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One-watt TV label implementation in Malaysia

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Abstract

Many countries, from the US to Australia, are now interested in implementing stand-by power energy label for household appliances, in stages, until the 1-W (watt) target is achieved. TV sets consuming 1-W power are widely available in the developed nations. In a developing country like Malaysia, however, the penetration of 1-W stand-by power TV is very low and unless a mandatory label programme is introduced, the degree of penetration is not likely to rise. This paper attempts to calculate the emission pollutants reduction and the energy savings by implementing the 1-W stand-by power label for TV sets in Malaysia. It is estimated that this effort will enable CO_2 (carbon dioxide) emissions reduction of 1477.7 kT (kilo tonnes), NO_x (oxides of nitrogen) reduction of 4673.0 tonnes, and CO (carbon monoxide) reduction of 763.7 tonnes in the country during the energy label period of 20 years. Additionally, Malaysia will benefit from energy savings of approximately, 2794.9 GWh (gigawatt hours).

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Nomenclature

AEI_s	Annual stand-by power efficiency improvement of TV sets (%)
AS_i	Applicable stock in year 'i' of TV sets
c, k	Constant values
Em_p^n	Emission 'p' for fuel type 'n' for unit electricity generation (kg/kWh)
ER_i	Emission reduction in year 'i' of TV sets (kg)
ES_i	Energy saving in year 'i' of TV sets (GWh)
L	Average life span of a TV set (year)
LEI_s	Label efficiency improvement of TV sets (%)
NA_i	Number of households with TV sets in year 'i'
NA_{i-1}	Number of households with TV sets in year 'i-1'
NA_{i-L}	Number of households with TV sets in year 'i-L'
P_{sb}	Average stand-by energy consumption of a TV set (W)
PE_i^n	Percentage of electricity generation in year 'i' of fuel type 'n' (%)
S	Year energy label programme enacted
S_i	TV saturation level per household in year 'i'
SF_i	Scaling factor in year 'i' of TV sets (%)
Sh_i	Shipments in year 'i' of TV sets
t_{sb}	Average duration of a TV set in stand-by mode (h/year)
UES_i	Initial unit energy saving in year 'i' of a TV set (kWh/year)
W_{sb}	Annual unit stand-by losses of TV set (Wh/year)
x	Year predicted; year start
y	Predicted value
Yse_s	Year energy label enacted for TV sets
Ysh_i	Year 'i' of shipment of TV sets

Introduction

Conventional power stations burn fossil fuels to produce electricity. This process releases pollutants such as CO_2 (carbon dioxide), NO_x (oxides of nitrogen), and CO (carbon monoxide) into the atmosphere. In Malaysia for example, approximately, 7.36 MT (million tonnes) of CO_2 was emitted due to the power generation in 1980. This figure shot up to approximately, 31.33 MT in 1996 (World Energy Council 2001). Meanwhile, electricity consumption in the residential sector increased from 8949 GWh (gigawatt hour) in 1997 (National Energy Balance 1997) to 12 564 GWh in 2001 (National Energy Balance 2001). This study calculates the potential energy savings and the potential CO_2, NO_x, and CO emissions reduction by implementing a mandatory energy label programme for 1-W stand-by power TV.

Data assessment

Survey data

A recent survey (in 2003) conducted on 262 households across Malaysia showed that in an average Malaysian household, the TV was in the stand-by mode for approximately, 4.3 h (hours) a day. It was also found that when a TV set was not utilized, it was either switched to the stand-by mode via a remote control (sometimes TVs were left idling for the whole day) or was switched off at the plug mounted on the wall (which draws 0 W). The TV saturation level in Malaysia was approximated at 1.5 per household and the average stand-by power of TV was found to be 4.5 W, after metering and conducting a market survey on nearly 500 TVs. Hence, from the above data, it was predicted that a significant amount of emissions pollution could be reduced as Malaysia had a high saturation level of TVs per household.

Household and electricity data

Three types of data were necessary for this study. These were the TV ownership data (Department of Statistics 1970; 1991; and 2000), percentage of electricity generation based on fuel-type data (Jaafar and Yusop 1998; Annas 2003), and the emissions for unit electricity generation data (Department of Electricity and Gas Supply 1999).

