EVALUATION OF GREENHOUSE GAS POLLUTION PREVENTION PROGRAM

For the Clean Energy and Environment Office (CLEEO) of USAID/India

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ACRONYMS

ABC	Alternative Bagasse Cogeneration
CCS	Climate Change Supplement
CenPEEP	Centre for Power Efficiency & Environmental Protection
CII	Confederation of Indian Industry
CLEEO	Clean Energy and Environment Office (of USAID/India)
CO_2	Carbon Dioxide
COTR	Contracting Officer's Technical Representative
CTI	Clean Technology Initiative
NETL/DOE	National Energy Technology Laboratory, United States Department of Energy
ECC	Efficient Coal Conversion
EPRI	Electric Power Research Institute
GEP	Greenhouse Gas Pollution Prevention Program
GOI	Government of India
GHG	Greenhouse Gases
ICLEI	International Council for Local Environmental Initiatives–Local Governments for Sustainability
IDBI	Industrial Development Bank of India
ITCOT	Industrial and Technical Consultancy Organisation of Tamil Nadu (India)
kWh	Kilowatt hour
MSEB	Maharashtra State Electricity Board
MW	Megawatts
MSI	Management Systems International
NETL	National Energy Technology Laboratory
NTPC	NTPC Ltd. (formerly National Thermal Power Corporation)
PASA	Participating Agency Service Agreement
PLF	Plant load factor
PMI	Power Management Institute
SEB	State Electricity Board
SI	Social Impact
SOW	Statement of Work
TVA	Tennessee Valley Authority
UP	Uttar Pradesh
USDOE	United States Department of Energy

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EXECUTIVE SUMMARY

INTRODUCTION

In August–September 2011, Social Impact, Inc. (SI) with sub-contractor Management Systems International (MSI), carried out an evaluation of the major components of the Greenhouse Gas Pollution Prevention Program (GEP) for the clean energy and environment office (CLEEO) of USAID/India. The largest component of this long-running (April 1995–September 2011) program in India focused on reducing CO_2 emissions from coal-fired thermal power plants. This GEP component was implemented in close partnership with the country's biggest power producer, NTPC Ltd. Most elements of the program were implemented by the National Energy Technology Laboratory (NETL) and the United States Department of Energy (DOE) through a Participating Agency Service Agreement (PASA). USAID contributed a total of $39.2 million to support GEP activities, of which $5.2 million was used for direct contracting by USAID with Louis Berger International, and $2 million for other, smaller contracts.

The original objective of GEP was to reduce the volume of emissions of greenhouse gases (GHGs) per energy unit generated in the coal-based power sector, while increasing energy productivity and encouraging biomass fuel use in selected utilities and sugar industries. The initial phase of GEP (1995–2000) was composed of two components, Efficient Coal Conversion (ECC) and Alternative Bagasse Cogeneration (ABC), aimed respectively at increasing awareness, available information, and practical examples of the applicability of the state-of-the-art pollution prevention, efficient coal conversion and combustion for power generation, and industrial co-generation technologies in sugar mills. In 1999, new activities under the Climate Change Supplement (CCS) were added to the agreement with the government of India. The PASA was modified in 2003 to include several new areas (distributed generation, alternative transportation, hydrogen economy, and regulatory assistance).

The evaluation focused mainly on the efficiency improvement activities of Indian power utilities and secondarily on the bagasse cogeneration activities. This evaluation is meant to serve as a reference point for USAID as it develops new programs in the energy sector.

EVALUATION METHODOLOGY

The methodology for the evaluation was mixed methods, and included a desk review of available program documentation from USAID, DOE and Indian partners; a limited literature review; key informant interviews in India and in the United States; and site visits to a sample of participating coal power plants and other program partners in India. The methodology also included quantitative validation of carbon dioxide (CO_2) emissions avoided or reduced. The evaluators are confident that sufficient data has been gathered to support their findings, conclusions, and recommendations.

Findings

Effectiveness

The project has been cost-effective as measured by the cost of achieving its objective. The USAID contribution to the ECC and ABC components of the GEP was $32 million. This means that USAID was able to achieve a reduction of one ton of CO_2 at a cost of $0.32 to U.S. taxpayers—highly cost-effective when compared to the cost of tons of CO_2 reductions through the Clean Development Mechanism (in 2010 priced at about $14 per ton). The results of this evaluation confirm that CenPEEP (Centre for Power Efficiency & Environmental Protection), which has worked with NETL on activities resulting in the majority of CO_2 emissions avoided through GEP, has been very effective at meeting the needs of NTPC, and other Indian utilities that were supported, in the area of efficiency improvement at conventional coal-fired power plants. NTPC has undergone significant change in its organizational culture since the inception of GEP, and now possesses a culture of efficiency. Apart from the achievements in reducing CO_2 emissions, this is likely the most important outcome of GEP.

Relevance

GEP's starting premise—that reduced CO_2 emissions per unit of power produced in the country could be achieved—was relevant in the context of India's power sector management, operations, and investment practices, which placed no measure on efficient power production. Now, over fifteen years later, the prime objective of GEP remains highly relevant, given India's status as fourth largest GHG-emitting nation, coupled with coal's position as the largest source of energy for electric power for decades to come.

Outcome and Impact

The GEP program has had a highly significant impact on NTPC's culture, operations, profitability and GHG emissions. Total avoided emissions as of September 2010 under the ECC and ABC components of the GEP are estimated to be 99.1 million tons of CO_2, with state electricity boards (SEBs) contributing 63.7 million tons, followed by NTPC Ltd. with 29 million tons (both for the ECC component), and the ABC component with 6.4 million tons. Indirectly, GEP contributed to potentially many million tons more of emission reductions because CenPEEP and GEP provided direct assistance to SEBs for efficiency gains and because GEP outcomes had an impact on equipment manufacturing, design standards, and lending practices. CCS activities strengthened and complemented the overall ECC achievements.

GEP has led to additional beneficial outcomes in coal savings valued at close to $1.5 billion, air quality improvements near NTPC coal power plants (although the evaluators did not have access to hard data on air quality), and some economic spin-offs to U.S. service providers in the coal power sector.

Sustainability

There is significant evidence that the new institutional capacity of the major Indian partner will be sustained. Within NTPC, adoption of systems, practices, and technologies has been followed by plant-level performance monitoring that is now institutionalized. CenPEEP and other NTPC representatives express a firm commitment to maintain CenPEEP, even should U.S. support cease. New knowledge gained through GEP has also been institutionalized through the training program offered by NTPC's Power Management Institute (PMI). New capacities have also been achieved at the SEBs where GEP has intervened. Nonetheless, sustainability and replication of practices within most SEBs remains a question mark. Although in some cases, such as the Maharashtra State Electricity Board (MSEB), an efficiency group was set up as a result of CenPEEP's support.

Process Findings

Overall, the evaluation team found effective program management by USAID. GEP had the advantage of a committed and technically competent participating agency in the National Energy Technology Laboratory, United States Department of Energy (NETL/DOE), and a strong local partner in NTPC. USAID exercised reasonable oversight of GEP. The governance structure established by GEP and communication initiatives undertaken by GEP partners supported effective communication with the government of India (GOI). As the implementation partner, NETL/DOE was located in the U.S. Therefore, USAID program officers played a pivotal and effective role in acting as a conduit between NTPC and NETL. However, USAID was less effective in GEP in the areas of performance management, reporting, and monitoring and evaluation. For instance, no logical framework was ever developed for GEP, the few program reports to be found are primarily activity reports and provide little information on progress toward higher-level outcomes, and no evaluations of GEP had been undertaken until this final evaluation.

LESSONS

1. Significant gains in reducing GHGs, lowering costs, and increasing reliability and availability can be had through low-cost measures in existing Indian coal-fired power plants.

2. The constraints on improved environmental and operational performance are not technical in nature, but rather are institutional. Thus, to be effective and sustainable, the culture of organizations must change, which requires commitment at the top to champion change alongside efforts at the bottom to demonstrate how the change will impact operations and how it is to be developed.

3. Training and demonstration projects/practices will only be widely replicated and sustained if systems related to the new practices are put in place concurrently.

4. There were significant advantages in working with a neutral body such as USDOE in the early years of the GEP.

5. A large part of the GEP's success has been the continuity of staff at USAID, NETL, and CenPEEP and their dedication even after their assignments have ended. The contributions of Electric Power Research Institute (EPRI), Tennessee Valley Authority (TVA), and other U.S. companies and individuals that spent months and years in India during the early days of GEP and the continuing support of U.S. utilities such as American Electric Power (AEP) has helped sustain CenPEEP and the GEP.

CONCLUSIONS

1. The prominence of coal in India's energy mix has risen since GEP began and coal will continue to be the primary fuel source for electric power for the foreseeable future.

2. The marginal abatement cost curve (a set of options available to an economy to reduce pollution) for India's power sector clearly indicates that improvement at current power plants, a negative net cost, and at future ultra/supercritical coal plants are lowest-cost options for reducing GHG emissions. This cost-curve result supports the finding on GEP's cost effectiveness and justifies continued work in the sector.

3. A large degree of GEP's success in sustainability can be attributed to the creation, evolution, and institutionalization of CenPEEP. Given the uncertain sustainability of the approach taken in GEP at the level of SEBs, there may be greater likelihood of success if a CenPEEP model is pursued at SEBs, or some hybrid of CenPEEP and the approach taken at the MSEB, which established an efficiency unit.

4. Stronger performance management and reporting in programs like GEP would not only comply with USAID directives, but would better allow USAID and external evaluators to monitor and evaluate project performance, capture and communicate successes and lessons, and make corrections to project interventions, as necessary.

RECOMMENDATIONS

The evaluation team recommends that:

1. Given that coal will remain India's dominant source of power , USAID continue to work with coal-fired power utilities because the environmental and development impacts of USAID's efforts in this sector are proven to be significant and cost-effective.

2. Depending upon the resources available:
    a. USAID collaborate with CenPEEP to continue working with existing coal-fired power plants to reach a broader audience in state plants, and create a central efficiency structure inspired by the CenPEEP model within selected SEBs; this structure could take the form of a model power plant to be used to demonstrate the project interventions; *or*

b. USAID invest in building a CenPEEP-like group to focus on the efficiency aspects of supercritical plants at the Sipat power plant—making it a model for efficiency and ensuring that U.S. experience and best practices in supercritical coal-fired plants is rapidly adapted and adopted in India; *or*
c. USAID pursue both options.

3. In future programming, USAID should ensure development of performance management plans as well as a monitoring and evaluation plan.

1.0 INTRODUCTION

This evaluation is of USAID/India's long-running Greenhouse Gas Pollution Prevention Program (GEP), aimed primarily at reducing CO_2 emissions from the coal-fired thermal power sector. The evaluation activities took place from August 8 to September 13, 2011 in India in Delhi, Noida, Hyderabad, Chennai, Tuticorin, Lucknow, Uchahar, and in the United States, in Washington, D.C. and Pittsburgh, Pennsylvania. The evaluation team consisted of an evaluation methods specialist, an energy analyst, and an Indian expert on coal-based power generation.

The evaluation documents the impact of GEP in as much detail as possible, and serves as a reference point for USAID as it develops new programs in the energy sector.

The evaluation is organized in the following manner:

- Findings, organized around the following themes:
  - Effectiveness (Have the interventions achieved what they were meant to achieve?)
  - Relevance (Was the program, and does the program continue to be, in line with the government of India's needs?)
  - Outcome and Impact (What has been the effect of the projects on the beneficiaries?)
  - Sustainability (Are the gains to the beneficiaries likely to continue over time?)
  - Process (management, donor coordination)
  - Gender Integration
- Lessons Learned
- Conclusions
- Recommendations

We have taken care to ensure the report is accessible not only to those familiar with it, but to general readers also, and that the lessons learned from GEP have applicability to other development programs.

2.0 PROJECT DESCRIPTION

2.1 THE PROBLEM STATEMENT

At the time of GEP's inception in 1995, nearly seventy percent of India's power generation capacity utilized coal as fuel and operated over a wide range of efficiencies, with an average efficiency of less than thirty percent.[1] Improving the operating efficiencies of these plants would not only reduce the gap between the demand and supply of power, but would also reduce greenhouse gas (GHG) emissions considerably in the short term.

2.2 PROGRAM LOGICAL FRAMEWORK

GEP did not develop a formal program logical framework, nor did it have a performance management plan. In order to understand and illustrate the logic behind the GEP interventions and how they would lead to the expected outcome results, the evaluators constructed a basic program logical framework for the ECC component, based on their research.

In simplified terms, GEP consisted of two major areas of intervention:

1. Demonstration, training, and technology transfer at NTPC plants in many key subcomponents of coal-based power generation.
2. Establishment of a center of excellence—CenPEEP—as a technical resource to the NTPC network and to interested SEBs.

The logic follows that these interventions would lead to outcomes and impact, namely:

- Changes in overall plant performance
- A shift in operational and management focus from plant load factor (PLF), or the quantity of electricity generated, to heat rate improvement (HRI), or the number of units of coal required to generate a kWh of electricity, and efficiency gains in NTPC plants
- Reduced or avoided CO_2 emissions

In addition, there was an implicit logic that GEP interventions would lead to change in the organizational culture of NTPC and CenPEEP.

The logic of GEP also suggests that a secondary set of interventions at targeted SEBs (without establishing a CenPEEP equivalent) would achieve similar efficiency gains and reduced CO_2 emissions. These interventions were to be undertaken through demonstrations in candidate SEBs. CenPEEP also catered to the SEBs through consultancy and the PIE program.

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[1] USAID. *Participating Agency Service Agreement between AID and USDOE for GEEP*, 1995. (Attachment A, Statement of Work, p. 1)

2.3 PROJECT OBJECTIVE

The primary goal of the GEP was to increase environmental protection in the energy sector. *Its original objective was to reduce the volume of emissions of greenhouse gases (GHGs) per energy unit generated, while increasing energy productivity and encouraging biomass fuel use in selected utilities and sugar industries.* Subsequently, the scope of the project was broadened in 1999 to include activities related to sustainable development and climate change. *The objective was broadened to "increased environmental protection in energy, industry, and cities."*

The outputs from the project were expected to include:

- Demonstration and use of advanced, efficient, generation techniques for sugar mill cogeneration. Demonstration of advanced, efficient, generation techniques for coal-fired power plants.

