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INTERNATIONAL SUPPORT FOR DOMESTIC CLIMATE POLICIES

Climate Co-Benefit Policies in India: Domestic Drivers and North-South Cooperation

ANOOP SINGH

Convened by: Climate Strategies

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Nov 25th 2008

Project Leader: Karsten Neuhoff, Senior Research Associate, University of Cambridge

Contributing Authors:

Name of Author	Institution
Anoop Singh	Indian Institute of Technology (IIT) Kanpur

This paper was produced as part of a wider project investigating international support for domestic climate policies. All papers are available at www.climatestrategies.org

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About Climate Strategies

Climate Strategies aims to assist governments in solving the collective action problem of climate change. It connects leading applied research on international climate change issues to the policy process and to public debate, raising the quality and coherence of advice provided on policy formation. Its programmes convene international groups of experts to provide rigorous, fact-based and independent assessment on international climate change policy.

To effectively communicate insights into climate change policy, Climate Strategies works with decision-makers in governments and business, particularly, but not restricted to, the countries of the European Union and EU institutions.

Contact Details:
Managing Director: Jon Price
Climate Strategies
c/o University of Cambridge,
13-14 Trumpington Street
Cambridge, CB2 1QA, UK

Office: +44 (0) 1223 748812
www.climatestrategies.org
jon.price@climatestrategies.org

1. Introduction

The Indian economy is at a development crossroads. At this juncture, it should choose a sustainable path towards economic development by reducing its carbon dependence and lowering its contribution towards climate change. The path towards sustainability should embrace greener resources of energy and efficient technology for extraction and conversion of energy. Further, efficiency in transmission and distribution, and its consumption at the users' end needs due attention as well. Towards this end, economic, policy, regulatory and institutional inputs would play a defining role in the decision-making process of various stakeholders.

India's contribution to the historical GHG inventory is low. In per capita terms GHG emissions were recorded to be 1.3 tonnes of CO_2 equivalent in 1994 (UNFCCC, 2005). However, CO_2 emissions on account of energy use are expected to grow substantially and reach 5.5 billion tonnes by 2031-32 under a scenario for high coal use (GOI, 2006a). Increasing demand for fossil fuels for the electricity and the transport sector would significantly contribute towards this.

Concerns for energy scarcity and energy security are a very high priority for the government. Concerns for efficiency and environment within the energy supply chain are also important in the decision-making process. Due to the competing development objectives and resource constraints, costly policy options with significant environmental dividends are not realised to their full potential. This often leads to selection of options with lower investment costs, especially for energy generation, its transmission, distribution and utilisation. Nevertheless, numerous policy measures with climate co-benefits have been undertaken. Some of these are highlighted in the next section. This paper identifies three policy options, which have a large potential for mitigating GHG emissions from the Indian power sector. These policy options are: (i) adoption of clean and efficient coal based generation technology, (ii) up gradation of distribution network and (ii) improvement in efficiency of agricultural pump sets. These policies are evaluated in terms of their potential for mitigation of CO_2 emissions. The potential to implement the suggested policy options is evaluated in terms of domestic policy drivers and role of various stakeholders. The paper also highlights the need to look beyond the Clean Development Mechanism and to accelerate the mitigation process through long-term international cooperation.

2. Status of Climate Co-benefit Policies in India

India's concern for the environment has been demonstrated by various policy measures that have been undertaken to address local pollution. These include the Forest (Conservation) Act, 1980 and the Air (Prevention and Control of Pollution) Act, 1981. Industry-specific emission standards have also been developed for iron and steel plants, cement plants, fertilizer plants, oil refineries and the aluminium industry. The Environment (Protection) Act, 1986 (EPA) provides an umbrella framework for the co-ordination of central and state authorities established under the Water (Prevention and Control) Act, 1974 and Air (Prevention and Control) Act, 1981. This Act empowers the central government to set standards for emissions and discharges, including the location of industries and protection of public health and welfare. Standards for vehicle pollution were set up in 1990, and these have become increasingly stringent over time. In 2000, in addition to the revision of standards, separate obligations were stipulated for vehicle owners, manufacturers as well as enforcing agencies. From 1st April 2005, new vehicles in 11 cities need to comply with Euro-III equivalent emission norms. Euro-IV standards will be applicable in 10 cities from April 2010. Further, the oil refineries are required to produce fuels to facilitate compliance of various vehicle pollution norms.

In 2004, the Central Pollution Control Board (CPCB) outlined National Ambient Air Quality Standards (NAAQS) for major pollutants . Source-specific pollution standards for local pollutants are specified for power generation plants. Large, single-point sources, such as thermal power plants must undertake Environmental Impact Assessments (EIA) under the Environment (Protection) Rules (1986), and seek environmental clearance from the central government. Such clearance is subject to, amongst others conditions, compliance with standards for emission of particulate matter, stack height based on plant-size and NO_x standards for power plants using gas/naphtha.

Due to the increasing environmental burden of the high ash content in the Indian coal, the Ash Content Notification (1997) specified use of beneficiated coal (with ash content not exceeding 34%) for future plants. From June 2002, all thermal plants located beyond 1000 km from the pithead and any thermal plant located in an urban area or, sensitive area irrespective of the distance from the pithead, with the exception of pithead power plant, must use beneficiated coal. In addition, conditions have also been laid down for utilization of the fly ash produced from coal/lignite fired power plants.

In order to address the end use energy efficiency, the Energy Conservation Act 2001 has initiated a drive to improve efficiency of energy use in designated entities, which includes the majority of the energy intensive users including the power plants. The Bureau of Energy Efficiency (BEE) has been established to set standards and to promote energy efficiency. To meet objectives for a cleaner environment, various fiscal incentives have been extended for reduction and abatement of various pollutants. These measures include depreciation allowances, exemptions from excise or customs duty, and arrangement of soft loans for the adoption of clean technologies.

In the context of global environmental issues, India is a signatory to a number of international environment agreements and conventions. These include the Montreal Protocol on Substances that Deplete the Ozone Layer 1987, the Basel Convention on Transboundary Movement of Hazardous Wastes 1989, the UN Framework Convention on Climate Change (UNFCCC) 1992 and the Convention on Biological Diversity 1992.

Under obligation to the UNFCCC, direct policy interventions to address climate change have been initiated recently with the adoption of the India's National Action Plan on Climate Change (NAPCC). This outlines the following eight national missions as adaptive / mitigation policy options: (i) to increase the share of solar energy in the total energy mix, (ii) to implement energy efficiency measures, (iii) to launch sustainable habitats, (iv) to ensure effective water resource management, (v) to safeguard Himalayan glaciers and mountain eco-system, (vi) to enhance eco-system services, (vii) to make agriculture more resilient to climate change, and (viii) to set up a Strategic Knowledge Mission for focused research in these areas. Apart from providing impetus to solar energy, the NAPCC does not address large-scale GHG emitters especially in the power sector. We identify and discuss some of the policy options with significant potential for mitigation of emissions from the sector in the next section.

