air pollutants."[31] However, currently only 4% of coal in India is washed. This offers an

[26] Major Economies Forum on Energy and Climate Change, 2012.
[27] Pahuja et al., 2014.
[28] For example, this would include Muthukumara S. Mani, a senior environmental economist at the World Bank.
[29] World Bank, 2012.
[30] Mani, 2013.
[31] Ibid.

immediate opportunity to reduce climate-related and health damage from coal-fired power plants."[32]

BARRIERS: RENEWABLE TECHNOLOGIES

This section analyzes the policy landscape and institutions relevant to renewable sources of power, the barriers to large-scale deployment and recommends strategies to overcome those barriers. Specifically, given the high average annual mitigation potential and low cost per Mt CO2 emission reductions, the renewables section focuses on the barriers to expansion of solar power (photovoltaic and CSP), wind power (high and low penetration).

TECHNICAL, FINANCIAL, POLITICAL, MARKET AND OTHER BARRIERS BY SOURCE

Wind Power

India has a large potential for increasing the share of wind power in its energy mix. Increasing the share of wind power will directly decrease energy related emissions. According to the McKinsey Climate desk tool, high penetration wind power has the potential to reduce annual GHG emissions by 112 Mt CO_2eq.[33] More importantly, low penetration wind power (which assumes a lower percentage share of wind contribution to the energy grid) has a potential of decreasing emissions by 171 Mt CO_2eq annually. This is because low penetration technology requires less storage capacity, is less expensive, and can accommodate more diffused grid structures. According to India's Twelfth Five year plan, the wind potential in India is estimated at about 103,000 MW for 80 m hub height.[34]

Given recent technological innovations, it is possible to accelerate the large scale deployment of wind technologies and add around 30,000 MW to the total capacity by 2020.[35] However, this will require overcoming both of technical and institutional barriers. India's wind potential is unevenly distributed and concentrated in five major states: Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra and Gujarat. This means that it will be unrealistic to assume wind to be in the preferred power mix for all regions. In regions where the potential for wind power generation is significant, the availability of appropriate land can also act as a barrier.

Perhaps the most important barrier relates to the fact that wind power has significant seasonal and intra-day variations. This means that setting wind power targets without taking into account the capacity of the grid to balance this intermittency with alternative sources can be disastrous. This challenge becomes acute when considering the targeted 103,000 MC long term capacity. At such a scale, balancing possible intermittencies which are natural to wind power generation will be critical.

[32] Ibid.
[33] Wind energy penetration refers to the fraction of energy produced by wind compared with the total available generation capacity. A wind energy penetration figure can be specified for different durations of time.
[34] Twelfth Five Year Plan, 2012.
[35] Ibid.

Lastly, in terms of regulatory barriers, the growth of wind was largely a result of the 80% accelerated tax depreciation on wind power provided by the government. This tax break resulted in the addition of wind power capacity on the balance sheets of existing companies. While this saved companies income tax, it incentivized bad behavior as many of the wind projects were built in low wind speed areas and failed to deliver the promised production. This policy also reduced the involvement of foreign investors as they could not derive the income tax related benefits of this policy. Given the negative policy consequences, this tax was lowered to 15% in 2013. However, energy producers have since pressured the government to reverse the decision. Suzlon energy, a leading turbine maker has claimed that the removal of tax incentives has cut wind power production in 2013 by half (from 3300MW in 2011 to 1500MW in 2013).[36] This tension between incentives which drive innovation and capacity versus those that create dependence needs to be resolved if wind power is to reach its potential.

Recommendations for Wind Power

- *Improve regional level planning and coordination.* In order to leverage the potential of wind power, the government must specifically target developing capacity in the five states where potential is concentrated.
- *Increase competitiveness and drive down prices.* This can be done by reducing anti-competitive behavior by major equipment suppliers. Equipment suppliers usually undertake all developmental activities, as well as commissioning of projects and self-contracting of O&M activities. Since suppliers control the bulk of the process, buyers are forced to pay a premium for the wind power projects. This results in wind power projects being more expensive and restricts competition for equipment supplies.[37]
- *Improve the regulatory framework for Renewable Purchase Agreements.* Currently, some states such as Maharashtra, Gujarat, Madhya Pradesh and Karnataka do not allow the procurement of RE power from outside the state. This is detrimental for the overall development of RE in the country.[38]
- *Revisit land tenure policies*. Encouraging mixed use land use for wind power generation with agriculture will improve adoption rates as it will increase land availability in crucial states as well as decrease the costs (compared to commercial rent).
- *Enhance energy storage capacity*. R&D in energy storage that can provide backup for longer durations, like compressed air and high power density batteries among others is critical if large scale deployment is to be achieved. Similarly, it is important to invest in complimentary options like pumped hydro-storage to accommodate intermittent shortages.
- *Explore the technical potential and economic viability of off-shore wind energy*. This can boost production in states such as Andhra Pradesh and Tamil Naidu and circumvent land use conversion challenges in some regions.

[36] Kumar, 2014.
[37] IDFC, 2010.
[38] Ibid.

Solar Power

The expansion of solar power production in India is driven by the Jawaharlal Nehru National Solar Mission (JNNSM). The JNNSM targets an ambitious 20,000 megawatts (MW) of grid-connected solar power by 2022 (in a phased approach) and promotes programs for off-grid applications to achieve targets of 1,000 MW by 2017 and 2,000 MW by 2022. Solar power adoption is promoted through the use of a solar-specific renewable purchase obligation, which makes it mandatory for power utilities to source a specified share of their power from solar power plants.[39]

The JNNSM offers two types of major incentives: Generation based and capacity subsidies. Generation based incentives are provided to state utilities to encourage direct purchase of solar power from projects. Up until now, the Indian Renewable Energy Development Agency has selected 78 projects with a total capacity of 78MW for a generation based incentive of (US$0.20 per kWh).[40] Capital subsidies are provided by the government to support deployment of off-grid solar applications. These capital subsidies are given up to 30% of the benchmark costs as well as soft loans at interest rates of 5%.

The government also reduces tariffs and encourages solar development through the bundling of sources and adoption of reverse auctioning. Under the RPO, the bundling of solar power with cheaper conventional power helps reduce solar power tariffs for distribution utilities. Similarly, the adoption of reverse bidding mechanism enables qualified bidders to benefit from declining global prices for solar components. This in turn reduces the purchase price of both solar PV and Concentrating Solar Power (CSP) for the utilities, two important mitigation strategies identified in our analysis of the McKinsey Climate Desk data. These strategies have allowed India to increase its solar power installed capacity from 30 MW to more than 2000 MW in less than a decade.[41] While JNNSM has had successes in kick starting the deployment of solar power in India, it continues to face a number of barriers that inhibit large scale deployment.

Apart from the general lack of financing for scaling up renewable energy projects, solar power faces some specific financial barriers. The bundling strategy has been successful in reducing tariff rates thus far. However, the limited availability of unallocated thermal generation means that India may no longer have the option of bundling its solar power with other sources of cheap power. This would most likely drive up the per-unit cost of solar power.