The two components of the program aimed at increasing awareness, available information, and practical examples of the applicability of state-of-the-art pollution prevention; efficient coal conversion and combustion; and industrial cogeneration technologies in the Indian setting. The details are as follows:

Efficient Coal Conversion (ECC): The objective of this component was to reduce the amount of CO_2 produced per kilowatt hour of electricity generated by coal conversion. The project supported the development of an institution promoting efficient management of coal-fired power plants and facilitating the commercialization of advanced coal conversion technologies for sharing the benefits with Indian utilities. The role of the institution was to study means of burning coal more efficiently, promote electricity generation efficiency improvement and environmental protection by supporting Indian utilities in the efficient delivery of thermal power at the least cost.

In 1999, some new activities under the Climate Change Supplement (CCS) were added to support broader interests of the government of India and other stakeholders. In addition to continuing the work on efficient power generation, two new elements were added:

- Fostering climate-friendly initiatives, primarily through institutional development, capacity building, public outreach, and enhanced stakeholder participation
- Linking urban development and climate change via the design and demonstration of climate change abatement initiatives in cities, primarily in the areas of transportation and solid waste management. ***The urban component was carried out under a commercial contract with Louis Berger International and is not the subject of this evaluation.*** Smaller contracts to other organizations, such as ICLEI and Tetratech, as part of the climate change supplement amounted to a total of $2 million.

This component will end on September 30, 2011.

Alternative Bagasse Cogeneration (ABC): The objective of this component was to promote the commercialization of high-efficiency cogeneration in sugar mills, utilizing bagasse—the fibrous matter that remains after sugarcane stalks are crushed. It aimed to work closely with and be complementary to the GOI bagasse-based cogeneration plants. It also provided technical assistance to catalyze, stimulate and sustain private sector investments in sugar mills using alternate bagasse/biomass cogeneration (the combined generation of steam and electricity using plant residue such as bagasse) technologies in India. The ABC component worked closely with the GOI's National Bagasse Based Cogeneration Program and with the sugar industry to provide information, technical assistance, and training on all the feasible options. The project covered the incremental costs associated with the initial adoption of the technologies by bagasse cogeneration systems. USAID/India worked with financial institutions, such as the Industrial Development Bank of India (IDBI), and with the private sector throughout the life of the project. NETL supported the engineering/technical evaluation of the sugar mill retrofit/upgrade projects requesting financial assistance. This component was completed in 2003.

2.4 PROGRAM IMPLEMENTERS

The program elements addressed in this evaluation were implemented primarily by the National Energy Technology Laboratory (NETL), United States Department of Energy (USDOE), through a Participating Agency Service Agreement (PASA). NETL contracted work through its competitively-procured, site-support contracts with several U.S. firms specializing in various aspects of ABC and ECC and other GEP activities, including Burns & Roe Services Corporation (BRSC), Research & Development Solutions, Inc. (RDS), Energy & Environmental Solutions, Inc. (E2S), KeyLogic Systems, Inc., and Leonardo Technologies, Inc. (LTI). Most of these companies were partnerships formed by major U.S. engineering and science companies (e.g., WorleyParsons, Science Applications International Corporation [SAIC], and Washington Group) and specialty services companies specifically to meet NETL's support needs across its research, development, demonstration, and deployment programs in clean fossil energy, energy efficiency, and other areas. NETL also directly procured other support from industry organizations, such TVA and EPRI, through interagency agreements, cooperative agreements, and contracts for specific activities, mainly under ECC and follow-on related activities. Direct contracts were also placed by NETL with U.S. and Indian firms for support on various activities under ECC (e.g., Confederation of Indian Industry and Indian Institute of Technology), ABC (e.g. Winrock International India), and the alternative transportation task (Energy Conversion Devices and India Auto LPG Association). Nexant Inc. also was contracted directly by USAID to produce a feasibility report on integrated gasification combined cycle (IGCC), a technology that turns coal into a gas.

2.5 GEOGRAPHY OF PROJECT IMPLEMENTATION

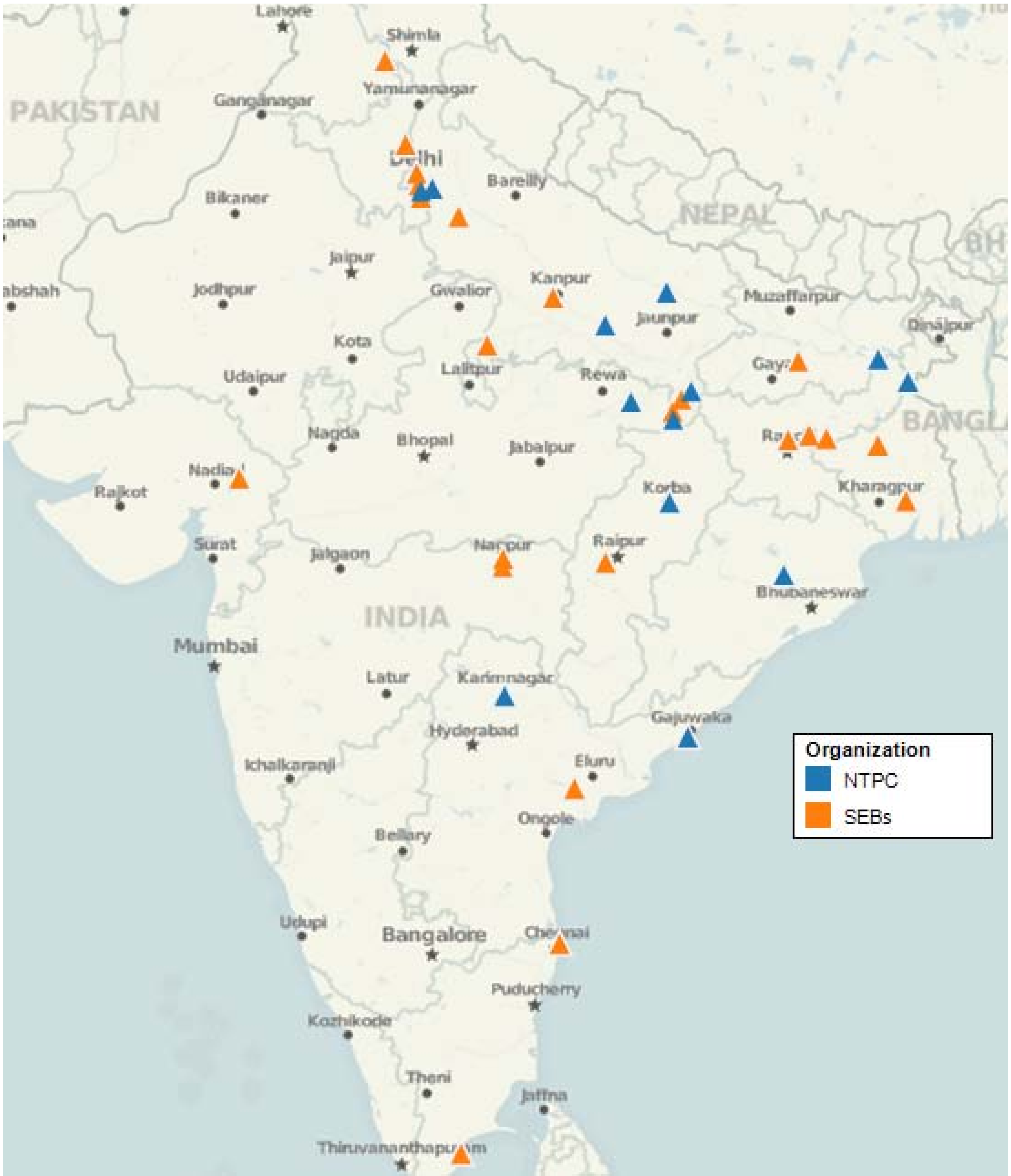
Implementation of GEP coal activities occurred throughout India via the NTPC Ltd (previously National Thermal Power Corporation Limited) network of coal-fired power plants, as well as those of targeted state utilities. Table 1 below provides details of the relevant NTPC and SEB plants.

Table 1: Power Plant Sites for GEP Intervention

NTPC Ltd.	State Electricity Boards (SEBs)
Uttar Pradesh Dadri Rihand Singrauli Unchahar Tanda	**Uttar Pradesh** Anpara Obra * Panki * Harduaganj * Pariccha *
Madhya Pradesh Vindhyachal	**Gujarat** Wanakbori
Andhra Pradesh Ramagundam Simhadri	**Maharashtra (MahaGenco)** Koradi Bhusawal
	Andhra Pradesh Vijaywada
Delhi Badarpur	**Delhi** Indraprastha * Rajghat *
Bihar Kahalgaon	
Orissa Talcher Super Thermal	**West Bengal** Kolaghat Durgapur, DVC * Durgapur TPS, DPL *
West Bengal Farakka	
Chattisgarh Korba	**Jharkhand** Patratu * Tenughat, TVNL * Chandrapura, DVC * Bokaro-B, DVC *
	Punjab Ropar
	Haryana Panipat Faridabad
	Tamil Nadu Tuticorin Ennore *
	Madhya Pradesh Birsinghpur Satpura
	Bihar Bihar SEB, Tenughat
	Chattisgarh Chattisgarh SEB
	Rajastham RRVUNL Suratgarh Kota

* Stations where CenPEEP worked with NTPC's Partnership in Excellence (PIE) Team.

Figure 1: GEP Intervention Locations in India



2.6 COST

USAID contributed a total of $39.2 million for the GEP, of which $5.2 million was used for a commercial contract with Louis Berger International, and $2 million for other, smaller contracts, elements that are not included in this evaluation. The evaluation team estimated that USAID's spending for the ECC and ABC components was allocated as $14 million for ABC (including an $11-million finance grant) and $18 million for ECC. NTPC contributed $21.4 million in personnel, testing equipment, and equipment for demonstration projects in the ECC component.

3.0 PURPOSE OF THE EVALUATION

The evaluation focused primarily on the efficiency-improvement activities of Indian power utilities and also reviewed the bagasse cogeneration activities. The few environmental activities that were added to the scope subsequently (such as fly ash resistivity, fly ash disposal, and alternative transportation) were broadly covered, but not explored in detail, in the interest of time.

The objectives of the study were to:

- Determine the impact and achievements of the program, relative to the overall objective of the program and the specific objectives of the two components.
- Validate the results of greenhouse gases (carbon dioxide) avoided, from the inception of the program till September 2009 (ECC component). Document the savings in carbon dioxide reduced/avoided from the ABC component. Insofar as available data permits, note any co-benefits from GEP.
- Determine the relevance of the project in present context.
- Document the challenges faced in implementation and the lessons learned.
- Make suitable recommendations for the future direction of projects related to cleaner coal.

The audiences for this assessment are USAID/India’s Clean Energy and Environment Office, and Front Office as well as the government of India counterparts. The assessment will also be used to disseminate the impact and outcomes of the program to other stakeholders in U.S and India.

4.0 EVALUATION METHODOLOGY

The methodology for the evaluation was mixed methods and utilized available data, such as utility records and project documents, and key informant interviews in India and in the United States, employing semi-structured questionnaires. Qualitative data were triangulated with quantitative data, such as mathematical calculations, to validate carbon dioxide avoidance figures provided by the GEP project. These calculations were used to extrapolate the value of savings the project provided in terms of the amount of carbon dioxide reduced.

GEP began in April 1995 and closes in September 2011, for a total performance period of sixteen years. With limited time and resources allocated for this final evaluation, the evaluation team addressed the effectiveness of the program across this time period to the extent possible, but recognized the inherent limitations of findings, conclusions, and recommendations regarding the earlier phases of the program. This is especially true of the ABC component, whose activities came to an end in 2003.

4.1 SPECIFIC METHODS

1. **Desk review of documents:** The Mission point of contact provided the evaluation team with the project reports, proposals, PASA documents, amendments and modifications, scope of work, etc., necessary to conduct the desk review. This was supplemented with material from NETL, NTPC, CenPEEP, Confederation of Indian Industry, and the team's own literature search. The team was provided with carbon dioxide avoidance calculations and data in the form of a spreadsheet, as well as a list of training and capacity building activities undertaken throughout the life of the project, for the ECC component only. The team studied these, as well as the other relevant documents, reports, and data.

2. **Key Informant Interviews (U.S.)**: U.S.-based stakeholders and implementers are located across the country, and thus, phone interviews were conducted with stakeholders outside of the Washington, D.C.-metropolitan area. In-person interviews were conducted with four individuals and phone interviews with five individuals, prior to the field visit.

3. **Key Informant Interviews (India):** The evaluators interviewed in person or by phone twenty relevant implementation partners, GOI partners, and subcontractors in India.

Appendix B provides details of persons contacted in India and the U.S.

4. **Site Visits:** Based on the recommendations of the program contracting officer's technical representative (COTR) and partner's feedback, site visits were conducted in order to see the GEP-funded facilities first hand and to conduct interviews with stakeholders. The sites purposefully were selected from among NTPC and SEB facilities where GEP intervened and from among other GEP collaborating organizations. The team visited CenPEEP, the SMART 24X7 control room in NTPC, Dadri and Unchahar Power Plants (NTPC), and the Tuticorin Power Plant (TNEB). The team also interacted with the NTPC Singrauli team on video call and discussed the NTPC Rihand experience with a former Rihand team member. The team visited the Confederation of Indian Industry (CII) in Hyderabad and the Industrial and Technical Consultancy Organisation of Tamil Nadu (India) (ITCOT) in Chennai. The team split into two groups to undertake these visits, so as to maximize the time and efforts.

5. **Quantitative Validation of carbon-dioxide-avoided figures for ECC (*and ABC, if possible*)**: GEP has already documented the amount of carbon dioxide avoided as a result of the ECC component. The evaluation team reviewed the available data and ran similar calculations in order to validate these figures. The team also attempted to validate the carbon dioxide avoided for the ABC component.

4.2 EVALUATION MATRIX

The evaluation matrix (Appendix E) systematizes the methodology by identifying the key evaluation questions to be answered; by elaborating any matters that merit consideration; and by identifying the sources of information the evaluators relied upon and methods of information collection for each question. The evaluation questions outlined in the matrix reflect the discussions between USAID/India staff and the evaluation team at their first meeting in Delhi and the resulting final, revised SOW for the evaluation. In order to bring focus to, and maximize the relevance and utility of, the evaluation, the evaluators gave highest priority to the questions highlighted in bold, which reflect that discussion and adhere to the main objectives for the evaluation as described in the SOW.

4.3 CONSTRAINTS AND LIMITATIONS

The evaluation team had less than two months to conduct this review of a program that ran for over fifteen years, including site visits to only a few coal-fired power plants in the vast Indian sub-continent where GEP was implemented. Given more time, the evaluation team could have explored in greater depth the challenges to adoption of the GEP model and to achieving organizational change at the SEBs. Had time and resources allowed, the team could have met with representatives of SEBs where GEP had not intervened, to investigate challenges for SEBs in adopting technologies and practices that have succeeded in the NTPC network and in certain SEBs (this further study of obstacles and challenges within specific SEBs could be pursued at the design stages of any future USAID interventions in clean coal).