3. Climate Co-benefit Policy Options for the Indian Power Sector

The Indian energy sector faces a number of challenges including capacity shortages, increasing dependence on fossil fuel imports, inefficiencies along the supply chain and inefficient pricing (Singh, 2006). Some of these challenges are more pronounced in the Indian power sector. As the largest consumer of coal in the country, it is also the largest contributor to CO_2 emissions (Table 1). Understandably, power sector should be a natural choice when it comes to designing and implementing GHG emission mitigation policies.

S. No.	Description	
1	Coal Based Power Generation Capacity (As on 31 July 2008)	77199 MW (53.03%)[#]
2	Coal Consumption by Power Sector (2007-08)	330 million tonnes
3	Emissions from Power Sector (2006-07)	460 million tonnes (92.8%)[$]

Table 1: Significance of Coal Based Generation Capacity (Source: CEA 2008a; CEA 2008b) Note: [#] Share in total capacity; [$] Share in total emissions from the power sector.

The scarcity of energy resources and capacity shortages have led to adoption of various climate co-benefits policies. These include energy conservation, promotion of renewable energy, setting environmental standards, energy labelling and energy pricing policies. In the context of global climate change, energy conservation is being further promoted through the Clean Development Mechanism (CDM). The Indian power sector offers many avenues to adopt policies that can bring in significant climate co-benefits. These policy options include adoption of efficient coal technology, promotion of renewable energy sources, up-gradation of distribution networks and improvement in end-use energy efficiency. These differ in terms of their contribution to mitigation of GHG emissions, implementation horizon, as well as their need for international cooperation. While some of the policy options are easily adaptable and under various phases of implementation, others are slow moving for want of resources, policy gaps, competing priorities and implementation hurdles (Table 2).

Due to large-scale emission reduction potential and inadequacy of existing policy push, we identify the following specific policy options with large potential for GHG mitigation in the Indian power sector:

(a) Clean and efficient coal-based generation technology (Generation)
(b) Up-gradation of distribution network (Network)
(c) Improving efficiency of agricultural pump sets (Utilization)

S. No.	Climate Co-benefit Policy	Implementation Horizon	Climate Benefit Potential	Existing Policy Push	Status of Adoption	Scope for International Co-operation
1	Clean and efficient coal-based generation technology	Long-term	Very Large	Low	Very Low	High
2	High share of renewable energy	Medium-term	Medium	High	Medium	High
3	Rehabilitation and refurbishments of old plants	Medium-term	Large	High	Medium	High
4	Improving efficiency of agricultural pump sets	Short to Medium-term	Large	Low	Very Low	High
5	Up-gradation of distribution network	Medium-term	Large	Low	Very Low	High

Table 2: Potential for Climate Co-benefit Policies in the Indian Power Sector.

These policy options target all of the three important segments of the Indian power sector, namely generation, transmission and distribution (T&D) and utilisation of electricity respectively. The merits of the identified policy measures and implementation challenges are further evaluated in Table 3 below.

Criteria	Efficient Generation Technology	Efficient Agricultural Pumps	Upgrading of Distribution. Network
Presence of large scale inefficiencies	Y	Y	Y
Ease of Policy Formulation	Y	Y	Y
Ease of Programme Design	Y	N	N
Large Identifiable Sources of Emission	Y	N	Y (indirectly)
Ease of Verification of Emission Reduction	Y	Y?	Y
Ease to Channelising Support from North	Y	Y?	Y
Political Acceptability	Y	Y?	Y
Ease of Implementation	Y	?	Y
Transparency in Implementation and Monitoring	Y	?	Y
Will it help reduce energy subsidy in future?	N	Y (large)	Y
Level of government priority for domestic financing	Low	Low and limited	Low and limited
Domestic Fiscal Policy Support Available	Y (SC – PC)	N	N

Table 3: Evaluation of Selected Policy for North-South Cooperation. Note: [$] For supercritical technology.

The three identified policy options exhibit large potential for reducing the carbon emissions from the Indian power sector by addressing inefficiencies present in the sector. The source of emissions can be identified in the case of large coal-based power plants. In the case of improvement in system efficiency and end use efficiency, the benefits are indirect, but substantial. Some of the implementation issues of each of the policy options will be discussed further in following sections.

4. Adoption of Efficient and Clean Coal Technologies

Policy Description: Adoption of efficient and clean coal technology for new capacity addition in the Indian power sector. Alternate scenarios being considered are (i) 20% share of supercritical technology and (ii) Additionally 10% share of ultra supercritical technology. Additionally, this should also include development of a carbon capture and storage (CCS) ready[1] Integrated Gasification Combined Cycle (IGCC) plant of commercial size.

Coal is expected to remain a significant fuel for power generation. Coal requirement for generation is expected to reach 1475 million tonnes by the year 2031-32 and is expected to fuel about 78% of the electricity generation in the country. By the year 2031-32, annual CO_2 emissions are expected to reach 5.5 billion tonnes in the high coal use scenario and 3.9 billion tonnes in the low coal and renewable dominant scenario (GOI, 2006a). The power sector in India has significant potential for reduction of GHG emissions through adoption of a variety of policies including efficiency improvement, loss reduction, fuel switching and adoption of efficient technology for new capacities. It was estimated that, by the year 2020, replacement of old and smaller plants, and adoption of efficient technology for new capacity (scenario EFF) could lead to 9% reduction in GHG emissions compared to a base case (Kroeze et al., 2004).

The government has specified supercritical technology for nine projects identified under the Ultra Mega Power Projects (UMPP) program. This would ensure that a total capacity of at least 36,000 MW would be setup using this efficient technology. A fiscal push has been provided by the government by granting full exemption from central excise duty for goods procured for setting up ultra mega power projects based on supercritical technology[2].

The thermal efficiency of coal-fired power plant in India is below the international best practice. In 2003, average energy efficiency of coal-fired power plants in India was 30% as compared to 42% for Japan (Graus et al., 2007). This can be attributed to the vintage stock of small-scale and inefficient technologies. A larger proportion of the existing coal-based power plants have low unit capacity and are based on sub-critical Pulverised Coal (PC) technology. A significant part of the capacity addition program in the 70s and 80s was undertaken using 200/210 MW units, most of which were manufactured domestically by the public sector undertaking, Bharat Heavy

[1] The carbon capture can also be included in case there is additional carbon/international funding for the incremental cost.

[2] Ministry of Finance (Department of Revenue) Notification No. 46/2008 Central Excise dated 14th August, 2008

Electricals Ltd. (BHEL). More than 160 units of 200/210 MW capacity are operating in the country. Apart from this, there are also much smaller plants with very poor efficiency records. Due to smaller unit size and old technology, these plants have been operating at considerably high heat rates, hence require higher energy input for producing a unit of electricity. This inefficiency is partly being addressed through Renovation & Modernisation (R&M) and Life Extension (LE) of existing power plants. This not only improves efficiency of existing plants, but also helps to augment capacity incrementally at a much lower investment.

