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Electricity sector restructuring in India: an environmentally beneficial policy?

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Abstract

It has been suggested that reforms to the electricity sector in developing countries encouraging the entry of independent power producers (IPPs) are likely to result in environmental improvements similar to those recently made in a number of developed economies. The present paper evaluates this claim by examining the experience of the Indian power sector. It finds that recent investments by IPPs have reduced the pollution-intensity of electricity generation in the country. Yet they have not brought the significant gains seen in countries such as the UK, nor are they likely to in the foreseeable future. This is largely a product of the nature and context of electricity sector reform in India which is less favourable to environmentally beneficial outcomes. Accordingly, the paper concludes by suggesting that the environmental benefits of restructuring are not automatic, but depend on the existence of an enabling structural, institutional and regulatory framework.

Keywords: Independent power producers; Pollution; Policy transfer

1. Introduction

There is widespread recognition that developing countries will need to make greater use of "clean" energy technologies if they are to avoid a dirty, inefficient industrialisation path. Approaches to advancing this process are often based on policies successfully innovated and deployed in developed economies (e.g., World Bank, 2000). Yet it is not always clear that these will deliver the same outcomes in developing countries where economic, institutional and regulatory conditions differ (Adams, 2001; Utting, 2002).

One such policy is electricity sector restructuring which, according to its supporters, not only results in lower prices for consumers, but improvements in environmental performance (Bacon and Besant-Jones, 2001). This, they claim, is most apparent in the case of generation where the opening-up of the grid to so-called independent power producers (IPPs)[1] in several developed economies has led to the commissioning of modern, clean generating plants, sometimes substituting older, heavily polluting ones in the process (IEA, 2001; The Economist, 2001). But will investments by IPPs produce similar environmental gains in developing countries?

This is an issue of critical importance. New ("greenfield") IPPs are expected to account for a significant share of capacity addition in many developing economies over coming decades (Hansen, 1998; Torrens and Stenzel, 1998; Izaguirre, 2000). For this reason, they will have a decisive influence on their future emissions trajectory and, with it, contribution to global environmental change. Unfortunately, with the exception of a handful of specific studies (Blackman and Wu, 1998; Murray et al., 1998; Couch, 1999), relatively little is known about the actual choices of IPPs in developing countries and the extent to which these differ from those made in developed ones (Crow, 2001).

The purpose of this paper is to contribute to the debate about the impacts of IPP involvement and, more broadly, the transfer of policies from developed to developing countries (Dolowitz and Marsh, 1996; Forsyth, 1999; Utting, 2002). To this end, it examines the recent experience of India, and asks whether current forms of restructuring are likely

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[1] IPPs are also referred to as non-utility generators in this paper.

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to lead to an improvement in the environmental performance[2] of the sector.

A priori there are grounds to support both cases. On the one hand, the portents for a repeat of the environmental gains made in the UK, and to a lesser extent, a number of other developed economies, would appear to be good. The Indian power sector has traditionally been dominated by state-owned utilities producing electricity, for the most part, using coal in relatively old, inefficient and polluting plants (Bhattacharyya, 1995). As such, one might expect IPP developers using modern, environment-efficient generating technologies to reduce the pollution-intensity[3] of electricity production. Yet, on the other, a combination of weak environmental regulations, abundant coal supplies and stringent cost pressures on project developers might suggest that they will be reluctant to invest in environmentally sound generating options, many of which are more expensive on a capital-cost basis.

The paper finds that recent investments by IPPs have reduced the pollution-intensity of India's generating capacity, and look set to do so over the next few years. Still, independents have not brought the significant gains witnessed in the UK, and are unlikely to in the longer-term. This owes much to the nature and context of electricity sector restructuring in India which is found to be less favourable to environmentally beneficial outcomes. Consequently, the paper concludes by suggesting that caution needs to be exercised in assuming that policy outcomes realised in one locale will necessarily be replicated in others. In doing so, it reinforces the argument that realising the economic and/or environmental benefits of privatisation and liberalisation crucially depends on the existence of a complementary institutional and regulatory infrastructure (Commander and Killick, 1988; Forsyth, 1999; Pesic and Ürge-Vorsatz, 2001).

The rest of the paper is structured as follows. Section 2 details the recent emergence of IPPs and reviews existing arguments about their environmental impacts in developing countries. Section 3 provides a brief introduction to the Indian electricity supply industry and examines the extent to which the involvement of IPPs is reducing the emissions-intensity of electricity generation. Section 4 seeks to explain why the environmental gains from restructuring in India have been, and are likely to be, relatively small. And Section 5 concludes by drawing lessons about the potential for electricity sector reform to generate environmentally beneficial outcomes in developing countries.