The absence of project documentation, such as annual work plans and reports, performance management plans, a program logical framework, and earlier evaluation reports, made the work of answering the evaluation questions more difficult than it might have been.

Despite these constraints and limitations, the evaluators are confident that sufficient data was gathered to support the findings, conclusions, and recommendations in this report.

5.0 FINDINGS

5.1 EFFECTIVENESS

5.1.1 Cost Effectiveness

The program has been cost-effective, as measured by the cost of achieving its objective.

The USAID contribution was $32 million, while the GOI put another $21.4 million directly into the program, bringing total costs to $53.4 million.[2] Against this, a total of 99.1 million tons of GHGs were avoided. Table 2, below, presents the results. These figures mean that USAID was able to achieve a reduction of one ton of CO_2 at a cost of $0.32 for the total GEP program. To put this in perspective, the World Bank's carbon finance unit had purchased some 208 million tons at a value of $1.7 billion by the end of 2010, or a cost of about $8.17 per ton. These values are not strictly comparable, because the Bank says it pays a premium for its tons in order to stimulate the market. Another comparative measure is the average cost of carbon emission reductions (tons of carbon reduced or avoided) through the Clean Development Mechanism, which in 2010 was priced at about $14 per ton.

USAID's contribution to the ECC component was $18 million and 93 million tons of GHG reductions can be credited directly to this spending. This means it cost USAID $0.19 per ton to achieve GHG reductions through the ECC component, a significant savings over other carbon reduction/offset programs. Similarly, for every dollar USAID spent on the ECC component, 5.58 tons of coal were removed from power production, and for every dollar USAID spent on the ECC component, Indian utilities saved $106.38.

Table 2: GEP Cost Effectiveness

	ECC	ABC	Total
USAID Cost ($)	$ 18,000,000	$ 14,000,000	$ 32,000,000
NTPC Cost ($)	$ 21,435,260		$ 21,435,260
Total Cost ($)	$ 39,435,260	$ 14,000,000	$ 53,435,260
Tons of Avoided GHGs	92,728,413	6,403,145	99,131,557
Cost/Ton ($)			
USAID Cost	$ 0.19	$ 2.19	$ 0.32
Total Cost/Ton	$ 0.43	$ 2.19	$ 0.54

The GEP cost-effectiveness table also shows the total cost, which includes the host country contribution. Thus, the total cost of reducing GHG emissions was $0.54 per ton, still relatively cheaper than for other such donor initiatives. The total for ECC with NTPC's contribution is $0.43 per ton.

5.2.2 Effectiveness of CenPEEP

The evaluation team assessed the effectiveness of CenPEEP as a knowledge think tank for the Indian power sector and its effectiveness in catering to NTPC, as well as to other utilities. This question has to be framed within the context of CenPEEP's mandate, approach and experience. CenPEEP's goals are to:

- *reduce GHG emissions* from coal-fired thermal power plants *by performance optimization* in terms of *efficiency, availability and reliability*

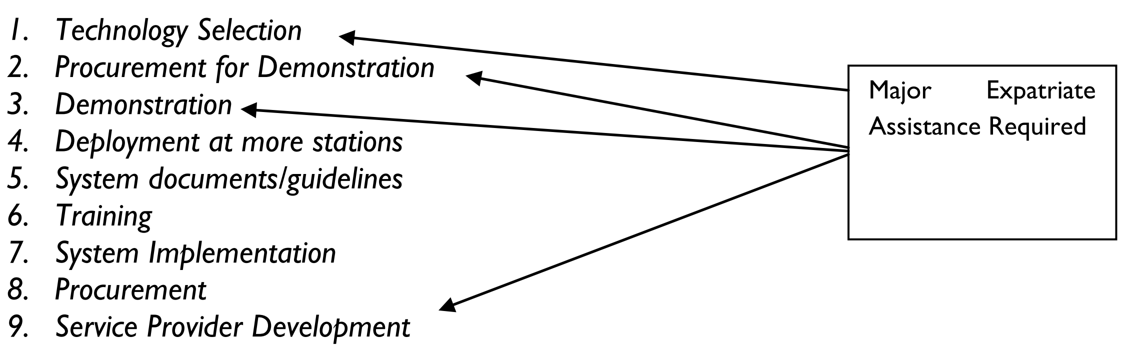
[2] Stakeholder contribution to ABC could not be determined since the project ended in 2003 and no written records on this aspect were available.

- *Technology acquisition* for performance optimization
- *Institutionalization* of cooperation for technology transfer was established to promote efficiency through awareness, systems, practices and introduction of the new technology.

In meeting these goals, it has gained substantial experience in low-cost maintenance at conventional coal-fired power plants, and it has grown to become an important part of NTPC operations and a widely respected organization throughout the industry. Its advice is sought and followed and efficiency advocates have spread to all generating companies. The measures introduced through GEP are now spread throughout the NTPC system and many of those also have been extended to gas-fired plants. These include Efficiency Management System, Reliability Centered Maintenance, Best Overhauling Practices Manual, ESP inspections, and Financial Risk Optimization. CenPEEP's regional offices at Lucknow, Uttar Pradesh and Patna, Bihar provide assistance to SEBs. CenPEEP is even providing consulting services for a fee, but is constrained in meeting needs due to its limited staff size.

CenPEEP's approach is called 'from technology selection to sustainability' and consists of the following steps, outlined in Figure 2:

Figure 2: CenPEEP's Technology Selection to Sustainability Approach



CenPEEP has (and still does) required outside (expatriate) experts to assist in this process, particularly in selecting technology, procurement, initial demonstration, and in service provider development. As CenPEEP moves from low-cost to more expensive performance enhancement measures at conventional power plants, it will still require this outside assistance. Additionally, if CenPEEP moves into establishing a similar service for supercritical technology, it will need outside assistance.

The results of this evaluation confirm that CenPEEP has been very effective in catering to the needs of NTPC in the area of efficiency improvement at conventional coal-fired power plants. However, its mandate is constrained or confined, because new areas, such as IGCC, are the focus of other NTPC departments.

CenPEEP has been less effective at SEBs than at NTPC due to factors beyond its control. In essence, those things that CenPEEP and NTPC management instituted through GEP are greater in scope than the steps listed above. Penetration, replication, and sustainability require, at a minimum, that a core group be established in the SEB (such as was done at NTPC through the creation of CenPEEP), that top management be fully supportive, financial resources be committed and "sustainability through systems and procedures" be established. These actions are clearly beyond CenPEEP's control and unless and until SEBs take these decisive steps, USAID assistance will be comparatively ineffective when directed at SEBs.[3,4]

5.3.3 Changes in Organizational Culture in NTPC-CenPEEP

As noted in previous sections on outcomes and impact, NTPC has undergone significant change in its organizational culture since the inception of GEP. Apart from the achievements of GEP in reducing CO_2 emissions, this is likely the most important outcome of the program. This organizational change is characterized by the features of penetration, replication and sustainability described in section 5.1.2. The change in attitude from an efficiency focus centered on PLF to one centered on HRI is evident in interviews with NTPC and CenPEEP staff and in CenPEEP presentations.[5] CenPEEP staff told the evaluation team that when GEP began, the NTPC focus had been exclusively on PLF – generation of as much electricity as possible without consideration for cost or efficiency in use of coal. They credited the knowledge, best practices, and technologies gained through GEP with shifting their efficiency focus to HRI. From the perspective of an American technical advisor, the GEP interventions that contributed to this organizational change led to significant improvements in HRI and increased generation of electricity, and constituted selling points for USDOE since emissions and fuel were being saved, and reliability of electricity production was increased.

5.2 RELEVANCE

5.2.1 Historical Relevance

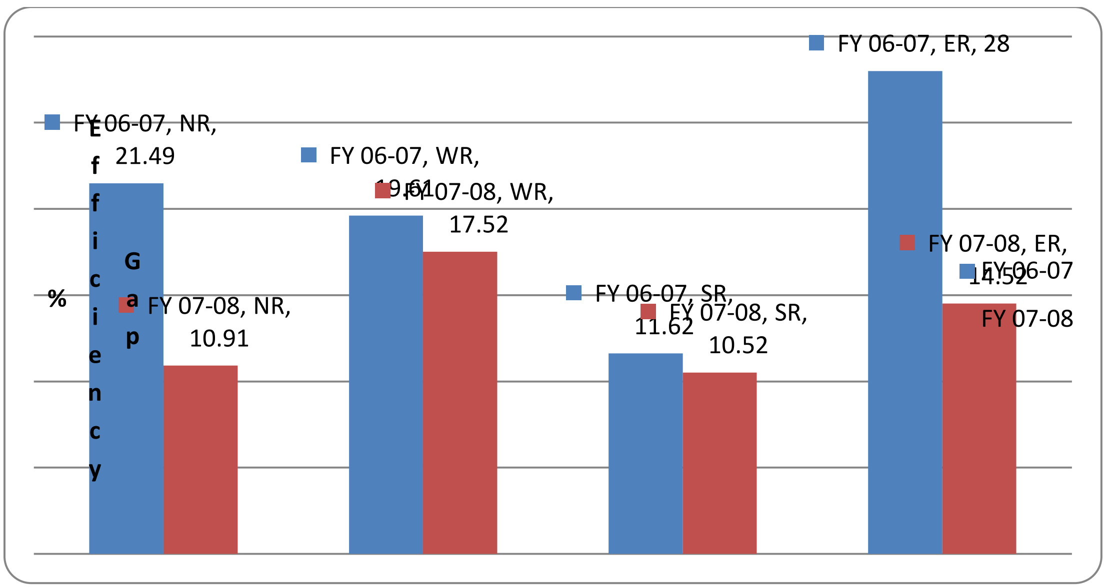
When GEP was first conceived, India was dependent for over seventy percent of its power on inefficient, coal-fired power plants and future sector plans called for a massive increase in generation capacity, most of which would come from coal. The program was originally designed with the primary objective "to reduce CO_2 emissions per unit of power produced in the country."[6] The premise was well grounded in the reality of India's power sector management, operations, and investment practices, which placed no measure on efficient power production, but rather on simply producing as much power as could be produced, even if it meant lower equipment lifetimes, lower efficiencies and higher costs in the long run.

[3] There are exceptions to this, such as MSEB and GSEB.
[4] The role of CenPEEP in the GEP was limited to demonstration. However, it also provided consultancy services to SEBs and supported them through a GOI program.
[5] CenPEEP. Presentation to GEP Evaluation Team, Noida, India. August 2011.
[6] Participating Agency Services Agreement between USAID India and USDOE, NETL, page 4.

5.2.2 Current Relevance

Now, over fifteen years later, the prime objective of GEP remains even more relevant than it did when GEP began. As of 2008, India was the fourth largest GHG emitting nation, behind only China, the United States, and Russia.[7] Based on the results of the major India energy planning exercises, including the recent Low Carbon Development Strategy, coal will remain the largest source of energy for electric power for decades to come. At the same time, the quality of Indian coal is deteriorating—requiring more coal per kWh of electricity generated.[8] NTPC has shown remarkable progress in adopting and adapting the GEP project interventions, which dealt primarily with low-cost measures.[9] SEBs still have not instituted these measures on a wide scale so there is still significant scope to implement GEP interventions in about seventy percent of the country's coal-fired electric power generation. The room for efficiency improvement is illustrated in Figure 3 below.

Figure 3: Power Plant Efficiency Gap



Source: CEA 2008 Annual Report. NR=Northern Region, WR=Western Regional, SR=Southern Region, ER= Eastern Region.

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[7] "CO_2 emissions from Fuel Combustion," 2010, International Energy Agency, page 9.

[8] Winrock International India. *Legacy of US-India Cooperation: Clean Coal Technologies for Power Generation (Draft)*. P.23. 2007.

[9] These were not simply low-cost measures, but also high-benefit ones. Low-cost measures can be considered inexpensive when taken as individual interventions, but the entirety of these measures at any single plant may represent a substantial investment. Nor have GEP interventions been limited only to low-cost measures. The replacement of air preheater seals, mill components, and steam turbine seals are relatively more expensive measures that were begun in the later years of GEP, but do not constitute the bulk of the activities carried out under GEP.

Moreover, the next generation of coal-fired power plants will be supercritical,[10] a technology well known in the United States but new to India. U.S. experience can benefit India in reducing the learning curve to operate supercritical plants efficiently.

Of equal importance is that when the program first began, supplying power at any cost was the focus as cost was simply a pass-through meaning that utilities did not compete on the price of power and they could simply pass through any cost increases to consumers. Now, cost of power figures prominently in dispatch[11] and utilities are looking for ways to cut costs. The GEP program has demonstrated significant cost saving. Efficiency has now become a major measure of performance, and coal use per kWh, and consequently GHG emissions per kWh, are lower than they otherwise would have been. Systems, practices and procedures introduced by GEP have been adopted and adapted in all NTPC plants, even gas plants. A culture of efficiency—marking a shift in focus from plant load factor, or capacity—has been established at NTPC and CenPEEP, whose genesis is owed to USAID through GEP, and is an integral part of the organization.

5.2.3 Responsiveness to Needs of GOI

This evaluation found that GEP responded well to GOI needs. This was due to several factors:

1. GEP was the continuation of a series of assistance activities in association with the USDOE and relationships had been earlier established and trust developed.
2. There was important continuity in key staff at CenPEEP and NETL. For example, while various individuals have held lead roles in both CenPEEP and NETL, Mr. P. Bhartiya, the current NTPC/CenPEEP Manager, Mr. A.K. Mittal of CenPEEP, Dr. Krishnan (Leonardo Technologies Inc.), and Mr. Scott Smouse of NETL, the current U.S. GEP Manager, have participated in GEP activities since the project began.
3. The program had a management structure, including a management committee consisting of top management from key stakeholders and advisory boards that encouraged cooperation, free flow of information and a convergence on activities.

Validation of responsiveness to the needs of the GOI can also be seen in the overwhelming adoption of GEP interventions and the replication in all NTPC coal-fired power plants and at some SEBs.

[10] Conventional coal-fired power plants, which boil water to generate steam that activates a turbine, have efficiency of about 32 percent. Supercritical (SC) and ultra-supercritical (USC) power plants operate at temperatures and pressures above the critical point of water, i.e. above the temperature and pressure at which the liquid and gas phases of water coexist in equilibrium, at which point there is no difference between water gas and liquid water. This results in higher efficiencies – above 45 percent. SC and USC power plants require less coal per megawatt-hour, leading to lower emissions (including carbon dioxide and mercury), higher efficiency and lower fuel costs per megawatt.