While poor efficiency of the existing vintage of plants can be best addressed through the R&M programs mentioned above, a significant environmental burden could be avoided by adoption of efficient and clean coal technologies[3] for new power generation. These include Supercritical Pulverised Coal (SC-PC), Ultra Supercritical Pulverised Coal (USC-PC), Atmospheric Fluidized Bed Combustion (AFBC), Pressurized Fluidized Bed Combustion (PFBC) and Integrated Gasification Combined Cycle (IGCC). The SC-PC technology has a higher efficiency than the conventional PC and has an additional capital cost of about 2% (NETL, 2007). The Ultra Supercritical Pulverised Coal (USC-PC) technology can achieve an efficiency of about 44 % (Davison, 2007). The IGGC technology can achieve a similar level of efficiency at a higher capital cost, it provides an option for carbon capture, though at a loss of overall efficiency (Table 4).

S. No.	Technology	Capital Cost ('000 USD per MW)	Thermal Efficiency $^{\&}$	CO_2 Emission Factor (tCO_2 / GWh)$^{@}$	CO_2 Emission Factor (tCO_2 / GWh)$^{\#}$
1	Subcritical Pulverised Coal (PC)	1549$^{\#}$		1073.75	809
2	Supercritical Pulverised Coal (SC-PC)	1575$^{\#}$; 1408$^{\&}$		941	764
3	Ultra Supercritical Pulverised Coal (USC-PC)		44%		743$^{\&}$
4	Integrated Gasification Combined Cycle (IGCC)	1733-1977$^{\#}$; Shell - 1613$^{\&}$ GE - 1439$^{\&}$	Shell - 43.1% GE – 38%		640 – 663$^{\#}$ Shell - 763$^{\&}$ GE - 833$^{\&}$

Table 4: Capital Cost and CO_2 Emission Factor Comparison for Coal Based Technologies (Source: @ - CEA (2008); & - Davison (2007); # - NETL (2007) Notes: No carbon capture considered; The CO_2 emission factors reported in column 5 for PC and PS-PC are for the Indian conditions. Those reported in column 6 are for US conditions.

While supercritical boiler technology for up to 1000 MW capacity plants has been commercialized elsewhere in the world, it has not made significant inroads in the Indian power sector. For the upcoming UMPPs, project developers have adopted unit sizes of 500 MW and 660 MW of supercritical technology . Apart from the UMPPs,

[3] Due to the policy orientation of the paper, we do not make a technical judgement on the most appropriate technology for the Indian context. This has been addressed by Davison (2007) and Kroeze et al. (2004).

few Independent Power Producers (IPPs) have adopted the SC-PC technology for new power generation capacity addition. While this would bring in some efficiency gains, larger efficiency gains from some of the technologies identified above, could be realised in the Indian context.

Some of the more advanced technologies like the Atmospheric Fluidized Bed Combustion (AFBC), Pressurized Fluidized Bed Combustion (PFBC) and Integrated Gasification Combined Cycle (IGCC) can help achieve overall efficiency of up to 50%. Little progress has been made in the adoption of these technologies. Two smaller IPP units, these include a pet coke-based 2x250 MW plant in Gujarat and a 1 x 150 MW plant in West Bengal, have been planned using the AFBC technology. A 6.2 MW IGCC demonstration plant has been commissioned by BHEL. A proposal for constructing a 600 MW IGCC demonstration plant has been under consideration for quite some time. Due to higher ash content in the Indian coal, off-the-shelf available technology can only be used for imported coal. Coastal location of such a plant would be suitable for imported coal while also making it amenable to CCS, especially at locations on the western coast where depleting deep sea gas reserves can serve as a potential storage for captured CO_2.

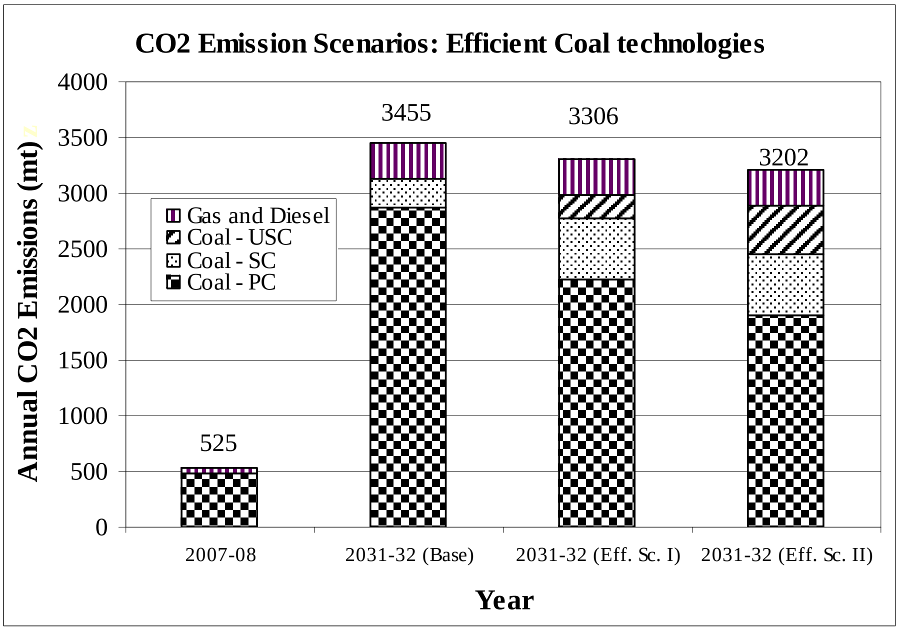

Figure 1: CO_2 Emissions Scenarios with adoption of Efficient Coal Technologies.

A policy simulation is undertaken to assess the impact of higher share of clean and efficient coal technologies on power generation. Power generation capacity in 2031-32 is expected to reach 145.6 GW. It is assumed that supercritical technology would have a 10% share, primarily due to the addition of UMPP using this technology. A scenario with 20% share of supercritical technology (Efficient Scenario – I) can lead to an annual emissions reduction of 150 million tonnes by 2031-32 (Fig. 1)[4]. An additional push for adoption of ultra super critical technology for up to 10% of the capacity share (Efficient Scenario – II) could bring about 253 million tonnes reduction in CO_2 emissions annually. These scenarios can respectively bring a 4.33%

[4] Detailed results and assumptions for these scenarios are reported in Table A-1 in Appendix.

and 7.33% reduction in the carbon emissions over a base case. The indirect environmental benefits include reduced deforestation pressure due to mining activity and other mining hazards and less energy consumption in coal transportation.