[2] The focus of this account is principally on air pollutants although it is acknowledged that there are many other forms of environmental damage associated with the construction and operation of power plants (e.g., ecosystem submergence).

[3] Pollution-intensity is defined as the quantity of pollutants associated with each unit of generating capacity and/or output.

2. IPPs: a new trend with far-reaching environmental impacts

2.1. Electricity sector reform and the emergence of IPPs

Historically, responsibility for expanding electricity supply in many developing countries fell to one or more state-owned utilities controlling generation, transmission and distribution. Over the past decade, however, this model has been challenged by two dynamics. The first is the broader ideological shift towards neo-liberalism which has seen many governments abandon state-led development policies in favour of more market-based ones. The second, meanwhile, has been the inability[4] and/or unwillingness of governments in developing countries to finance the large capacity additions needed to meet rapidly rising electricity demand,[5] prompting many to turn towards the private sector as a long-term operator and financier of power projects (Khatib, 1998; Izaguirre, 2000; Dubash, 2002).

It is against this background that developing countries have taken steps to restructure their power sector (Patterson, 1997; Khatib, 1998; Turkson, 2000; Bacon and Besant-Jones, 2001). In practice, this has involved different policies in different places, making electricity sector restructuring difficult to define (Brennan et al., 2002). Yet a common element has been measures to permit the involvement of IPPs, widely understood as generating entities that sell their electricity to a grid, owned and/or controlled by a third-party (Ripple and Takahashi, 1997). Pioneered in the US in the late-1970s,[6] independents have since proved popular in developing countries as a vehicle to augment limited public sector resources for electricity investments[7] (Hsu and Chen, 1997; Patterson, 1997; Forsyth, 1999).

Most IPPs are private firms. Some of these are large, transnational developers with projects in a number of different markets across the world, while other independents are locally owned and operated. Still others are joint-ventures involving both foreign and local equity partners (Murray et al., 1998; Crow, 2001; Branston, 2002). Projects promoted by IPPs range from large fossil-fuelled plants with capacities of several thousand

[4] Multilateral development banks (MDBs), which formerly supplied a significant share of funds for capacity addition in developing countries, have proved increasingly reluctant to extend financing to conventional energy projects (Ripple and Takahashi, 1997; Khatib, 1998).

[5] The IEA (2001, p. 212), for example, estimates that financing new generating capacity needed in developing countries over the period 1997–2020 will require US$1,709 billion.

[6] Under the 1978 Public Utilities Regulatory and Policies Act (PURPA) independent firms were allowed to set-up generation facilities and sell their power to existing utilities (Patterson, 1997).

[7] Asia boasts the largest number of IPPs with projects totaling some US$54 billion, followed by Latin America with approximately US$6 billion (Albouy and Bousba, 1998).

MW to small renewable energy facilities capable of generating little more than a few kW of electricity. Many analysts, however, exclude small-scale projects from the definition of IPPs, especially where they are unconnected to the main grid network. Accordingly, the rest of this paper only focuses on utility-scale, grid-connected capacity.

2.2. Prevailing thoughts about the environmental impacts of IPPs

The majority of analysts agree that IPPs will account for a large share of capacity addition in developing economies over coming decades (Izaguirre, 2000; Lefevre and Todoc, 2000; Bacon and Besant-Jones, 2001). Less clear, however, is the environmental significance of this trend with arguments being made for and against the idea that restructuring is likely to bring environmental benefits. Proponents of the former have based their argument on two key assumptions. First, as privately owned companies, IPPs are likely to have better levels of environmental performance than utilities, the bulk of which are under public ownership. This, on the one hand, is because they command superior compliance technologies and know-how. While, on the other, private firms are more responsive to formal and informal regulatory pressures than their counterparts in the public sector (IEA, 2001).

A second assumption is that IPPs in developing economies will make investments in generating capacity similar to those made in many developed economies that have restructured their power sectors (The Economist, 2001). These include, first and foremost, gas-based combined-cycle gas turbine (CCGT) plants whose low capital costs, short gestation times and modularity have made them popular with independents. In the UK, for example, virtually all of the IPP plants commissioned since the early-1990s have used this technology (Branston, 2002). This is significant since gas-fired CCGT plants are far less polluting than the conventional coal-fired ones which have long been favoured by state- and/or privately-owned utilities (Justus, 1997; Smeloff and Asmus, 1997). Indeed, because the so-called "dash to gas" in the UK led to the closure of older, coal-fired plants, electricity restructuring has been accompanied by a net reduction in CO_2 emissions and an even greater reduction in SO_2 (Collier, 1998; Pearson, 2000; Vrolijk, 2002).