[11] Power is dispatched (sold into the market) based on the cost of its production.

5.3 OUTCOME AND IMPACT

Before addressing the outcome and impact of GEP, the evaluators note that a high level of activity with respect to training, workshops, demonstrations, and visits by U.S. technical advisors was maintained over the life of the program. Selected activities are summarized in Table 3.

Table 3: Selected GEP Activities, 1995-2011

Activity	Quantity
Assistance from US Experts	50 people/1,125 person days
Workshops Held	150
Training Days	15000
Demonstrations	355
SEBs Assisted	14

5.3.1 GHG Emissions (metric tons of CO_2) Reduced or Avoided

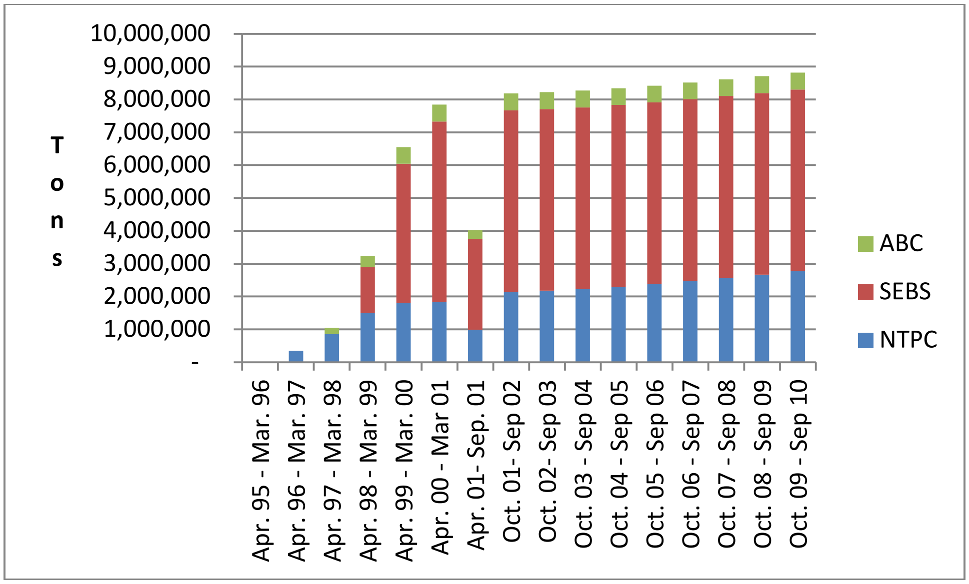
The GEP program has had a highly significant impact on NTPC's culture, operations, profitability, and GHG emissions. There are two principal ways of measuring the impact. The first is through standard financial accounting that looks at changes from one year to the next. NTPC, like any other company, conducts such annual exercises. Thus, any efficiency gains made in one year form the baseline for measuring the next year's performance. This is standard practice. For example, NTPC's annual report for the year 2009–2010 indicated that energy efficiency measures had saved the company 89.5 million rupees, or 72,747 tons of coal, at coal-fired power plants. The second method is to measure the performance without the project against the performance with the project. This latter method is most appropriate to the evaluation, but both methods are used in this report.

Approach to Validating Avoided GHG Emissions

The evaluation team was tasked with validating avoided GHG emissions reported by GEP partners. It relied on reports and written communications to conduct this exercise as well as discussions with partners on their methods of calculating avoided GHG emissions. In cases where the assumptions underlying the reported data were unclear and could not be verified by documentation or verbal communication, the evaluators chose the most conservative interpretation of the data. Full details of the approach and methodology used to validate avoided GHG emissions are presented in Appendix D.

The program has had a significant impact on both direct emission reductions and indirect emission reductions. Total direct emission reductions as of September 2010 are estimated to be 99.1 tons of CO_2[12], with the SEBS contributing 63.7 million tons, NTPC contributing 29 million tons, and ABC with 6.4 million tons (see Figure 4 below).

Figure 4: GEP Direct GHG Reductions



At NTPC and the SEBs, these reductions came from instituting low-cost measures, such as mill optimization, combustion optimization, and condenser cleaning and leak detection at coal-fired generating plants, totalling 27,535 MW at NTPC, 3,180 MW at MSEB, and 1,630 MW at Uttar Pradesh's (UP) Anpara power plant. Many of the GEP contributions were taken up by NTPC at their gas-fired plants as well, but no attempt has been made to estimate the accompanying reductions in GHG emissions at these plants. The ABC component was designed to increase the export of power from sugar mills using bagasse. Thus, it potentially offset not only cost, but the contribution of other generation technologies as well.

Indirectly, GEP contributed to potentially millions more tons of emission reductions, since CenPEEP and GEP provided direct assistance to SEBs through the PIE program and through GEP's impact on equipment manufacturing, design standards and lending practices (more details provided under Success Stories, Appendix F). Emission reductions have been documented in MSEB and Anpara that establish significant impacts in SEBs. Although quantification has not been done in other SEBs, the impacts are substantial.

5.3.2 Additional Benefits

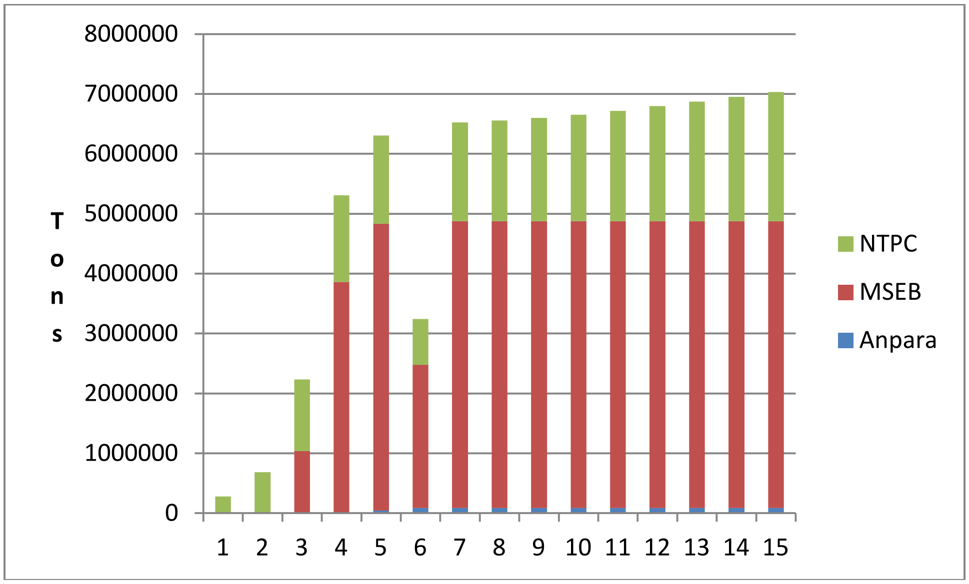
Beyond the achievements of GEP in reducing CO_2 emissions, it has achieved additional beneficial outcomes.

[12] Power plants at the SEBs are, on average, much less efficient than those at the NTPC.

Coal Savings

Most of the measures adopted through GEP lower GHGs because they lower coal consumption per kWh. This coal saving can be seen in Figure 5 below. Almost 23 million tons of coal have been saved through GEP-supported activities at NTPC from 1996-2010. To put this in perspective, NTPC consumed almost 131 million tons of coal in 2009. The coal savings for MSEB and UP totalled 56 million tons.

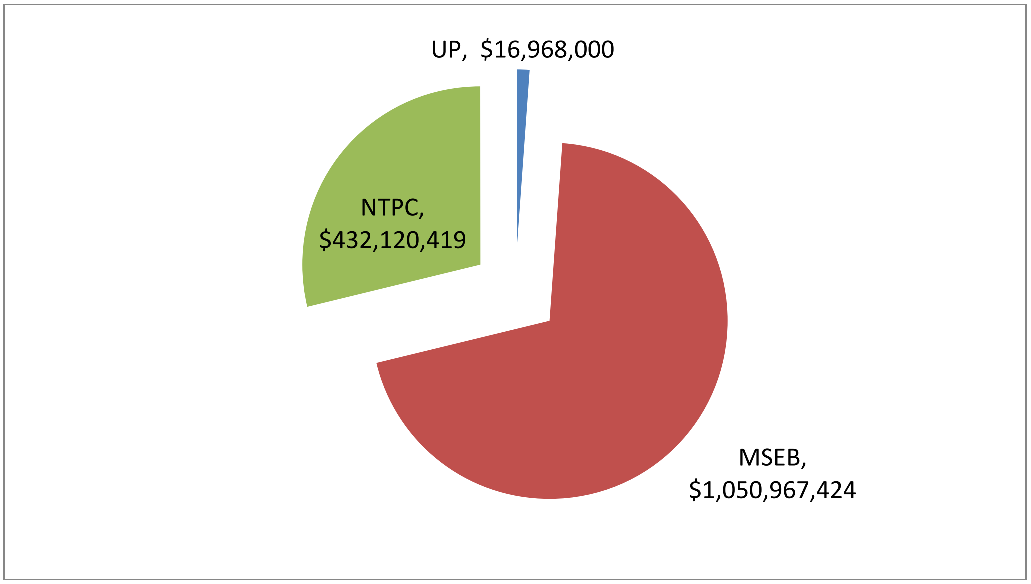
Figure 5: Annual Coal Saved over Baseline



Actual coal prices by year were not available at the time of this study, but based on the reported savings from energy efficiency measures from 2001-2010, the imputed nominal coal price is almost Rs. 800 per ton. This translates into a savings of almost $1.5 billion over the life of GEP from coal that did not have to be purchased, as can be seen in Figure 6. Clearly, GEP has had an important impact on fuel costs. These savings are equivalent to the capital costs of building over 1000 MW of new coal-fired generating capacity.[13]

[13] Project Appraisal Document on a Proposed Loan in the Amount of US$180 Million and a Proposed Grant from the Global Environment Facility Trust Fund in the Amount of US$45.4 Million to The Republic of India for a Coal Fired Generation Rehabilitation Project, World Bank Report No: 43378-IN, May 22, 2009. New power plant cost cited as Rs. 45 million/MW or approximately $1000/kW.

Figure 6: Cumulative Saving in Coal Costs



Air Quality

Efficiency gains that can be attributed to GEP at NTPC or SEB plants mean that less coal was burned per kWh of electricity generation and, therefore, fewer emissions of suspended particulate matter (flyash) were generated. This fact, combined with better performance of electrostatic precipitators (ESPs) and cleaner emissions at certain facilities, would have led to improvements in ambient air quality around these plants. However, the evaluation team could not access hard data about air quality, and therefore, makes no definitive findings in this respect.

Economic Benefits

The Confederation of Indian Industry – Green Building Council (CII-GBC) has been funded through GEP to address the shortage of qualified service providers in India that can meet the needs of coal-based power plants. CII has endeavoured to stimulate the growth of a 'Service Providers Network' in recent years in India, a concept kicked off by convening the Service Providers Network Conference in 2008 in New Delhi. Another conference was held in April 2010 in Hyderabad. These and other efforts have led to some significant business outcomes for a few U.S. service providers (e.g. condenser cleaning equipment and services for Conco, Inc.) and some initial contracts for Stephen Storm, Inc. for plant optimization tools and services and for SAS Global for coal pulveriser component upgrades.

Success Stories

GEP led to numerous success stories, several of which are summarized below (More details, along with other success stories, can be found in Appendix F).

- *Partnership in Excellence (PIE) Program:* PIE placed NTPC staff on long-term assignment at 26 coal-fired power stations of SEBs that had low capacity and low thermal efficiency. By significantly improving generation, efficiency and overall performance at most of the stations, GHGs emissions were reduced and additional capacity estimated to equal 835 MW was realized. The program ended in 2008.

- *SMART 24 X 7 System:* This fleet-wide monitoring system connects units at all NTPC generating stations, allowing more than fifty typical boiler and turbine efficiency parameters to be monitored centrally from headquarters. The system enables corporate office operators to detect problems in units much earlier than the plant operators themselves and apply timely remedies. In this way, the system contributes to running all units on optimum efficiency.

- *Heat Rate Improvement Guidelines:* In 2000, India's Ministry of Power released "Guidelines for Heat Rate Improvement," for implementation in Indian coal-fired power plants, prepared jointly by NETL, Tennessee Valley Authority (TVA), the Electric Power Research Institute (EPRI), and CenPEEP. The guidelines were based on U.S. utility practices and demonstrations in India through GEP, and provided gap analysis methods and tools, test procedures, and calculation methodologies from the United States.

- *Major Awards:* CenPEEP's contributions to improving efficiency in India's coal-fired power sector have been recognized by the Climate Technology Award in 2002, by the USEPA Climate Protection Award in 2003, by the India Power Awards in 2008, and by the BIS Star Quality Award in 2009.

5.3.3 Climate Change Supplement

The evaluation team examined the Climate Change Supplement (CCS) to the ECC component of GEP, principally with respect to its efficient power generation activities. The evaluators found that these CCS activities strengthened and complemented the overall ECC achievements. Some of the activities outside of efficient power generation appear not to have undergone the same level of cost-benefit analysis that was applied in ECC, and therefore, there was less uptake and application of certain technologies when compared to ECC overall. For example, in the distributed generation task component, NETL supported the demonstration of a U.S. microturbine to generate electricity using biogas in a dairy farm in West Bengal. Microturbine technology is not economical in comparison to grid-supplied power or other distributed generation options, such as diesel engines. According to NETL, the objective of this task was to introduce U.S. microturbine technology to India and to advance the technology such that it could operate off grid using low-quality biogas to meet future markets should technology costs become competitive through improvements and/or local manufacture. The microturbines were modified and continue to reliably operate as of the date of this report. Modest GHG reductions are being achieved by avoiding GHG-intensive methane emissions from the dairy farm. While the technology has been proven, its cost is still too high to penetrate the Indian market.

5.4 SUSTAINABILITY

5.4.1 Establishment by Indian Partners of Performance Monitoring Systems

Almost all GEP activities were directed at outcomes that were measurable, the most obvious example being avoided GHG emissions. The CenPEEP operating slogan is, "What cannot be measured cannot be saved," and GEP, together with CenPEEP, put in place the systems to make its work replicable and sustainable. Finally, because the systems, practices, and technologies have been embraced and results demonstrated, the measures of those are now part of plant-level performance monitoring. CenPEEP introduced the use of the PIE server to provide data on the operation of critical plant subsystems and to translate that into economic data.