If the 1-W label programme is to be implemented from 2005 onwards, prediction has to be made on the basis of the data currently available on TV ownership and electricity generation based on the fuel type. This is done using the curve-fitting method. Predicted data are shown in Tables 1 and 2. Table 3 presents emissions for the unit electricity generation based on the energy sources data. For the curve-fitting method, a polynomial of the order 'k' in 'x' is expressed in the following form (Equation 1).

$$y = c_0 + c_1x + c_2x^2 + \ldots + c_kx^k \tag{1}$$

Proposed energy label

The energy label proposed in this study is designed in line with the following criteria: it should be simple, easy to recognize, and should be clear in presenting to the consumers that a 1-W TV saves electricity (Figure 1). As for the legal status of the energy label, a mandatory status seems most suitable. This is essential to enforce emissions reduction in Malaysia as all TV manufacturers and vendors will per force have to abide by the 1-W specification.

Table 1 Predicted number of Malaysian households with TV sets

Year	*Households with TV sets*
2005	4 944 589
2006	5 140 298
2007	5 339 372
2008	5 541 811
2009	5 747 615
2010	5 956 783
2011	6 169 316
2012	6 385 214
2013	6 604 476
2014	6 827 103
2015	7 053 095
2016	7 282 451
2017	7 515 172
2018	7 751 258
2019	7 990 709
2020	8 233 524
2021	8 479 704
2022	8 729 249
2023	8 982 158
2024	9 238 432
2025	9 498 071

Table 2 Predicted percentage of electricity generation based on fuel types

Year	*Coal* (%)	*Oil* (%)	*Gas* (%)	*Hydro* (%)
2005	15.50	3.25	58.75	22.50
2006	15.84	2.96	56.80	24.40
2007	16.26	2.69	54.95	26.10
2008	16.76	2.44	53.20	27.60
2009	17.34	2.21	51.55	28.90
2010	18.00	2.00	50.00	30.00
2011	18.74	1.81	48.55	30.90
2012	19.56	1.64	47.20	31.60
2013	20.46	1.49	45.95	32.10
2014	21.44	1.36	44.80	32.40
2015	22.50	1.25	43.75	32.50
2016	23.64	1.16	42.80	32.40
2017	24.86	1.09	41.95	32.10
2018	26.16	1.04	41.20	31.60
2019	27.54	1.01	40.55	30.90
2020	29.00	1.00	40.00	30.00
2021	30.54	1.01	39.55	28.90
2022	32.16	1.04	39.20	27.60
2023	33.86	1.09	38.95	26.10
2024	35.64	1.16	38.80	24.40
2025	37.50	1.25	38.75	22.50

Table 3 Emissions per unit electricity generation based on different energy sources

	Emissions (kg/kWh)		
Fuel	*Carbon dioxide*	*Nitrogen oxide*	*Carbon monoxide*
Coal	1.1800	0.0052	0.0002
Oil	0.8500	0.0025	0.0002
Gas	0.5300	0.0009	0.0005
Hydro	0	0	0

Emission pollutants reduction calculations

The emission pollutants reduction is a function of the energy savings. Therefore, apart from contributing towards a cleaner environment, the energy label effort will also enable national energy savings. In this study, the method used for calculating the

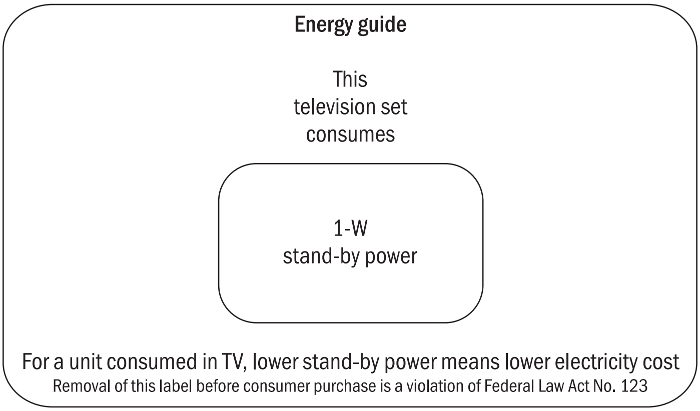

Figure 1 Proposed 1-watt energy label for TV

environmental impacts are adapted from Mahlia, Masjuki, and Choudhury (2002). The sample calculations following the mathematical expressions are calculated for the year 2005 (Table 4). Figure 2 shows the annual emissions reduction as a result of the 1-W label.

