Tariff-based incentives for improving coal-power-plant efficiencies in India

Ananth P. Chikkatur[*†]

Ambuj D. Sagar[†]

Nikit Abhyankar[§]

N. Sreekumar[§]

[*] Corresponding author: ananth_chikkatur@harvard.edu, 001-617-496-3106 (tel), 001-617-495-8963 (fax).

[†] Belfer Center for Science and International Affairs, John F. Kennedy School of Government, Harvard University, 79 John F. Kennedy Street, Cambridge, MA 02138, USA.

[§] Prayas Energy Group, Athawale Corner, Karve Road, Deccan Gymkhana Corner, Pune 411004, India.

ABSTRACT

Improving the efficiency of coal-based power plants plays an important role in improving the performance of India's power sector. It allows for increased consumer benefits through cost reduction, while enhancing energy security and helping reduce local and global pollution through more efficient coal use. A focus on supply-side efficiency also complements other ongoing efforts on end-use efficiency. The recent restructuring of the Indian electricity sector offers an important route to improving power plant efficiency, through regulatory mechanisms that allow for an independent tariff setting process for bulk purchases of electricity from generators. Current tariffs based on normative benchmarks for performance norms are hobbled by information asymmetry (where regulators do not have access to detailed performance data). Hence, we propose a new incentive scheme that gets around the asymmetry problem by setting performance benchmarks based on actual efficiency data, rather than on a normative basis. The scheme provides direct tariff-based incentives for efficiency improvements, while benefiting consumers by reducing electricity costs in the long run. This proposal might also be useful for regulators in other countries to incorporate similar incentives for efficiency improvement in power generation.

Key words: coal power; supply-side efficiency; efficiency improvement; incentives.

1. Introduction

Coal-based power plants dominate electricity generation in many industrialized as well as developing countries. Coal-based thermal plants account for about 70% of the electricity generated in India, and they consume nearly 80% of domestic coal production (Ministry of Coal, 2006). Generally, the use of coal offers a number of advantages: it is often the most economical fuel, especially when compared with natural gas or oil; coal used for power generation is often produced domestically, which enhances energy security; and coal conversion technologies are well-established with a long manufacturing and operational history.

In India, coal is the dominant domestic fossil fuel resource in the country, and policy-makers and planners have traditionally considered coal to be a cornerstone of the nation's energy future, especially in relation to the economics of the other alternatives (such as naphtha, LNG or advanced renewables[1]), their constrained supply (diesel and imported natural gas), or related societal concerns (as in the case of nuclear and hydroelectricity) to make a dominant contribution to India's electricity sector in the short-to-medium term.

However, the increased use of coal in power generation also has negative impacts. In addition to the environmental and social consequences of coal mining, coal-based power generation contributes significantly to local (and regional) air pollution through the emission of particulates, sulfur and nitrogen oxides in stack flue gases, and water pollution through release of waste heat and effluents. On a global scale, the coal power sector is the single largest contributor to the emissions of carbon-dioxide (CO_2) (IEA, 2005),[2] which has been identified as the primary culprit in the human influence on the global climate (IPCC, 2001). India is currently the fourth largest emitter of carbon worldwide and its emissions are growing rapidly at about 5.5%/year (compared to 3.2% for China, 1.6% of US, and 1.1% globally) (World Bank, 2005).[3] Coal contributed about 62% of total CO_2 emissions of 817 Tg in 1994, of which 43% was from energy transformation (electricity generation and petroleum refining) (MoEF, 2004).

Many of the recent discussions on options for reducing CO_2 emissions from coal-based power generation have been on carbon capture and storage (i.e., capture of CO_2 from the flue gas combined with subsequent geological storage of compressed CO_2 (IPCC, 2005), analogous to the flue gas capture of particulates and sulfur oxides)—an option that has been primarily driven by its GHG mitigation potential in industrialized countries. However, increasing coal-conversion efficiency in power plants still remains the most cost-effective method for reducing CO_2 emissions (NRC, 1995), as well as that of other pollutants. In a developing country such as India, where there is much scope for improving power plant efficiencies, this option deserves significant and immediate attention. Furthermore, coal reserves in India may not be as large as traditionally thought to be – recently revised estimates indicate that there might only be 44 billion tons of coal reserves.[4] Assuming that these estimates are accurate, the coal era in India might only last into the first half of the 21st century under a business-as-usual scenario (Chand and Sarkar, 2006; Chikkatur, 2005; Planning Commission, 2006). This gives further reason to view coal as an invaluable resource that must be utilized efficiently, i.e., one needs to generate as much electricity with as little coal as possible to enhance energy security of the country. Thus, improving the efficiency of Indian power plants in India continues to be recognized as an important aspect of energy policy (Planning Commission, 2006).[5]

Although the efficiency of coal-based power plants in India has improved in recent years, it still remains low in absolute terms (Shukla et al., 2004). The average net efficiency of the entire fleet of coal power plants in the country is only 29%, although the 500-MW units[6] operate with a better net efficiency of about 33% (CEA, 2005; Chikkatur, 2005). In terms of gross efficiency, the 500 MW units operate at 35%, although the average design gross efficiency of these units is about 38%. At the unit level, there is wide variation in efficiency or heat rates[7], even within a particular technology category (see Figure 1a). Furthermore, there are no fixed patterns in heat rates in terms of seasonal variations, and, in many cases, there is little or no correlation of heat rates with plant load factor (PLF). Thus, Indian power plants (as a whole) can significantly improve their efficiency, as indicated by the large gap between the actual and design efficiencies (see Figure1b).

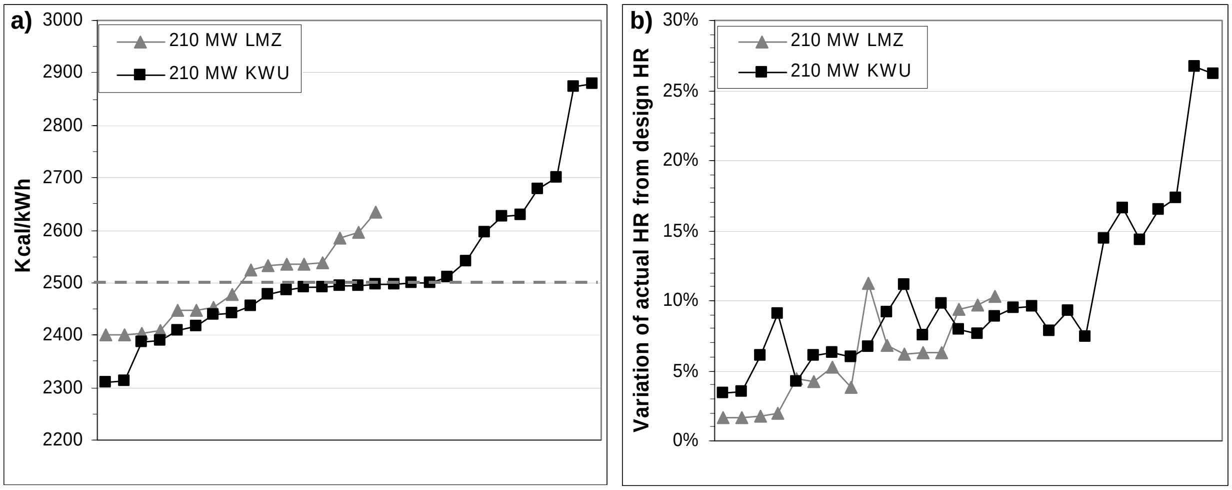

Figure 1: Heat Rate of Indian power plants. a) Shown are gross heat rates of 210 MW units of two different turbine technology categories: units with turbines of Russian (LMZ) design (triangles) and units with turbines of German (KWU) design (squares). Each data point represents the average gross heat rate of a unit, with the units from each technology category sorted by increasing unit heat rates. The dashed line indicates the current benchmark of 2500 kcal/kWh for these units. b) The average variation from design gross heat rate is shown for the same units as in (a), maintaining the same sort-order (i.e., the unit represented by the left-most data point in (b) corresponds to the unit with lowest heat rate in (a), and so on. In general, as the heat rates increase, the variation from the design heat rate also increases, albeit with some fluctuations. For each unit, the heat rate and the variation from design is based on data collected by the Central Electricity Authority (CEA) and averaged over 45 months (April 2000 to December 2003). Source: (CEA, 2005).

It has been estimated that the efficiency of existing Indian power plants can be improved by at least 1-2 percentage points (Deo Sharma, 2004). The cost of energy inputs[8] account for nearly 40-60% of the total cost of generation, with energy costs becoming more important as the capital assets of the power plant depreciates over time and the loan gets repaid. Not surprisingly, the efficiency or heat rate of power plant is the most sensitive parameter in determining tariffs (see Figure 2).[9] A 1% improvement in efficiency of a power plant would result in cost reductions of about 0.4% (see Figure 2) and reduce coal use, and corresponding air pollution and CO_2

emissions, by 3% (Deo Sharma, 2004). This combination of the potential for significant gains in efficiency and the wide range of benefits that would result from any such improvements provide a powerful impetus for designing policy mechanisms that could successfully motivate utilities to enhance the efficiency of their power plants.