Plants monitor the data independently of CenPEEP. Results are quantitatively measurable. There are numerous, key-efficiency parameters that are monitored in real time at the plant. The plant manager begins each day with a review of the previous day's operating performance. First and foremost for review are the efficiency measures. Control room operators monitor efficiency of subsystems and this monitoring is also conducted on an economic basis. Opportunities are sought to improve financial performance and are passed on from one shift to the next. Data are collected at the plant by automated systems that are regularly tested and calibrated, and routine monitoring takes place at the plant, regional and headquarters level.

Additionally, NTPC has installed the SMART 24X7 system for early detection of plant problems, monitoring sixty-five subsystems at its plants. These data are available in the control room. It is also monitored by NTPC HQ so that problems can be detected before they otherwise would be by standard plant control-room systems and advance action can be taken. The system is still being rolled out and is expected to be available shortly at all NTPC plants.

5.4.2 Sustainability of New Institutional Capacity

There is significant evidence that new institutional capacity of the major Indian partner will be sustained. As noted above, within NTPC, adoption of systems, practices and technologies has been followed by plant-level performance monitoring. Plants monitor data independently of CenPEEP. In interviews with CenPEEP and NTPC representatives, the commitment to maintain CenPEEP, even should U.S. support cease, was expressed by at least eight individuals. One NTPC representative stated "We would keep CenPEEP alive. USAID funding [for CenPEEP] is now negligible for NTPC." New knowledge gained through GEP has been institutionalized through the training program offered by NTPC's Power Management Institute (PMI).

New capacities have also been achieved by operational and managerial staff at the SEBs where GEP has intervened. By training SEB personnel in many areas, the capacity of certain facilities has been strengthened. Nonetheless, sustainability and replication of practices within SEBs remains a question mark. The evaluation team was constrained by time in delving too deeply into obstacles to sustainability of capacity at SEBs, but one factor is the lack of significant change in organizational culture regarding efficiency at SEBs. Some changes in attitudes to efficiency have occurred within SEBs, but only at the level of individual plants, not at the senior management or head office level, with the exception possibly of MSEB. Other factors blocking organizational change at SEBs include political and economic pressures facing most SEBs.

5.5 PROCESS FINDINGS

5.5.1 Effectiveness of Management

Overall, the evaluation team found effective program management by USAID. This effectiveness was demonstrated in the selection of a committed and technically competent participating agency in NETL/DOE and a strong local partner in NTPC on the ECC component. The start-up and early phases of GEP were greatly assisted by the presence of an in-country NETL advisor for four years.

A GEP governance structure was established composed of an advisory board and executive committee. These governance bodies included representatives from USAID and USDOE, India's Ministry of Power, as well as stakeholders such as NTPC, Confederation of Indian Industry, private sector firms, and others.

The fifteen-year program continuously innovated and added new components under the guidance of USAID and exercised reasonable oversight of GEP. USAID's program officer also played an effective role as a conduit between NETL and NTPC.

Despite normal officer turnover at USAID, program management was aided by the continuity of many key individuals at both NETL and CenPEEP over the life of the program.

Finally, the evaluators note that USAID acted upon all the recommendations contained in the 2008 audit by the Office of Inspector General.

5.5.2 Performance Management and Reporting

USAID was less effective in GEP in the areas of performance management and reporting. No logical framework was ever developed for GEP (as noted in "Project Description, Program Logical Framework"). Apart from a lack of conformity with ADS Chapter 201 (Planning) or with ADS 203 (Assessing and Learning), not having a logical framework makes the work of day-to-day program management more difficult for USAID officers. It also means there have been missed opportunities to capture and communicate results and lessons, and to make course corrections, should they have been needed. Avoided CO_2 emissions were essentially the only outcome indicator being measured and monitored during the life of the GEP. While success in achieving results against this indicator is a good story, it misses the story on other major project achievements, such as changes in organizational culture within the principal Indian partner. Although some of these aspects were captured in papers and presentations given by CenPEEP and NETL, they do not appear in program reports.

A related aspect of management is the quality of reporting. USAID did not require NETL to submit annual reports or work plans, and only intermittently required monthly reports throughout GEP, depending on the management style of the USAID GEP project manager. These monthly reports generally were activity reports and provided no information on progress toward higher-level outcomes. The absence of annual reports means that little has been documented regarding the challenges that undoubtedly faced the implementation partner or Indian partners over the life of the GEP and how these were overcome, and thus represents a loss of potential, key lessons learned.

Finally, the evaluation team notes that this final evaluation is the only evaluation that has been carried out in the life of a project spanning more than fifteen years. Again, this practice has not been consistent with ADS guidelines, but, equally importantly, has missed opportunities to document achievements and lessons and to formally document adjustments in the program that were agreed upon through discussions between USAID GEP staff and NETL GEP managers.

Coordination with GOI and stakeholders

The governance structure established by GEP supported effective communication with the GOI. Newsletters published by CenPEEP and CII, and others served to keep the GOI and stakeholders in the information loop.

5.6 GENDER INTEGRATION

Gender integration was not an objective of GEP, and therefore, no indicators were established and no data was tracked on this issue during the life of the project. However, the issue was introduced in the SOW for the evaluation. The evaluators gathered some data from key informant interviews and a limited review of literature with a view to informing future initiatives in cleaner coal.

Indian partner organizations involved in GEP recognize the heavy gender imbalance (weighted roughly eighty percent male to twenty percent female) in their staff of professional engineers and managers. They note that the Indian power sector traditionally has been a male-dominated sector. On the positive side, these organizations say the trend is moving toward redressing imbalances, as their intake of new staff members contains a higher percentage of females (although still outweighed by males). These organizations appear willing to pursue gender integration in future initiatives, if only at the level of women’s participation.

U.S. implementing organizations demonstrate good awareness of the potential for gender integration in the clean coal sector through encouragement of women's professional involvement and other measures. Finally, the evaluation team notes that USAID has previous experience and analytical resources for gender integration in India's energy sector.[14]

6.0 LESSONS

1. Significant gains in reducing GHGs, lowering costs, and increasing reliability and availability can be had through low-cost measures in existing Indian coal-fired power plants.

Table 4 below presents the key performance measures for the GEP-ECC, for which USAID and NTPC[15] funding totaled $39.4 million dollars over the life of this program.

Table 4: Key ECC Component Results[16]

	Tons	Cost or Value ($)
GHG emission reductions	92,728,413	0.43
Coal saved	78,752,932	$1.5 billion

In turn, this funding contributed to generating savings of $1.5 billion to date in coal costs alone. In simple terms, this means that program costs were paid back in less than nine months.

Additional benefits are increased revenues from greater availability, increased sales due to lower costs (higher efficiency), increased revenues from lower auxiliary power, and increased productivity and reduced costs due to shortened times for overhauling coal-power plant equipment and components. At the individual intervention level, the measures instituted through GEP-ECC were for the most part low-cost measures as described throughout this report. Many of these were so-called housekeeping measures and their low cost is verified by the fact that SEB plants that have been introduced to the project's interventions by NTPC staff have adopted many of the measures at the plant level and without investment support from headquarters.

2. The constraints on improved environmental and operational performance are not technical in nature, but rather are institutional. Thus, to be effective and sustainable, the culture of organizations must change, which requires commitment at the top to champion change alongside efforts at the bottom to demonstrate how the change will impact operations and how it is to be developed.

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[14] For example, the evaluation report of the Distribution Reform, Upgrade and Management (DRUM) Project includes an extensive gender assessment of the energy-service needs of women and men.

[15] Includes cost of CenPEEP, pilot projects, equipment, etc., but excludes the salaries of regular NTPC staff that worked with the project at their plants.

[16] Tons of coal saved comes directly from NTPC and the SEBs' efficiency monitoring reports and communications that form the basis for the GHG emission calculations. The cost of coal is based on average prices or Rs. 800 per ton.

The power plant level interventions that GEP funded were not cutting edge technologies but were tested, proven and widely used measures in the United State, for the most part. At first, NTPC personnel had to be convinced that such low-cost measures would work, because India and Indian coal are different than the United State and the coal burned in U.S. plants. This is precisely why Dadri was chosen. It was a newer plant, was very efficient by Indian standards, and situated close to the NTPC senior management. However, years of operating procedures and management culture had to be reversed and new lessons learned. Prior to GEP, the focus had been exclusively on PLF – generation of electricity without consideration for cost and the belief that greater efficiency could only be had at the expense of PLF. Again, Dadri proved that this was not the case. Finally, because *efficiency isn't something you do once, it's an all the time thing*, systems had to be put in place that necessitated routine testing, monitoring, and corrective measures.

The entire culture of performance had to be changed and it was. Now, plant staff routinely monitors the efficiency of subsystems and what any given level of efficiency is costing or rewarding the plant in real-time revenues. CenPEEP states this best in its routine presentations about their approach to optimization:

- "Predictive maintenance is an attitude and not a technology
- Technology are only tools and fascinating – it is systematic implementation which brings magical results
- Technology is only 30% of the issue, rest is communication"[17]

3. Training and demonstration projects/practices will only be widely replicated and sustained if systems related to the new practices are put in place concurrently.

These systems are required to demonstrate and document the efficiency gains and impact on PLF and this proof of impact is required to get management buy-in. Furthermore, the systems are required to help change the established habits of years of sacrificing plant performance and cost for PLF. Again, CenPEEP states this best in its presentations on its approach to optimization:

- "What cannot be measured, cannot be saved
- What is convenient will only sustain
- Sustainability through Systems and Procedures
- ***Institutionalization essential for sustainability***
    - Local capability building
    - Widespread dissemination and training
    - Systems' to sustain the improvements"[18]

While CenPEEP and NTPC have been providing assistance to the SEBs, the observation of the evaluation team is that sustained improvement and replication have only been demonstrated in those SEBs where the systems are in place, where there is commitment from top management and where there is widespread dissemination and training. MSEB is beginning to be such a SEB.

[17] CenPEEP. Presentation to GEP Evaluation Team, Noida, India. P. 13. August 2011.
[18].Ibid, p. 11

4. There were significant advantages in working with a neutral body such as USDOE in the early years of the GEP project.

The team has observed and been told directly by CenPEEP, NTPC, and others that working with a neutral organization had many advantages in a project like GEP.

- First, USDOE did not represent any specific technology, process or practice. Through its many initiatives it works with the vast majority of U.S. manufacturers, utilities, service providers, and researchers. In this way, it is able to choose the best or even competing technologies or practices to test and then demonstrate. This advantage was cited as critical by key informants at NTPC head office, CenPEEP, and NTPC plants.
- Second, in India the vast majority of power is still dominated by the government and the respect and access given to government personnel of a foreign donor is generally greater than that accorded the private sector. This allowed GEP a shorter time to gain respect and trust than might otherwise have been the case.
- Third, the convening power of the USDOE is significant in the electric power business. It has been able to convince U.S. utilities, manufacturers, and service providers to donate time and resources to the GEP project.
- Fourth, with CenPEEP being set up to model a research/think tank, USDOE/NETL has provided a good model for how CenPEEP can move forward, drawing on universities, manufacturers and the private sector. In essence, it has served as a role model.

5. A large part of the GEP's success has been the continuity of staff at USAID, NETL, and CenPEEP and their dedication even after their assignments have ended. The contributions of Electric Power Research Institute (EPRI), Tennessee Valley Authority (TVA), and other U.S. companies and individuals that spent months and years in India during the early days of GEP and the continuing support of U.S. utilities such as American Electric Power (AEP) has helped sustain CenPEEP and the GEP.

7.0 CONCLUSIONS

1. *The prominence of coal in India's energy mix has risen since GEP began and will continue to be the primary fuel source for electric power for the foreseeable future.*

Under any scenario, including India's Low Carbon Emissions Strategy, "coal-fired generation plants are likely to continue to dominate energy supply to the grid despite best efforts to increase the share of less carbon-intensive sources of power. This is a consequence of the lack of significant alternative natural resources in India, lack of availability of clean technologies, such as solar, at affordable prices, problems associated with the implementation of planned investment programs, and the abundance of (global and domestic) coal and its relative cost advantage. ”[19]

2. *The marginal abatement cost curve (a set of options available to an economy to reduce pollution) for India’s power sector[20] clearly indicates that improvement at current power plants, a negative net cost, and at future ultra/supercritical coal plants are lowest-cost options for reducing GHG emissions. This cost-curve result supports the finding on GEP’s cost effectiveness and justifies continued work in the sector.*

Table 5: Power Sector Carbon Abatement Costs

Technology Mitigation	Cost ($/ tonne)
Renovation and modernization, including efficiency	-ve*
Coal ultra/supercritical	17.4
Small hydro	29.1
IGCC based on Imported Coal	45
H-frame CCGT	45.4
IGCC based on Indigenous Coal	53.9
Biomass gasifier	60
Wind turbine	63.2

* - Indicates a net positive benefit for this activity

Source: Supporting Low-Carbon Growth Opportunities in Developing Countries, Presentation at the UN Conference on Climate Change and Official Statistics Oslo (Norway) 14-16 April 2008, World Bank.

3. *A large degree of GEP’s success in sustainability can be attributed to the creation, evolution, and institutionalization of CenPEEP. Given the uncertain sustainability of the approach taken in GEP at the level of SEBs, there may be greater likelihood of success if a CenPEEP model is pursued at SEBs, or some hybrid of CenPEEP and the approach taken at the MSEB, which established an efficiency unit.*

4. *Stronger performance management and reporting in programs like GEP would not only comply with USAID directives, but would better allow USAID and external evaluators to monitor and evaluate project performance, capture and communicate successes and lessons, and make corrections to project interventions, as necessary.*

[19] India: Options for Low-Carbon Development, World Bank, 2009.

[20] Supporting Low-Carbon Growth Opportunities in Developing Countries, Presentation at the UN Conference on Climate Change and Official Statistics Oslo (Norway) 14-16 April 2008, World Bank.

8.0 RECOMMENDATIONS

The evaluation team recommends that:

1. Given that coal will remain India's dominant source of power, USAID continue to work with coal-fired power utilities because the environmental and development impacts of USAID's efforts in this sector are proven to be significant and cost-effective.

2. Depending upon the resources available:
    a. USAID collaborate with CenPEEP in working with traditional, coal-fired power plants to reach a broader audience in state plants, and create a central efficiency structure inspired by the CenPEEP model within selected SEBs; this structure could take the form of a model power plant to be used to demonstrate the project interventions; *or*
    b. USAID invest in building a CenPEEP-like group to focus on the efficiency aspects of supercritical plants at the Sipat power plant, making it a model for efficiency and ensuring that US experience in supercritical coal-fired plants is rapidly adapted and adopted in India; *or*
    c. USAID pursue both options.