Proponents of IPPs also point to their willingness to make investments in two other generating options: (1) co-generation involving the simultaneous production of heat and electricity; and (2) non-hydroelectric renewables, and especially wind. Much like gas-fired CCGT, these environment-efficient generating routes have historically been neglected by utilities. Yet, in many countries that have opened-up their grids, independents have been responsible for a marked increase in their contribution to electricity supply (Weber, 1998; Hirsch, 1999; Darmstadter, 2002).

Critics, however, have questioned whether the environmental gains associated with restructuring in the UK, and to a lesser extent several other developed economies, will necessarily be replicated in developing ones. This, they suggest, is because the starting point for electricity sector reform differs, often quite significantly, between these countries. In developed economies, restructuring has taken place against a backdrop of excess capacity and well-developed regulatory institutions. Similarly, measures to involve IPPs have been accompanied by structural reforms to promote competition in the sector (Bruggink, 1997; Brennan et al., 2002). This contrasts with developing countries where capacity shortages predominate, regulatory institutions remain weak and IPPs face limited competition in supply. Consequently, there is little or no guarantee that developers in these countries will make similar investments, including environmentally beneficial ones (Rosenzweig and Voll, 1997; Forsyth, 1999).

Unfortunately, what little research has been undertaken in developing countries has reached mixed conclusions about the environmental consequences of increased IPP participation. A number of studies have indicated a positive role, finding that IPPs adopt more efficient conversion technologies than utilities (Blackman and Wu, 1998; Murray et al., 1998). Others, meanwhile, have underlined the need to be more cautious about the potential benefits of IPPs. To this end, they point to the tendency of many transnational developers to build coal-fired plants, rather than less-polluting gas-fired CCGTs or renewables (OECD, 1997; Qudrat-Ullah and Davidsen, 2001; Greenpeace, 2002). Moreover, far from incorporating the latest, efficient conversion technologies, they describe how the majority of IPPs are opting for relatively proven, standardised designs with lower levels of environmental performance than recently commissioned plants in developed economies (Torrens and Stenzel, 1998; Couch, 1999; Vernon, 1999).

2.3. The importance of local context

No doubt, one reason why previous studies have reached differing conclusions about the environmental impacts of IPP involvement is that they have been based on very different methodological assumptions. Yet, there may be another, more straightforward explanation. Far from there being a single, universal outcome associated with electricity sector restructuring, the actual impact of non-utility participation may well vary according to local circumstances. This idea, of course, has underpinned critiques of environmentally beneficial restructuring. It has also been a recurrent theme of recent conceptual work which, in broad terms, has

Table 1
Factors shaping the environmental outcome of IPP involvement[a]

Variable	Relative impact on pollution-intensity of electricity generation	
	Beneficial	Detrimental
Existing fuel mix in the utility sector	High share of coal and/or other pollution-intensive fuels	High share of hydro and nuclear
Conversion and end-of-pipe technologies used by utility producers	Existing capacity characterised by dirty, inefficient conversion technologies and/or limited end-of-pipe controls	Existing capacity characterised by clean, efficient conversion technologies and/or effective end-of-pipe controls[b]
Capacity utilisation in utility sector following entry of IPPs	Reduced electricity generation from pollution-intensive utility plants	Increased electricity generation from pollution-intensive utility plants
Tariff structure for IPP developers (i.e., the terms under which developers are remunerated by the power purchaser)	Encourages IPP developers to select generating options with low specific capital costs (specifically, gas-fired CCGT) over ones with low specific variable costs (especially coal)	Favours generating options with low specific variable costs over ones with low specific capital costs (although where the payment structure advantages hydro this may produce environmental gains)
Fuel supplies available to IPP developers	Ready availability of cheap, secure and/or indigenous gas; abundant wind farm sites	Abundant low-cost, indigenous coal reserves combined with limited gas
Policy on fuel imports/usage	Few restrictions on the type and/or quantity of fuel used for IPPs projects	Restrictions on import and/or usage of low-emitting fuels through quotas and fiscal instruments[b]
Government policy on renewables/co-generation	Purchasing entity required to buy share of power from renewable and/or co-generation capacity; fiscal concessions or other financial support for promoters	Policy restrictions on the development of renewables and/or co-generation by private developers
Environmental regulations for IPP plants	Stringent environmental regulations for new capacity; enhanced requirements for IPP developers	Similar environmental requirements for old utility plants and new IPPs[b]
Restrictions on imports of capital goods	Low and/or zero duty on imported conversion and end-of-pipe technologies	High duty or non-tariff barriers on imported equipment, including high-efficiency conversion technologies and advanced end-of-pipe devices[b]
Local manufacturing capabilities in conversion and end-of-pipe technologies	Full range of equipment available from locally based vendors on a competitive basis	Limited capabilities in the design and manufacture of clean conversion technologies and more advanced end-of-pipe devices[b]