Given the lack of mature debt markets, Scheduled Commercial Banks (SCBs) dominate the infrastructural lending market in India (accounting for ~80% of debt disbursements). So far, SCB's have shied away from financing solar projects in the initial phase of the JNNSM due to the lack of adequate risk reducing mechanisms and the crowding out effect of concessional source of financing (e.g. suppliers credit and direct lending by IO's). Given the current lack of interest from the SCB's, Phase II of the JNNSM, which will require approximately US $4.1

[39] Pahuja et al., 2014.
[40] Ibid.
[41] World Bank Press Release, 2013.

billion in financing, will face critical funding shortages.[42]

In terms of technical barriers, a recent World Bank report noted that India's solar PV manufacturing facilities face resource constraints in the shape of a lack raw materials, limited access to low-cost financing, and underdeveloped supply chains.[43] In solar thermal, where local manufacturing is more complex, India has not been able to manufacture some critical components and the indigenous PV manufacturing industry has had limited success. Moreover, the rapid advancement of solar PV technology not only slows down local manufacturing, it creates planning challenges for the JNNSM. For example, during the first phase, JNNSM prioritized the adoption of Thin Film (TI) PV technology through a Domestic Content Requirement (DCR). The DCR required the alternative Crystalline Silicon (c-Si) to only be sourced from domestic manufacturers whereas there was no such requirement for TI PV's. This led to imported TI technology dominating the Indian market and accounting for 70% of all PV installations. However on the global scale, the share of TI technology is steadily declining. As a result, the DCR policy which was meant to increase local production in fact led to increase imports and a greater technology gap. This raises the question as to whether a domestic content requirement is itself fundamentally flawed, or whether it can be designed in a less heavy-handed and intrusive manner.

From a regulatory perspective, the development of solar power, like any other large infrastructural project in India, faces constrains from a land use and conversion perspective. Land acquisition and converting land use designations is difficult in the current regulatory framework with delays in approvals and clearances at the state level being common. Similarly, the limited availability of field-level data, lack of supporting infrastructure for water and power evacuation, and the limited coordination between the central and state institutions compounds the challenges faced in scaling up from phase I of the JNNSM. Lastly, the absence of a clear mapping of responsibilities of institutions in the public domain makes decision making hard and increases regulatory burdens on individual projects. [44]

Recommendations for Solar Power

- *Address structural impediments to public finance.* Public funding will play an essential role in realizing the JNNSM's objectives. The evolutionary nature of solar PV and CSP technologies, their higher cost, and the risk perception amongst private investors and financiers in this segment makes it important for the government to target structural barriers to finance. Access to commercial financing and its pricing can be improved if risk-reducing instruments and financial innovations such as risk guarantee schemes, credit guarantee enhancement schemes, and subordinated public finance are incorporated to improve the investment climate.[45]

- *Encourage local manufacturing through coordinated industrial policies.* While the solar manufacturing industry is identified as 'strategically important' in India's National

[42] World Bank ESMAP, 2013.
[43] World Bank Press Release, 2013.
[44] World Bank ESMAP, 2013.
[45] Ibid.

Manufacturing Policy, India's current PV manufacturing capacity is limited and unable to break into the high technology upstream segments of the industry.[46] In order to improve the industry's state of affairs, it is important for the government to coordinate its DCR policy with its industrial policy. This can be done focusing on local comparative advantages, creating robust local and international forward and backward supply chain linkages, and drawing up clear technology scenarios for solar (PV and CSP) generation.[47]

- *Enhance role of state.* While improving public finance is important, the long term viability of solar power is dependent on a larger public sector involvement in identifying, scoping, and undertaking preliminary activities. This reduces the risk of private sector participation and can also have important co-benefits such as regulatory standardization across states.

- *Adopt a cluster based approach to solar power development.* Employing a solar parks model akin to that used in Gujrat makes sense for India. Developing solar power generation capacity in clusters optimizes land, water and evacuation infrastructure, and allows for better transmission and grid management.

BARRIERS: NUCLEAR POWER

Though nuclear power cannot be classified as a renewables technology, it produces zero emissions during actual power production, similar to wind and solar power. The use of nuclear power in India is gradually increasing. According to the US Energy Information Administration, India has 20 operational nuclear reactors in six nuclear power plants with a capacity of 4.4 gigawatts, while seven reactors totaling 5.3 gigawatts (electric) are under construction and expected to come online by 2016.[48] This expansion is in line with the government's long term plan to increase the share of nuclear energy for electricity from 2-4% to 25%.[49] These plans have received a boost with the Indo-US civil nuclear agreement announced in 2005 and completed in 2008. This agreement removed the sanctions imposed on India with regard to civil nuclear commerce in the wake of its 1974 nuclear test. Following the Indo-US nuclear agreement, India signed agreements with the UK, France, Russia, Kazakhstan, Argentina, and other countries for access to nuclear parts and fuel.[50]

Political barriers have recently stalled the development of India's nuclear power capacity. The Indian public protested against the use nuclear power after the Fukushima disaster in Japan and has since increased pressure on the government to commit to greater regulations and auditing of installed capacity.[51] In response, the Atomic Energy Regulatory Board (AERB) conducted stress tests on all nuclear sites. Resistance from communities to nuclear power also originates in land acquisition disputes, which are a feature of numerous infrastructure projects in India.

[46] World Bank ESMAP, 2013.
[47] Ibid.
[48] US EIA, 2012.
[49] Ibid.
[50] US EIA, 2012.
[51] Ibid.

Although a new land acquisition law was passed by the Indian parliament in 2013, its operationalization is yet to be seen, with several states resisting its implementation.

Another political barrier for nuclear energy expansion is the disagreement with the United States on nuclear liability. India's nuclear liability law is not in conformity with the International Convention on Supplementary Compensation for Nuclear Damage (CSC). This has caused some of the supplier countries to hold back on conducting nuclear commerce with India. India recently ruled out any dilution to its liability law, and this dispute remains a barrier to nuclear energy expansion in the country

Recommendations for Nuclear Power

- *Address public safety concerns.* The future growth of nuclear power will require addressing public concerns about safety of nuclear power, and consensus-building at the national and local levels.[52]

- Ensure the implementation of the new land acquisition law in a fair and comprehensive manner after evolving a consensus with state governments.

- *Improve grid infrastructure.* Large, centralized nuclear power plants require robust, high capacity grid infrastructure. Such infrastructure currently does not exist in many coastal areas, where new plants are planned.

- *Resolve the dispute over nuclear liability with the U.S. and other countries.* The international community could be more realistic about Indian insistence of the supremacy of its parliament over any nuclear accidents.

[52] Twelfth Five Year Plan, 2012.

INDUSTRY

India has the fourth highest level of energy consumption for industrial activities in the world.[53] Industrial sector CO_2 emissions (including direct and indirect emissions) in India in 2010 were 633 $MtCO_2$, which represents 38% of India's total CO_2 emissions.[54]

Global GHG emissions in the industrial sector are projected to increase by 8.6 $GtCO_2e$ (55.4%), growing to 24.3 $GtCO_2e$ by 2030, under the BAU scenario. Industrial emissions in India are expected to rise by 1.7 $GtCO_2e$ (165.2%) in the BAU scenario.[55] Of the various industry sub-sectors, iron & steel and cement form the major components.

Iron and Steel
Emissions from the iron and steel industry are currently 3.3 $GtCO_2e$ globally, but most heavily concentrated in the developing world. China, the E.U., and India are the biggest emitters in iron and steel at 2.0 $GtCO_2e$, 0.3 $GtCO_2e$, and 0.2 $GtCO_2e$ respectively.[56] As development continues to progress, India's steel emissions are expected to see a 0.4 $GtCO_2e$ (264.4%) increase by 2030.

Cement
Distribution of emissions in the cement industry is similar to that of iron and steel. Of the global total emissions of 2.8 $GtCO_2e$ in cement, China is responsible for 1.6 $GtCO_2e$, the E.U. for 0.2 $GtCO_2e$, and India for 0.2 $GtCO_2e$.[57] India's cement industry emissions are projected to increase by 298.3%, a 0.5 $GtCO_2e$ rise.

As industrialization continues to occur at a rapid pace in India, emissions in the industrial sector will dramatically exceed the potential savings from increased energy efficiency.[58] To curb this growth in industrial emissions, new abatement measures beyond mere efficiency improvements will have to be introduced and existing measures strengthened, particularly in iron and steel production and cement. The recommendations outlined in this report focus on increasing energy efficiency through the use of new technologies, switching to less GHG-emitting fuels for industrial processes, reusing scrap and waste materials in manufacturing, and adopting carbon capture and sequestration (CCS) techniques.