Annual unit stand-by loss

The annual unit stand-by losses can be described as a product of the average energy consumption of TVs in the stand-by mode

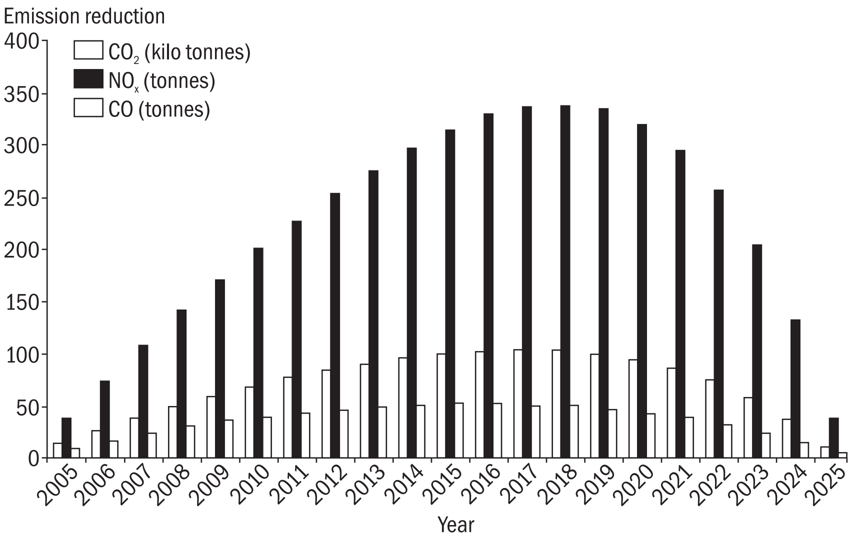

Figure 2 Annual emissions reduction from 1-watt energy label

and the average duration (in hours) of the TV in the stand-by mode in one year. The input data for this calculation is shown in the previous section (the section on the 'Survey data'). The annual unit stand-by losses are calculated for the TV sets in presence of the energy label (1-W TV) and in its absence (conventional TV) (Equation 2).

$$W_{sb} = P_{sb} \times t_{sb} \qquad (2)$$

$$W_{sb\ (conventional)} = 4.5\ \mathrm{W} \times (4.3\ \mathrm{h/day} \times 365) = 7062.75\ \mathrm{Wh/year}$$

where, $W_{sb\ (conventional)}$ is the annual stand-by loss from conventional TV, which is the TV set without the presence of one-watt label.

$$W_{sb(1\ watt)} = 1.0\ \mathrm{W} \times (4.3\ \mathrm{h/day} \times 365) = 1569.5\ \mathrm{Wh/year}$$

where, W_{sb} is the annual unit stand-by loss of a TV set, P_{sb} is the average stand-by energy consumption of a TV set, T_{sb} is the average duration of a TV set is in stand-by mode in one year, and $W_{sb\ (conventional)}$ is the annual stand-by loss from conventional TV, which is the TV set without the presence of 1-W label.

Shipment

The mathematical expression of the shipment data can be written as below and the average life span of a TV is approximately, 11 years (Webber and Brown 2002) (Equation 3).

$$Sh_i = [(Na_i - Na_{i-1}) + Na_{i-L}] \times S_i \qquad (3)$$

$$Sh_{2005} = [(4\ 944\ 589 - 4\ 752\ 244) + 3\ 013\ 855] \times 1.5$$

$$Sh_{2005} = 4\ 809\ 300$$

where, Sh_i is the shipments of TV sets in year 'i'; Na_i, Na_{i-1}, and Na_{i-l} are the number of households with TV sets in year; 'i', 'i-1', and 'i-l' respectively; and S_i is the TV saturation level per house hold in year 'i'.

Initial unit energy saving

The initial unit energy saving in this study is the difference between the annual unit stand-by losses of a TV in presence of

1-W label (1-W TV) and the annual unit stand-by losses of a conventional TV in absence of the energy label (Equation 4).

$$UES_s = W_{sb(conventional)} - W_{sb(1\ watt)} \quad (4)$$

$$UES_s = 7062.75 - 1569.5 = 5.5 \text{ kWh/year}$$

where, UES_s is the initial unit energy saving of TV sets in year 's' (kWh/year); s is the year the energy label programme was enacted, $W_{sb\ (conventional)}$ is the annual unit stand-by losses of a conventional TV set, and $W_{sb\ (1\ watt)}$ is the annual unit stand-by losses of the TV set in presence of 1-W label.