[a] *Source*: Author based on published literature.
[b] Fuel and technological choices of IPPs likely to be little or no different to utilities.

identified three factors said to define the environmental outcome of IPPs in practice (OECD, 1997; USAID, 1998; Burtraw et al., 2000; IPCC, 2001; Brennan et al., 2002). These are:

- The pollution-intensity of electricity generation from existing utility capacity;
- Changes in electricity generation from utility plants following the entry of IPPs into the market; and
- Various government policies and resource endowments which shape the fuel and technological choices of IPP developers.

Table 1 lists these factors in more detail, together with the conditions under which they generate positive and negative environmental outcomes.

Accepting, for the moment, that the environmental outcome of electricity sector restructuring is indeed context-specific, the question becomes whether the conditions commonly associated with positive outcomes are found in developing countries; or simply restricted to a handful of developed economies advanced as ''win-win'' models of environmentally beneficial electricity sector reform.

The rest of this paper seeks to address these issues using the example of the Indian electricity sector. It is acknowledged from the outset that India is not representative of all developing economies that have recently allowed IPPs to generate power for the grid. In particular, unlike many of its counterparts in Asia and Latin America, the country lacks sizeable gas reserves and a natural gas infrastructure (Mitchell et al., 2001). Even so, it shares a sufficient number of characteristics to suggest that meaningful conclusions might be drawn about the environmental implications of electricity reform in developing countries.[8]

3. Examining the Indian experience

3.1. From public monopoly to private franchise

Historically, and in common with the vast majority of developing countries, India's electricity sector has

[8] China is similarly characterised by limited gas reserves and large, indigenous coal deposits (Khatib, 1998; Mitchell et al., 2001).

Table 2
Capacity by fuel-type for IPPs and utilities[a]

Category	Capacity by fuel-type (%)						
	Coal[b]	Gas[c]	Fuel oil[d]	Nuclear	Hydro[e]	Wind	Total (MW)
Utilities							
Commissioned	62.47	7.35	0.6	2.78	26.74	0.06	97,724
Planned 2002–2007	60.22	3.49	0.23	3.19	32.87	0.0	40,746
IPPs							
Commissioned	7.27	61.08	8.23	0.0	1.98	21.44	6738
Planned 2002–2007	24.00	39.60	5.93	0.0	13.35	17.12[f]	8763

[a] *Source*: Central Electricity Authority (2002), Planning Commission (2002) and Ministry of Power (2002).
[b] Includes lignite.
[c] Includes naphtha.
[d] Includes diesel and refinery residue.
[e] Large- and medium-scale hydro only.
[f] Author's best estimate based on discussions with local experts.

predominantly been developed in the public sector. This was the direct result of government policy adopted soon after independence in 1947, which not only reserved all new capacity addition for the state, but also made available large funds for investment under its five-year plans. Chief responsibility for power sector development was allocated to vertically integrated state electricity boards (SEBs) set-up in the early-1950s to manage electricity production, transmission and distribution at the state level. They were subsequently joined by nine central generating companies, established in the mid-1970s by the federal government to supplement the activities of the SEBs.[9] In little over four decades, these state- and central-sector entities commissioned nearly 65 MW of capacity. Over seventy percent of this was coal-fired with much of the remainder fuelled by hydro (Rao et al., 1998).

Growing power shortages, together with acceptance that existing public-sector utilities lacked the resources to meet capacity expansion requirements, led the government to open the electricity generating sector to private participation in 1991 (Arun and Nixson, 1998). Both domestic and foreign IPPs were allowed to commission power plants. Moreover, in an effort to secure their participation, the government offered potential investors a generous package of incentives, including a guaranteed rate of return on equity (Council of Power Utilities, 1999).

Nearly 7 GW of capacity has been commissioned by IPPs since the early-1990s; a figure that many analysts expect to increase substantially over coming decades (World Bank, 1999; IEA, 2002). Have these investments brought significant environmental gains? And are they likely to do so in the longer-term? In order to answer these questions, the remainder of this section considers the influence of IPPs on three critical variables that determine the emissions-intensity of the electricity generation sector: (1) the share of different fuels used to produce electricity; (2) the conversion and end-of-pipe technologies used by generating companies; and (3) output from existing utility generators.