3. In future programming, USAID should ensure development of performance management plans as well as monitoring and evaluation plan.

APPENDICES

APPENDIX A. SCOPE OF WORK

USAID/INDIA
GREENHOUSE GAS POLLUTION PREVENTION PROJECT (GEP)
FINAL EVALUATION
DELIVERY ORDER STATEMENT OF WORK

I. Purpose and Objective of the evaluation

USAID/India intends to carry out an evaluation of the GEP program. It is one of the longest running environment programs of the Mission implemented in close partnership with the country's biggest power producer, National Thermal Power Corporation (NTPC) Limited. The evaluation will focus on the efficiency improvement activities of Indian power utilities as well as the bagasse co-generation activities. The few environmental activities that were added to the scope subsequently (such as fly ash resistivity, fly ash disposal, alternate vehicles, etc.) should be broadly covered but not be dwelled upon in too much detail in the interest of time. USAID envisions one comprehensive report that covers both the components of the program.

The objectives of the review are:

- Determine the impact and achievements of the program relative to the overall objective of the program and the specific objectives of the two components.
- Validate the results of greenhouse gases (carbon dioxide) avoided from the inception of the program till September 2009 (ECC component). Document the savings in carbon dioxide reduced/avoided from the ABC component. Also note associated co-benefits from GEP in terms of improved local air quality and reductions in other pollutants.
- Determine the relevance of the project in present context.
- Document the challenges faced in implementation and the lessons learned.
- Make suitable recommendations for the future direction of projects related to cleaner coal.

The primary audience for this assessment is USAID/India's Clean Energy & Environment Office and Front Office.

II. BACKGROUND

i) Program Objective

The primary goal of the Greenhouse Gas Pollution Prevention Project (GEP) is to increase environmental protection in the energy sector. *Its original objective is to reduce the volume of emissions of greenhouse gases (GHGs) per energy unit generated while increasing energy productivity and encouraging biomass fuel use in selected utilities and sugar industries.* Subsequently, the scope of the project was broadened in 1999 to include activities related to sustainable development and climate change. *The objective was* *broadened to "increased environmental protection in energy, industry and cities".*

The outputs from the project are expected to include:

- Demonstration and use of advanced efficient generation techniques for sugar cogeneration.
- Demonstration of advanced efficient generation techniques for coal-fired power plants.

ii. GEP Overview

The two components of the program aimed at increasing awareness, available information, and practical examples of the applicability of the state-of-the-art pollution prevention, efficient coal conversion and combustion, and industrial cogeneration technologies in Indian setting. The details are as follows:

- **Efficient Coal Conversion (ECC):** The objective of this component is to reduce the amount of CO_2 produced per kilowatt hour of electricity generated by coal conversion. The project aimed to support the development of an institution promoting efficient management of coal-fired power plants and facilitating the commercialization of advanced coal conversion technologies for sharing the benefits with Indian utilities. The role of the institution was to study means of burning coal more efficiently, promote electricity generation efficiency improvement and environmental protection by supporting other Indian utilities in the efficient delivery of thermal power at the least cost.

- **Alternative Bagasse Cogeneration (ABC):** The objective of this component was to promote the commercialization of high-efficiency cogeneration in sugar mills utilizing bagasse. It aimed to work closely with and be complementary to the Government of India (GOI) bagasse-based cogeneration plants. It also provided technical assistance to catalyze, stimulate and sustain private sector investments in sugar mills using alternate bagasse/biomass cogeneration technologies in India. The ABC component worked closely with the Government of India (GOI) National Bagasse Based Cogeneration Program and with the sugar industry to provide information, technical assistance and training on all the feasible options. The project covered the incremental costs associated with the initial adoption of the technologies by bagasse cogeneration systems. USAID/lndia worked with financial institutions, such as the Industrial Development Bank of India (IDBI) and with the private sector throughout the life of the project.

iii). Project Implementation

Partner:	National Thermal Power Corporation (NTPC)
Implemented by:	National Energy Technical Limited (NETL), United States Department of Energy (USDOE)
Type of instrument:	PASA with NETL/USDOE
PACD:	September 30, 2011

Launched in 1995, GEP is a long running program of USAID/India with the Government of India. It consists of two key components that were briefly described above (ECC and ABC). Initially the ECC component focused on efficient coal conversion but in 1999, few activities were added to the scope that would increase awareness, practical examples and available information of actions that fulfill sustainable development as well as simultaneously benefit the global climate.

The evaluation will focus on evaluating the two main components of GEP program. A brief detail of the activities undertaken under the two components are presented below:

1. Efficient Coal Conversion (ECC)

The work under ECC component (efficient power generation) was envisaged as a tool to combat climate change via promotion of advanced power generation technologies and efficient management systems through the continued emphasis on optimizing operations at existing power plants and widespread dissemination of high priority options for efficient power generation.

In 1999, some new activities under the Climate Change Supplement (CCS) were added to supplement the activities carried out under GEP-ECC. In addition to continuing the work on efficient power generation, two new elements were added. This included:

- Fostering climate friendly initiatives primarily through institutional development, capacity building, public outreach and enhanced stakeholder participation, and
- Linking urban development and climate change via the design and demonstration of climate change abatement initiatives in cities primarily in the areas of transportation, and solid waste management.

The program focused on providing technical assistance and training to the Indian utilities for improving their heat rate. It introduced best technologies through demonstration of selected advanced efficient coal conversion technologies and state-of-the-art monitoring and maintenance practices in selected utilities in the country. In addition, training of power plant managers and engineers in clean and cost-saving energy practices was an important component of the program.

As a part of the program, an institution, Center for Power Efficiency & Environmental Protection (CenPEEP), was established in partnership with NTPC Limited as a knowledge think tank for the Indian power sector. The program also provided technical assistance and training to other coal-based power plants of State Electricity Boards (SEB) through CenPEEP, which resulted in a significant reduction of emissions and savings of millions of dollars in coal costs.

Some other key activities undertaken as a part of the program are listed as follows:

- Conducted a detailed feasibility study on the application of IGCC power generation technology operating on high ash Indian coals.
- Commissioning and operation of India's first 1.5 million tons per annum non-coking coal washery at Bilaspur, Madhya Pradesh.

- Conducted detailed assessments and implementation of heat rate improvement measures and technologies in three state coal fired utilities in West Bengal, Punjab and Tamil Nadu supported under the Asia Pacific Partnership program on Clean Development and Climate.
- Publication of operational guidelines for the operation and maintenance of power plants.
- Organized International Conference on Service Provider's Network in 2008 and 2011 to encourage business deals.
- Feasibility study on SMART 24x7 systems at NTPC.

The various activities undertaken under this component of the program have led to significant CO_2 avoidance. From April 1996 to September 2009, 110 million tons of CO_2 emissions have been avoided. This translates to removing one million cars every year over a period of 13 years.

2. Alternative Bagasse Cogeneration Component (ABC)
This component focused on promoting the commercialization of high-efficiency cogeneration in sugar mills utilizing bagasse. It was also designed to encourage the use of supplemental biomass fuels when bagasse was not available.

Industrial Development Bank of India (IDBI) managed the project's investment related activities. NETL provided technical assistance for training, outreach, and performance evaluation through Winrock International India (WII) and SAIC (subcontractor). The Indian sugar mills provided the majority of the funding and installed cogeneration units at their respective facilities. The partners worked together to overcome barriers in implementing projects and power purchase agreements. In doing so, they set a precedent by demonstrating both high efficiency and long-term (270 days) cogeneration operation using biomass fuels in India.

Two study tours to the United States and Mauritius were organized for personnel from Indian sugar mills to exchange information on high-efficiency cogeneration. Several training programs and workshops were conducted. In collaboration with the World Alliance for Decentralized Energy (WADE) and the Cogeneration Association of India, WII conducted the 3rd International Combined Heat & Power (CHP) and Decentralized Energy Symposium, and USAID International Conference and Exhibition on Bagasse Cogeneration on October 24-26, 2002, in New Delhi.

The total installed cogeneration capacity in these projects was approximately 200 MW to generate an estimated 500 million kWh of electricity valued at US$25 million, offsetting 550,000 metric tons of carbon dioxide emissions annually. USAID support to these private sugar industries through technical and financial demonstration of bagasse-based cogeneration ushered in the business practice of cogeneration of power in India's sugar sector.

Since the end of USAID assistance in 2003 for bagasse cogeneration, about 600 MW of power has been added to the Indian grid from new projects on a purely commercial basis, taking the installed capacity to nearly 800 MW against a potential of 5,000 MW. More bagasse cogeneration projects are being added by several sugar mills on commercial terms without external financial aid.

III. EVALUATION SCOPE

i) Statement of Work

This statement of work is for a performance evaluation, including an assessment of the appropriateness of the program, the level of impact, cost-effectiveness and future directions. The team will gather both qualitative and quantitative data based on the following specific objectives.

1. IMPACT:

- Assess the performance of the implementation partner (NETL) and key sub-contractors (LTI, KeyLogic, USEA and CII) in executing their respective scopes of work for the project. Were they able to meet their responsibilities under their contracts or agreements? Did they coordinate and collaborate well with each other and with the host government and stakeholders at all levels?
- Assess the overall impact of the program, including the extent to which the program has contributed to achieving the assistance objective and has achieved the objectives of the two components.
- Assess the value of savings from the program in terms of coal saved and carbon dioxide savings from both the components (ECC and ABC). Note any co-benefits from GEP such as improved local air quality and reductions in other pollutants.
- Capture any success stories and lessons learned from GEP that can be shared and communicated.

2. RELEVANCE:

- Assess whether the GEP programs were able to respond to the needs of the Government of India (GOI).

3. EFFECTIVENESS:

- Appraise the extent to which NTPC was satisfied with the technical assistance provided by US partners intended to develop capacity within CenPEEP.
- Assess the effectiveness of CenPEEP as a knowledge think tank for the Indian power sector and its effectiveness in catering to NTPC as well as other utilities.
- Provide an assessment of the cost-effectiveness of the program in meeting its objectives. What has been the return on USAID’s investment?
- Assess whether the outputs from technical assistance, training and other activities been utilized by the targeted beneficiaries. For instance, have the practices and results from GEP have been institutionalized by NTPC in its operations?

4. SUSTAINABILITY:

- Assess the sustainability of CenPEEP as well as the program in terms of creating institutional capacity within the country.
- Investigate whether systems have been established internally for tracking, monitoring, and reporting on results attributable to GEP activities and whether these systems utilize independently verifiable information. For example, does NTPC have a system for monitoring heat rate improvement?
- Provide recommendations for future program in cleaner coal in terms of its relevance in the present Indian energy context.
- Identify potential gender considerations in any future programming in cleaner coal in India.

ii) Methodology

The evaluators should consider a range of possible methods and approaches for collecting and analyzing the information which is required to assess the evaluation objectives. Data collection methodologies will be discussed with, and approved by, USAID/India prior to the start of the assignment.

1. Desk review of documents: USAID/India will provide the team with all relevant project specific documents such as proposals, reports, scope of works, etc. The evaluation team is expected to go through these as well as the official website of CenPEEP (NTPC) and collect other relevant documents, reports, and data. The evaluation team is expected to be aware of the background of the program before meeting the GOI partners. The Mission point of contact will provide the evaluation team with project reports, and other documents needed for conducting this desk review.

2. Team Planning Meeting: A team planning meeting will be held by the evaluation team in India before the evaluation begins. This will be facilitated by the team leader, and will provide the Mission with an opportunity to present the purpose, expectations and agenda of the assignment. The evaluators shall come prepared with a draft set of tools and guidelines and preliminary itinerary for the proposed evaluations. TPM will also provide an opportunity to the evaluators to explain the strategy that will be adopted for the evaluation to USAID /India. In addition, the TPM will also:

- Clarify team members' roles and responsibilities
- Establish the timeline, share experiences and thoughts on the evaluation methodology
- Interview questionnaire to be prepared in advance and finalized during the TPM
- Finalize the data collection tools and guidelines

3. **Site Visits and Interviews:** The evaluator will meet relevant implementation partners, GOI partners, and subcontractors.

- Interviewees will include following key members (see Annexure 1 for the contact details of key resources):
  - NETL (Scott Smouse, Program Manager), LTI (Dr Radha Krishnan), Key Logic

(Babatunde Fapuhunda)

  - Other U.S. based experts, consultants and sub-contractors associated with the program.
  - NTPC (Mr Deshpande) and CenPEEP officials (Mr Pankaj Bhartiya, MrBandhopadhyay and A K Mittal)
  - Other Indian based experts, consultants and partners associated with the program.

- Interview questions will be prepared in advance and finalized during the TPM
- Site visits will be planned based on the recommendation of the program COTR and partner's feedback. It will essentially comprise visit to CenPEEP, Dadri Power Plant, a power plant of NTPC, and Tuticorin Power Plant. The team should split into two groups to undertake these visits so as to maximize the time and efforts.
- As the program is being implemented under the PASA agreement with NETL, the implementation partners, key subcontractors and most of the resource people are based in the U.S. It is recommended to interview these resource people over phone and email in U.S.

4. Preparation of draft report and final report, with inputs from USAID/India: Based on the information collected, interviews and site visits, the evaluation team will prepare a draft report which will be finalized after soliciting feedback from USAID/India. On the completion of the site visits, and after meeting with the GOI counterparts and implementation partners, the evaluation team will present key findings to USAID during an exit briefing.

iii) Timeline

USAID/India anticipates that the period of performance of this review will be from August 2011 to September 2011, for about five weeks. The team should be comprised of three people and the recommended timeline is as follows.

- Two weeks in U.S. to read program documents, draft the evaluation work plan, interview implementation partners, subcontractors, and other resource people.
- One day of consultations in Delhi with USAID team;
- One week working in India which includes one week of travel within the country as well as meetings in Delhi (two groups visiting different areas and meeting different people).
- 1 ½ weeks for final consultations and drafting the report in Delhi, including giving a presentation to USAID on assessment findings, prior to finalization, and
- Two days to finalize the report.