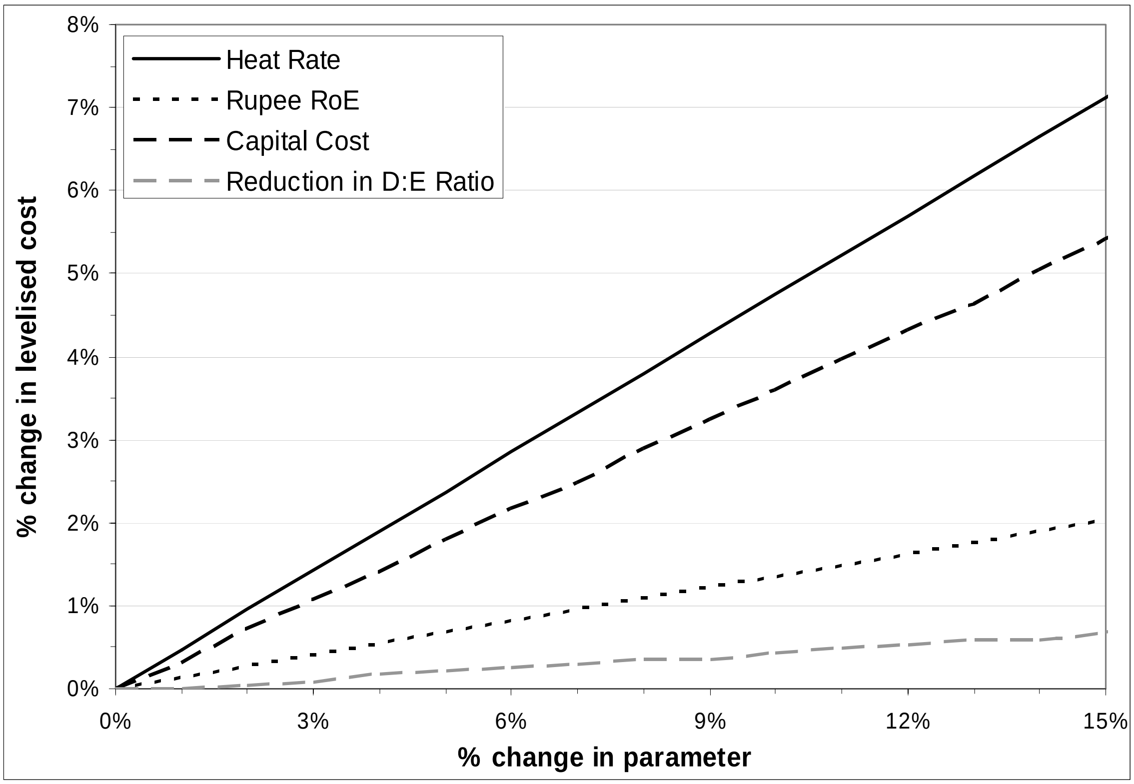

Figure 2: Sensitivity of cost to various parameters. The percent change in the cost of electricity generation is shown as a function of percent changes in key parameters that determine the cost: heat rate, the return on equity (RoE), capital cost, and debt-to-equity ratio.

The low generation efficiency is usually blamed on a variety of technical and institutional factors such as poor quality of coal, bad grid conditions, low PLF, degradation due to age, lack of proper operation and maintenance at power plants, ownership patterns, regulatory framework, and tariff structure and incentives (CEA, 2005; Khanna and Zilberman, 1999; Shukla et al., 2004).

However, regardless of reason, it is increasingly apparent that there will not be significant improvements in power-plant efficiency unless there are either mandates to do so or provisions of appropriate incentives for improving efficiency. While the Ministry of Environment and Forests in India mandates the control of air, water and solid waste pollution from power plants, it does not provide any guidelines for overall plant efficiency. Efficiency of power plants is generally considered to be a technical operational issue outside the purview of the environmental guidelines, despite the fact the improving efficiency of power plants reduces coal use (per MWh generated) and thereby directly contributes to reduction of pollution. Rather, the management of operational parameters is left to electricity regulators.

It is in this context that we believe that regulatory mechanisms are an important conduit for improving power plant efficiencies in India. Significant restructuring and regulatory reforms have been introduced in the electricity sector of many developing countries over the past decade (Dubash, 2002; Dubash and Singh, 2005). Public benefits such as improving efficiency and environmental performance have generally not received sufficient attention in these reforms (Dubash, 2002), although there are few exceptions such as Ghana's emphasis on energy efficiency (Edjekumhene and Dubash, 2002) and Brazilian regulations which increased energy efficiency investments (Jannuzzi, 2005). Similarly, Indian electricity regulators have already made some efforts to improve the generation efficiency with limited success. There is already some increase in average thermal power plant efficiency since the introduction of reforms, but this can be mainly attributed to changes in fuel mix (i.e. increased installation of more efficient natural gas plants) rather than increases in overall power plant efficiencies (Perkins, 2005;

Shukla et al., 2004). Hence, there is plenty of scope for greater efficiency gains (and public benefits) through better regulations and good governance (Dubash, 2002).

Current electricity regulations in India continue to be based on cost-plus mechanisms, despite the regulators hope that competitive bidding for tariffs will be available in the future. While competitive pricing (in the wholesale electricity market) might reduce costs and improve efficiency of power plants, it is not yet feasible in the Indian context because relevant institutions and market mechanisms are not developed enough.

Under the current approach of cost-plus tariffs, regulators approve the fixed and variable costs of utilities based on a range of benchmarks determined by the regulators.[10] Profits of the utility (i.e. rate of return on investment and other incentives) are included in the tariff calculation – hence the term 'cost-plus'. Inevitably, choosing appropriate benchmarks for this calculation becomes an important role of the regulators in this scheme. The current choice of benchmarks, nominally based on performance, has been marred by information asymmetry (as we detail below), leading to possible manipulation by regulated utilities.

In this paper, we propose an incentive scheme based on benchmarks determined by actual performance rather than the prevailing normative approach, while providing additional performance-based incentives for improving efficiency. The combination of the incentives with the actual performance benchmarks should yield consumer benefits in the long run by making it more profitable for power plant operators to make efficiency improvements.[11] Our proposal to improve efficiency at the supply-side also complements other efforts focused on end-use efficiency, such as efficient appliances, lighting, etc.

The following section discusses some aspects of regulatory approaches to power tariffs broadly and in the current Indian context. The next sections then detail the outline of our proposal.

2. Regulatory approach for tariffs

2.1 Theory

There are two competing hypotheses regarding the goal of regulators: 1) to pursue public interest in economic efficiency (including broader elements of social welfare) and 2) to maximize the welfare of regulated groups[12] (Porter and Sagansky, 1976). For electricity supply, public interest would entail the availability of reliable, efficient, and low-cost electricity for consumers, as well as wider public interest goals of conserving fossil fuel reserves and reducing in emission of air pollutants (including carbon dioxide). At the same time, fair electricity tariffs (for both whole-sale and retail electricity supply) are attractive to electric utilities, as firms make sufficient profit to sustain current and future public and private investments in the sector. These two goals are inherently competing, making even-handed regulatory decisions difficult and contentious from both the public and the firm's perspective. Furthermore, regulators in developing countries must also consider the burden of high tariffs on poorer section of society and introduce some amount of gradualism in attaining economic electricity rates (Edjekumhene and Dubash, 2002). While regulators aim to balance these competing interests, they are also subject to various constraints in the process that are not included in traditional textbook theories on regulation.

Traditional textbook theories on second-best[13] optimal pricing for regulated firms assume that regulators have perfect information about technology, costs and consumer demand attributes of regulated firms (Joskow, 2006). It is expected that the regulators can minimize costs while providing sufficient profits for the firms by using this information. However, in reality, regulators face many constraints – informational, transactional, and administrational and political – that prevent them from fixing appropriate tariffs (Laffont and Tirole, 1993). Informational constraint refers to the ability of regulated firms to control and withhold information to regulators in order to affect decisions. Transactional constraint refers to transactional and contract costs that can arise when writing and enforcing regulations. Regulators can also face constraints in terms of administrative rules and regulations, lack of financial and human resources, and political and legislative pressures. Given that these constraints hamper regulators from achieving their goals, much of the regulatory history has reflected efforts to mitigate information disadvantages and other constraints. These efforts include transparency, public hearings, written decisions, opportunities for third-party participation, access to firm's accounting records, monitoring of performance, financial auditing, appeals court review and legislative oversight (Joskow, 2006).

Informational constraint, wherein the regulated firms can control information flow to regulators, is a crucial element affecting regulatory decisions (Owen and Braeutigam, 1978). Information flow can be about both endogenous variables, such as firm's effort, management practices, etc., and exogenous variables like impact of varying input costs, differences in serving consumers of different attributes (urban vs. rural), etc. (Joskow, 2006; Laffont and Tirole, 1993). This information asymmetry can lead to two kinds of problems for the regulator – *adverse selection* and *moral hazard*.