BARRIERS

Significant barriers exist to adoption of many of the recommended strategies (see below) for emissions reductions in the industry sector. Most notably, India does not have the technical capacity for implementation of some of the BATs and also, has no financing mechanism in place to encourage uptake.

[53] Gambhir, 2012, 21.
[54] Gambhir, 2012, 22.
[55] McKinsey Climate Desk, 2009.
[56] McKinsey Climate Desk, 2009.
[57] Ibid.
[58] OECD/IEA, 2011, 10.

Technical

Increased energy efficiency and lower industrial emissions will require upgrading many existing steel and cement plants to use cleaner technologies. Where India does not possess these technologies or have the capacity for extensive research and development, technology transfer from developed countries could help to realize the emissions reductions potential in this sector.

Financial

The upfront costs of many of the BATs recommended are prohibitively expensive for the majority of actors in India's industrial sector. As such, alternative financing mechanisms will have to be explored. There is some potential for CDM projects in this sector, but they have not been initiated as frequently as in other sectors. Another strategy is government subsidization of energy efficient equipment or tax incentives for investing in technological and efficiency upgrades.

Recommendations for Industry

As highlighted in the companion Energy Efficiency report, industrial GHG abatement potential of 6.8 $GtCO_2e$, globally, is possible through the following measures:

- *Energy efficiency Improvements*. Replacing older factory equipment with more energy efficient technologies and adopting more efficient production techniques.
- *Fuel and Feedstock Switching*. Switching industrial processes away from high emitting fuels like coal, which is responsible for supplying approximately 28% of industrial energy in India, to natural gas or renewables.[59]
- *Co-generation or Combined Heat and Power (CHP)*. Heat is a natural by-product of energy and electricity generation. If this heat is captured, it can be used in heat-intensive industrial processes like iron reduction for steel and cement clinker production
- *Recycling and Recovery*. Recycling and reuse of scrap steel and waste plastic in industrial processes can lower production emissions.
- *Carbon Capture and Sequestration (CCS)*. Capture and storage of industrial CO_2 emissions can prevent release of these emissions into the atmosphere.

Of the total industrial emissions abatement potential of 6.8 $GtCO_2e$, achievable through the above measures, the iron and steel sector in India accounts for 0.2 $GtCO_2e$ and the cement sector for another 0.2 $GtCO_2e$.

Iron and Steel

India's Twelfth Five Year Plan recommends the following measures for emissions mitigation in the iron and steel sector:[60]

[59] Gambhir, 2012.
[60] Twelfth Five Year Plan, 2012, 124.

- A shift in the process mix of the iron and steel sector towards more efficient processes
- Diffusion of energy efficient technologies into the sub-processes of various process routes mentioned above
- Waste heat recovery systems for moisture reduction and power generation
- Utilization of renewable energy in specific process/plant/colony applications
- Increased use of waste as alternate fuels
- Increased scrap utilization
- Improving quality of coke and coal before its use in the industry
- Low carbon captive power generation

Technology improvements in the iron and steel industry that should be pursued in India include the following:[61]

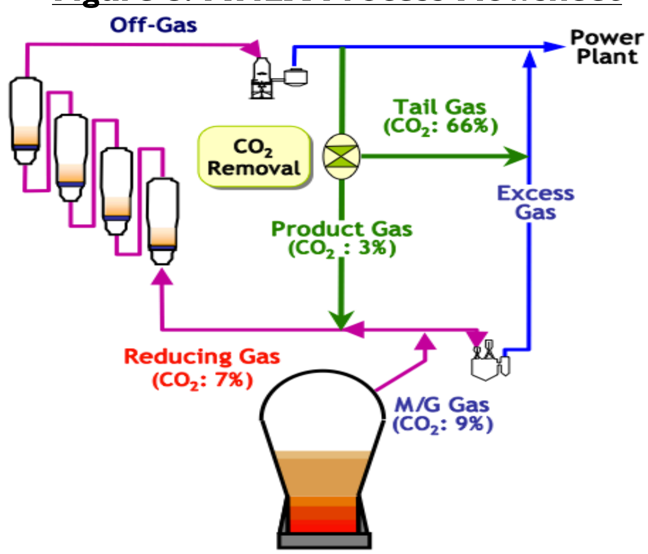
- *Smelting reduction.* Smelting reduction processes, like FINEX, which is a fluidized-bed process, have both energy savings and CO_2 emissions reduction potential. FINEX processes have 4% more emissions reduction potential than blast furnace processes. Energy consumption of the FINEX process is less than 700 kg-coal/t-HM.[62] Additionally, investment costs for FINEX are only 80% of the investment costs of a traditional blast furnace.
- *Top-gas recycling blast furnaces.* Top-gas recycling removes CO_2 from the top gas and stores it. The remaining stream, which contains the reducing agents H_2 and CO, is then heated and re-injected it into the blast furnace. Sequestration of the CO_2 together with reuse of the top gas has the potential to reduce blast furnace emissions by 75%.[63]
- *Use of charcoal and waste plastics.* Waste plastic can be used as a substitute for higher CO_2 emitting reducing agents in blast furnaces.[64] Charcoal has also been used as an alternative to coke but, while lowering emissions somewhat, it does not produce substantial energy efficiency gains.
- *Steel recycling.* Recycling scrap steel consumes less energy than new steel production and so has great potential for avoided emissions. The recycled steel can forego the reduction process and be melted in an electric arc furnace, limiting the energy used in production.
- *Efficiency improvements in direct reduced iron (DRI) technology.* DRI is a less energy intensive process than traditional steel production methods. DRI processes can be fueled by either natural gas or coal, though coal is less energy efficient. India already

[61] IEA, 2010, 35.
[62] Institute for Industrial Productivity, 2014.
[63] Afanga et al., 2012.
[64] IEA Energy Technology Transitions for Industry, 2012, 69.

produces more DRI than any other country in the world.[65] But, while 90% of global DRI production utilizes natural gas, India predominately relies on coal-based production. Furthermore, the composition of the coal used in India has a higher than average percentage of non-combustible components, like ash and moisture, which reduce efficiency. The average ratio of coal to DRI in India is between 1.2 to 1.5 t-coal/t-DRI. (1.05-1.2 t-coal/t-DRI for more advanced plants), which is significantly higher than in plants that use coal with lower percentages of non-combustible constituents. Additionally, DRI production in India uses counter-current rotary kilns, which only use 60% of the heat for reduction. Utilization of the remaining heat that is discharged from the kiln could substantially improve energy efficiency.[66]

- *CCS.* Equipping steel production plants with CCS infrastructure has significant potential to reduce CO_2 emissions by capturing the emitted CO_2 and storing it geologically before it enters the atmosphere. Although this technology is still in pre-demonstration stage in other parts of the world, India could focus on harnessing it rapidly once it is shown to be viable.

Figure 8: FINEX Process Flowsheet



[65] Gambhir, 2012, 24.
[66] Ibid.