S.No.	Responsibility	Stakeholders	Description
1	Policy Formulation	* Ministry of Power * State Govts. (state-specific projects)	Adoption of Supercritical, Ultra Supercritical and IGCC technology for identified projects above 500 MW and with appropriate time-line.
2	Policy Description	* Ministry of Power, * State Govts. * CERC & SERCs * Central Electricity Authority * Generation Companies * Equipment Manufacturers	* All new additions to capacity to utilize supercritical technology if plant size is 500 MW or above. * Identification of plants for use of ultra supercritical and IGCC technology. * Setting responsibilities for programme design, implementation and monitoring.
3	Programme Design	* Ministry of Power * Central Electricity Authority * State Govts. * Generating Companies * Equipment Manufacturers	* Identification of projects for completion during the 12th five-year plan onwards and specification of project size and time line for adoption of the SC, USC and CCS-ready IGCC technology. * Assessment of technological capability and manufacturing base in the country, and international scenario. * Need for technology tie-ups with technology developers * Status of domestic manufacturing base and international technology availability. * Assessment of need for fiscal measures and direct financial support.
4	Implementation	* Project Developers * Equipment Manufacturers * Central Electricity Authority * International Cooperation	* Specification of SC, USC and IGCC technology in bid documents of the identified projects * Enhancement of domestic manufacturing capacity * Facilitation of technology cooperation
5	Monitoring	* Ministry of Power * Central Electricity Authority	* Domestic manufacturing capacity for SC and USC plants * Status of international technology collaboration * Outcome of IGCC demonstration plants
6	Financing	* International Cooperation * CDM financing	Incremental cost of SC, USC and IGCC Cost of CCS for demonstration plants

Table 5: Stakeholder Responsibility: Adoption of Supercritical and Ultra-Supercritical Technology.

Adoption of a clean and efficient coal technology for the Indian power sector can be achieved through a combination of policy directives and financial incentives. A policy formulation by the Ministry of Power, in consultation with the state governments and other stakeholders, can specify adoption of supercritical technology for new power projects of 500 MW[5] and above. Table 5 outlines responsibilities for various stakeholders towards implementation of such a policy.

5. Improving Efficiency of Agricultural Pump Sets

Policy description: The policy prescription is to implement a joint programme for replacement of inefficient agricultural pump sets (including motor/engine and pump assembly) along with mandatory electronic metering of such electricity connections. Such a program should be supplemented with feeder metering and system up-gradation of the low-tension (LT) network with High Voltage Distribution Systems (HVDS)[6]. The distribution companies (discoms) should also undertake separation of rural feeders with partial support from APDRP.

The agriculture sector accounts for about 25 % of the electricity consumption in India[7]. The *agricultural pump set energisation programme* has led to a significant rise in the number of agricultural consumers. Up to 31st March 2008, around 15.47 million pump sets have been energized in the country (CEA, 2008). This has contributed towards higher food grain production in the country. Most of such connections have been provided on an unmetered basis. Agricultural tariffs for electricity are heavily subsidized or at times agricultural consumers have been provided with free electricity. As a side effect of this policy, there is widespread accumulation of millions of inefficient pump sets across the country. Large-scale inefficiency and inadequate subsidy support have bled the balance sheets of utilities for decades. While agricultural consumers account for a higher proportion of total sales across states, their contribution in terms of revenue remains low (Fig. 2). Direct payment of subsidy and gradual reduction of cross-subsidy has been institutionalised under the Electricity Act 2003 and by the exercise of regulatory jurisprudence by the State Electricity Regulatory Commission (SERC). Metering of agricultural consumers remains a key challenge, as it does not have political support in many states. Inefficiency of agricultural pump sets has been an area targeted for improvement under various government initiatives. However, it remains to be addressed on a larger scale to conserve scarce electricity and to help achieve significant reduction in carbon emissions from the sector.

[5] This is the minimum commercially available size of the plant unit available in the domestic as well as international market.
[6] Up-gradation of rural distribution network with HVDS is highlighted here due to its catalytic contribution towards reduction in losses in distribution network. It is further discussed in the next section.
[7] Due to a lack of metering of a significant number of agricultural consumers, this may be an overestimation by the utilities to hide high system losses, often due to theft.

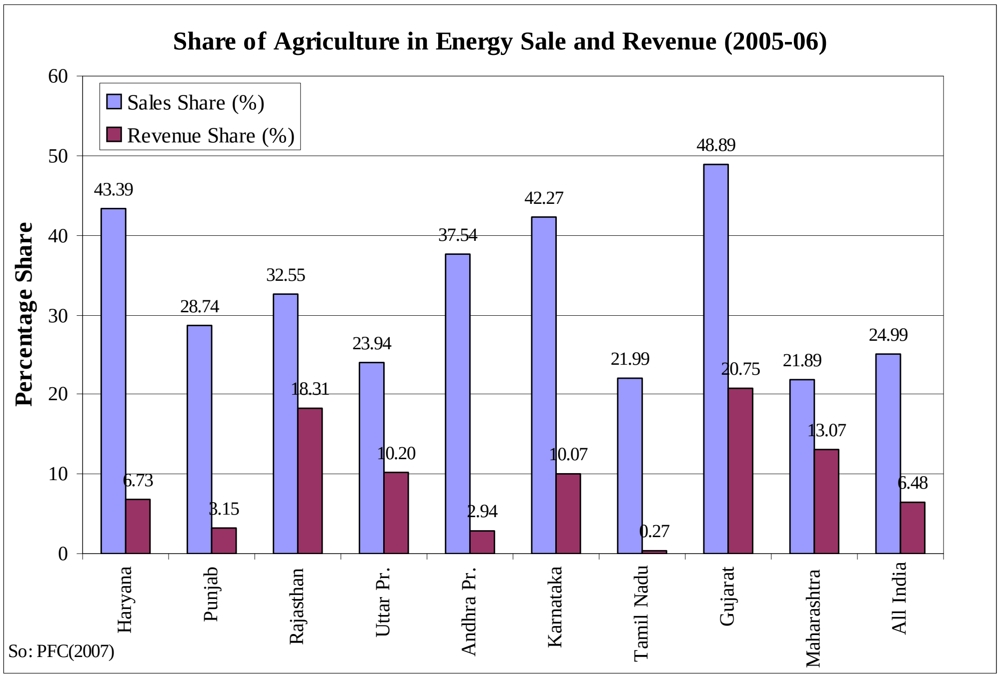

Figure 2: Significance of Agriculture Consumers in Power Sector.

World Bank (2001) reported that average efficiency of electrical pump sets in four field study locations in Haryana was 21-24%. The study found that only 2% of the pumps surveyed had efficiency levels above 40%. Significant energy efficiency savings could materialize if inefficient pump sets are replaced by low-rating but efficient pump sets[8]. The exchange of pump sets could improve energy efficiency by 20-45% (Table 6).

Step	Measure	Energy Conservation Potential
1	Replacement of GI suction pipe and GI foot valve with low friction RPVC pipes and valve.	20%-25%
2	Replacement of suction pipe, foot valve, and delivery pipes.	30%-35%
3	Replacement of suction and delivery pipes, foot valve, and pump with properly sized energy efficient mono-block pump.	40%-45%

Table 6: Stakeholder Responsibility: Adoption of Supercritical and Ultra-Supercritical Technology (Source: World Bank 2001).