According to Joskow (2006), adverse selection occurs when regulators rely on a *fixed price* contract or a *price cap* mechanism where prices are adjusted according to exogenous input price and performance benchmarks. The advantage of such a mechanism is that it provides high-powered incentives for firms to reduce production costs and increase managerial effort, as they would keep all the cost savings as profit. If the regulators had perfect information about a firm's technological environment and impact of managerial effort, then they could appropriate fixed prices such that the firms are not extracting economic *rent* from consumers. However, a firm can withhold information about cost opportunities from regulators in order to convince the regulators that it is a 'higher-cost' firm than it actually is. The regulators are then forced to set higher prices for services, and are hence faced with an *adverse selection* problem, as they seek to differentiate high-cost and low-cost firms (Joskow, 2006). In general, the firm is highly motivated to continue to maintain the information asymmetry, and extract rent from consumers.

Alternatively, where the regulators are uncertain about the quantity, quality, and impact of managerial effort in firms for reducing costs, they can use the firm's past actual costs to set tariffs based on the firm's ex-post realized costs. This is the standard approach for 'cost-of-service' or 'cost-plus' regulations. Assuming that the firm's financial auditing is accurate and that the regulators have perfect information, the mechanism does not allow any rent in excess profits for firms, as they are compensated fully for their costs. Since the regulators can easily determine the high and low cost firms, there is no problem of adverse selection. However, there is also no incentive (or profit-motive) for firms to reduce cost, and they may choose to exert little or no managerial effort to reduce cost. This might lead to a situation where the realized costs might be higher than their efficient levels. Thus, the regulators face a *moral hazard*, wherein they have to rely on the morality of the firms to maintain high managerial effort despite regulatory incentives (Joskow, 2006).

Given this fundamental tradeoff between incentives and rent extraction, much of the recent regulatory theory has focused on ways in which information asymmetry can be reduced. For example, Laffont and Tirole (1993) have suggested that regulators offer firms a menu of cost-contingent regulatory mechanism in between the two extremes, such that high-cost firms choose an option closer to cost-plus and low-cost firms choose fixed-price options. By studying firms' choices, regulators gain additional information about the firm. Another option is to have a sliding-scale (or profit-sharing) contract based partially on realized *ex post* costs and partially on costs fixed *ex ante* (Joskow, 2006; Schmalensee, 1989). "Yard-stick" regulation or setting of competitive benchmarks can be another important method by which regulators can gain information (Shleifer, 1985). This is an efficient mechanism by which the price for each firm is based on the cost of other firms. Unless all of the firms collude, this mechanism sets efficient prices as it induces each firm to compete with each other.

2.2 Electricity regulation and tariffs – the Indian scenario

Independent electricity regulation in India is relatively new, having been introduced in late 1990s as part of a major program of economic liberalization and structural reforms that was launched in 1991. A key goal was to develop a rational decision-making process and introduce market forces in the power sector to turn it around, while developing good governance practices of transparency, accountability and public participation. The first independent electricity regulator was setup in Orissa in 1996, as part of the World Bank reforms for the state's power sector (Dubash and Rajan, 2001). A legislative act in 1998 established the Central Electricity Regulatory Commission (CERC) and the Electricity Act of 2003 further consolidated the reforms for the entire sector by requiring all electricity boards to unbundle and establish independent electricity regulatory commissions. The main goal of these regulators is to reduce the cost of electricity for consumers, while maintaining a good enough investment climate for the utilities to add capacity to ameliorate exiting power shortages and meet expected demand growth.

One of the key responsibilities of the CERC is to determine the tariffs for bulk power purchases between the central utilities, such as the National Thermal Power Corporation (NTPC), and the state electricity boards (SEBs) and companies. The CERC has so far enacted two key regulatory orders to set the terms and conditions for tariff determination for central utilities from the period 2001 to 2004 and 2004 to 2009. These orders now form a basis for determining tariffs for power generation in the country, especially since the CERC's orders establish precedents and guidelines for state electricity regulatory commissions (SERCs).

Independent electricity regulation in India has had mixed success, but the institutional changes have nevertheless helped improve the operation of the electricity system (both generation and transmission[14]). In addition, and importantly so, the generally transparent and inclusive approach taken by the regulators in enacting these orders has provided an important space for incorporating the concerns of various stakeholders, including public interest issues (Prayas, 2003).[15] Thus, after nearly eight years, it is now quite well accepted that regulation in the power sector is here to stay and that this is an important mechanism by which the electric sector can be improved.

The current approach to tariffs in the Indian power sector is based on a cost-plus mechanism, wherein the regulators set benchmarks for parameters determining both the fixed (or capacity) charge and the energy (or variable) charge components of tariffs. Elements of fixed charges include depreciation, interest on loans and finance charges, return on equity, operation and maintenance expenses, interest on working capital, and taxes; whereas energy charges mainly cover fuel cost. Energy charges are paid according to fuel consumption for scheduled generation, while the fixed charges are paid in proportion to generator's availability (ability to generate), regardless of actual energy generation. Energy charges, which can account for nearly 40-60% of total tariff, are calculated using fixed operational benchmarks, and not on actual operational data.

Scheduled generation from a generator is determined by (national, regional, and state) load dispatch centers, based on projected demand and generator's declared capacity for the day. The protocol for dispatch is based on a 'merit order' that is prepared once a year, primarily based on the energy cost of generators. However, the merit order is not always determined by cost, as there are exceptions for contractual obligations and promotion of non-conventional and certain central generators (Prayas, 2004). Furthermore, the chronic power shortages in the country imply that even inefficient generators are dispatched to cope up with demand. Therefore, the merit order by itself does not promote efficiency in the Indian context.

In the following sections, we will first discuss the history and current status of operational benchmarks (also known as ‘operational norms’), and then two existing incentive-based schemes, the PLF incentive and the availability based tariff (ABT), that are aimed at pursuing public interest goals.

2.2.1. Operational norms

Currently, operating benchmarks are set by regulators – CERC in the case of central utilities and SERCs in the case of state-owned utilities. This system of relating energy cost using performance benchmarks is a form of performance-based regulation, with incentives provided for power plants to operate better than the normative performance benchmarks (Rao, 1999; section 4.8.3.1). Power plants that operate better than the norms make additional profit, as their tariff for the energy cost is based on the norms, rather than the actual costs. Analogously, power plants that operate worse than the norms will face revenue loss, as their energy costs are higher than the tariff allowed by the regulators.[16] In theory, this system provides high-powered incentives for power plants to improve efficiency, especially if regulators have perfect information about operational data to set appropriate benchmarks. However, as discussed below, the utilities (particularly the central utilities) have withheld crucial information about heat rates such that the regulators have been unable to set appropriately tight benchmarks, and therefore face the full brunt of an adverse selection problem. This directly affects consumers, as energy costs are fully passed onto them.

In fact, information asymmetry regarding heat rates has been long-standing problem in India. Prior to regulatory reforms, the Ministry of Power in 1992 set financial and operational benchmarks for central generating utilities.[17] Given that this was the first time performance-based tariffs were set and that there was not much accurate information about actual operational data, it was natural that benchmarks for calculating energy cost would be set high (not unexpectedly – see discussion on adverse selection in section 2.1). It was initially hoped that operational benchmarks set in 1992 would be updated with actual operational data on a periodic basis, such that consumers would get some of the benefits of improved performance (CERC, 2000b; section 5.3.2). However, such reviews of norms did not occur (Rao, 1999). In 2000, the CERC, vested with the power to determine tariffs, attempted to tighten the benchmarks in a systematic and transparent manner with the help of experts from the Central Electricity Authority (CEA).[18] However, this effort was thwarted by serious disagreements between the CEA and the central utilities (NTPC, NLC, and NEEPCO[19]). There was no consensus on the benchmarks, and as the CERC noted, "[r]econciliation of extreme positions […] is not possible in the absence of authentic data relating to actual performance of power plants relating to heat rate. This information is not readily available" (CERC, 2000b; section 5.4.4).[20]

Hence, the operational norms for the tariff period from 2001 to 2004 remained fixed at its 1992 levels, with the CERC (2003) ordering NTPC, NLC and NEEPCO to provide operational data to CERC on a quarterly basis. [21] Despite this order in 2000, the CERC (2003) realized that these generators were not providing accurate and useful data to the commission, and noted that "[i]n absence of necessary information, the Commission feels handicapped while reviewing the tariff norms for the tariff period commencing from [April 1, 2004]." Upon further prodding, the central utilities ultimately provided information about heat rates and other operational data to CERC. In the open hearings of the Commission in 2003 (CERC, 2004a), the utilities demanded that the operational norms be maintained at the 1992 levels, and that actual data should not have any bearing on performance-norm-based regulation – an argument that implies that they were unwilling to share any economic rent with consumers. On the other hand, consumers of bulk electricity (i.e., SEBs) demanded that norms be based on actual data of best operating power plants – an argument that ensures maximum rent extraction from the generators. These arguments also highlight the inherent conflicts that exist in CERC as they attempt to meet their "twin objectives" of facilitating fresh investments in the industry while at the same time ensuring reasonable price of electricity for end consumers (CERC, 2004a).