Cement

The Twelfth Five Year Plan highlights the following strategies for emissions reductions in the cement sector: [67]

- Diffusion of energy-efficient technologies in various sub processes of cement manufacture.
- Waste heat recovery systems for moisture reduction in coal and raw materials and for power generation.
- Utilization of renewable energy in specific process/plant/colony applications.
- Increased use of waste as alternate fuels, rationalizing the various policies that regulate this activity.
- Increased blending using fly ash from thermal power plants and granulated blast furnace slag from steel plants, and the increased use of composite cements.
- Improving quality of coal before its use in the industry.
- Low carbon captive power generation.
- Increase of blended cements in the public procurement

Technology improvements in the cement industry that should be pursued in India include the following:[68]

- *Energy efficiency and shift to best available technologies (BATs).* Uptake of advanced technologies in the cement industry have the potential for efficiency gains and emissions reductions. Currently India predominately uses rotary kilns for cement production, but converting to more advanced technologies, like fluidized bed kilns, could significantly reduce emissions through lower thermal energy use and greater heat recovery. Fluidized bed kilns have the potential to achieve 10% reductions in CO_2 emissions. However, this technology is not yet widely available in the cement industry, so investments in R&D for this kind of technology will need to be made before it can be scaled up.[69]

- *Fuel-switching and alternative fuels.* Cement production India relies heavily on coal, but adoption of natural gas or alternative fuels (like waste tires, plastics, chemical waste, waste pellets, wood waste, and sewage sludge) could reduce emissions and increase energy efficiency.

[67] Twelfth Five Year Plan, 2012, 125.
[68] IEA, Cement Technology Roadmap, 2010, 43.
[69] Institute for Industrial Productivity, 2014.

- *Clinker substitutes.* Compared to the global average of 0.79, India's clinker to cement ratio of 0.84 is relatively high.[70] Substitution of fly ash or blast-furnace slag for cement clinker could reduce CO_2 emissions and potentially cement costs as well.[71]

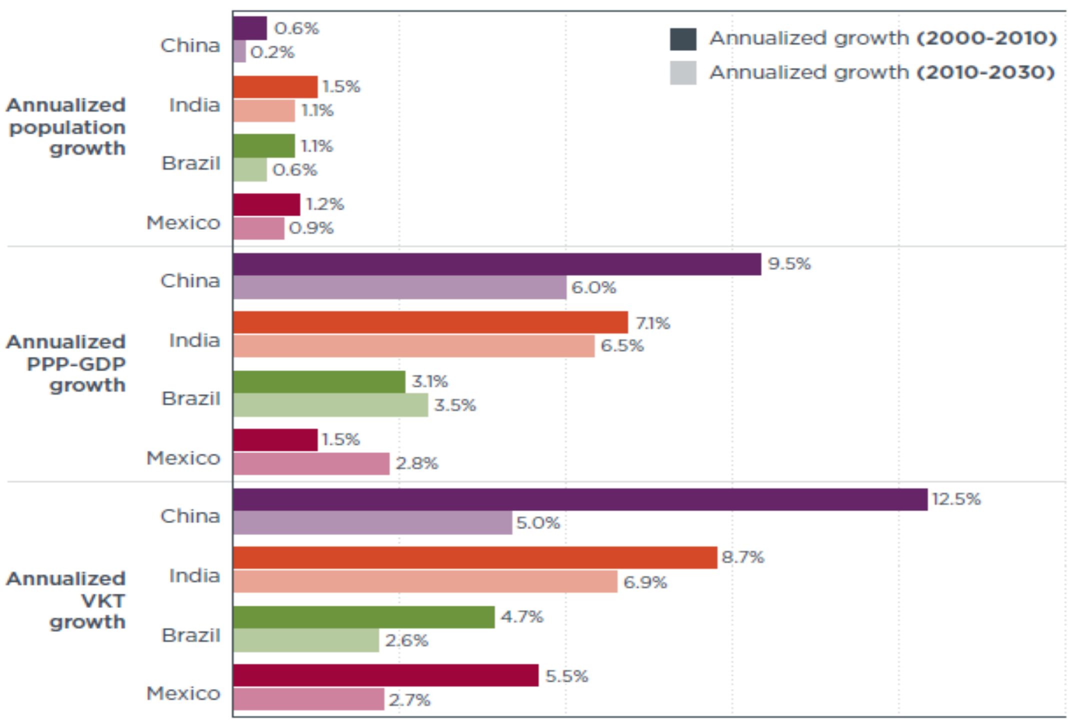
- *CCS deployment.* Similar to iron and steel production, CCS deployment in cement production has the potential to reduce CO_2 emissions. However, cement plants are less suitable to retrofitting and the average cement plant can last up to 50 years.[72] This means that, moving forward, CCS infrastructure should be part of cement plants' initial construction.

[70] Trudeau et al., 2011, 24.
[71] Dutta and Mukherjee, 2010, 24.
[72] IEA Cement Technology Roadmap, 2009.

TRANSPORT

Following economic liberalization that began to take effect in 1991, passenger and freight road traffic increased in step with a nearly 63.69% increase in GDP per capita between 1991 and 2013.[73] From 1995-2005, GDP nearly doubled, and the number of registered motor vehicles increased from 5.4 million in 1980 to 72.7 million in 2003.[74] During this period, foreign and domestic investment in road infrastructure projects increased in an effort to promote access to markets and encourage economic development. Where essentially no new major road transport infrastructure projects were constructed from 1947 to 1988[75], nearly 700,000 km of highways have been constructed since 1995, and demand for vehicle km traveled is projected to increase, as figure 9 suggests.

Figure 9: Comparative trends in population growth, economic development, and mobility demand growth



Source: ICCT, Briefing on Health, 2013

The road transport sector is also one of the fastest growing sources for greenhouse gas emissions in India, and an important factor in India's economic success over the past two decades. In fact, transportation accounts for a 6.4% share of India's GDP, with road

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[73] Ramachandra and Schwetmala, 2009.
[74] Ramachandra and Schwetmala, 2009.
[75] However, India's state-owned rail network expanded considerably during this period.

transportation contributing 4.5%.[76] From 2007-2010, the transport sector's share of net GHG emissions in India increased from 7.5% to 9%, and this share is projected to increase from 203 $MtC0_2e$ in 2005 to 905 $MtC0_2e$ in 2025 if policies to reduce the carbon intensity of India's transportation are not implemented.[77] Though transport was responsible in 2010 for only part (14%) of the energy sector's share of total emissions, it is the largest end-user of oil nationally, consuming nearly 50% of total demand, which is problematic given that India is a net oil importer as of 2012.[78] Demand for passenger and freight mobility is primarily located in densely populated urban areas. Within urban transport, freight contributes nearly 55% of total road emissions due to lorry reliance on diesel for fuel, which contributes to PM emissions and black carbon or soot.[79]

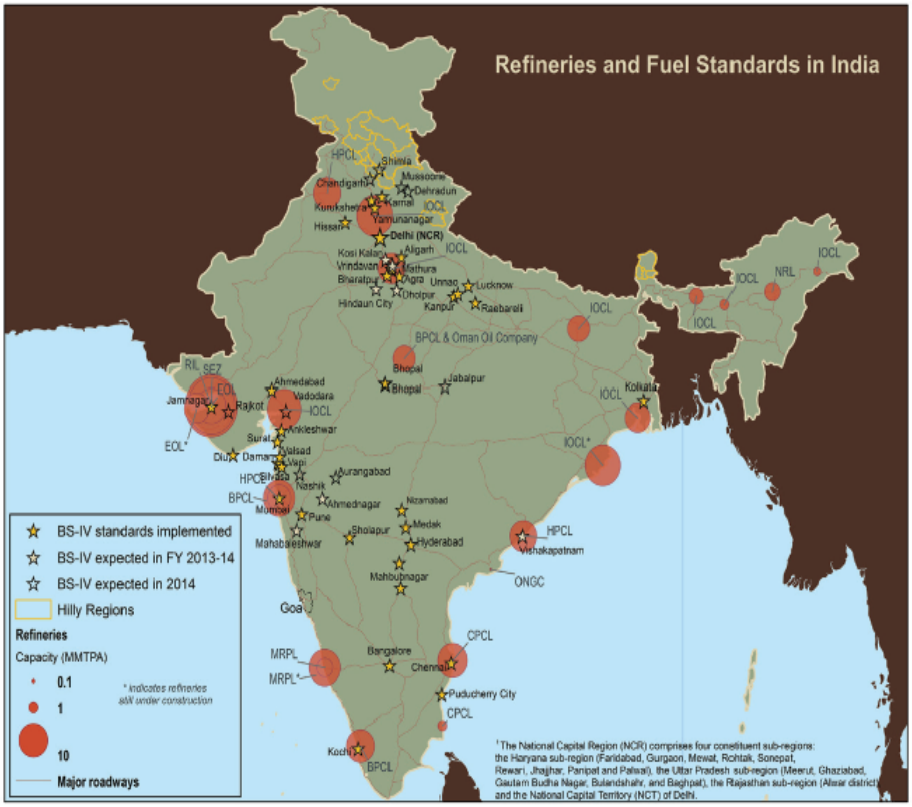
This section discusses the legal and economic structure of the transport sector in India and potential strategies for reducing India's GHG emissions from transport. The focus is on road transportation due to its majority share of transport emissions. As of 2007, road transport contributed 87% of the total emissions from the transport sector, or 123.56 of a total 142.04 $MtC0_2e$.[80] Emissions from rail amounted to 6.84 $MtC0_2e$ or 5%, aviation contributed 10.21 $MtC0_2e$ or 7%, and maritime navigation contributed 1.43 $MtC0_2e$ or 1% of total emissions from transport.[81] Two-wheelers and motor vehicles comprise 88% of road transport, though two-wheeler market penetration is more extensive in India due to the relatively low cost of upfront capital compared to motor vehicles.[82]