The reasons for the propensity of poor efficiency in agricultural pump sets include poor quality and reliability of electricity supply, high cost of efficient pump sets and ‘flat pricing’. Most states use flat pricing of electricity, wherein farmers are charged

[8] The farmers often invest in over-sized pump sets due to poor voltage supply, which reduces water output of the pump sets. Indiscriminate use of ground water has also led to depletion of the water table in many parts of the country. This has also led to the adoption of high capacity pump sets.

on the basis of a fixed charge per kW of motor load per month. Even while metered tariffs exist in states, farmers' unwillingness to pay and apathy for distribution utilities ensure that a significantly high proportion of agricultural supplies remains un-metered and continue to be billed under the flat pricing system. Due to the zero marginal costs to the farmers, flat pricing of electricity does not provide any incentive for energy conservation. World Bank (2001) recommended that the replacement of pump sets should be implemented in conjunction with rehabilitation of rural distribution system to maximize energy savings. The rehabilitation of the agricultural feeders will improve power quality supplied to the pump sets, enabling them to operate more efficiently and reduce burnouts, thus extending their operational life. An overall system efficiency of up to 50% is easily is achievable.

Inefficient pricing of electricity and lack of finances has led farmers to choose cheaper, inefficient pump sets. Even in cases where efficient motors may have been purchased originally, local repairs may have led to deterioration in efficiency. A large-scale program to replace inefficient pumps along with upgrading the metering of electricity supplies can bring in significant double dividends[9]. This would not only help bring down electricity consumption over the lifetime of efficient motors but would also help in addressing the persistent challenge of metering agricultural supplies. The design of such a program and its implementation needs the careful attention of various stakeholders including the government, the regulators, the utilities as well as the consumers. There is a need to overcome historical 'mistrust' that consumers have of utilities by creating awareness about net positive benefits to farmers. While this seemingly addresses domestic issues, it would also provide significant long-term benefits in terms of reduction in CO_2 emissions. As a very positive and significant outcome, reduction in electricity consumption by agricultural pumps would improve acceptability of metered tariffs. Further, up-gradation of the distribution network with HVDS would significantly reduce network losses and improve power quality to the benefit of the consumers.

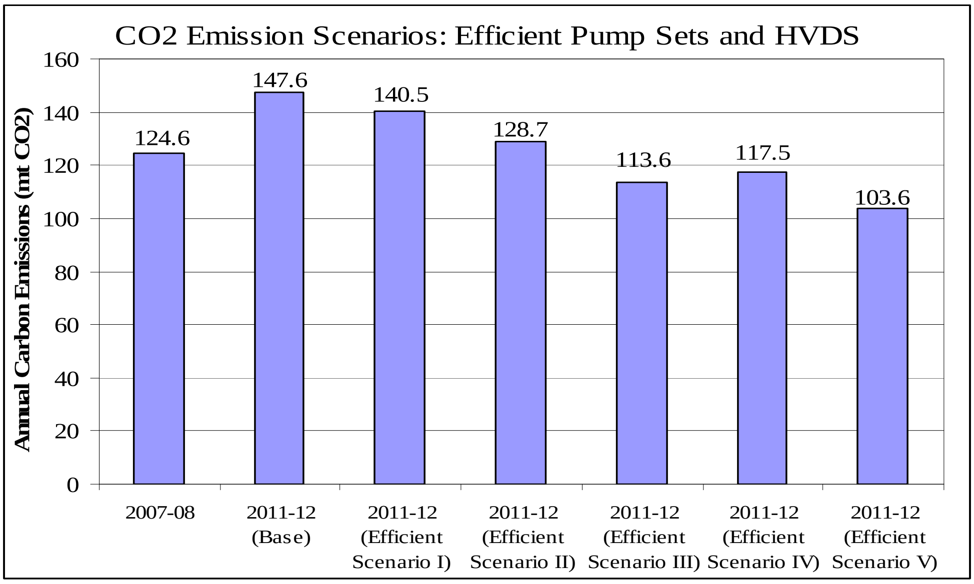

Figure 3: CO_2 Emissions Scenarios with adoption of Efficient Pump sets and HVDS.

[9] Apart from this, other options include renewable energy based water pumping, promotion of water conservation techniques like drip irrigation, rain water harvesting for ground water recharging and sustainable agricultural practices

We construct alternate policy scenarios for varying degrees of penetration of efficient pump sets. It is assumed that the number of agricultural pump sets would grow to 20 million by 2011-12. In efficient scenarios, all new pump sets are expected to be efficient, and hence require a fewer number of hours of operation[10], and have 10% lower rating. Similar assumptions are made for all pump set replacements. The T&D loss level is expected to fall from 32.25% in 2007-08 to 25% by 2011-12. Figure 3 provides estimates of reduction in CO_2 emissions under alternate scenarios for adoption of efficient agricultural pump sets[11] and HVDS.

Launched on May 18, 2006, the National Energy Labelling Programme is is voluntary in nature and is currently limited to room air conditioners, refrigerators (no-frost), direct-cool and tubular fluorescent lamps. Equipment such as motors, agricultural pump sets and distribution transformers are expected to be included in the labelling programme only at a later date. When introduced, due to its voluntary nature, it may not bring any material difference to the millions of inefficient pump sets that are in operation across the country. Lack of metering and flat pricing does not provide any incentive to adopt efficient pump sets. Larger scale disorganised manufacturing of such pump sets has made the task even more challenging. An absence of labelling for energy efficiency standards neither encourages manufacturers nor creates sufficient awareness amongst users.

Distribution is within the purview of the state entities. Hence policy initiatives and program development for replacement of agricultural pump sets requires greater participation of state-level entities. The central government's support is crucial for setting standards and for providing supplementary funding for metering and system up-gradation (Table 7). The expertise of the Rural Electrification Corporation (REC) would be useful in helping the design of such a rural-based programme. This would, however, present substantial challenges for verification of the objectives achieved. The role of State Electricity Regulatory Commissions (SERCs) along with REC would be very useful in this context.

[10] In the base case, pumps are assumed to operate for 4.3 hours, at the level recorded in 2007-08. It is assumed that efficient pump sets require only 3.8 hours of operation.
[11] Detailed results are reported in Table A-2 in Appendix.