In its recent tariff order for the period 2004 to 2009, the CERC decided to tighten the benchmark for 500 MW units from 2500 kcal/kWh to 2450 kcal/kWh[22]; however, the benchmark for the 200/210/250 MW units was maintained at the level of 2500 kcal/kWh set in 1992. They also decided to apply the same benchmarks for both existing and new stations. Thus, these decisions about the heat rate benchmarks do not appear to give much consideration to the potential for improvement in the heat rates. Instead, the regulators simply noted that they "have carefully considered the issue of station heat rate norms and are of the view that there is scope for reducing norm without affecting operational flexibility in 500 MW sets series. [They] also feel that the station heat rate norms for 200/210/250 MW sets could be retained at the current level" (CERC, 2004a). Although the benchmarks have now been set until 2009, the issue of determining appropriate heat rate benchmarks will continue to be a problem for the CERC.

2.2.2. PLF incentive

Incentives to ensure high PLF was introduced in 1992 by the Ministry of Power, along with the operational norms discussed above. It is generally important to ensure that the power plants generate as much electricity as possible, especially in country with frequent electricity shortages.

To ensure high generation (i.e., high PLF), a PLF norm was set at 68.5% in 1992, wherein the full recovery of fixed charges was subject to plants meeting the PLF norm. Furthermore, power plants were offered an incentive of Rs. 0.01/kWh for every 1% increase in PLF above the norm (Rao, 1999). The incentive was mainly targeted at improving economy and efficiency of the generators, while encouraging private investment into the electricity sector. Unfortunately, the incentive was too strong and it encouraged plants to generate electricity without regard for load matching, i.e., they continued to generate electricity even during off-peak hours resulting into excess generation and grid instability.

In 2001, as part of its comprehensive review of the 1992 operational norms, the CERC tried to tighten the PLF norms. First, it changed the metric for recovering fixed charges from PLF to availability, in order to reduce the perverse generation of electricity regardless of demand. It then fixed the normative availability as 80% and the recovery of fixed charges below the target availability was on a pro-rata basis. Incentive for PLF, however, was kept unchanged at Rs. 0.01/kWh for every 1% increase in PLF above the normative level (CERC, 2000b). In the 2004 terms and regulations, the normative PLF is kept at the same level at 80% but the generator is now offered a flat incentive of Rs. 0.25/kWh for every unit generated in excess of the normative PLF (CERC, 2004b).[23]

Similar to the operational norms, the PLF incentive is applicable to the state plants as well, in that the rate and norms of the PLF incentive set by the CERC are supposed to act as guidelines for the SERCs. However, many states deviated from these norms to favor the new privately owned Independent Power Producers (IPPs) in their states. For example, some states offered

PLF incentives only to IPPs but not to state-owned plants. Although there have been other discrepancies and misinterpretations about mode and period of payment, greater transparency in the SERCs and public objections are preventing such deviations.

2.2.3. Availability based tariff (ABT)

While the PLF incentive is mainly aimed at increasing generation in power plants, it is also important that generation is properly matched to load/demand conditions. Excess (reduced) generation during off-peak (peak) hours can lead to increased (decreased) system frequency, leading to grid disturbances. Since both the fixed and the energy charges are in proportion to the energy generated, it became profitable for power plants to continue generation even when demand had come down (Bhanu Bhushan, 2005). This resulted in grid indiscipline, wide fluctuations in system frequency and frequent grid disturbances – a result of inappropriate financial signals in the tariffs.

To correct this problem, the CERC instituted a new innovative incentive scheme in 2002 called the Availability Based Tariff (ABT) for all central generation utilities in India (NTPC, NLC, and NEEPCO) and their bulk consumers mainly consisting of various SEBs. The ABT adds another component to the generation tariff of a power plant – a charge for unscheduled interchange of power with the grid (UI charge). If a generator deviates from its scheduled generation (i.e., an unscheduled interchange), the ABT allows an UI charge whose rate depends upon system frequency at that time and on whether the excess/reduced generation is beneficial or harmful to the grid. For example, when system frequency is less than 49.02 Hz, every unit generated in excess of the scheduled generation, is compensated at Rs. 6/kWh.[24] On the other hand, if system frequency is more than 50.5 Hz, the generator is not compensated for any excess generation over schedule. The UI charge would be negative if power plant is delivering less power than scheduled. Thus, generators do not have any incentive in generating power during off-peak hours (when frequency is high) whereas they have a strong incentive to generate more during peak load hours (when frequency is low). Same mechanism and rates apply for bulk consumers if they draw more or less than their share; hence, discouraging electricity demand during peak hours. Also, the recently notified National Tariff Policy requires the state regulators to implement ABT for intra-state power transfers.

Initially, however, the utilities (generators as well as bulk consuming SEBs) were reluctant to accept such financial incentives / disincentives for their behavior (CERC, 2000a). CERC (2000a) order on ABT was even challenged in the Supreme Court, which after two years of litigations upheld the CERC's order and ABT was finally implemented in 2002. Even after implementation ABT faced a lot of teething problems including problems of metering, accounting and financial reconciliation. Enforcing the mechanism, grid discipline and making utilities actually pay the UI charges still remain as implementation roadblocks. Nonetheless, the ABT scheme has greatly helped in improvement of frequency profile and stabilization of the national grid (Planning Commission, 2006), although there have been a few instances of major grid collapse due to overdrawl by SEBs.[25]

In summary, the present generation tariff in India consists of 4 parts, *viz.*, (i) fixed (capacity) charge based on availability + (ii) energy charge based on scheduled generation + (iii) UI charge, if any, based on utility behavior with respect to load demand + (iv) PLF incentive, if any. While UI charges incentivise good social behavior, PLF incentive is used to encourage good performance of plants. Thus, the PLF and UI incentives work in tandem and the utilities have to decide what's best for them economically.

3. A proposal for incentive-based efficiency improvement

While incentives for frequency and PLF improvement exist and have been successful, the current fixed-benchmark approach for relating heat rates to tariffs has limitations, as discussed above. Thus, despite the CERC's early hopes of having continuous efficiency improvement though gradual tightening of operational norms (Rao, 1999), information asymmetry combined with the CERC's difficult balancing act of meeting conflicting objectives, has led to an impasse on setting tighter performance benchmarks. Hence, the development and application of a more nuanced approach, along the lines of 'yard-stick' regulation should yield significant benefits, especially given the observed wide variation in unit heat rates (Figure 1) and the high sensitivity of costs to heat rates (Figure 2). Hence, we propose a three-pronged scheme intended to promote continuous efficiency improvement in regulated power plants. All three elements of the scheme form an integral part of our proposal and their cumulative impact would result in increased efficiency and consumer benefit. The scheme, as outlined below, is applicable only to existing power plants in the country. Future power plants, which might include advanced technologies such as supercritical pulverized coal, will need to be considered separately.[26]

3.1 Revised performance benchmark

The basic tariff is calculated on the basis of a benchmark defined by the <u>median</u>[27] of <u>actual</u> (gross) <u>heat rates</u>[28] of peer groups of power plant units[29], rather than on the basis of normative benchmarks fixed by the CERC. Peer groups should be determined by existing technology categories, such as 500 MW, 210 MW KWU design, and 210 MW LMZ design[30]. The median heat rate (MHR) benchmark will be determined using data from all existing units in the country, regardless of ownership (i.e., central, state, and private power plants) or vintage. According to the CEA (CEA, 2005), the vintage of power plants is not correlated with heat rates[31], and hence we do not further divide the peer group into subcategories based on vintage. In any case, inclusion of all coal power plants in the country is necessary to ensure that they all have incentives to improve their performance.

We are conscious of the linkage between power plant heat rate and PLF. Heat rate is generally higher for a plant operating at low PLF. If low PLF is a result of external factors, such as low demand for electricity[32] or a shutdown for maintenance, an appropriate correction factor should be applied to the heat rate based on either the PLF or availability.[33] Whether such corrections should be normative or be dealt with on a case-to-case basis is a matter of regulatory decision. In other cases, plant performance could be reduced due to poor coal quality, a factor that might be out of the management's control. This is another issue that would need some attention.

The tariff for any period will be determined by the median heat rate of the preceding time period.[34] Therefore, at the beginning of any time period, the utilities will know the MHR benchmark that will apply for the period. This should help reduce uncertainties regarding their revenue stream. Thus, the tariff for the *k*th power plant, $T_k = FC_k + CP_k \times MHR$, where FC_k is the fixed cost and CP_k the price of delivered coal for the *k*th power plant, and MHR is the median heat rate for the relevant category of power plants. Figure 3 illustrates how changing the tariff for a 210 MW unit from the current approach (which sets the tariff based on the heat rate fixed at

2500 kCal/KWh) to a median-heat-rate approach would work. As an illustration, we assume that the MHR is 2475 kCal/kWh.