3.2. Shifts in the fuel mix

Since their entry in the early-1990s independents have reduced the overall pollution-intensity of India's fuel mix. This has been the result of two factors. First, as shown in Table 2, the majority share of IPP investments have been gas-based and therefore considerably less polluting than current utility capacity which is dominated by coal. Second, IPPs have dramatically expanded the share of India's electricity produced from wind, commissioning over 1400 MW. This is in stark contrast to utilities who have shown negligible interest in developing non-conventional energy sources.

Partly offsetting these relative gains has been the reluctance of IPPs to invest in hydroelectric plants. In fact, only a mere 2 percent of their capacity is fuelled by this emissions-neutral power source, compared with nearly 27 percent in the utility sector.[10] Still, applying emission factors to their respective fuel mixes (Table 3) indicates that the pollution-intensity of the current IPP fuel mix is markedly lower than the utility one.[11]

Looking towards scheduled capacity addition over the period 2002–2007 a familiar pattern emerges. The

[9] The central sector generating entities are similar to recent entrants in the IPP sector in that they sell their power to a third-party distributor. However, in terms of financing and tariff remuneration, they have far more in common with more conventional, vertically integrated utilities.

[10] This figure, however, excludes more than 1000 MW of small hydro projects (i.e., <25 MW) developed in the private sector.

[11] Note, these estimates assume that IPPs and utilities use similar conversion and end-of-pipe technologies.

Table 3
Specific emissions from IPP and utility capacity (g/kWh)[a]

Category		CO_2	NO_X	SO_2	SPM
Commissioned capacity	Utilities	675.53	4.76	4.55	1.49
	IPPs	366.77	1.31	1.00	0.18
	All[b]	654.92	4.53	4.31	1.40
Planned 2002–2007	Utilities	611.62	4.38	4.20	1.39
	IPPs	433.64	2.25	2.03	0.56
	All[b]	580.11	4.00	3.82	1.24

[a] *Sources*: Author's calculations based on emission factors reported in Eberhard et al. (2000), Mittal and Sharma (2002) and Rabl and Spadaro (2002).
[b] Aggregate of IPP and utility capacity.

characteristic preference of IPPs for gas continues although it looks set to play a less dominant role in the overall fuel mix than has been the case in the past. Similarly, the comparatively high share of utility capacity powered by coal and hydro stays remarkably stable, at approximately 60 and 33 percent, respectively.

Not surprisingly, therefore, impending IPP investments look set to be markedly less polluting than scheduled capacity addition in the utility sector. Moreover, although estimates reveal that the emissions "gap" between these producers will narrow over coming years, in reality they are more likely to widen. Few analysts expect any of the six coal-based projects slated to come-up in the IPP sector to be built in practice. Instead, the bulk of capacity addition is likely to be fuelled by gas and renewables[12] (Power Line, 2002a, 2003), meaning that specific emissions are likely to be far lower than suggested in Table 3.

Still, although indicating that IPPs are shifting the fuel mix towards less emissions-intensive sources, there are two reasons to question the significance of this trend. One is that the reduction in the overall pollution-intensity of generating capacity has been relatively small. This stems from the fact that IPPs currently account for a mere 6.5 percent of installed capacity in India. Furthermore, with the bulk of forthcoming capacity addition likely to take place in the utility sector (Power Line, 2002b), this figure is unlikely to rise much in the near future. In fact, without a significant (and unexpected) burst of activity in the IPP sector, they will continue to have a relatively minor influence on the pollution-intensity of electricity generation in the country, irrespective of their fuel choices.

The other reason to question the benefits of IPPs is that, looking beyond the current decade, coal looks set to play a far greater role in their fuel mix. A large number of coal-fired plants have already been planned by independents (see Table 4). However, the poor financial health of the purchasers of IPP power (i.e., the SEBs) has meant that developers have been unable to secure external finance for these projects (Dua, 2003), whose capital requirements are far higher than equivalent gas-fired CCGT ones. Nonetheless, recent structural reforms at the state level—and specifically, the unbundling, corporatisation and/or privatisation of SEBs—are likely to strengthen the financial position of power purchasers and, with it, the willingness of financial institutions to fund coal-fired projects (World Bank, 1999; IEA, 2002). This, in turn, points to a long-term increase in the pollution-intensity of IPPs, bringing their emissions closer to levels currently seen in the utility sector.[13] Indeed, had it not been for the precarious state of SEB finances, it is doubtful whether the pollution-intensity of recent investments by independents would have been significantly lower than utilities'.