This evaluation, including submission of the final report must be completed by September 30, 2011.

iv) Evaluation team composition, technical qualifications and experience requirements

All team members must have relevant prior experience in South Asia, and preferably in India; familiarity with USAID's objectives, approaches, and operations; and prior evaluation/assessment experience. In addition, individual team members should have the technical qualifications identified for their position below:

- **Senior Energy Analyst:** The Senior Analyst should have an excellent understanding of the energy sector, particularly of coal based thermal power generation. S/he should have significant experience of monitoring and evaluating energy programs throughout the world, in particular Asia. A minimum of 12 years of experience of working on design, management and evaluation of energy programs. S/he should possess a solid understanding of issues related to thermal coal based generation in India and its environmental implications. *(LOE up to 35 days).*

- **Evaluation Methods Specialist (Team Leader):** This expert will have deep knowledge of evaluation methodologies and their practical applications. S/he will serve as Team Leader and will be responsible for coordinating all evaluation activities and ensuring the production and completion of a quality report, in conformance with this scope of work. These reports will become public documents for distribution among the program's key stakeholders, including high-level U.S. government policy makers and officials, host country government officials, private sector and NGO leaders, and other audiences. S/He should have experience of handling evaluation programs of similar complexity. *(LOE up to 35 days).*

- **One expert on coal based power generation (Local):** In addition to the Team Leader and Evaluation Specialist, the contractor should propose an additional local power sector specialist with extensive knowledge of working in India, particularly with sub-critical coal based thermal plants. The expert should have relevant educational qualification and good understanding of the coal based generation. S/he should also have an extensive understanding of best practices in coal based power generation, advanced cleaner coal technologies and other environmental issues related to power generation. The expert should also have the experience of evaluating energy projects and working with the GOI as well as the private sector.

Summary Table: Labor

Labor Category	**Maximum LOE**
Evaluation Methods Specialist (Team Leader)	35
Senior Energy Analyst	35
Expert on coal based power generation (Local)	21

Note: Assuming 6 days in a work week.

In addition, each team member should have, at minimum, the following skills and experience:

1. An understanding of the country context.
2. Demonstrated skill in written and oral communication.
3. Demonstrated knowledge of USAID policies and procedures.
4. Ability to work effectively in, and communicate with, a diverse set of professionals.

v) Relationships and Responsibilities

- Contractor will be responsible for obtaining visas and country clearances for travel for consultants.

- Contractor will be responsible for coordinating and facilitating assessment-related field trips, interviews, and meetings in conjunction with the USAID/India and the implementation partners.
- Contractor will be responsible for submitting a budget for all estimated costs incurred in carrying out this review. The proposed cost may include, but not be limited to: (1) international and in-country travel; (2) lodging; (3) M&IE; (4) in-country transportation; and (5) other office supplies and logistical support services (i.e., laptop, communication costs, etc.) if needed.
- In-country logistics to include transportation, accommodations, communications, office support, etc.

v) Reports and Deliverables

- **Draft Work Plan and Pre-Departure Briefings**: The evaluation team will develop a draft work plan prior to departure from Washington, DC. The team will meet with Department of Energy and relevant USAID/India staff prior to initiating the field trip and meeting with key counterparts and partners in India.
- **Exit Briefing:** The evaluation team will provide an oral briefing of its findings and recommendations to the Clean Energy and Environment Office (CLEEO) Director and other relevant USAID/India staff at the conclusion of the visit.
- **Draft Report**: The evaluation team will present a draft report of its findings and recommendations to the CLEEO Office Director before return to the United States.
- **Final Report:** Ten paper copies of the final report as well as an electronic version in Word shall be submitted within five working days following receipt of comments from USAID and its implementing partners. Ten copies will be provided to USAID/India. The final report should include an executive summary of no more than three pages, a main report with conclusions and recommendations not to exceed 20 pages, a copy of this scope of work, evaluation questionnaires used to collect information on each of the program components, lists of persons and organizations contacted and minutes of the meeting with different stakeholders.

APPENDIX B. PERSONS CONTACTED

INDIA

USAID/India, American Embassy
Mr. S. Padmanaban, Director, SARI/E

ICF International
Sandeep Tandon, Head, Energy Efficiency & Climate Change

NTPC Ltd.
N. N. Mishra, Director of Operations
A. K. Jha, Regional Executive Director (North)

CenPEEP
G. J. Deshpande, Executive Director (OS)
Pankaj Bhartiya, General Manager
S. Bandhopadhyay, General Manager, CenPEEP, NTPC
A. K. Mittal, Addl General Manager, CenPEEP, NTPC Ltd.
A. K. Arora, Deputy General Manager, CenPEEP
Surendra Prasad, Deputy General Manager, CenPEEP
S. P. Karna
D. K. Dubey, General Manager
R. S. Yadava, Additional GM, CenPEEP, Regional Office Lucknow.

Godawari Power & Ispat Limited
B. N. Ojha, Former – Director of Operations, NTPC and Independent Director – Board of Directors

Confederation of Indian Industry (CII)
S. Raghupathy, Executive Director , Sohrabji Godrej Green Business Centre, Hyderabad
S. Kathikeyan, Counselor

Industrial and Technical Consultancy Organization of Tamil Nadu Ltd., Chennai
D. Vaidyanathan (Alternative Bagasse Cogeneration)

Indian Institute of Technology – Delhi
Dr. Avinash Chandra, Professor
Centre for Energy Studies

West Bengal Green Energy Development Corporation
S. P. Gon Chaudhuri, Managing Director

Synergy Renewable Energy
Amitabh Kumar Gupta, Managing Director

UNITED STATES

National Energy Technology Laboratory, US Department of Energy
Scott Smouse, Program Manager, GEP
Dr. Sai V. Gollakota, Project Manager

Leonardo Technologies, Inc.
Dr. Radha Krishnan

KeyLogic Systems, Inc.
Babatunde O. Fapohunda, Principal Engineer

P&RO Solutions
Patrick Abbott,Vice President, Sales & Marketing

Southern Company Mercury Research Center
Wim Marchant, Director (retired)

Stephen Storm, Inc.
Stephen K. Storm, C.E.M., Senior Consultant/Alliance Team Manager

United States Energy Association
John Hammond, Manager, Energy Partnership Program
Matthew Gebert, Senior Program Coordinator

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APPENDIX D. GHG CALCULATIONS

Greenhouse Gas Emission Reductions[21]

The GEP project contributed and continues to contribute to reduced GHG emissions ***directly*** in three principal ways:

1. First, the project increased efficiency at NTPC's coal-fired power plants. As discussed above, the application of no-cost and low-cost measures have been introduced and replicated throughout the system in a systematic and sustainable manner. This meant that more electricity could be produced per ton of coal and therefore that fewer GHGs were emitted per kilowatt hour.
2. Second, the project worked directly with selected SEB plants, introducing the same and similar methods as introduced at NTPC.
3. Third, the project worked with sugar mills and IDBI to introduce high- efficiency cogeneration technology and to demonstrate the business case by providing financing. GHG emissions were reduced or avoided through the substitution of bagasse for fossil fuels in the boilers and bagasse-cogenerated electricity for self (fossil fuel) or grid generated power and by making in some instances power available to the grid.

Indirectly, the project contributed to GHG emission reductions through:

- The increased use of fly ash in cement and asphalt production
- CenPEEP's outreach to SEBs outside of the project-funded activities, such as PIE
- The expansion of high-efficiency bagasse cogeneration at sugar mills that were not part of the project

Table 1 presents the annual avoided GHG emission directly attributable to the project.

[21] The sources for the data and/or emissions include the Draft Legacy Report, CenPEEP's internal efficiency reporting, communications from SEBs, and interviews.

Table 1: annual avoided or reduced GHG emission Year	NTPC[22]	SEBs[23]	Bagasse Cogen	TOTAL
Apr. '95–Mar. '96				
Apr. '96–Mar. '97	349,337			349,337
Apr. '97–Mar. '98	853,680		196,810	1,050,490
Apr. '98–Mar. '99	1,493,116	1,409,913	338,332	3,241,361
Apr. '99–Mar. '00	1,808,658	4,229,739	510,261	5,138,745
Apr. '00–Mar '01	1,840,222	5,490,430	510,261	3,611,174
Apr. '01–Sep. '01	992,298	2,766,048	255,131	1,935,327
Oct. '01–Sep '02	2,138,368	5,532,095	510,261	4,024,426
Oct. '02–Sep '03	2,178,368	5,532,095	510,261	4,064,426
Oct. '03–Sep '04	2,228,368	5,532,095	510,261	4,114,426
Oct. '04–Sep '05	2,298,368	5,532,095	510,261	4,235,423
Oct. '05–Sep '06	2,378,368	5,532,095	510,261	4,315,423
Oct. '06–Sep '07	2,473,368	5,532,095	510,261	4,410,423
Oct. '07–Sep '08	2,571,868	5,532,095	510,261	4,508,923
Oct. '08–Sep '09	2,667,061	5,532,095	510,261	4,604,116
Oct. '09–Sep '10	2,771,975	5,532,095	510,261	4,709,030
Total	**29,043,423**	**63,684,990**	**6,403,145**	**99,135,557**
Total Cost				**$32,000,000**
Cost per ton				**$0.32**

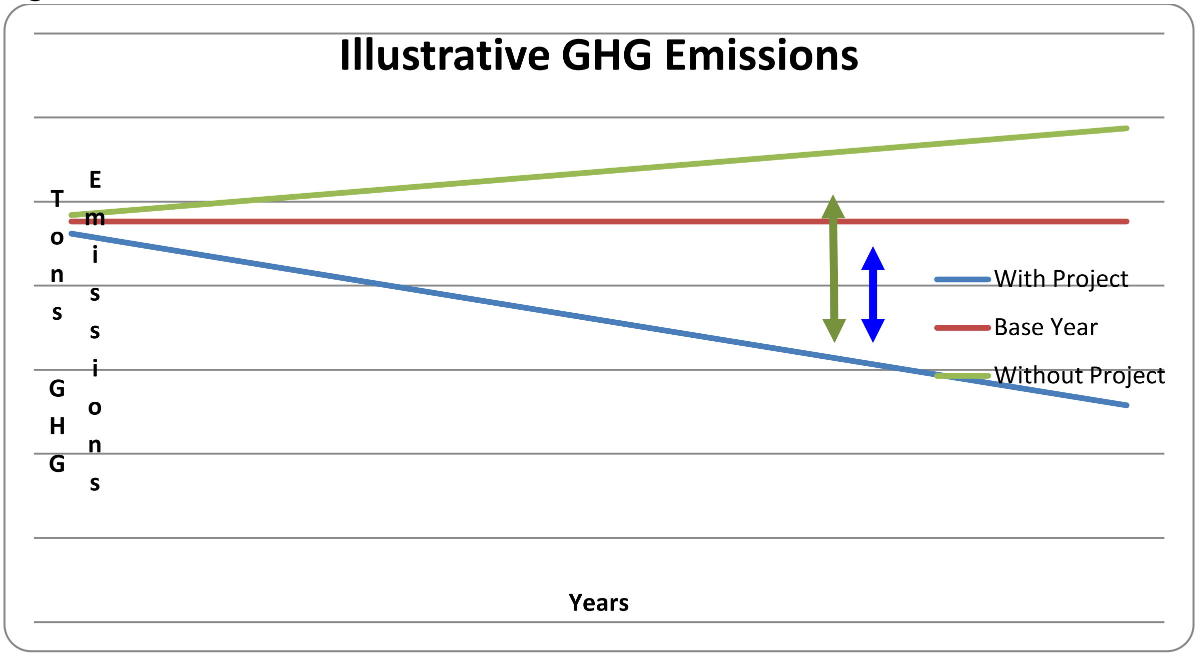
Calculation of GHG Emission Reductions

NTPC/CenPeep

To appropriately measure changes brought about by GEP, it would have been necessary to establish a baseline of what GHG emissions would have been in the absence of the project. Rarely is that a static continuation of the project's emission profile in the year prior to the project's beginning. For example, an appropriately established baseline for NTPC's coal plants would have taken into account those changes that would occur without the project, such as degradation of coal quality or continued degradation of efficiency at NTPC plants due to the then operating practices. Figure 1 illustrates how the selection of the baseline impacts measurement of the project's performance.

[22] NTPC emission reductions were calculated based on plant-level efficiency improvements. During this period, there was no improvement in coal quality (which could have improved efficiency measures), in plant load factor or in other variables outside of those attributable to GEP.
[23] MSEB and Anpara.

Figure 1: Illustrative GHG Emissions



The reddish-brown line, or base-year conditions, shows a constant level of emissions assuming that the plants emissions would remain the same over the fifteen-year period. The blue line represents the "with project" scenario and the lowered emissions as a result of increased efficiency. The below area represents the savings in GHG emissions from instituting the project. Now, note the higher level of emissions or those that would have occurred without the project represented by the green line. For the "without project" scenario and the continuation of base year emissions to be the same many variable would have to remain constant. These include coal quality, plant load factor, forced outage, and efficiency.

When GEP began, NTPC did not measure efficiency and, in the absence of knowledge of these parameters, it was assumed that the baseline would be the plants current heat rate or the kilocalories (cal) per kilowatt hour (kWh) generated. Coal quality has been deteriorating since this project began and availability and efficiency were known to decline until plants were rehabilitated. So this implicit baseline underestimates what could have been expected to happen. To improve or maintain PLF to meet power demand, routine maintenance was sacrificed with a general deterioration in heat rate (efficiency). More coal had to be used to offset the lower levels of efficiency, resulting in higher CO_2 emissions over time. The without project baseline would have incorporated this deterioration in plant conditions. Because it did not, the actual change in emissions is a conservative measure. Moreover, CenPEEP reports only the improvement at coal plants and not those at gas plants. Gas plants have benefited from many of the measures instituted under GEP as systems have been instituted NTPC wide. Again, this leads to a conservative estimate of emission reductions.

It is assumed that all improvements in efficiency can be attributed to CenPEEP and, therefore, GEP. Prior to the establishment of CenPEEP, all NTPC plants were operated on the basis of PLF maximization. Once CenPEEP was established, efficiency measures became an over-riding factor in plant management and all efficiency measures implemented were the direct result of the GEP project.

Measuring Efficiency and GHGs

Efficiency is measured at the plant level. Improvements are the change between the current year's efficiency (t) and the base year efficiency (b). For example, if the base year heat rate was 2,392.5 Kcal/kWh and the current year's heat rate is 2,393.01 Kcal/kWh, there has been an improvement of 1.41 Kcal/kWh. This means that less coal is required to produce a kilowatt hour of electricity and, therefore, less CO_2 per kWh compared to the base year. The conversion of a ton of coal to CO_2 is based on the molecular weight of CO_2 and carbon percentage in a ton of coal. Twelve kg of carbon, C, produces 44 kg of CO_2. Thus, 44/12 kg of CO_2 is produced from each kg of carbon. If the carbon in as-fired coal is 34%, then a kg of coal produces (44/12) x 0.34 or 1.247 kgs of CO_2. Plant-level emissions were then calculated based on the change in annual coal consumption x 1.247 to convert to GHG emission reductions.