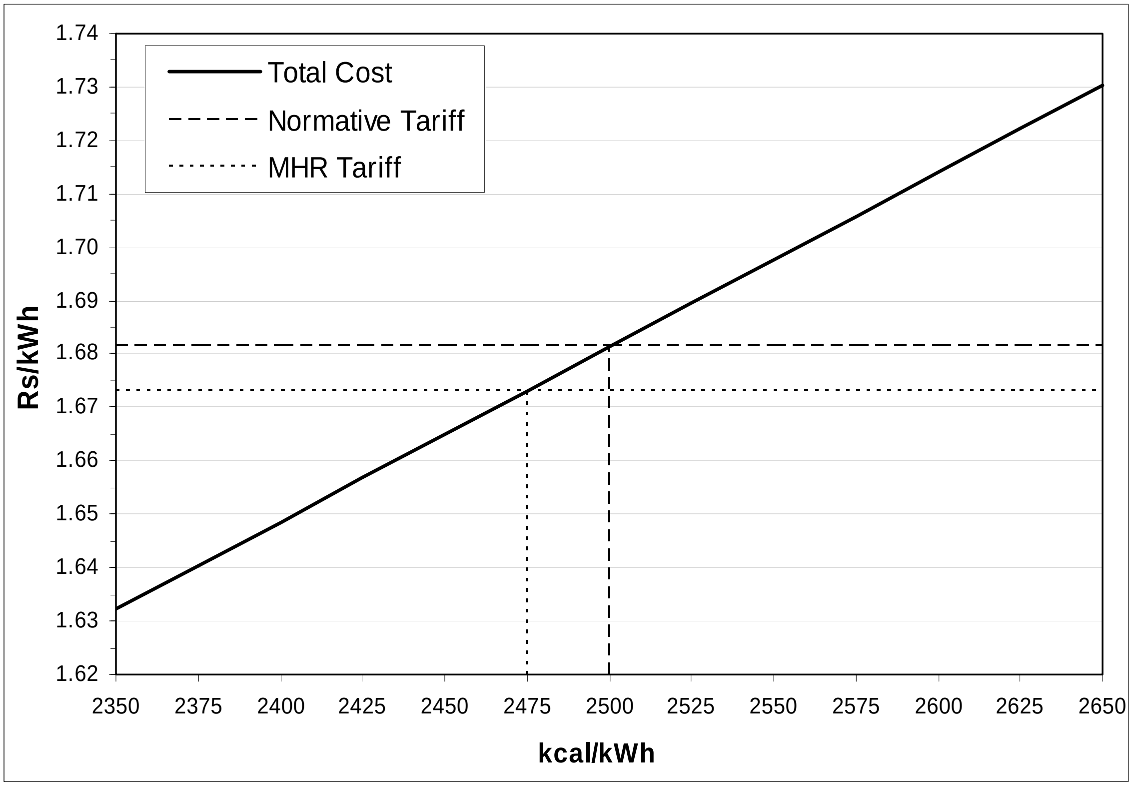

Figure 3: Tariffs for 210 MW units with the current fixed heat rate benchmark (using current heat rate of 2500 kcal/kWh) and with the median-heat-rate based approach (assuming a MHR of 2475 kcal/kWh). Units with heat rate better the median-heat-rate (left-side of MHR) receive profits, whereas those worse (right-side of MHR) will bear losses. The calculation for the total cost assumes a 210 MW unit with a capital cost of Rs. 40 million/MW, ROE of 14%, and debt-to-equity ratio of 70:30. Costs are after repayment of loan. The coal price is set at Rs.0.3/1000 kcal delivered and the remaining parameters are assumed at normative levels as in CERC Tariff Regulations 2004 (CERC, 2004b).

The major advantage of such an approach over the current tariff model is that it will automatically be adjusted over time (the exact period of the re-adjustment can be decided by the regulators after discussions among the stakeholders). It also obviates the need for a negotiation every time the tariff has to be updated. On the down side, the application of this approach is contingent on the availability of unit-level performance data – an issue that will be addressed later in the paper.

3.2 Relative performance incentive

A 'relative performance incentive' (RPI) provides additional motivation for plants to improve their efficiency relative to each other. This is a mechanism intended to provide a positive incentive for good performance rather than a penalty for poor performance – it is therefore targeted only at power plants whose efficiency performance is better than the median, with the level of incentive escalating with increasing deviation from the median efficiency.

There are two aims of the RPI: 1) high efficiency plants continue to be motivated to improve their performance; and 2) plants at or around the median efficiency get a strong incentive to reduce their heat rates. Thus, there is a step incentive at the median heat rate[35] followed by a gradual rise, which is in proportion to the deviation from the median efficiency. The step should provide a significant incentive to the median-performing plants to improve their efficiency and avail of the potential increase in profit margins. The gradual rise after that, in combination with the median-heat-rate-based benchmark, is intended to provide high-performing power plants with sufficient motivation to undertake heat-rate-improving activities and investments even as they reach closer to their design heat rate when further efficiency improvements becomes increasingly difficult. These power plants also warrant special attention since their PLF is generally higher than the average PLF for all coal-based power plants.

Thus, the incentive can represented as RPI = $A + B \times [(\mathrm{MHR} - \mathrm{HR}_k)/(\mathrm{MHR}\text{-}\mathrm{HR}_{best})]$, where the incentive for the *k*th power plant is linearly scaled with reference to the best-performing unit in the peer group (whose heat rate is HR_{best}). Regulators can set the appropriate values for the incentive through variables *A* and *B*, where *A* represents the step increment at the median, and *B* is a cost-scaling factor for gradual rise. Both *A* and *B* can be modified over time to adjust the incentives as the MHR comes closer to the design efficiencies of the power plants and further improvements become more difficult.

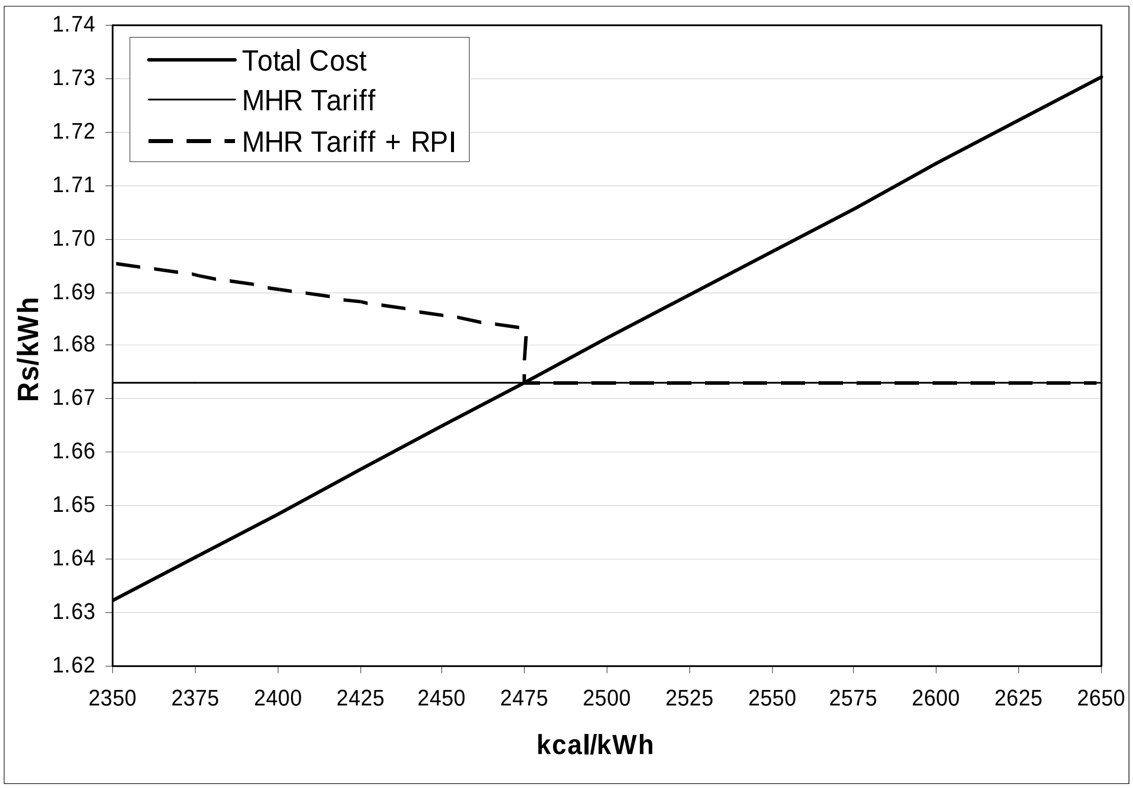

Figure 4**:** Illustration of the relative performance incentive for plants with performance at or better than the median heat rates. Note that the difference between the total cost and the MHR tariff represents profit of plants without any additional incentives; the difference between the dashed line and the MHR tariff represents the additional profits resulting from the RPI incentive. The assumptions underlying these calculations are the same as for Figure 3.

Figure 4 illustrates an application of the relative performance incentive. The tariff for plants above the median rises with an initial step of Rs. 0.01/kWh, followed by a rise of Rs. 0.01/kWh for every decrease in heat rate of 100 kcal/kWh. Note that these numbers are chosen for illustration only – the decision to set the appropriate level of incentives is best left to regulators.