Table 4
Planned IPP projects (2001)[a]

Category	Coal	Gas	Fuel oil	Hydro	Total
Capacity (MW)	23,046	25,942	5363	2654	56,005
No. of projects	34	71	54	8	167
Share (%)	41.15	44.54	9.58	4.74	100

[a] *Source*: Power Line (2001).

3.3. Changes in conversion and end-of-pipe technology

As well as shifting the fuel mix towards cleaner energy sources, at least in the short-term, the available evidence suggests that the involvement of IPPs is likely to improve the efficiency through which these fuels are converted to electricity. Many of the recently commissioned CCGT plants in the IPP sector, for example,

[12] These include grid-connected biomass/bagasse, solar and hydro whose precise contributions, although unknown, are likely to amount to several thousand MW (Puri, 2003).

[13] Recent discoveries of indigenous gas, however, mean that the share of coal in the future IPP fuel mix may be smaller than previous estimates have suggested (Sarkar and Jayaram, 2003).

have levels of efficiency higher than any of the gas-fired units in the utility sector. Likewise, nearly all of the coal-fired IPP projects are scheduled to use sub-critical pulverised coal technology with a design efficiency of approximately 38 percent, a figure that is markedly higher the average value of 31.6 percent for equivalent plants in the utility sector (Sivaramakrishnan and Siddiqi, 1997).

A similar conclusion applies to end-of-pipe controls where coal-fired IPP developers are specifying electrostatic precipitators (ESPs) with design efficiencies of at least 150 mg/Nm^3. Moreover, many of the larger promoters are opting for ESPs capable of 100 mg/Nm^3, and some as low as 50. The majority of precipitators installed on stations operated by utilities in the state sector, by contrast, have far lower capture efficiencies (Govil, 1998). Consequently, they are unable to achieve anything like the statutory norm of 350 mg/Nm^3 for older plants, let alone 150 mg/Nm^3.

Yet, despite their apparent technological superiority, IPP investments need to be evaluated in context. First, the bulk of utility capacity was built one or more decades ago when higher efficiency designs were not available to power producers in the country. Environmental regulations were also comparatively weak, or absent altogether at this time, meaning that the requirements for pollution-control equipment were far lower than those facing today's developers.

Second, differences in the technological specification of recently commissioned and/or planned plants in the IPP and utility sectors are small or non-existent. Most of the coal-fired plants developed by utilities since liberalisation in the early-1990s, for example, have efficiencies equal to units planned in the IPP sector. Moreover, the country's leading public-sector utility, the National Thermal Power Corporation (NTPC), has gone beyond any of the independents by selecting supercritical technology for its forthcoming 1980 MW Sipat-I station.[14]

The specifications of end-of-pipe technologies have also been surprisingly similar. The majority of coal-fired utility plants, for example, are being fitted with ESPs with capture efficiencies in the range of 100–150 mg/Nm^3. Likewise, in common with their counterparts in the IPP sector, only a handful of utilities plants feature flue gas desulphurisation (FGD), and none selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR).

Therefore, although it is perhaps inevitable that IPPs are adopting technology that is less environmentally damaging, this principally reflects the fact that many utility plants are relatively old, rather than the inherent superiority of independents.

3.4. Electricity production from existing utilities

The addition of nearly 7 GW of IPP capacity over the past decade has not reduced output from utility capacity. Instead, all of the indications suggest that electricity production from these plants has actually risen. The plant load factor (PLF) from utilities in the state and central sector, for example, increased from a combined average of 58.4 percent in 1992–1993 to 70.85 in 2001–2002 (Planning Commission, 2002).

4. Explaining the Indian experience

Overall, therefore, the experience of India provides ambiguous support for the idea that the policy of involving independents in developing countries can bring environmental gains. In common with their counterparts in developed countries, independents have shown a clear preference for gas-fired CCGT and, to a lesser extent, wind. Further, because these energy sources are far less polluting than coal, a fuel which continues to dominate utility capacity and investments, the involvement of IPPs has resulted in a familiar reduction in specific emissions.

Yet, it is clear that the magnitude of these gains has been relatively small, and far below levels in the UK where electricity sector restructuring has produced an absolute reduction in GHG emissions. This can be explained by two factors. First, the response of independents in India has been relatively disappointing, having commissioned a mere 7 GW of capacity since liberalisation in 1991. By comparison, more than 22 GW of CCGT plant has been built by IPPs in the UK over the same period (DTI, 2002). Hence, despite similar fuel preferences, the net impact of independents in India has been far smaller. Second, capacity addition by IPPs has not reduced electricity generation from older, more emissions-intensive utility plants. In practice, this means that the significant gains achieved in the UK from the closure of heavily polluting coal- and oil-fired plants have not been obtained.