Transport in India currently relies on more traditional forms of fuel like coal and natural gas (98%), and oil (2%), though electric vehicle (EV) and alternative and biofuel technology are currently in different stages of development.[83] Road transport primarily consumes diesel and petrol, and GHG emissions from the transport sector include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).[84] Given that road transport modes rely on primarily dirty fuels, it will be important to slow the shift of increased freight traffic occurring with high rates of economic growth in India to the highways and major roadways.

The legal mechanism enabling the Indian government to set vehicular emissions standards originates from the Air (Prevention and Control of Pollution) Act (APCPA) of 1981, which mirrors the Clean Air Act of the United States. Through the APCPA, state governments in India are given the ability to create standards of air emission output for industrial plants, automobiles, and any other point source that is not a ship or aircraft in cooperation with the Central Pollution Control Board (CPCB).[85] The Environmental Protection Act of 1986 extended this regulatory scope to the central government, and the Motor Vehicle Act of 1988 added to the abilities of the central government to regulate motor vehicle emissions.

[76] Gota and Fabian, 2009.
[77] Gota and Fabian, 2009.
[78] OECD/IEA, 2012.
[79] Gota and Fabian, 2009.
[80] Government of India, Ministry of Environment and Forests, 2010.
[81] Ibid.
[82] Ibid.
[83] Mahindra, an Indian automobile manufacturer, currently produces two EV models, the Reva and e20. Mahindra Reva, 2013.
[84] Government of India, Ministry of Environment and Forests, 2010.
[85] ICCT/Dieselnet, 2014.

Figure 10: Implementation of Bharat III and IV



Source: ICCT 2013

Urban air quality is generally poor in India due to the heavy concentration of particulate matter from road traffic congestion, which has been elevated in recent years due to the increase of HDV trucks on India's road and highway system.[86] Concern about the public health impacts from poor air quality thus provided the critical mass to push the APCPA through, which led to the implementation of the India-1 vehicular standards for new vehicles, a precursor to the Bharat III standards currently in place. Resembling EU standards, the Bharat delineates a path for lowering permissible levels of pollutants until 2015. As of 2010, 13 major cities have implemented the Bharat IV standards, which parallel the Euro IV standard, with all other cities set to follow the Bharat III standard.

The Bharat standards regulate the allowable amount of particulate matter and emissions from two, three, and four-wheeled light-duty vehicles, medium and heavy-duty vehicles, and diesel-powered non-road vehicles including locomotive technology, agricultural tractors and electricity generation.[87] Particles that are addressed by the Bharat standards include carbon monoxide (CO), particulate matter (PM), nitrogen oxides produced during combustion (NO_x), and non-methane hydrocarbons (NMHC), though CO_2 does not fall under the regulatory scope of the

[86] Ibid.
[87] ICCT/Dieselnet, 2014.

Bharat standards.[88] Policy making in India is also complicated by an extensive bureaucracy, and so implementation of the Bharat III and IV standards is variable.[89]

Ministries involved in transportation policymaking and regulation include the Ministry of Environment and Forests (MoEF), of which the CPCB is part; the Ministry of Petroleum and Natural Gas (MoPNG); the Ministry of Road Transportation and Highways (MoRTH); and six institutes charged with testing new vehicles that are supervised by the MoRTH.[90] The MoEF and MoRTH are responsible for determining emissions standards for new vehicles, and individuals states are responsible for enforcing them.[91] Rail, maritime, and aviation modes are regulated by the Ministry of Railways, Indian Navy and Ministry of Shipping, Directorate General of Civil Aviation, respectively

BARRIERS & RECOMMENDATIONS

The biggest issues plaguing the transport sector in India are financing and accountability. Land acquisition also presents a major barrier. In order to address visibility at a national level, India's Climate Action Plan in its next iteration should address issues of financing and governance should be addressed more explicitly. Globally, state and international actors should address transportation in terms of co-benefits through including objectives like equal access to sustainable, low-carbon transport in the UN Sustainable Development Goals. Targeting equitable access and quality of life co-benefits rather than the flow of vehicles and targets for emissions reductions will provide a more solid sell for policy makers, particularly if they are given tools like emissions calculators to understand the benefits of less-carbon intensive transport projects like bus rapid transport (BRT) to their constituent communities.

Public-Private Partnerships

Funding for low-carbon transport projects is a considerable barrier to transport reform in India in terms of planning. India, like many emerging economies, does not possess the required capital to sponsor implementation of the expensive infrastructure projects necessary to reduce the carbon intensity of its transport sector.[92] Current funding options like CDM have provided limited support for select transport projects in South America and Southeast Asia, but comprise only 0.6% of the 6707 projects that have received funding under CDM to date.[93] Other funding mechanisms like the World Bank's Clean Technology Fund and the Global Environment Facility have also made only modest contributions to funding transport infrastructure projects in developing countries worldwide.[94]

An alternative funding mechanism to CDM is the UNFCCC's Green Climate Fund. However this fund has just been capitalized and its net funding levels and disbursement modalities remain uncertain. Joint bilateral investment and Public Private Partnerships (PPP) at the municipal and

88 Ibid.
89 Ibid.
90 Ibid.
91 Ibid.
92 Madan, 2014.
93 IPCC, 2013.
94 Ibid.

state-level have also been advocated by some experts,[95] as administrators at this level often face substantial financial burdens with little national support. Some experts advocate PPP as an alternative to CDM funding.[96] These joint ventures involve the Indian government, the private sector, and foreign governments. The Clean Energy Project sponsored by the United States State Department, for example, has provided funding for urban infrastructure projects and clean energy development, which has had positive implications for the transport sector in India.[97] However PPP for road projects in India have generally yielded disappointing results thus far.[98] Thus there is a need to re-examine the framing of the PPP model to see if it is viable in its current form under Indian conditions.