3.3 Self-improvement incentive

A 'self-improvement incentive' (SII) provides financial benefit for power plants to improve efficiency in relation to their own past performance. The greater the improvement in the power-plant performance in relation to the previous time-period, the higher the incentive; at the same time, poorer-performing power plants are given a higher incentive than better-performers. This latter element is incorporated into the SII so as to ensure that poor performing power plants have extra motivation for enhancing their performance – the absence of such an arrangement could otherwise lead to a scenario with a bimodal distribution, where the high-performing power plants continue to improve their heat rates (and become more profitable) while the poor performers continue to lag further behind.

Improvements in heat rate can result from changes in managerial and operational practices – these are generally low cost and yield continuous, incremental improvements. Renovation and modernization (R&M) investments, on the other hand, can lead to quantum jumps in performance, although with much higher levels of investment. Figure 5 shows the relationship between changes in generation cost as a function of heat-rate improvement for a number of different-sized investments. Investments made by power plants (such as R&M) increases the fixed cost component of the tariff, while efficiency improvement made as a result of the investments can reduce the energy cost component of the tariff. Clearly an investment is desirable only if does not lead to an increase in the overall generation cost. Thus, the SII is provided only in such cases, wherein the reduction in energy costs resulting from efficiency improvements is large enough to outweigh the rise in fixed costs.[36] Furthermore, the SII provides greater rewards more cost-effective investments.

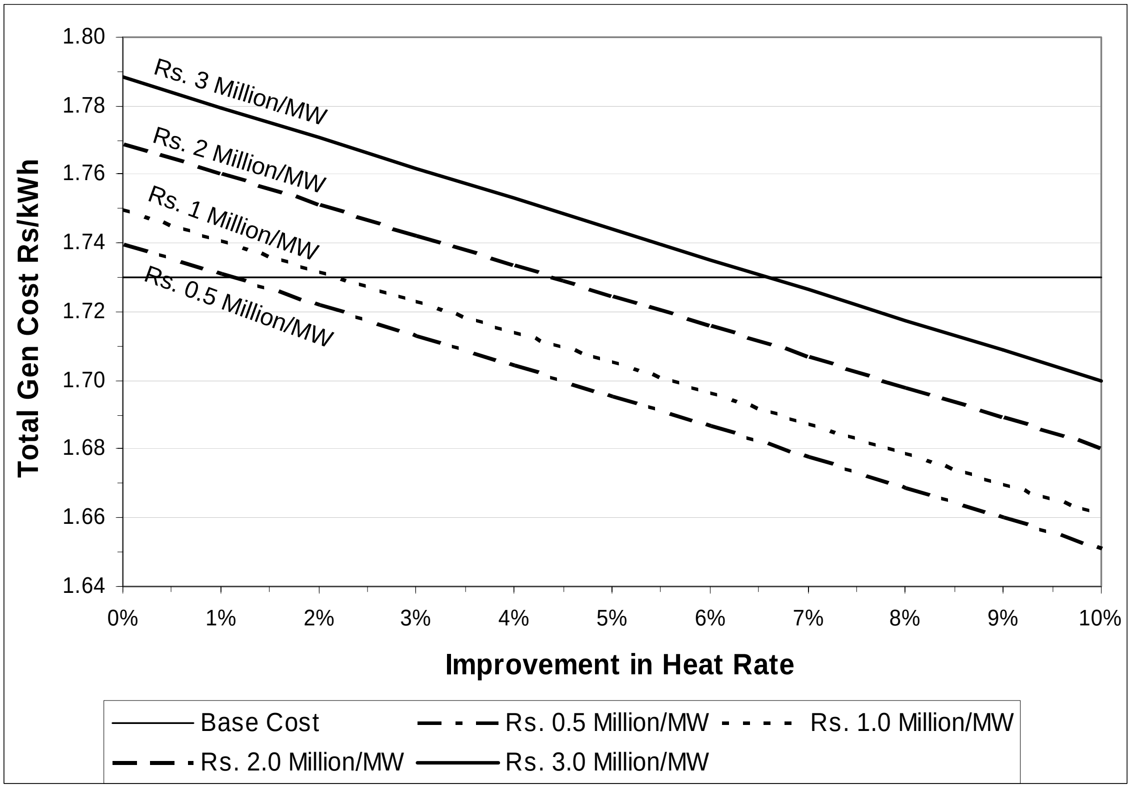

Figure 5: Change in generation costs as a variation of improvements in heat rate that occur different levels of investments. The initial base cost in this illustration is Rs. 1.73/kWh. The assumptions underlying these calculations are the same as for Figure 3.

Thus, this incentive can be represented as SII $\propto [TC_p - TC_c] \times [\Delta HR/HR_p] \times [(HR_p/MHR)]$, with the first term, $TC_p - TC_c$, representing the difference between the total generation cost (TC)[37] for a power plant between the previous and current time periods; the second term, $\Delta HR/HR_p$, representing the improvements in a unit's heat rate (ΔHR) relative to its heat rate for the previous time period; and the third term representing the ratio of the unit's heat rate relative to the median heat rate from the previous period. An additional multiplier can be utilized to set the appropriate maximum incentive.

Figure 6 provides an illustration of the SII, with the worst performing units receiving the greatest benefit, thereby reducing their losses.

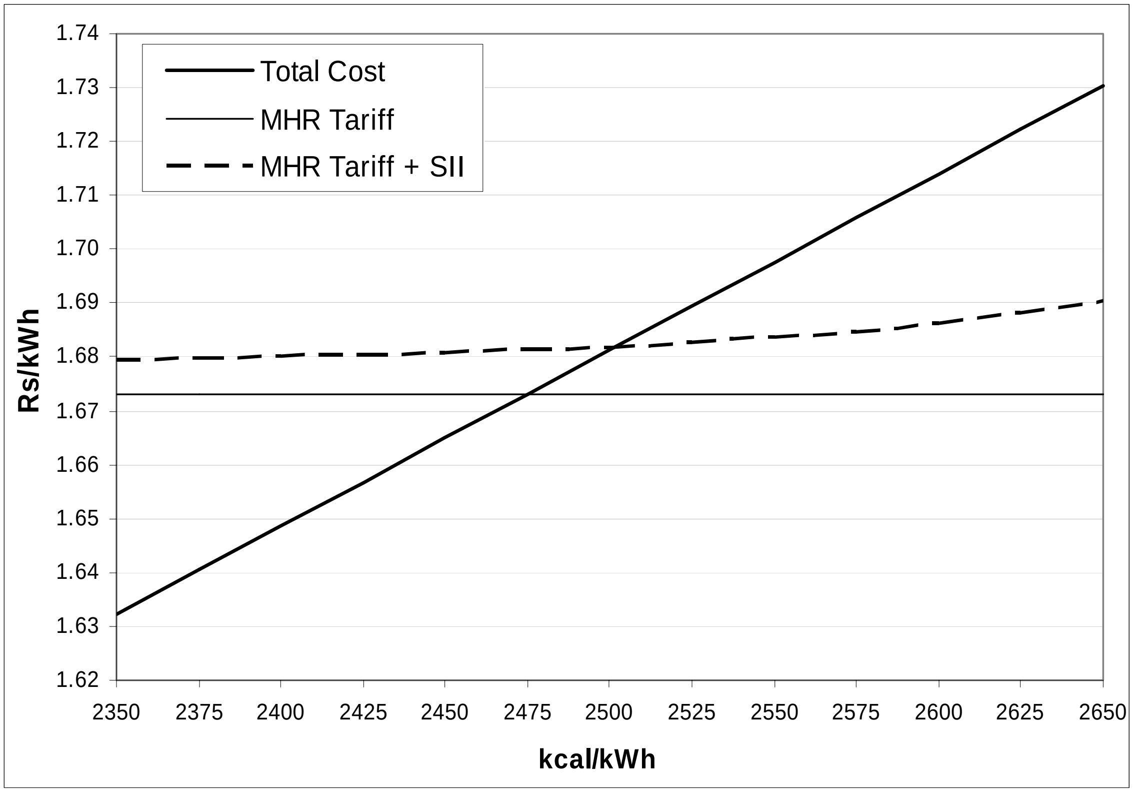

Figure 6: Illustration of self-improvement incentive. Note that the incentive holds for all units that demonstrate an improvement in heat rates, but for the same percentage improvement, poorly performing plants with a high initial heat rate receive greater benefits. Similar to the RPI, the SII provides additional profits for those plants that improve their heat rates. In this illustration, we assumed that there was 4% improvement in heat rate with an investment of Rs. 1 Million/MW. All other assumptions are the same as in Figure 3.

3.4 Summary of proposed incentive scheme

The proposal described above offers a number of benefits:

- By setting benchmarks based on actual performance, the regulators will have access to information that they were not privy to earlier. Much of the contention regarding normative heat rate benchmarks would be eliminated, and there would be constructive focus on how best to measure heat rates and create mechanisms for data collection.
- The RPI and SII incentives work concomitantly with the MHR based benchmark to improve heat rates, similar to the existing interlinking of PLF and UI incentives for increasing generation. Thus, the combined effect of all three elements of the proposal would result in improved efficiency of the system.