Scaling factor

The scaling factor would linearly scale down the unit energy savings because efficiency of the TV stand-by mode will be improving 6.7% per year even without the label programme. The rapid improvement in the stand-by power consumption is due to efforts of the developed countries to introduce the 1-W label programme by 2005. Currently, in Malaysia, there were a number of TV sets for which a low stand-by power of 1-W or less was being metered, although the average stand-by power for the TVs remained 4.5 W. The average stand-by power is not expected to improve unless a mandatory label programme is introduced. The scaling factor can be expressed in a mathematical form as given in Equation 5.

$$SF_i = 1 - [Ysh_i - Yse_s]\frac{AEI_s}{LEI_s} \quad (5)$$

$$SF_{2005} = 1 - [2005 - 2005]\frac{6.7\%}{78\%} = 1$$

where, SF_i is scaling factor in year 'i' of the TV sets, Ysh_i is the year of the shipment of the TV sets, Yse_s is the year the energy label was enacted for the TV sets; AEI_s is the annual stand-by power efficiency improvement of TV sets (%), and LEI_s is label efficiency improvement of TV sets (%).

Unit energy saving

The unit energy saving can be expressed as shown in Equation 6.

$$UES_i = SF_i \times UES_s \quad (6)$$

$UES_{2005} = 1 \times 5.5 = 5.5$ kWh/year

where, UES_i is the initial unit energy saving of TV sets in year 'i' (kWh/year), UES_s is the initial unit energy saving of TV sets in year 's' (kWh/year), and SF_i is the scaling factor of TV sets in year 'i' (%).

Applicable stock

The applicable stock of 1-W TV in 2004 is taken to be zero. This is because it is assumed that 1-W TV sets will start penetrating the Malaysian market only after the label programme is established. The applicable stock is expressed in mathematical form as given in Equation 7.

$$AS_i = Sh_i + AS_{i-1} \qquad (7)$$

$$AS_{2005} = 4\ 809\ 300 + 0 = 4\ 809\ 300$$

where, AS_i and AS_{i-1} are the applicable stocks of TV sets in the years 'i' and 'i-1', respectively, and Sh_i is the number of shipments of TV sets in the year 'i'.

Annual energy savings

The mathematical expression for annual energy savings can be written as given in Equation 8.

$$ES_i = (Sh_i \times SF_i + AS_{i-1}) \times UES_i \qquad (8)$$

$$ES_{2005} = (4809\ 300 \times 1 + 0) \times 5.5 = 26.5 \text{ GWh}$$

where, ES_i is the energy saving of TV sets in year 'i' (kWh), Sh_i is the number of shipments of TV sets in year 'i', SF_i is the scaling factor of the TV sets in year 'i' (%); AS_{i-1} is the applicable stock of TV sets in year 'i-l'; and UES_i is the initial unit energy saving of TV sets in year 'i' (kWh/year).

Emission pollutants reduction

The mathematical expression for emissions reduction can be written as given in Equation 9.

$$ER_i^a = ES_i\,(PE_i^1 \times Em_p^1 + PE_i^2 \times Em_p^2 + \ldots + PE_i^n \times Em_p^n) \qquad (9)$$

$$ER_{2005}^{CO_2} = 26.5 \times 10^9(15.5\% \times 1.18 + 3.25\% \times 0.85 + 58.75\% \times 0.53)$$

$$ER_{2005}^{CO_2} = 13.8 \text{ kilo tonnes}$$

$$ER_{2005}^{NO_x} = 26.5 \times 10^9(15.5 \times 0.0052 + 3.25 \times 0.0025 + 58.75 \times 0.0009)$$

$$ER_{2005}^{NO_x} = 37.5 \text{ tonnes}$$

where, ER_i^a is emission reduction of pollutant 'a' in year 'i'; ES_i is the energy savings of TV sets in year 'i' (kWh), PE_i^n is percentage of electricity generation in year 'i' of fuel type 'n', and Em_p^n is emission 'p' for fuel type 'n' for unit electricity generation (kg/kWh).

Results and discussion

Table 4 shows that the proposed 1-W label programme in 2005 will contribute towards the CO_2 emissions reduction of 1477.7 kT, NO_x of 4673.0 T, and CO reduction of 763.7 T at the end of 2025 in Malaysia. Besides this, the nation will also benefit from energy savings of approximately, 2794.9 GWh.

From Figure 2, it is clear that the energy label programme would be effective for only about 20 years. After that, it needs to be updated. Therefore, it is suggested that the energy label specification be updated to 0.5 W in 2025 because TVs with stand-by power below 1 W are already available in the developed countries.