Nor does the weight of evidence indicate that these environmental benefits will be seen in the long-term, despite the likely addition of considerable IPP capacity. This is because a significant share of it looks set to be fuelled by coal, marking a significant departure from the majority of developed economies where the investment portfolio of IPPs have included very few coal-fired plants (Justus, 1997; Burtraw et al., 2000; Vrolijk, 2002).

What accounts for these mixed results? The present paper suggests that the answer lies in a combination of

[14] Black and Veatch (2000) report that 660 MW supercritical coal-fired units under Indian conditions are likely to achieve a net efficiency of 36.4 percent compared to 35.7 percent for equivalent subcritical units.

generic preferences, on the one hand, and local circumstances, on the other. Beginning with the former, it is possible to identify two key factors responsible for similar patterns of technological choice:

(a) *Generic preferences of developers*: Unlike public utilities, IPPs are profit-seeking entities, heavily reliant on third-party commercial debt to finance their projects. These characteristics cause developers to favour generating options which exhibit: (1) comparatively low up-front capital costs; (2) short gestation periods; and (3) low levels of technological risk (Justus, 1997; USAID, 1998; Pearson, 2000; Branston, 2002). In practice, these requirements are typically best met by gas-fired CCGT, hence the popularity of the technology with developers, even in very different market settings.

(b) *Public support for renewables*: In common with the majority of developed economies, measures to restructure the electricity sector in India have been accompanied by regulatory and fiscal support for the uptake of renewables (Jagadeesh, 2000; Puri, 2003).

Differences in the outcome of restructuring, meanwhile, can largely be explained by local specificities in the context and nature of electricity sector reform. Six of the most important are described here. The first two explain the comparatively small gains associated with the involvement of independents in India; and the remaining four, the unique preference for coal-fired plants in the country:

(a) *Capacity shortages*: The majority of developed economies enjoy a surplus of generating capacity. Consequently, the commissioning of additional IPP capacity has sometimes hastened the closure of older, more polluting coal-fired plants (Hansen, 1998; Branston, 2002; Brennan et al., 2002). India, by contrast, currently suffers from a chronic supply deficit (Planning Commission, 2002). Therefore, despite recent capacity addition in the IPP sector, few utility plants have been taken out of service for the simple reason that they continue to be needed for the supply of baseload power.

(b) *Electricity purchasers*: Unlike their counterparts in the majority of developed economies, the purchasers of IPP power in India (i.e., the SEBs) have weak finances (Crow, 2001; Power Line, 2002a). One consequence of this is that developers have been unable to secure finance for their projects. This, in turn, has checked capacity expansion by IPPs and their influence on the overall pollution-intensity of electricity generation.

(c) *Fuel supplies*: In many developed economies, the existence of "deregulated" gas markets and well-developed distribution infrastructures has meant that IPP developers have had access to relatively cheap, secure supplies of gas (Mitchell et al., 2001; Victor, 2002). The availability of natural gas for power generation in India, by contrast, is far more limited. Not only are indigenous reserves relatively small, but a combination of geopolitical tensions and concerns over foreign exchange leakage have restricted imports from neighbouring countries (Vernon, 1999; IEA, 2002). The country, however, is well endowed with coal resources, particularly in central and eastern parts, and has good access to imports from South Africa and Australia (Seam and Philpott, 1999; Shukla et al., 1999). As a result, compared to Europe and North America where gas is the first (or even only) choice for private developers, coal has emerged as a far more viable option for IPPs in India (IEA, 1999).

(d) *Mode of entry*: India, in common with many other developing countries, has operated a so-called "tendering" system whereby the specifications of new projects is largely determined by the national and/or regional government (Hsu and Chen, 1997; Murray et al., 1998). This contrasts with the "authorization" route operated in developed economies such as the UK and the US, where subject to various conditions, IPPs are allowed to commission plants of any capacity, fuel type and/or technology (Burtraw et al., 2000). Whereas project developers in the latter have selected fuel on the basis of projected market returns, the choice of fuel for IPP projects in India has additionally been guided by public-sector considerations. This has further privileged coal as a fuel source for new generating capacity owing to its security of supply and rupee denomination, both of which have been deemed strategically important by the government.

(e) *Environmental regulations*: Statutory environmental requirements for new power projects in India are considerably less stringent than in the majority of developed economies, and even some developing economies (Couch, 1999). In practical terms, this has reduced the incentive for investments in "clean" generating options, and gas-fired CCGT in particular, since coal-fired promoters can achieve regulatory compliance at low cost using relatively simple end-of-pipe controls.