  ⇒ High-efficiency and median-efficiency power plants are given additional incentive for improving their performance. Since such power plants account for a significant majority of the power generated in the country, even small efficiency improvements can translate to significant positive gains for the power sector. Power plants around the median are specifically targeted with an incentive for improving their performance and thereby bringing down the median heat rate for the next time period.

  ⇒ Financial incentives through the SII are provided to all plants that continuously improve the efficiency of their operations through better management or through cost-effective R&M. This is particularly important for inefficient power plants – these power plants should significantly improve their performance or be phased out over time.

  ⇒ The current broad distribution of heat rates will eventually be reduced to a much narrower distribution centered around a low heat rate, as all plants aim to reach the best possible efficiencies.

- The MHR and RPI parts of the scheme result in power plant revenues being dependent on their performance relative to the median. Since the median heat rate is determined by the performance of all plants in a peer group, this scheme sets up an incentive for each unit to ensure that other operators are reporting accurate performance data. This is a major shift from the current situation where operators do not have any incentive to report accurate performance data to the CERC. Furthermore, central, state, and private generators all compete with each other, as the median heat rate is based on all their heat rates.

- It should be noted that efficiency improvement for any power plant is limited by its design efficiency. As the distribution of plant efficiencies becomes narrower (i.e., as the MHR starts approaching the design heat rates), improvements will become more difficult and the incentive structure may need to be adjusted accordingly.

- Furthermore, while some utilities might already have the technical and institutional capacity to improve the heat rates of their plants, poorer performing utilities will require technical and financial assistance to increase the efficiency of their power plants and to build the capacity to do so on an ongoing basis. This aspect needs particular attention since the success of this scheme hinges on poor performing plants having enough technical, financial and institutional support to improve their performance.

- Finally, use of the median hate rate as the benchmark, combined with various incentives to improve the heat rates of all the power plants, should result in a continuous improvement in the efficiency of the whole power sector, with concomitant economic, environmental, and energy-security benefits.

3.5 Issues for Regulators

As discussed earlier, the proposed incentive scheme for efficiency improvement should ideally be applied to all coal-based power plants across the country – including center, state, and private plants. However, the specifics of the structure, scope and period of applicability of the incentives will need to be determined by the Regulatory Commissions (both at the central and state levels). The CERC would need to take the lead in crafting various elements of the RPI and SII mechanism, especially the magnitude of incentives. The structure as laid down by CERC can be a framework for the state regulators, who may assign appropriate weights to these incentives depending on the state-specific issues. This arrangement is exactly the same as followed today for developing the tariff terms and conditions, allowing for transparency and public participation in the process. Though we have suggested that incentives may be different at the state and central levels, the heat rate benchmark for particular technology categories should be the same across the country. As discussed earlier, this norm should be the median heat rate, determined by actual heat rates of all units irrespective of their ownership – state, central and private.

Regulators also need to address a few other questions:

(i) How often to account for changes in the heat rates of the units, which in turn affect the median heat rate?

(ii) If a generator receives SII as a result of reduction in its heat rate, how long should it continue to receive this incentive?

(iii) How to structure the incentive scheme to minimize gaming by the utilities?

As the proposed incentive structure depends on actual performance of generating plants, the answer to the above questions relates to how often the actual unit heat rates are measured and the heat rate benchmark revised. Although it is a matter of regulatory judgment, we suggest that the heat rate benchmark be revised annually. This is in contrast to current practice where operational norms are revised on a five-year basis. We believe that such long time periods allow utilities to extract unduly high rent from the consumers, and also it propagates data opacity.

The RPI for any time period will change both with the changing MHR (determined from previous time period) and a unit's actual performance in the current time period.[38] In case of SII, the incentive should be applied over longer time periods (where the length could depend on the level of investment and shutdown period for doing R&M for heat rate improvement) so that the utility can reap the SII benefit over a time period long enough to make it financially attractive, especially if it undertakes a major R&M effort to improve its performance.

Regulators must assess possible scenarios under which the utilities could game this incentive scheme. For example, utilities might be able to periodically increase their heat rates and then gain the benefit of SII or RPI in subsequent time periods, and yet be better off than continuous reductions in heat rates. Such possibilities need to be thoroughly evaluated and appropriate safeguards must be put it place to prevent gaming.

4. Data collection and public dissemination

The successful implementation of these proposals hinges on monitoring, collection and reporting of accurate unit heat rate data that utilities may regard as confidential or may be unwilling to release for other reasons. As discussed earlier, utilities in India have been reluctant to provide accurate data to regulators, despite the regulators' efforts in this regard.[39] By providing incentives that are directly linked to actual performance, this proposal encourages utilities to report accurate data and also to push for compliance by their peers.

There are a number of possible institutional arrangements to collect better data and reduce the current information asymmetry.[40] For example, the utilities themselves could assess and collect unit heat rate data (using standardized guidelines, set with CEA guidance, if needed) in a consistent and systematic manner. An association of utilities could then verify and monitor the accuracy of this data for all reporting power plants. On the other hand, even the assessment and collection function could also be turned over to such an industry association. In either case, an independent body will be needed for oversight of the overall process to ensure its success – autonomy, technical expertise and absence of any vested interests must be the primary requirements of this authority.

While the collection of accurate performance data and the possibility of benchmarking against peers are critical, we believe that at least some aspects of the data must be released publicly. Even if confidentiality concerns preclude releasing detailed unit-level performance data to the public, we suggest placing power plant units into bins based on their heat rates[41] and making this category-level data publicly available. The advantage of such a structure is that it allows for plants to maintain the confidentiality of their actual performance data, since the regulators only have to reveal the bin in which they are currently situated. At the same time, the public and investors have some information about the performance of any power plant in absolute terms as well as relative to peers in the country and global benchmarks.

This could have two positive outcomes:

- Public scrutiny of such data may raise the pressure to improve performance in individual plants/utilities;
- Availability of aggregate or detailed peer-group performance could have an influence on utilities through the financial markets;

Even the simple act of having to collect and report accurate data may result in performance improvement in plants – experience from other arenas has shown that firms are often unaware of many details and nuances of their own performance. By the dint of having to collect and report such data, firms gain a much better understanding of their own performance, which in turn provides an internal incentive for improvement (Afsah et al., 1997).

It is increasingly understood that information is a powerful ally of regulators to improve environmental (and other forms of) performance and it is now often considered part of a regulators' toolkit. Such collection, integration, and sharing of information allows for performance assessment and benchmarking, and it can be thought of as a softer alternative to traditional regulation – although no less effective. A particularly effective example comes from the United States in the form of the Toxics Release Inventory (TRI). The TRI mandates collection and public dissemination of data on releases and transfers of certain toxic chemicals as well as on waste management and source reduction activities from industrial facilities. Analysts suggest that the TRI has contributed to significant reduction in industrial pollution (Jobe, 1999; Karkkainen, 2001). Karkkainen (2001) argues that the "TRI has convincingly demonstrated the reach and power of standardized and, therefore, comparable and aggregable performance data as a tool to measure, monitor, benchmark, and improve environmental performance." Information-based approaches have also been successfully implemented in developing countries, with the PROPER program in Indonesia being a prominent example (Afsah et al., 1997).

5. Discussion and conclusion

Enhancing the efficiency of power plants will benefit consumers in the long run because of reduced generation costs that will result from continuous performance improvements. In the short term, though, the additional incentives might increase tariffs slightly, depending both on the relationship between the MHR and the prevailing benchmark, and on the level of incentives allocated by the regulators. However, we expect that there should be significant consumer benefit as the utility behavior changes in response to the incentives. In this sense, the proposal is not intrinsically revenue neutral, unlike "feebates".[42]

Greater efficiency of power plants also translates into more efficient use of coal, resulting in enhanced energy security for the nation over the long term. As the utilities focus on efficiency improvements, they will demand improvements in coal supply, which in turn will provide incentives (and demand) for upgradation of coal-supply infrastructure. More efficient power plants will also result in local and global environmental benefits.

The existing information asymmetry between regulators and generators would be reduced as the heat rate benchmark is based on actual values, rather than on normative judgments. Importantly, the MHR based approach eliminates the contentious negotiations between the utilities and the regulators regarding the setting of operational norms. Equally important is the potential for collection of accurate data and its public disclosure, which would greatly advance the consumer interests. At the same time, confidentiality of heat rate data can be protected, if necessary, through the release of only bin-level data, as discussed earlier.

We understand that some utilities may be reluctant to agree to the kinds of proposals discussed here. However, given the urgent need to improve the efficiency of the country's power sector, another possible alternative could be the imposition of strict and continuously tightening performance norms derived purely from regulators' judgments.[43] Such an alternative scenario may induce the utilities to sign on to the kinds of proposal discussed in this paper.

It is important to reiterate that while improving the efficiency of power generation is a key element of overall improvements in the power sector, other elements, especially transmission and distribution, must also continue to receive attention. It is only through concerted action on all fronts that the performance of the Indian power sector will be at par with the other, more dynamic parts, of its industrial economy and help underpin the country's growth.