Conclusion

The study highlights the importance of the 1-W stand-by power energy label for TV sets to mitigate emission pollutants in Malaysia and to contribute towards energy savings. The resources used to generate electricity can now be used more efficiently and most importantly, the emissions reduction will ensure a cleaner environment. Furthermore, if this effort is expanded to include all the household appliances, the impact will be greater. Overall, this study has proved that the introduction of the 1-W energy label for TV sets is of tremendous benefit both to the government and the environment.

Table 4 Energy savings and mitigation of emission pollutants in Malaysia due to 1-W TV label

Year	*ES* (GWh)	CO_2 (kT)	NO_x (T)	*CO* (T)
2005	26.5	13.8	37.5	8.8
2006	51.9	26.6	73.1	16.7
2007	76.0	38.5	107.0	23.8
2008	98.7	49.4	139.3	30.0
2009	119.7	59.4	170.0	35.5
2010	138.7	68.6	199.2	40.2
2011	155.8	76.9	226.9	44.2
2012	170.3	84.3	252.5	47.4
2013	182.1	90.6	275.9	49.8
2014	191.1	95.9	296.6	51.5
2015	196.9	100.0	314.0	52.4
2016	199.2	102.7	327.4	52.5
2017	197.9	103.9	335.9	51.8
2018	192.5	103.2	338.3	50.1
2019	182.8	100.3	333.2	47.5
2020	168.6	94.9	319.1	43.8
2021	149.4	86.5	294.3	39.0
2022	125.1	74.5	256.5	32.8
2023	95.1	58.5	203.5	25.2
2024	59.4	37.8	132.5	15.9
2025	17.4	11.5	40.5	4.7
Σ	2794.9	1477.7	4673.0	763.7

ES – energy savings; CO_2 – carbon dioxide; NO_x – oxides of nitrogen; CO – carbon monoxide

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The impacts of density regulation on cities and markets: evidence from Mumbai

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Abstract

Land use regulation exists in various countries in various forms. Density regulation is a class of urban land use regulations aimed at controlling development on urban land. Although it is justified on several grounds, the adverse impacts of such regulation on cities and markets have not received much attention of policy and decision-makers. In a burgeoning metropolis like Mumbai, for example, where land and housing needs are very high, regulations like these constrain the housing supply through a reduction in the available built space. This, in turn, results in widely varying impacts: it would have constrained the operation of land (and housing) markets, resulting in high cost of real estate; it would have also impacted on the city, in terms of the adverse effect on housing affordability, location, and extent of informal and poor-quality housing, and the resulting of crammed conditions. Further, density regulation might have aided the displacement of poor spatially into disadvantaged housing due to the filtering process operating through a mechanism of high land prices. Moreover, it would have spurred investment in property taking speculative dimensions, making it worthy to hold built-up land and housing units. Finally, high land prices in Mumbai gave excessive returns to the factor of land, which could be deployed to the rent-seeking activities.

Introduction

Land use regulation exists in various countries in various forms, primarily as an instrument for better allocation of land resource (here, in cities, built space) for various but competing uses in cities. Development control regulations are commonly a part of the land use regulation system in many countries and density regulation is one of the various forms of development-control regulations. Land use regulation is also central to the land use planning systems worldwide but with varying degrees of stringency and operational conditions.[1] In spite of the existence of such regulation systems over decades (even more than a century), there is mounting criticism of some features of the systems, essentially related to the relative success or failure in achieving the objectives of the system itself. Accordingly, economists and public policy analysts are increasingly becoming concerned about the role of land use regulation as it inevitably intervenes with free market allocation of land and housing, thereby resulting in both inefficiencies and inequities of their consumption (both, over space and sections of society). As cities are moving towards increasing the role of markets in allocation of economic goods and services, land and housing also assume economic importance and their efficient allocation assumes greater importance. This has prompted several researchers to assess the impact that land use planning and/or regulation makes on operation of land and housing markets as well as the impacts on society, which has been approached in varied analytical frameworks. For example, comparative study using the multivariate analysis method was approached with the view that the planning system creates scarcity rents for land in different uses by acting as a constraint on land supply through use allocation as well as development control (Cheshire and Sheppard [1989]). Monk, Pearce, and Whitehead (1996) undertook a comparative study where differential effects of planning constraints prevailing at the local level depending upon the extent of substitution effect between the areas were discussed. Regarding the method of multivariate analysis using both OLS and recursive least squares, Mayo and Sheppard (1996) used the

[1] Here, we avoid too much discussion on the planning types, methods, and practices. For such a detailed understanding, one can refer to Friedman (1995), which synthesizes a good amount of literature and provides directives for action within the (political and social) ideological frameworks.

approach of different planning systems resulting in different supply elasticities with the lower supply elasticities associated with those imposing greater risk to the developers.