S. No.	Responsibility	Stakeholders	Description
1	Policy Formulation	* Ministry of Power * State Govts.	* Replacement of inefficient agricultural pump sets in a phased manner * All new agricultural connections to be provided with efficient agricultural pump sets at incremental cost * Metering of consumers and up-gradation of distribution network to HVDS
2	Policy Description	* Ministry of Power * Rural Electrification Corporation * Bureau of Energy Efficiency * Bureau of Indian Standards * Distribution utilities * Industry representatives	* Setting specific technical standards for motors, pumps, and individual components and energy efficiency labelling * Identification of the specific areas for phased implementation of the scheme * Setting responsibilities for programme design, implementation, monitoring and financing
3	Programme Design	* Rural Electrification Corporation * State Electricity Regulatory Comms. * Distribution utilities * State Govts. * Local Administration/ rural bodies' /NGOs/ Consumer organization.	* Selection of specific areas across states for pilot programme * Phasing of motor replacement program across various states * Setting Guidelines for implementation and verification.
4	Implementation	* Rural Electrification Corporation * Bureau of Energy Efficiency * Bureau of Indian Standard * Distribution Utilities * Rural bodies, NGOs.	* Phased rollout of the programme for replacement of inefficient agricultural pump sets * Contract Design, contract award, progress reporting, verification and testing
5	Monitoring	* Rural Electrification Corporation * State Electricity Regulatory Commissions (SERCs) * State Govt. * Local Distribution Utilities * Ministry of Power	* Monthly progress report along with verification certificate from local rural bodies /NGOs / Consumer organizations * Sample quality testing by an independent agency to be appointed by the SERC * Quarterly Progress Report on implementation * Estimation of benefits accrued in terms of reduction in network losses and emission reduction * Rating of agricultural supply and utilization by an independent domestic agency
6	Financing	* Ministry of Power (APDRP) * Ministry of Finance * Rural Electrification Corporation * Distribution Utilities * CDM * International Cooperation	* Partial APDRP Funding for network up gradation and feeder separation of rural network. * Fiscal incentives to manufactures of top rated efficient motors and pump sets. * International funding for inefficient pump sets replacement Programme. * Carbon credits under programmatic CDM.

Table 7: Stakeholder Responsibility: Adoption of Efficient Agriculture Pump sets.

6. Distribution Network to High Voltage Distribution System (HVDS)

Policy Description: The existing low-tension (LT) distribution system in India is largely supported through 100 kVA or 63 kVA distribution transformers, which feed various consumers through long LT lines rated at 400 Volts. With HVDS, a greater part of the LT network can be upgraded to 11 kV lines with numerous small capacity transformers to feed consumers. Any residual LT lines would be replaced with Aerial Bunched Conductors (ABC). Additionally, metering of DTs and their LT connectivity would add further impetus to efficiency improvements and transparency in the system[12].

The distribution network for electricity in the rural areas is epitomized by the significant loss of electricity, due to technical as well as non-technical reason. The average transmission and distribution (T&D) losses[13] are estimated to be 31.25% for 2004-05 (CEA, 2006). High T&D losses, which continue to financially bleed the sector, are very high compared to industrialized countries. Theft of electricity has often been cited as a reason for such a high level of non-technical or commercial losses. Low voltage overhead distribution lines are susceptible to wire tapping for theft of electricity. A high proportion of low voltage lines in the network and poor quality of distribution networks are also a cause for a high level of technical lossesA working group on power for the 11th five-year plan suggested a greater emphasis on High Voltage Distribution System (HVDS) to bring HT/LT ratio of the network from 1:2.5 currently to 1:1 (GOI, 2006b).

In order to curb pilferage of electricity, a number of distribution utilities have undertaken replacement of overhead lines with Aerial Bunched Conductors (ABC). Benefits of ABC and HVDS are significant due to the reduction in network losses. In spite of the attractive payback period, high investment requirements and lack of finances remain key impediments in this effort. HVDS has been implemented on a limited basis in the states of Andhra Pradesh, Delhi, Gujarat, Maharashtra, Uttar Pradesh, West Bengal and Karnataka (GOI, 2006b). HVDS investment in Andhra Pradesh was partly supported through lending from the development bank of Germany, KfW[14].

An Accelerated Power Development and Reforms Programme (APDRP) was initiated in 2000-01 to restore the commercial viability of the distribution segment by supporting investment schemes and providing incentives for reduction in cash losses. Under APDRP, partial funding is made available for a variety of investments including renovation and modernisation of sub-stations, up-gradation of feeders and distribution transformers, feeder and consumer metering, high voltage distribution system (HVDS), consumer

[12] These are being supported with greater focus under the APDRP.
[13] This may be an underestimation as part of such losses are often camouflaged as a higher share of unmetered supplies to agriculture consumers.
[14] During the year 2007-08, the Rural Electrification Corporation supported 64 schemes for conversion of Low Voltage Distribution to High Voltage Distribution System (HVDS) with a loan assistance of Rs.16.68 billion. This was partially supported by an ODA loan of 70 Million Euro (Rs.4180 million) from KfW for HVDS implementation in the Chittoor and Kadapa Districts in the state of Andhra Pradesh (REC, 2008).

indexing, Supervisory Control and Data Acquisition (SCADA) systems, computerised billing etc. Up until 30th April 2008, APDRP has supported various projects entailing an investment of over Rs. 17 billion (US$344 million) including the APDRP funding of Rs. 8.72 billion (US$177 million). Due to a variety of competing requirements for this funding, actual support available for HVDS is limited.

Table 8 highlights the achievements of rural HVDS projects in the state of Andhra Pradesh. However domestic funding for such a program is limited, states of Andhra are too small compared to the level of investment required. Some of the other states including Madhya Pradesh and Haryana have initiated such programs with the assistance of the Asian Development Bank, KfW[15] and the World Bank.

S. No.	Particulars	Kottur-ss I	Bangarupalem –ss
1	No. of Pump sets	39	38
2	Connected Load (kW)	133.85	96.94
3	Original Length of LT Line (km)	3.6	3.3
4	Length of LT Line after HVDS (km)	1	0.8
5	Length of HT Line after HVDS (km)	2.6	2.5
6	% of line loss	18.63%	16.30%
7	% of line loss after HVDS	5.47%	3.77%
8	Net Incremental Investment ('000 Rs.)	275	215
9	Payback Period (years)	3.41	3.85

Table 8: Impact of High Voltage Distribution System (HVDS) on Network Losses (Source: APSPDCL, undated).

[15] KfW has committed a 2nd line of credit of 70 million Euro to REC under their Energy Efficiency Programme–II to support HVDS projects in Uttar Haryana Bijli Vitaran Nigam (UHBVN) (REC, 2008).

S.No.	Responsibility	Stakeholders	Description
1	Policy Formulation	* Ministry of Power * State Govt.	* Conversion of low voltage distribution network to HVDS (with system strengthening, DT metering and IT enablement) * Conversion of LT lines with ABC
2	Policy Description	* Ministry of Power * Central Electricity Authority * SERCs * Distribution Utilities * Industry Representative	* Setting specific standard for ABC and HVDS system * Timeline for implementation in identified areas/states * Setting responsibilities for programme design, implementation, monitoring and financing
3	Programme Design	* Ministry of Power * Central Electricity Authority * SERCs * Distribution Utilities	* Phased program for conversion of LT network to HVDS system * Setting responsibilities for identification, coordination with MoP and SERCs for implementation
4	Implementation	* Power Finance Corporation (APDRP) * Rural Electrification Corporation * Distribution Utilities * Contractors awarded on competitive bid basis.	* Phased rollout of the programme for HVDS implementation * Contract Design, contract award, progress reporting, verification and testing
5	Monitoring	* SERC * Distribution Utilities * MoP * Consumer Organization	* Monthly progress report * Quarterly Progress Report on implementation * Estimation of benefits accrued in terms of reduction in network losses and emission reduction
6	Financing	* APDRP, MoP * Distribution Utilities * Ministry of Finance (Fiscal Incentives) * International Cooperation * CDM	* Fiscal incentive for ABC & HVDS manufacturers * System strengthening, DT metering and IT enablement to be part financed by Distribution Utilities and through APDRP. * Carbon credits under programmatic CDM * International funding

Table 9: Stakeholder Responsibility: Upgrade Distribution Network to HVDS.