SEBs

While CenPEEP and GEP have been active at many SEBS, only emission reductions from MSEB and Anpara in UP have been included in this report. This is because only these entities reported efficiency gains to CenPEEP. The team has checked the SEB calculations and data, which were found consistent with best practices for GHG emission calculations. We did not confirm this by visits to these plants, but there is no reason to assume that once these low-cost measures have been implemented that they are ever abandoned. Our visits to other sites and interviews with NTPC personnel support this assumption. The baseline was the same as that adopted for the NTPC coal plants.

Bagasse Cogeneration

The ABC component of GEP provided technical assistance, awareness/outreach and grant funding to develop high-pressure cogeneration at nine existing sugar mills for power export to the grid. According to the draft Legacy Report and reports from the REPSO, 200 MW of sugar mill capacity was installed through the project, resulting in the annual export of 630,000 MWh and the avoidance of roughly 510,000 tons of CO_2 annually. These emissions are avoided in principle because renewable power put on the grid reduces the demand for power from non-renewable resources, mainly coal.

The conversion from MWh to tons of CO_2 follows a standard process[24]:
Tons of CO_2 = 0.81 (G.E.F) x MWh
G.E.F. – Combined MarginGrid emission factor for Indian Grid

[24] This method differs from employed in the draft Legacy Report and is more in keeping with standard practice to measure GHG emissions.

Differences between USAID Estimates and Evaluation Team

The evaluation team was provided a spreadsheet by both USAID and NETL for GHG emissions avoided that was initially prepared by USAID. The impact is a downward revision from 100 million tons to 73 million tons over the reported period.

Differences with NETL/USAID estimates

There are differences from the NETL/USAID estimates and this can be traced primarily to a simple spreadsheet formula replication that appears to have been unintentional and to a lesser degree to a change in time frame calculation error.

1. In 2001, USAID requested NTPC to report GHG data on a different time period following the USG fiscal calendar. So, NTPC reported for a six-month period and then reported on an annual basis thereafter. In the conversion, NTPC did not correct for six months of operation but mistakenly took a full year's results. To compound this simple error, the person or persons that developed the results for the other interventions followed the same example.

2. NTPC calculates efficiency gains, and hence, CO_2 emissions reductions, based on year-to-year improvement in plant heat rates. Each year's additional emission reductions are added to cumulative of the prior year reductions, and are reported as avoided emissions from the baseline prior to GEP. The team has confirmed this as an appropriate correction.

   While this is appropriate for NTPC, it is not appropriate for other interventions that did not follow the NTPC method of accounting. For example, this was applied to the ABC component with the result that emissions avoided greatly exceed the possible limits of the ABC project. A maximum of 200 MW was installed under the ABC component with a total generation of 630 million kWh per year. This translated into 510 thousand tons of GHG avoided annually. In year 3, the calculations indicated 1 million tons of GHG avoided. By September 2007, it totaled 5.2 million annually. It seems that the error occurred simply because it was assumed that these calculations would follow those of NTPC and simple error was made.

3. The calculation for MSEB and Anpara was taken from letters to CenPeep documenting the improved efficiency and the measures taken. Since those letters were for fixed points in time and no reporting took place after 2001, the team fixed the date of the last report as the maximum improvement in efficiency and simply continued the efficiency gains reported in that year for the following years.

APPENDIX E. EVALUATION MATRIX

Evaluation Questions[25]	Tool	Source	Comments/definition
Impact			
1. Assess the performance of the implementation partner (NETL) and key sub-contractors (LTI, KeyLogic, USEA and CII) in executing their respective scopes of work for the project. Were they able to meet their responsibilities under their contracts or agreements? Did they coordinate and collaborate well with each other and with the host government and stakeholders at all levels?	1. Document review 2. Key informant interviews 3. Site visits	1. NETL/subcontractors 2. USAID-India 3. NTPC/CenPEEP	Incomplete set of project reports.
2. **Assess the overall impact of the program, including the extent to which the program has contributed to achieving the assistance objective and has achieved the objectives of the two components.**	1. Document review 2. Key informant interviews 3. Site visits	1. NETL/subcontractors 2. USAID-India 3. NTPC/CenPEEP 4. Other Indian partner organizations (including SEBs)	Definition of impact: *A results or effect that is caused by or attributable to a project or program. Impact is often used to refer to higher level effects of a program that occur in the medium or long term, and can be intended or unintended and positive or negative.* USAID ADS 200
3. Assess the value of savings from the program in terms of coal saved and carbon dioxide savings from both the components (ECC and ABC). Note any co-benefits from GEP such as improved local air quality and reductions in other pollutants.	1. Document review 2. Key informant interviews 3. Quantitative validation of avoided CO_2 4. Site visits	1. NETL/subcontractors 2. USAID-India 3. NTPC/CenPEEP 4. Other Indian partner organizations (including SEBs)	Using internationally accepted methodology.
4. **Capture any success stories and lessons learned from GEP that can be shared and communicated.**	1. Document review 2. Key informant interviews 3. Site visits	1. NETL/subcontractors 2. USAID-India 3. NTPC/CenPEEP 4. Other Indian partner organizations (including SEBs)	Follow up by USAID communication staff.
Relevance			
5. **Assess whether the GEP programs were able to respond to the needs of the GOI.**	1. Document review 2. Key informant interviews 3. Site visits	1. NETL/subcontractors 2. USAID-India 3. NTPC/CenPEEP 4. Other Indian partner organizations (including SEBs)	

[25] Questions highlighted in bold indicate higher priority questions for the evaluation, as discussed at the initial meeting in Delhi of the USAID-India staff and the evaluation team, and as reflected in the objectives described in the SOW.

Effectiveness			
6. Appraise the extent to which NTPC was satisfied with the technical assistance provided by US partners intended to develop capacity within CenPEEP.	1. Document review 2. Key informant interviews 3. Site visits	1. NETL/subcontractors 2. USAID-India 3. NTPC/CenPEEP	
7. Assess the effectiveness of CenPEEP as a knowledge think tank for the Indian power sector and its effectiveness in catering to NTPC as well as other utilities.	1. Document review 2. Key informant interviews 3. Site visits	1. NETL/subcontractors 2. USAID-India 3. NTPC/CenPEEP 4. Other Indian partner organizations (including SEBs)	
8. Provide an assessment of the cost-effectiveness of the program in meeting its objectives. What has been the return on USAID's investment?	1. Document review 2. Key informant interviews 3. Site visits	1. NETL/subcontractors 2. USAID-India 3. NTPC/CenPEEP	
9. Assess whether the outputs from technical assistance, training and other activities been utilized by the targeted beneficiaries. For instance, have the practices and results from GEP have been institutionalized by NTPC in its operations?	1. Document review 2. Key informant interviews 3. Site visits	1. NETL/subcontractors 2. USAID-India 3. NTPC/CenPEEP 4. Other Indian partner organizations (including SEBs)	
Sustainability			
10. Assess the sustainability of CenPEEP as well as the program in terms of creating institutional capacity within the country.	1. Document review 2. Key informant interviews 3. Site visits	1. NETL/subcontractors 2. USAID-India 3. NTPC/CenPEEP 4. Other Indian partner organizations (including SEBs)	
11. Investigate whether systems have been established internally for tracking, monitoring, and reporting on results attributable to GEP activities and whether these systems utilize independently verifiable information. For example, does NTPC have a system for monitoring heat rate improvement?	1. Document review 2. Key informant interviews 3. Site visits	1. NETL/subcontractors 2. USAID-India 3. NTPC/CenPEEP 4. Other Indian partner organizations (including SEBs)	
12. Provide recommendations for future program in cleaner coal in terms of its relevance in the present Indian energy context.	1. Document review 2. Key informant interviews 3. Site visits	1. NETL/subcontractors 2. USAID-India 3. NTPC/CenPEEP 4. Other Indian partner organizations (including SEBs)	
13. Identify potential gender considerations in any future programming in cleaner coal in India.	1. Key informant interviews 2. Site visits	1. NETL/subcontractors 2. USAID-India 3. NTPC/CenPEEP 4. Other Indian partner organizations (including SEBs)	GEP did not address gender equality, but it is to be a consideration in future programming.

APPENDIX F. GEP SUCCESS STORIES

Partnership in Excellence (PIE) Program

The PIE program was designed to address poor performing stations at SEBs – building on the successes achieved at NTPC plants through GEP. The Central Electricity Authority identified 26 coal-fired power stations in the country at 13 different state utilities that were operating at PLF less than 60%. Average operating thermal efficiency at these power plants was also low compared with its design value due to poor operations and maintenance conditions. The program provided funding and placed NTPC staff in the plants full time for as long as three years. NTPC worked with 13 power stations to achieve performance improvements.

The NTPC officers were deputed at these poor performing power stations as partners. The methodologies, practice and procedures for operation and maintenance acquired by CenPEEP under GEP were implemented directly or indirectly at the SEB plants to the extent possible.

This program resulted in significant improvements in generation, efficiency and overall performance at most of the stations, at a reasonable cost and in the shortest possible time. This in turn reduced GHGs emissions per unit of power generated at these stations. There was an additional generation of 4,963 million kWh from these 13 stations during April 2006 – Feb 2007, which is equivalent to an **additional capacity of 835 MW**[26]. The program ended in 2008.

Anpara TPS Efficiency Improvement

Anpara Thermal Power Station of UPRVUNL is equipped with 3x210 MW and 2x500 MW subcritical coal-fired units, representing a total of 1630 MW of installed capacity. CenPEEP conducted workshops and demonstrations for performance efficiency monitoring and optimization. The measures recommended for performance optimization of the boiler and for turbine were found very useful and adopted by the plant engineers. This resulted in a drastic improvement of plant performance and specific coal consumption was reduced in 2002 by 0.007 kg/kWh compared to the previous year (2001). This finally resulted in a saving of about 85,000 tons of coal in that year and a savings of 110,000 tons of GHG annually.

Great improvement in performance and reductions in GHGs emission at MSEB

Maharashtra State Power Generation Company Limited (MAHAGENCO) has a total installed capacity of 9,996 MW and operates seven sub-critical coal-fired power generating stations with installed capacity of 6800 MW. With assistance from CenPEEP through workshops, seminars and CenPEEP staff in carrying out coal flow and other performance optimization tests, vigorous monitoring of efficiency/heat rate started at various power stations of MAHAGENCO under the supervision of top-level management in August 1998. It resulted in great improvements in the performance of units in the next

[26] Assumes an average PLF of 74 percent based on system performance.

two years (Oct 1998 to Oct 2000) in terms of improved PLF, improved loading factor, reduced specific coal consumption, reduced stack emissions and reduced generation cost.

These improvements were great motivation to the staff to maintain these practices for better future performance of the units, which in turn established the sustainability of these practices instituted under GEP.

An average improvement of heat rate of 200 kcal/kWh has been reported at MSEP plants due to the above measures, which contributed significantly to overall GHG reductions under GEP.

Change in Specifications by BHEL

As a result of the experience of NTPC through GEP and NTPC interaction with BHEL, BHEL has changed its equipment design to meet new efficiency norms established during execution of the project.

1. BHEL has improved its conventional designs for better heat rate of turbines and high efficiency of boilers during last ten to fifteen years to minimize specific coal consumption, leading in turn to reductions in GHG emissions. Auxiliary power consumption has also been reduced by using energy efficient auxiliaries. Additional feedback from NTPC has resulted in improvement in ESP design.
2. The new power generating units are now equipped with increased instrumentation to measure various efficiency related parameters and improved control systems to monitor those parameters.
3. Other design modifications that can partly or wholly be attributed to GEP include turbine internals, blades profiles, and seals to improve heat rate; measurement of individual turbine cylinder efficiencies on line and off line; and more ports to provide a better array for flue gas temperature measurement at air heater inlet/outlet.

Changes in Overhauling Procedures

As a result of encouragement provided directly or indirectly by the GEP, BHEL has changed its practices for overhauling of units, which resulted in reduced outage times and enhanced post-outage performance of units, both of which contribute to better plant economics. The revised practices encompass online condenser cleaning, replacement of acid cleaning by EDTA cleaning; use of modern diagnostic instruments ,like thermovision cameras and helium leak detection for fault identifications and parameters monitoring; replacement of previously used asbestos and lead-based insulation with modern insulating materials; introduction of mattress insulation for main turbine insulation; and application of eddy current techniques for opening and closing of turbine bolts.

SMART 24 X 7 System

Development of the **SMART 24x7** system for an early detection of incipient equipment problems and to forewarn plant engineers is a great achievement under GEP program.
A pilot is underway in NTPC’s Southern Region, but the system is envisioned to connect all units at all NTPC generating stations and to monitor all important parameters centrally

at NTPC's Corporate office. More than fifty typical boiler and turbine efficiency parameters are presently being monitored centrally through the system. The system provides historical data trending and implementation of uniform standardized procedures of problem detection, resolutions, operation and maintenance practices on all of the units of NTPC stations. The system enables corporate office operators to detect a problem in a unit much earlier than the plant operators knew it and thus in time rectification of the problem. The system contributes for improving operational efficiencies and to run the units on optimum efficiency.

Heat Rate Improvement Guidelines

In 2000, the Ministry of Power released a comprehensive set of "Guidelines for Heat Rate Improvement" for Indian coal-fired power plants, prepared jointly by NETL, Tennessee Valley Authority (TVA), the Electric Power Research Institute (EPRI), and CenPEEP. The guidelines were based on U.S. utility practices and demonstrations in 200-MW and 500-MW units in India through GEP, and provided gap analysis methods and tools, test procedures, and calculation methodologies from the United States. The guidelines were circulated to all state utilities and were turned over to the Central Electricity Authority (CEA) for implementation in power generating plants across India.

Major Awards to CenPEEP

CenPEEP's contributions to improving efficiency in India's coal-fired power sector have been recognized by several Indian and global awards. In 2002, CenPEEP received the Climate Technology Initiative's World Climate Technology Award, for supporting the adoption of more-efficient coal power plants in India. In 2003, CenPEEP received the USEPA Climate Protection Award (corporate and governmental category). In addition, CenPEEP has received several Indian power sector awards (India Power Awards 2008 and BIS Star Quality Award 2009) that recognize both the technical achievements of the partnership under GEP, but also the broad impact of the CenPEEP across the sector. The awards made between 1998 and 2009 recognize exceptional innovation, personal dedication, and technical achievements in climate protection.
NTPC Comment: As appendix, please include technology demonstrated as a part of GEP. Please find attached.

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