Density regulation is one class of land use regulation that directly affects the amount of development of housing on land. In fact, it came into existence in the UK, the US, and other European countries as a response to the widely held public health concerns about providing habitable space in the post-World War era. However, there exist other site-specific regulations (for example, open space requirements), use restrictions, and height restrictions, which also influence the amount of built space. However, research on this aspect of land use regulation is quite limited and that too confined to a few studies carried out in the UK and the US. Mumbai is a burgeoning metropolis in India wherein the land and housing needs are very high, yet, on the contrary, several constraints limit the supply of land and housing: density regulation is one such regulation that might have been impeding a better allocation of built space, thereby resulting in varying impacts on markets, urban space, and economic agents. This paper examines the impacts of this aspect of land use regulation in Mumbai and seeks to inform the policy and decision-makers as well as the academic and research community about these impacts. It therefore, seeks to contribute to the discussion and debate over the impacts of land use regulation and its role in achieving the objectives in general, through an example of the impacts of one aspect: the density regulation. The paper also seeks to make a contribution to the paucity of empirical literature on this aspect of regulation, particularly in the developing countries, which assumes importance in light of the need for building more compact cities (though debate on it started again).

So far, we have broadly discussed land use regulation impacts, with density regulation impacts forming a subset. Subsequently, various approaches in assessing the regulation impacts have been reviewed and the approach used in the current study is given. However, before that, we need to become familiarized with the origins, objectives, and operation of density regulation in the form of the FSI (floor space index) restrictions in Mumbai, which is attempted hereunder.

Density regulation in Mumbai

Density regulation in Mumbai has emerged as part of the larger town planning system, particularly through the DCRs (development control regulations) of the MCGM (Municipal Corporation of Greater Mumbai), with an objective of achieving a balance between the demand for, and supply of infrastructure services. The DCRs form an integral part of the development plan prepared by the municipal corporation and relate to the use of provisions in various zones, prescription of development density, in terms of dwelling units per hectare, and the built-up area (Phatak 2000). The FSI, which is a ratio of the floor space area to plot area that prescribes the maximum built space on land, is an important means of density regulation highlighted in the paper.

The 1964 DCRs came into existence as part of the response of the local government (which is also the planning agency) to the demands for decongestion of the island city as it was felt that the island city was already overcrowded and predominantly industrialized. However, decongestion policies also had an objective of creating a new township in New Mumbai and encouraging the population movement into the new town (Shaw 2004). Although the 1964 DCRs prescribed relatively good FSIs – 4.5 for the CBD (Central Business District) and 1.0 for suburbs – the modified DCRs in 1995 were quite conservative in allowing the development on land (GoM 1991) (Table 1 provides a summary of the permissible FSI in various parts of the city). The prescription of low densities, which was started in the 1964 DCRs, overlooked the widening gap between the housing needs and supply, particularly in the formal sector. Yet, the modified DCRs in 1995 made the density regulation taking the form of uniform blanket regulation, and the formal housing (built space) supply became rigid and less responsive, which, in turn, had city-wide ramifications.

Table 1 Allowable FSI (floor space index) in Mumbai

Area	*Allowable FSI*
Mumbai (island) city	1.33
Mumbai suburbs	1.00
Mumbai suburbs (classified)	0.75
Mumbai suburbs (rural areas)	0.50

Source GoM (1991)

The density regulations, in the form of FSI restrictions, are quite often justified to serve various purposes, whereas the outcomes are different from those intended. There are several unintended and undesirable consequences, which resulted from such legislation. Important among them is the impact on relative affordability of housing, which is discussed. The pressure on housing due to the density regulation is evident not only from a large amount of population living in the informal housing (which is evident from the rising proportion of slums), but also from the relaxations that were made in projects like re-development of old cessed buildings and slum rehabilitation projects, in order to make them financially viable (Phatak 2000). Moreover, such a ratio assumed too much importance in the public policy and it is now used in public finance (Phatak 2000). This is akin to designing and creating scarcities in land and housing markets first, and then attempting to address them through concessions and relaxations. The approach to study and methodology followed after reviewing the literature surveyed is laid down in the next section. Density regulations have a wider range of impacts on the city space, inhabitants, and their behaviour, which is also discussed subsequently.