7. Need for International Cooperation and Financing

Due to perverse incentives, policy gaps and lack of financial resources the identified policy options have not currently been taken up on a scale that can deliver significant climate co-benefits. Traditional CDM financing could be rather limited especially for pump set replacement and HVDS. These also demand significant monitoring as per CDM guidelines. Adoption of ultra supercritical technologies could be designed as per specific project. CDM financing has provided incremental finance for a variety of energy efficiency and emission reduction projects in developing countries like India. Clean and efficient coal technologies have not received due attention in the CDM[16] process until recently. A methodology for new grid connected fossil fuel fired power plants using a less GHG intensive technology (#ACM0013) has recently been approved by the CDM Executive Board. Project proposals are yet to be submitted under this methodology.

In the case of generation projects based on competitive bidding, the bidders would choose the most cost effective technology unless the policy mandates differently. A unilateral choice of cleaner technology may reduce a bidder's chance of winning the bid on a cost basis. Further, even if the successful project developer later wishes to adopt a cleaner technology with support from CDM financing, they must bear the risk of non-approval, by the CDM executive board, of the proposal. They must also bear the additional cost in the case of inadequate CDM financing.

A case for replacement of agricultural pump sets and up-gradation of distribution networks can be made under the programmatic CDM. However, the financing may remain inadequate to meet the desired level of investment. The cost of monitoring of emissions reduction as per CDM procedures may be substantial in such a case. Table 10 presents the case for international financing. The role of international cooperation would be more significant due to demand for efficient technology and technical collaboration to strengthen manufacturing base in the country.

A variety of national and international routes for additional financing have been developed in the context of climate change. Apart from multilateral institutions, these include a mix of public and private initiatives (TERI, 2006). A Clean Energy Financing Vehicle (CEFV) was proposed to facilitate the transfer of high efficiency technology to mitigate climate change. This was proposed to blend carbon finance with grants to bring down costs of new technologies and energy infrastructure, and to mitigate technology risks (World Bank, 2006a, b).

Apart from technical and financial cooperation, there is scope for supporting capacity building activities that help strengthen the local institutions to adopt environmentally benign initiatives.

[16] CDM support for advanced cleaner coal technologies such as IGCC or CCS seems to be unlikely in the near future due to availability of low hanging fruits such as efficiency improvements and renewable energy (Watson et al. , 2006).

S.No.	Policy	Consumers	Distribution Utility	State Govt.	Central Govt.	CDM Financing	International Financing
1a	Efficient Agricultural Pump sets	NIL for existing pump sets. Incremental cost of efficient pump sets (new connections)	---	---	Y - Partial (BEE)	Programmatic CDM	Y
1b	Consumer Metering & IT	----	Y		Y - (APDRP)	N	N
1c	Strengthening of Rural distribution Network	---	Y	--	Y - Partial (APDRP)	Y - Partial	Y - Partial
2a	Up gradation of Distribution Network with HVDS	N	Y	---	Y - Partial (APDRP)	Y - Partial	Y - Partial
2b	DT Metering & IT	N	Y	N	Y - Partial (APDRP)	N	Y - Partial
3	Efficient Generation Technology	N	N	N	N	Y?	Y
4	Awareness and Capacity Building	N	Partial	Y (through Generation companies) Partial	Y	N	Y

Table 10: International Cooperation for Financing of Climate Co-benefit Policies.

The implementation of the three suggested policy measures as discussed in the previous sections highlights the role of a number of stakeholders including government, the utilities, regulatory institutions, leading domestic institutions engaged with the power sector, NGOs and consumers. The challenge of implementation of the suggested policy measures could be significant in the case of programme design and monitoring. There is a lot of scope for learning from implementation of similar initiatives from other countries through North-South as well as South-South cooperation. A twinning approach across similar institutions, departments, and other stakeholders renders easy access to the expertise of other countries.

9. Conclusions

Growing developing economies like India can not easily adopt a recommended path to sustainable development due to competing development objectives and resource constraints. The Indian power sector offers significant potential for efficiency improvements and mitigation of emissions along the supply chain of electricity. However, proposed steps are difficult to implement on a desirable scale due to the poor financial state of the sector, which is a result of a variety of technical, operational, organisational and socio-political reasons. The need to expand the network and enhance power generation through options with lower investment costs remains the key objectives in the sector. Investment for efficiency improvement, especially in the distribution utilities, is often supported from outside, including the central government, and the multilateral and bilateral agencies.

The benefits for GHG emission reduction could outweigh the cost associated with the suggested policy measures. However, implementation of the suggested measures is not without its challenges in design and implementation of the proposed options. The biggest challenge would be in the implementation of the programs involving distribution utilities. Historical mistrust and lack of accountability provides obstacles for the policy makers. Realizing this, a number of new initiatives targeted within the domain of the distribution utilities are being implemented through central sector utilities, which have relatively successful. Given historical experience and political constraints, it is important to involve various stakeholders in the design and implementation of programs that involve direct interfacing with consumers. A phased implementation of such programs would provide learning experience and an opportunity to fine-tune the program in its future phases of implementation.

The suggested policies are expected to generate large emission reductions and would ultimately provide a conducive environment for efficient pricing policies, the development of which has plagued the sector for decades. A significant reduction in the losses of the electrical system and improvement in end use efficiency would help alleviate any adverse impact of a reduction in price subsidies. Improved metering and governance would help reduce pilferage of electricity, and thereby redress consumption patterns, as more users would consume electricity through metered connections and would have the incentive to reduce their demand. Given the prevailing financial constraints in the sector, international financial support would be more than justified, to bring about significant reductions in carbon emissions from the sector.