(f) *Mode of competition*: IPPs projects in India have been developed on a power purchase agreement (PPA) basis, whereby developers sign long-term contracts with purchasing utilities for the supply of power at an agreed rate (Ripple and Takahashi, 1997; Crow, 2001). In many developed countries, meanwhile, producers often compete in "wholesale" power markets, either through bilateral contracts with large customers and/or an electricity pool (Hansen, 1998; Burtraw et al., 2000). Because of price volatility, wholesale markets are characteristically subject to relatively high levels of investment risk, providing developers with a strong incentive to minimise on capital expenditure. Conversely, by guaranteeing a fixed rate of return, the long-term PPAs available to IPPs in India have increased the willingness of promoters to advance capital-intensive projects, including coal-fired ones.

5. Lessons from the Indian electricity sector

The experience of India provides limited support to the argument that the opening-up of the grid in developing countries can generate significant environmental gains. As in developed ones, these have largely been the result of the distinctive generating options favoured by IPPs, on the one hand, and utilities, on the other. There would, in other words, appear to be characteristic patterns of technological choice and change associated with a policy of encouraging new independents into electricity generation, even under very different conditions.

Despite these parallels, it is difficult to escape the conclusion that the magnitude of these gains are likely to be relatively small in India, especially when set against the achievements made in the UK. Proximately, this can be explained by the limited progress made by IPP developers in adding new generating capacity and, in the long-term, the likelihood that a significant share of capacity will be fired by coal. Yet, underpinning these discrepancies are important differences in the institutional, regulatory and structural context in which electricity sector reform is taking place in these countries.

Consistent with recent critiques, therefore, the case-study suggests that the environmental benefits commonly associated with restructuring and non-utility participation are not automatic (Rosenzweig and Voll, 1997; Collier, 1998; Forsyth, 1999; Pesic and Ürge-Vorsatz, 2001). Rather, they depend on the existence of complementary regulatory, institutional and structural conditions, a point recognised in other work that has considered the economic and/or environmental impacts of privatisation and liberalisation (Rees, 1998; Jenkins, 2000; Utting, 2002).

Many of the impediments to realising the environmental gains of electricity reform identified in the Indian case would appear to be common to many, although by no means all, developing countries. These include, of particular importance, weak environmental regulations, PPA-type tariff arrangements and capacity shortages (Hsu and Chen, 1997; Murray et al., 1998; Couch, 1999; Crow, 2001). However, whilst this suggests that local conditions in developing countries are less favourable to environmentally beneficial outcomes, it is clear that two of the most significant determinants shaping the environmental outcome of restructuring are not neatly structured between developed and developing countries. These are local fuel availability and the environment-intensity of existing utility capacity, both of which have the potential to overshadow the influence of other factors. Indeed, cross-national differences in these conditions would appear to go a long way in explaining why researchers have reached very difficult conclusions about the likely environmental impacts of reform, even in developed economies (IPCC, 2001; Vrolijk, 2002).

What does this suggest for practitioners? Most obviously, it points to the need for caution in assuming that the environmental gains obtained from a generic policy in one context will produce similar results elsewhere. Although it may be convenient to generalise based on specific examples—manifest most bluntly here by the recurrent use of the UK to highlight the alleged benefits of liberalisation—this study suggests that it can be misleading. Policy-makers, in short, need to be sensitive to geography.

In fact, recognising this point is the first step in designing interventions that will enable the potential gains of increased private involvement to be harnessed. There are, of course, limits to what policy-makers can do in this respect. The local availability of fuel, for example, is more-or-less fixed in the short-term. Yet there is much more that policy-makers can do than what they cannot. This includes: enacting structural, regulatory and tariff reforms needed to strengthen the long-term financial position of power purchasers; putting in place a comprehensive framework of environmental law that incentivises clean generating options; removing restrictions on the import and/or usage of clean fuel sources; and providing fiscal and/or other support for environmentally sound generating options whose cost and performance characteristics render them unfavourable in a liberalised market.

Not all of this will be possible, or even economically desirable, for governments in developing countries to achieve alone. This suggests a role for international assistance on a bilateral or multilateral basis. If the experience of India is anything to go by, this might usefully be deployed to build capacity, particularly in areas of designing and implementing regulatory frameworks. Additionally, it will be needed to support the demonstration and adoption of renewables and other environment-efficient generating technologies which have yet to achieve competitiveness with more conventional, pollution-intensive substitutes.

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