Finally, this proposal might also be of value to regulators in other countries undergoing power sector restructuring to incorporate incentives for supply-side efficiency improvement; although, the proposal will have to be modified as necessary to match local conditions. The scheme would apply in situations where there are well-defined technology categories and a large enough number of utilities/companies which have varied generation efficiencies. A benchmark could then be set based on actual performance of various units, and appropriate relative-performance and self-improvement incentives could be devised to move the units towards better efficiency over time.

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NOTES:

[1] The use of renewable sources in India is relatively small and it is used mainly in niche applications and locations; it currently contributes only about 0.5% of generation. Although their increased use is necessary and important, they are unlikely to play a significant role in the short term.

[2] Coal based electricity and heat contributed nearly 6.5 billion tons of CO_2 (27%) out of a total 25 billion tons of fuel-combustion-based CO_2 emissions in 2003 (IEA, 2005).

[3] Nonetheless, the recent emissions are still about 1/5th and 1/3rd of U.S. and China emissions, respectively. At the same time, India's carbon emissions on a per-capita basis are less than half that of China and almost 1/20th that of United States (World Bank, 2005).

[4] See, for example, (Chand and Sarkar, 2006; Chikkatur, 2005). This is in contrast to the conventional view that India has about 90-96 billon tons of coal reserves (BP, 2005; IEA, 2004; Ministry of Coal, 2006).

[5] Efficiency improvement in transmission and distribution is also an important aspect related to the final tariff paid by consumers – a subject that will not be addressed in this paper.

[6] In this paper, the terms "power plant" and "unit" are synonymous with each other; it consists of a boiler, a steam turbine, a generator and their auxiliary equipment. In India, the most common unit size is the 210 MW built by BHEL, and the largest operating unit size is 500 MW (mostly built by BHEL). The term 'power station' refers to a location in which there can be multiple power units/generators. A generation utility may manage and operate multiple power stations.

[7] The thermal efficiency of a power plant is usually measured in terms of its heat rate, which is the amount of the energy input needed to generate one kilowatt-hour of electricity. Efficiency is inversely proportional to heat rate (efficiency = 860/heat rate in kcal/kWh).

[8] The energy cost (EC) per kWh is the part of the tariff that is primarily related to coal price (CP in Rs./kg), the coal quality (CQ in kcal/kg) and the heat rate in kcal/kWh (HR), i.e. EC = HR x CP / CQ .

[9] Efficiency is calculated using the high heating value (HHV) for coal. The average fleet gross efficiency is about 32% (36% for 500 MW units), based on CEA (2005) data. See (Chikkatur, 2005) for more details.

[10] In practice, a pure cost-plus method is rarely applied, as the regulators examines expenditures against the usefulness and prudence of expenditure (Prayas, 2004).

[11] There is some question about the effectiveness of profit-oriented incentives for state-owned enterprises, where financial performance is not necessarily linked to manager and employee remuneration. In many cases, losses and lack of productivity have been covered by government subventions.

[12] This second hypothesis has been termed as the "interest-group" or "capture" theory, wherein regulation is supplied in response to demands of interest groups seeking to maximize the income of their members (Posner, 1974).

[13] Second-best optimization becomes important in cases of constraints such as budgetary constraint, taxes, regulations, etc. (Lipsey and Lancaster, 1956-1957).

[14] For example, the innovative ABT incentive mechanism has helped reduce frequency variations in the grid; meanwhile the norms of operations for power plants have helped establish baseline operational standards. Both these mechanisms are discussed in later sections.

[15] It should be noted that not all regulatory commissions operate transparently, nor have they provided sufficient space for including public interest issues (Prayas, 2003).

[16] In many cases, state and central regulators have relaxed the benchmarks for poorly performing power plants in order to ensure that they do not face enormous losses. Although this is done on a case-to-case basis, it can undermine the entire incentive scheme.

[17] In 1992, the government of India partially implemented the recommendations of the K. P. Rao Committee. This committee, for the first time, suggested that electricity tariffs are to be based on performance, and specified operational norms for power plants.

[18] The Central Electricity Authority (CEA) is a statutory organization that advises the central government on various technical and policy matters in the electricity sector.

[19] NTPC Limited, formerly known as the National Thermal Power Corporation, is the single largest utility in India; Neyveli Lignite Corporation (NLC) is a lignite mining and power generation company; North Eastern Electric Power Company (NEEPCO) is focused on hydro and thermal generation in the northeastern states of India.

[20] In general, utilities have tended to underreport their performance to extract maximum benefits from normative tariff. There is also the issue of utilities (operating successfully for decades) not accepting the oversight authority of newly formed regulatory institutions.

[21] CERC expected the central utilities to provide data relating to heat rate, coal consumption, secondary fuel oil consumption, PLF, availability, and auxiliary consumption.

[22] There is further reduction of 40 kcal/kWh in the heat rate norm for 500 MW units that have electrically driven boiler feed pumps.

[23] Rs. 0.25/kWh is simply based on the actual incentives accrued by generators in the past.

[24] The maximum UI rate has been determined based on the prevailing cost of generation of a typical liquid fuel plant indicating that excess demand may be met through liquid fuel generation, primarily naphtha.

[25] Though UI charges are handled at the regional level, CERC had to intervene in these cases and penalize the concerned SEBs.

[26] The danger of including new power plants in this scheme is that utilities might only install plants with technologies that come under categories covered in this scheme, rather than deploy advanced, high efficiency technologies. Of course, the proposed scheme can be extended to cover these new technologies, although this is beyond the scope of this paper.

[27] We use the median rather than the mean (average) because it is less sensitive to a distribution with wide tails. Furthermore, the median allows for half (and only half) of the power plants to receive incentives.

[28] We use gross heat rates as the indicator for simplicity. The use of net heat rates might be better, as it would include auxiliary power consumption.

[29] Note that we use unit heat rates rather than station heat rates, as in the current CERC regulations. The station heat rates do not provide accurate data, as many power stations in India have different units within them, such as 210 MW and 500 MW units. The 2000 CERC draft for operational norms was based on unit heat rates; however, it has since then been changed to station heat rates. Another possible option could be to use "fleet" averages of various utilities, categorized by technologies; however we do not explore this option here.

[30] We have not included plants of 100/110 MW size and smaller, since they are all extremely old and will likely be soon phased out.

[31] The CEA (2005) has found no conclusive trend on ageing based on heat rate data collected by them, and in many cases the performance of older units is found to be better than the younger units. This could be because of lack of availability of reliable data on linkage between R&M expenses, vintage and plant performance. As and when such reliable data is available, vintage may be considered as one of the criteria for categorization of plants.

[32] This would be clear from availability and scheduled generation of the plant.

[33] Such correction factors were applied in the CEA (2005) report.

[34] Clearly the appropriate length of the time period will be an issue of much discussion. While utilities will doubtless argue against frequent revision of benchmarks, we believe this hurts consumer interests by allowing utilities to extract excessive economic rent.

[35] In this illustrative example, the step is kept at the median heat rate for simplicity. The step could also be set a 1% below the median heat rate in order to ensure that plants near the median value are motivated to reduce their heat rates.

[36] Generally, R&M would also increase PLF, thereby allowing a faster recovery of the fixed costs related to R&M investment through increased generation. This could reduce the "fixed cost" considered for the provision of the SII.

[37] The total cost, TC, is the sum of the fixed cost and the energy cost based on the median heat rate, without any incentives.

[38] Since this calculation is necessarily post-facto (i.e., the energy charges/incentives for any period can only be determined after the end of the period), the utilities could get initially paid on the basis of performance in the previous time period, and then later corrected as data becomes available.

[39] This is an unfortunate reality in the Indian context, where the authority of independent regulation is yet to be fully established, especially given the political support enjoyed by many state-owned-enterprises. In theory, regulatory commissions in India have the right to audit utilities and obtain information; however, this right does not seem to have been exercised routinely (personal communication, Girish Sant, July 2006). In contrast, for example, many public utility regulatory commissions in the United States audits utilities if relevant information is withheld (personal communication, Ashley Brown, May 2006).

[40] Though we are specifically concerned with heat rates, one could also argue for monitoring and collecting, at the same time, other performance parameters such as PLF, auxiliary consumption, secondary oil consumption, and coal consumption.

[41] The size of the bins should be large enough to mask individual plant data, while at the same time providing fine enough resolution for meaningful comparison. The size of the bins can be a percentage of the MHR; for example if the MHR is 2475 kcal/kWh, the bins can be 1% of it (i.e., 24.75 kcal/kWh).

[42] The term *feebate* comes from the environmental policy arena and derives from a combination of *fee* and *rebate*. The basic concept is straightforward wherein high pollution options (such as gas guzzling vehicles) are levied a fee (tax) and this money is used to provide a rebate to lower polluting options (such as fuel-efficient cars).

[43] Note that the CEA's 1997 draft of operational norms was rather aggressive; although not inconsistent with the country's needs.