Political Tractability

There are also considerable technical and information barriers that prevent policy makers from making transport reform a priority. The practice of quantifying emissions in India is relatively new, and measures are often inconsistent. Standardized emissions calculators that resemble those used in the United States and by WRI's EMBARQ may provide a powerful way for local and state-level decision makers to see the way that low-carbon transport policies affect their constituents directly.[99]

Though it is in the interest of state and local governments to enforce standards on vehicular emissions in terms of public health and improving efficiency in the long-run, issues remain in enforcing the Bharat III standards.[100] Currently, a mere third of fuel consumed by motor vehicles in India meets Bharat IV standards, and high sulphur levels in the rest of the country have caused a lag in the implementation of other vehicle emission control technologies like the diesel particulate filter.[101] In order for diesel-powered vehicle emissions to be reduced in any significant way, all new vehicles must meet Bharat IV standards.[102] Coincidentally, ten percent of all deaths worldwide resulting from vehicular emissions occurs in India, with total number of deaths projected to quadruple if more stringent vehicle emissions standards are not adopted.[103]

As with buildings, energy efficiency savings could deliver big health and emissions reduction benefits in the transport sector at a minimal cost. According to the ICCT, using local enforcement mechanisms for Bharat IV in a way similar to US CAFE standards would improve accountability. In this vein, there should be a focus on city and state level enforcement mechanisms rather than national ones. This would enable bottom-up improvements among policy-makers, planners, and citizens as India's cities attain higher levels of urban density. Ultimately, the goal of this policy area is to ensure the comprehensive and sustained functioning of low-carbon intensive transport systems.

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[95] Among these are the EMBARQ group at the World Resources Institute, Washington DC.
[96] Madan, 2014.
[97] Columbia University, 2014.
[98] Business Standard, December 5, 2013.
[99] Madan, 2014.
[100] ICCT, 2013.
[101] Ibid.
[102] Ibid.
[103] ICCT, 2013.

Policy areas that fall under the National Action Plan for Climate Change include the *National Mission on Sustainable Habitat*, which contains a focus on improving urban planning and encouraging a modal shift to public transport. Dedicated freight corridors (DFCs) along the Eastern and Western Routes have also been made a priority under the 11th and 12th Five Year Plans, and through increased axle weight and high speed (100km/hr) will speed up the pace of shipping in India.[104] DFCs are projected to output 2.25 fewer carbon emissions than non-DFC railways in India and will help decrease the burden on road networks. Since the 1990s, road transport's share in freight has grown to 65%.[105]

If the above issues of transparency, accountability, and visibility are addressed in reforming and strengthening existing policies like the Bharat Emissions Standards, then it will be easier to improve the efficiency of transport in India and better ensure co-benefits like equitable access. If demand for more carbon intensive forms of transport can be curbed so that India's modal mix does not come to resemble that of the U.S. and EU member countries, this will have a positive impact on the quality of life in India and its total output of GHG emissions. By focusing on co-benefits like reduced congestion and improved fuel efficiency, then political candidates and actors in the public and private sector may make reform in transport a greater priority.

[104] World Bank, 2014.
[105] Ibid.

GENERAL BARRIERS & RECOMMENDATIONS

In the sections above, we analyzed key emissions sectors, laying out the main barriers to transiting to low-carbon pathways and policy recommendations to get there. This section highlights barriers and consequent policy recommendations in the overall climate mitigation planning in India.

India has a wide array of national and state initiatives aimed at climate change mitigation (see Table 2). Broadly, these policies emphasize the primacy of India's energy security and focus on the necessity of increasing the share of renewables in India's energy mix, making energy generation and use more efficient, and making transport more efficient.

The main recommendations of this report are to strengthen these existing initiatives and, in some cases, to set specific targets and codify policies that will meet the objectives of the NAPCC. This section of the report outlines potential barriers to implementation of existing and proposed policies and suggest solutions for overcoming those barriers.

POLITICAL

Barriers

Fragmentation and lack of cohesive strategies. The initiatives proposed in the NAPCC are oriented toward broadly defined goals. With few exceptions, these missions lack fully formulated action plans with concrete objectives. Without specific targets identified, it is difficult to both implement policies and to measure progress. Further, implementation of each of the NAPCC's Missions is under the authority of a different nodal agency. There is great potential for plans to be waylaid by the massive bureaucracy of the national government, which lends itself to lack of inter-ministerial coordination.

Another problem with the NAPCC's sprawling plans, is that many of the missions have no clear strategy for localized implementation. Some, like the Renewables Purchase Obligation (RPO), though focused at the state level, target fairly monopolized industries. The monopoly concentration might make such industries good targets for change since any actions by the large emitters would have major emissions implications for the overall economy. For policies where this is not the case and offenders are more diffuse–fuel efficiency standards, for example–policy design and implementation will be more of a challenge.

Scaling projects from the national to the local level, or even from one locality to another, has been a long-standing issue in India.[106] For example, in the transport sector, the divergent nature of state politics in India contributes to the difficulty of enforcing vehicle manufacturers in India to comply with vehicle emissions standards.[107] At the administrative level, there is also a significant conflict of interest present in the role of the six testing agencies, which are a form of

[106] Madan, 2014.
[107] ICCT, 2013.

public-private partnership heavily subsidized by Indian vehicle manufacturers.[108] There is also the issue of the ability of the Indian central government to formally recall vehicles that fail to meet Bharat IV and III standards after several testing cycles, which as of 2013, has not occurred on a wide scale.[109]

Recommendations

- *Improve coordination.* Overcoming political and governance barriers requires a degree of coordination between various government agencies, the private sector, and state and local governments of a kind that has traditionally been a huge challenge in India. In this regard, the election of a single-party government to power in 2014 could help, but unless state governments are included in any initiatives, they are likely to falter. Governance reforms require increased transparency, accountability, and the strengthening of institutions in India. They also require the development of a private sector that has longer-terms horizons for responsible corporate governance.

MARKET

Barriers

Concentrated nature of India's markets. Many Indian sectors that require a focus for climate mitigation actions are highly concentrated. For example, India's coal sector is highly centralized, with production and distribution monopolized by two state-operated companies. Aside from operational inefficiencies, the concentrated nature of coal in India has limited the effectiveness of emissions reduction policy. For example, when the government levied a cess on coal, it had little effect on use. Because of the coal companies' control of the coal market it was not necessary that they pass the cost of the cess on to consumers. Thus the policy has had little if any effect on coal consumption.

Recommendations

- *Look for private sector opportunities.* There may be entry points for attracting private sector attention for investing in renewables in India. According to Ernst and Young UBM-India, India was rated the fourth most-attractive place to invest in renewables due to rising per-capita incomes and increases in access to energy.[110] The central government in India may also mandate that conventional power generation plants set up renewable energy generation technology on plant premises.[111] This mandate would fall in line with the recommendation of the NAPCC that India generate 10% of its power from renewables.[112] Moving this momentum beyond the consultation stage to implementation could have wide-ranging impacts for accountability in India's energy production sector and be an important step in changing its energy mix trajectory.

[108] Ibid.
[109] Ibid.
[110] Economic Times, 2012.
[111] Bhaskar, 2014.
[112] Ibid.

SOCIAL

Barriers

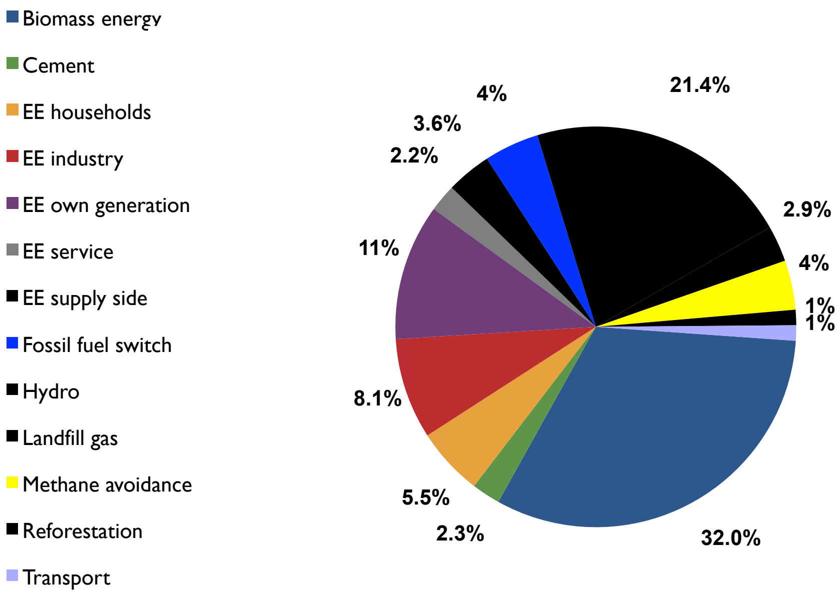
Perspectives on responsibility for action on climate change. Citing India's recent emergence as an industrializing nation and its relatively low per capita emissions, many argue that responsibility for current emissions levels should instead be based on historic contributions to climate change. The Twelfth Five Year Plan states: "Since it is cumulative emissions that affect climate variability, it is the historical emissions of developed countries that have been the major contributor to climate change."[113] As such, many feel that India should be given the chance to pursue growth without the hindrance of emissions restrictions in the same way that developed countries were able to. This stance has led to reluctance among Indian policymakers to codify international treaties on emissions regulations.[114]