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Appendix

S. No.	Description	Current Status	Base Case Estimate	Efficient Scenario - I	Efficient Scenario - II
	Capacity$^{\$}$	2007-08	2031-32	2031-32	2031-32
1	Total Power Generation Capacity (GW)	145.6	778.0	778.0	778.0
2	Coal Based Thermal Generation (GW)	77.2	412.6	412.6	412.6
3	Coal Based Thermal Generation - PC (GW)	77.2	371.3	288.8	247.5
4	Coal Based Thermal Generation - Supercritical (GW)	0.0	41.3	82.5	82.5
5	Coal Based Thermal Generation - Ultra Supercritical (GW)	0.0	0.0	41.3	82.5
6	Gas and Diesel Based Thermal Generation (GW)	15.9	85.0	85.0	85.0
7	Hydro Based Generation (GW)	36.2	193.3	193.3	193.3
8	Nuclear Based Generation (GW)	4.1	22.0	22.0	22.0
9	Renewable Based Generation (GW)	12.2	65.2	65.2	65.2
	Generation$^{@}$				
10	Coal Based Thermal Generation('000 GWh)				
11	Coal Based Thermal Generation - PC ('000 GWh)	442.00	2602.18	2023.92	1734.79
12	Coal Based Thermal Generation - Supercritical ('000 GWh)	0.00	289.13	578.26	578.26
13	Coal Based Thermal Generation - Ultra Supercritical ('000 GWh)	0.00	0.00	289.13	578.26
14	Gas and Diesel Based Thermal Generation ('000 GWh)	76.67	633.17	633.17	633.17
15	Hydro Based Generation ('000 GWh)	120.38	677.17	677.17	677.17
16	Nuclear Based Generation ('000 GWh)	25.26	144.65	144.65	144.65
17	Renewable Based Generation ('000 GWh)	16.03	114.22	114.22	114.22
18	Annual Gross Energy Generation (GWh)	680.35	4460.53	4460.53	4460.53
	Emissions				
19	Coal Based Thermal Generation (mt CO_2)				
20	Coal Based Thermal Generation - PC (mt CO_2)	475	2865	2228	1910
21	Coal Based Thermal Generation - Supercritical (mt CO_2)	0	272	544	544
22	Coal Based Thermal Generation - Ultra Supercritical (mt CO_2)	0	0	215	430
23	Gas and Diesel Based Thermal Generation (mt CO_2)	36	318	318	318
24	Hydro Based Generation (mt CO_2)	0	0	0	0

25	Nuclear Based Generation (mt CO_2)	0	0	0	0
26	Renewable Based Generation (mt CO_2)	0	0	0	0
27	Annual Carbon Emissions (mt)	511	3455	3306	3202
28	Annual Savings Potential for Carbon Emissions (mt CO_2)			150	253
29	Annual Savings Potential for Carbon Emissions (%)			4.33	7.33
30	Carbon Savings over plant life (mt CO_2)#			2994.48	5064.20

Table A-1: Savings in CO_2 Emissions: Adoption of Supercritical and Ultra-Supercritical Technology

Note: Efficient Scenario I - 20% Share of Supercritical technology,
Efficient Scenario II - 20% Share of Supercritical technology and 10% share of Ultra Supercritical technology;
Note: For base case, it is assumed that only 9 UMPPs with a capacity of 4000 MW each and some additional IPP plants would adopt Supercritical technology. This is assumed to account for 10% of the generation capacity by 2031-32;
- Considering average plant life of 20 years; 2031-32 projected capacity based on 8% pa growth scenario in GOI (2006a).
$ - Projections for total power generation capacity are based on GOI (2006a). It is assumed that fuel-wise capacity share in 2031-32 would remain the same as in 2007-08 (coal - 50.03%, Gas & Diesel - 10.93%, Hydro - 24.84%, Nuclear - 2.83%, Renewable - 8.38%)

$ - Projections for fuel-wise power generation are based on the following assumption for PLF (coal - 80%, Gas & Diesel - 85%, Hydro – 40%, Nuclear - 75%, Renewable - 20%)

S. No.	Description	Base Case Estimate	Base Case	Efficient Scenario I	Efficient Scenario II	Efficient Scenario III	Efficient Scenario IV	Efficient Scenario V
	Year	2007-08	2011-12	2011-12	2011-12	2011-12	2011-12	2011-12
1	Number of Agricultural Pump sets[@] (million)	15.47	20	20	20	20	20	20
2	Average pump capacity[$] (kW)	3.91	3.91	3.82	3.67	3.67	3.52	3.52
3	Total Connected Load of Agricultural Pump sets (GW)	60.49	78.20	76.43	73.42	73.42	70.40	70.40
4	Average Hours of daily use[$] (hours)	4.3	4.3	4.19	3.99	3.99	3.8	3.8
5	Annual Energy Consumption (GWh)	94,935	122,735	116,803	107,011	107,011	97,645	97,645
6	T & D losses (%)[$]	31.25	25	25	25	15	25	15
7	Energy Generation at Bus Bar (GWh)	138,088	163,647	155,737	142,681	125,895	130,193	114,876
	Generation							
8	Gross Coal Based Thermal Generation (GWh)	106,052	125,681	119,606	109,579	96,687	99,988	88,225
9	Gross Gas and Diesel Based Thermal Generation (GWh)	15,571	18,453	17,561	16,089	14,196	14,681	12,954
10	Gross Hydro Based Generation (GWh)	20,852	24,711	23,517	21,545	19,010	19,659	17,347
11	Gross Nuclear Based Generation (GWh)	4,662	5,525	5,258	4,817	4,251	4,396	3,879
12	Gross Renewable Based Generation (GWh)	1,381	1,636	1,557	1,427	1,259	1,302	1,149
13	Total Gross Generation (GWh)	148,517	176,006	167,499	153,457	135,403	140,026	123,552
	Emissions							
14	Coal Based Thermal Generation (mt CO2)	117	138	132	121	106	110	97
15	Gas and Diesel Based Thermal Generation (mt CO2)	8	9	9	8	7	7	7
16	Hydro Based Generation (GWh)	0	0	0	0	0	0	0

17	Nuclear Based Generation (GWh)	0	0	0	0	0	0	0
18	Renewable Based Generation (GWh)	0	0	0	0	0	0	0
19	Annual Carbon Emissions	124.6	147.6	140.5	128.7	113.6	117.5	103.6
20	Annual Savings Potential for Carbon Emissions (mt CO2)			7.1	18.9	34.1	30.2	44.0
21	Annual Savings Potential for Carbon Emissions (%)			4.8	12.8	23.1	20.4	29.8
22	Carbon Savings over plant life (mt CO2)[#]			85.6	227.0	408.7	362.2	528.0

Table A-2: Savings in CO_2 Emissions: Adoption of Inefficient Agriculture Pump sets

Note:
Efficient Scenario I - All New Connections with Efficient Pump sets
Efficient Scenario II - All New Connections with Efficient Pump sets and 50% Replacement of Old pump sets
Efficient Scenario III - All New Connections with Efficient Pump sets and 50% Replacement of Old pump sets, HVDS
Efficient Scenario IV - All New Connections with Efficient Pump sets and 100% Replacement of Old pump sets
Efficient Scenario V - All New Connections with Efficient Pump sets and 100% Replacement of Old pump sets, HVDS
Assumptions: Efficient motors would bring down average pump set rating by 10%
Note: [#] - Life of a pump set is assumed to be 12 years.

Title: Climate Co-Benefit Policies in India: Domestic Drivers and North-South Cooperation
Publisher: Climate Strategies 2008
Contact: Contact: Jon.price@climatestrategies.org
Climate Strategies
C/O University of Cambridge
13-14 Trumpington Street,
Cambridge, CB2 1QA

For citation and reprints, please contact the publisher Climate Strategies

Acknowledgement:

Climate Strategies is grateful for funding from their core supporters including The Carbon Trust (our founding supporter) governments of UK (DEFRA, OCC, DFID), France (ADEME with inputs from French Ministry of Finance), Grant Thornton, European Climate Foundation, Swedish Energy Agency and GDF SUEZ.