Recommendations

- *Focus on co-benefits.* Whatever feelings exist on liability for current levels of emissions, the Twelfth Five Year Plan does acknowledge that, irrespective of responsibility, India is highly vulnerable to climate change and that actions must be taken to slow its effects. In order to make these mitigation measures more palatable, current policies have been designed with an emphasis on their benefits beyond emissions reductions, and "the recent emergence of the idea of 'co-benefits' based actions that deliver both development and climate gains"[115] has begun to shape domestic policies. Striving for energy security is less of a political risk than pursuit of climate change mitigation, and, in fact, has broad political support.[116] India's energy future is uncertain. The country's current growth trajectory could mean that its energy demand will soon outpace its limited supply. In order to reduce import dependence, alternative domestic energy sources will have to be developed. Policies that emphasize more efficient use of current energy sources as well as switching to renewables are more politically viable than those that focus on fuel-switching solely for the sake of emissions reductions.

[113] Planning Commission, Twelfth Five Year Plan, 2012, 222.
[114] Dubash , 2012, 3.
[115] Dubash, 2012, 10.
[116] Dubash , 2012, 10.

Figure 11: CDM projects by Sector



Source: UNEP, 2013

Policies that aim for increased efficiency will do better politically to stress potential savings on energy costs. This is true for building efficiency, more efficient coal technologies, and fuel efficiency standards. Efficiency policies in these sectors should be framed as strategies for saving money by using less energy.

FINANCIAL

Barriers

Limited Capital. The NAPCC is estimated to require Rs. 230,000 crore to accomplish its objectives. This amount exceeds what India can achieve through budgetary allocations, so external funding mechanisms need to be identified in order to fulfill the needs of the NAPCC Missions.[117] While the Kyoto Protocol's Clean Development Mechanism (CDM) is one possible solution (see Recommendations section below) these projects have primarily focused on the energy sector and provided little funding for transport.

Funding for expensive sustainable transport projects is a considerable barrier to transport reform in India in terms of planning. India, like many emerging economies, does not possess the required capital to sponsor implementation of the expensive infrastructure projects necessary

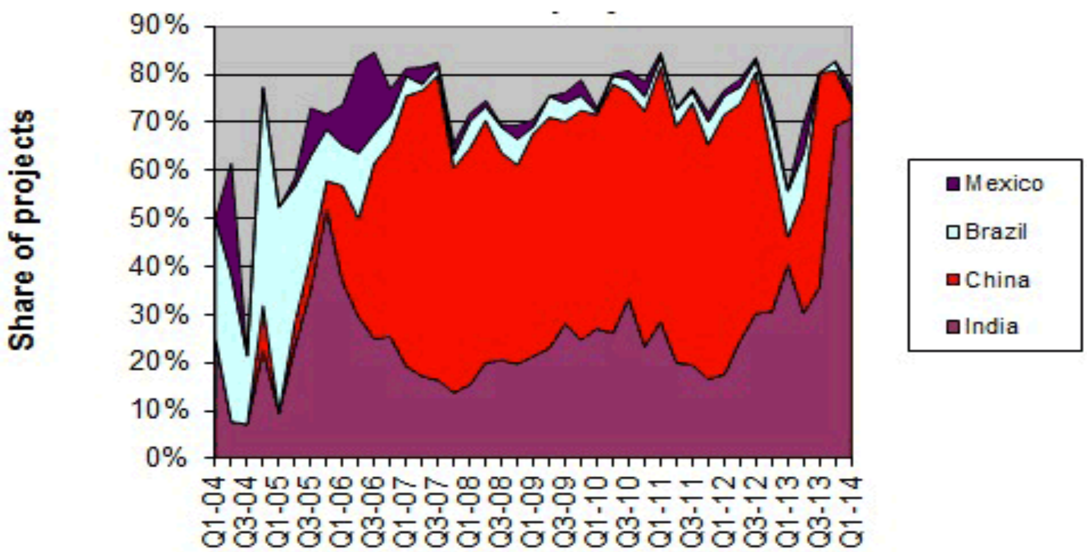
[117] Twelfth Five Year Plan, 2012, 226.

to reduce the carbon intensity of its transport sector.[118] Current funding options like CDM have provided limited support for select transport projects in South America and Southeast Asia, but comprise only 0.6% of the 6707 projects that have received funding under CDM to date.[119] Other funding mechanisms like the World Bank's Clean Technology Fund and the Global Environment Facility have also made only modest contributions to funding transport infrastructure projects in developing countries worldwide.[120]

Recommendations

- *Press for additional sources of international finance.* As India seeks to pursue low carbon inclusive growth strategies, Clean Development Mechanism (CDM) projects have potential, specifically in the energy sector. In the earlier stages of CDM, there was a reluctance to undertake these projects, but recent years have seen a shifting mentality within the industrial and business sectors. In 2012, there were 2244 CDM projects in India, making it the second highest recipient of CDM projects. These projects "have the potential to offset almost 10% of India's total emissions per year."[121] India's share of total CDM projects has continues to rise sharply in the last year (Figure 12).

Figure 12: All CDM Projects in Brazil, Mexico, and India as Fraction of All Projects



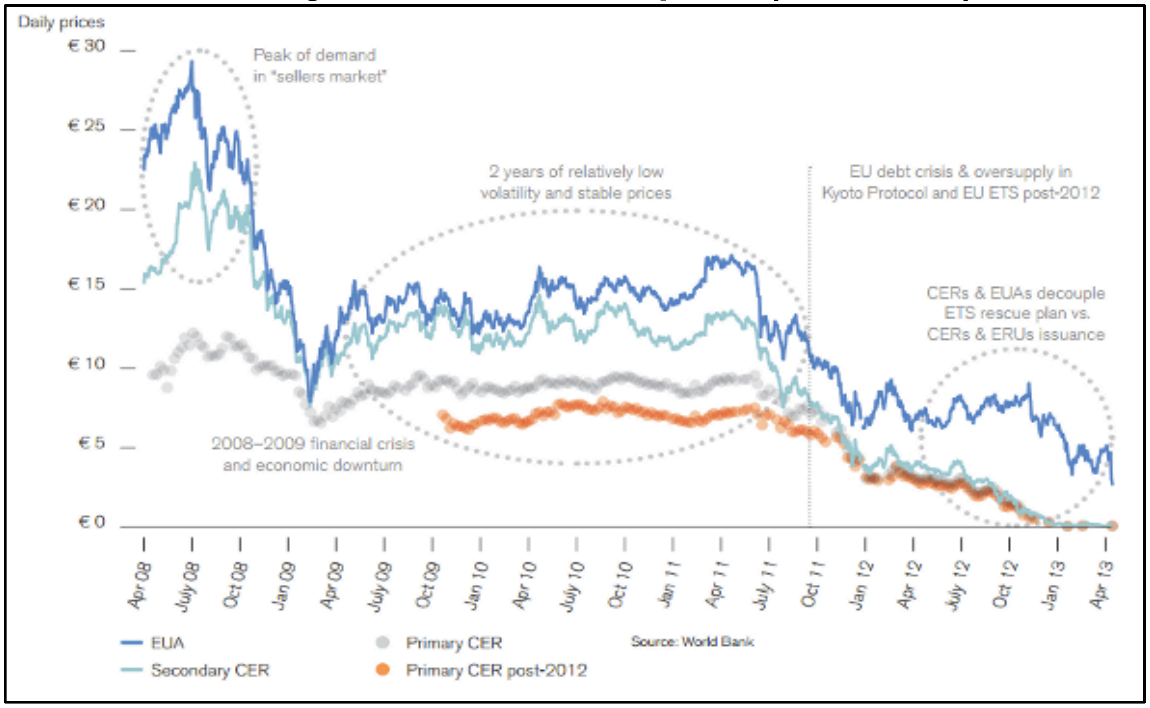
Source: UNEP, 2013.

One drawback of CDM projects is that Certified Emission Reduction (CER) credits are not currently worth enough to draw substantial interest in CDM. The value of CERs has fallen

[118] Madan, 2014.
[119] IPCC, 2013.
[120] Ibid.
[121] Twelfth Five Year Plan, 2012, 223.

dramatically over the past several years, due in part to the EU debt crisis and a general oversupply of credits (see Figure 13). Further, much uncertainty exists about the status of CDM during the second commitment period under the Kyoto Protocol and beyond. While there is still potential for progress through existing CDM projects and those in the pipeline, a depressed market for CERs and confusion about the state of CDM moving forward makes it insufficient as a financing recommendation.

Figure 13: EJA and CER prices (2008 - 2013)



Source: World Bank, 2013

TECHNICAL

Barriers

Lack of capacity for implementation. Coal is at the forefront of India's energy mix and current policy goals stress the need for more advanced, cleaner coal technologies. The Twelfth Five Year Plan identifies development of ultra-super critical and super critical coal technologies for more efficient coal plants as a priority.[122] The Plan goes on to stress the need for research and development for coal mine degasification, which could facilitate extraction of deep coal deposits as well as capture of coal bed methane. Currently, however, India does not have the technical capacity to achieve these advancements in coal technology.

Barriers to accessing accurate and relevant information also prevent the uptake of climate change mitigation policy makers from making transport reform a priority. Proving reliable

[122] Twelfth Five Year Plan, 2012, 119.

metrics may allow policy makers to see the incentives enforcing national-level policies, like Bharat III standards.[123]

Recommendations

- *Mobilize international capital.* Many of India's technical barriers to climate change policy implementation could be overcome with increased funding. To reiterate one of the recommendations discussed for overcoming funding barriers, externally financed projects often bring with them capacity-building components. CDM or public private partnerships often facilitate technology transfers, which is one option for overcoming India's technical barriers.

CONCLUSION

Developing countries like India are faced with the need to protect and foster economic growth while increasingly threatened by vulnerability to climate change. India has largely resisted emissions reductions commitments that might hinder growth. However, evolving discourse on climate change in India has led to the adoption of strategies characterized by co-benefits. This report has explored some of these policies, specifically within India's prominent GHG contributing sectors that show the most abatement promise: energy production, industry, and transport.

India is moving in the right direction with its current efforts towards emissions reductions, but a much greater effort is required from the state, private sector, and citizenry if the 2 C target for global warming is to be achieved. As this report has outlined, the NAPCC as well as other policy thrust areas are targeting sectors that make up a large percentage of India's total emissions. The prevalent focus on co-benefits, prioritizing energy security, is helping climate change policy gain traction in India. What is still needed is to turn more of the existing initiatives into practical and applicable policies on the ground. This will require increased funding and technical capacity, accelerated political buy-in, major governance reforms, fostering of markets for emerging energy sources, and working with state and local governments to develop localized implementation strategies. The international community could encourage India to redouble its efforts in these areas.

[123] ICCT, 2013.

TABLE 2: EXISTING MITIGATION MEASURES	
NATIONAL ACTION PLAN ON CLIMATE CHANGE (NAPCC)	
Jawaharlal Nehru National Solar Mission (JNNSM)	**Goals:** • Developing new solar technologies and increasing uptake of solar • Aiming for 20,000 MW of installed capacity by 2020 **Policies:** • Renewable purchase obligations (RPO) will require that a share of the power supplied by power utilities come from solar power plants **Co-benefits:** • Provides energy security by reducing dependence on fossil fuels and imports
National Wind Energy Mission	**Goals:** • To accelerate progress in wind energy **Policies:** • Assessment of the potential for wind energy harvesting • Creation of incentives for investment in wind energy **Co-benefits:** • Provides energy security by reducing dependence on fossil fuels and imports

TABLE 2: EXISTING MITIGATION MEASURES	
National Mission for Enhanced Energy Efficiency	**Goals:** • To promote energy efficiency, primarily in the industrial sector **Policies:** • Market Transformation for Energy Efficiency (MTEE) • Energy Efficiency Financing Platform (EEFP) • Perform, Achieve, and Trade (PAT) Mechanism for Energy Efficiency • Framework for Energy Efficient Economic Development (FEEED) **Co-benefits:** • Provides energy security by reducing dependence on fossil fuels and imports • Reduces electricity costs
National Mission on Sustainable Habitat	**Goals:** • Aims to increase energy efficiency in buildings and public transport **Policies:** • Energy Conservation Building Code • Improved urban planning and modal shift to public transport **Co-benefits:** • Decreased energy costs
COMPLEMENTARY POLICIES	
Renewable Purchase Obligation	**Goals:** • Increasing the share of energy derived from renewable sources **Policies:** • Mandated quota that requires power utilities to purchase a percentage (set at the state level) of their power from renewable sources **Co-benefits:** • Promotes energy security and reduces import dependence

TABLE 2: EXISTING MITIGATION MEASURES	
National Electricity Policy	**Goals:** • Increasing the share of energy derived from renewable sources • Creating a more competitive market for renewable energy **Policies:** • Use of differential tariffs to promote the adoption of solar, biomass, and wind energy **Co-benefits:** • Promotes energy security and reduces import dependence
National Rural Electrification Policy	**Goals:** • Increasing the share of energy derived from renewable sources **Policies:** • Government provision of a 90% capital subsidy for alternative energy projects in off-grid areas **Co-benefits:** • Provides electricity solutions in areas where connecting to a grid is not possible • Promotes energy security and reduces import dependence
Bharat Standards	**Goals:** • Lowering vehicular emissions **Policies:** • Bharat III and IV regulate the allowable amount of vehicular particulate matter and emissions **Co-benefits:** • Decreases energy costs • Improves air quality
POLICY THRUST AREAS	

TABLE 2: EXISTING MITIGATION MEASURES	
Advanced Coal Technologies	**Goals:** • Adoption of super-critical coal technologies • Research and development for ultra-super critical coal technology • Cleaner and more efficient use of coal **Policies:** • Research and Development **Co-benefits:** • Focuses on using coal more efficiently to promote energy security and reduce import dependence
Improved Urban Public Transport	**Goals:** • Reducing road traffic • Improving fuel efficiency **Policies:** • Improving public infrastructure • Lower tax burden on bus utilities **Co-benefits:** • Reduces fossil fuel consumption, lowering the need for fuel imports • Makes mobility more inclusive • Improves air quality • Relieves road congestion • Improves road safety
Dedicated Freight Corridors along Major Routes	**Goals:** • Reducing road traffic • Improving fuel efficiency **Policies:** • Making freight corridors more accessible **Co-benefits:** • Reduces fossil fuel consumption, lowering the need for fuel imports

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