Approach/methodology

The subject of land use regulation impacts has been studied from varied perspectives and analysed in different frameworks. For example, the neo-classical theory suggests that land-use regulation affects the outcome of land and housing markets by influencing demand for and supply of land for housing, essentially, the equilibrium quantity and price (Monk, Pearce, and Whitehead 1996). From a welfare economic perspective, it may reduce the efficiency as well as equity of land allocation through markets (Hirsch 1979); from the Marxian socialist economic perspective, it may result in a class struggle over land or displacement of the working class by filtering down (Lyons 1996); whereas, institutional economists and public choice theorists argue that it reduces the scope for private bargaining (Mills 1991) while promoting harmful practices (Mills 1989). Pollakowski and Wachter (1990) provide an excellent summary of the various approaches undertaken by researchers in various frameworks, providing good insights and highlighting shortcomings in literature. Whereas Pogodzinski and Sass (1991) present a good classification and review of literature on land use regulation impacts in context of the US, a somewhat similar attempt has been made by Monk, Pearce, and Whitehead (1996) in context of the UK. Examination of land use regulation impacts on land markets and housing in context of Asia has not been an area of attention for researchers excepting those in Singapore and Hong Kong.

Even though land use regulation impacts can be modelled from varied perspectives and in various analytical frameworks, empirical literature on the impacts of land use regulation primarily focused on the impacts on land and housing markets, that is, either price or quantity of land and/or housing. The neoclassical economic theory suggests that unfettered markets can achieve efficient allocation of resources, including land (Begg, Fischer, and Dornbusch 1994). However, land is considered to be different from other economic goods due to a variety of reasons (Begg, Fischer, and Dornbusch 1994): (a) it is a factor input of the house or dwelling unit built on it, (b) it has characteristics of both, consumption (like any commodity) and investment good (like any asset), (c) it is spatially fixed and immobile, and (d) it has a strong link with other institutions (like law) due to inheritance.

Without going into details of these differences, it can be said that akin to several other goods, ceteris paribus any impediment on the free operation of land and housing markets would reduce the supply of the built space (and housing units) from S’ (free market level) to S. As shown in Figure 1, price of the built space under density regulation (P) would be higher than the price (P’) in absence of it even when the demand can be assumed as fixed.

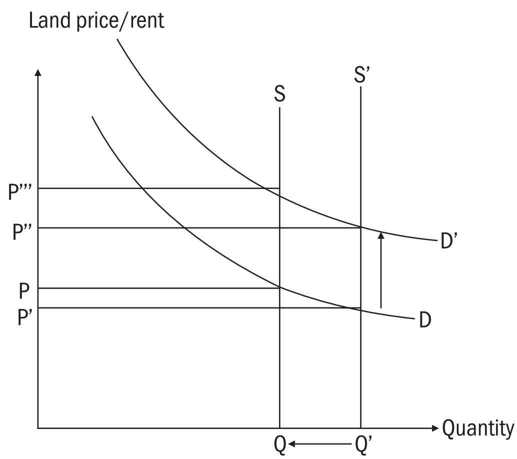

Figure 1 Illustration of land-use regulation effects on land markets

However, land supply scarcity would also influence the demand for it as the price paid per unit space will be more due to land scarcity. This, in turn, would shift the demand from D to D' and the corresponding price would rise to P"' under supply restriction, which is further above the price level P" in absence of it. The result is an increase in land and housing prices, and it, thereby, results in an undesirable impact on the lower-income sections of society through a relative decline in the housing affordability.

In this paper, the impacts of operation of density regulations in Mumbai are analysed with help of secondary data and anecdotal evidence. The geographical scope of the study has been confined to municipal boundaries of Greater Mumbai. The operation of land use/development control regulations in general, and density regulation in particular, were understood through departmental publications, for example, GoM (1991) and through interactions with expert individuals. The impacts of density regulation can be categorized and grouped under market, spatial, and behavioural impacts and the secondary data can then be analysed under these broad categories, which is also illustrated in Figure 2.

The *market impacts* discussed here feature those on land prices (thus, in turn, on house prices). Secondary data was used to support and substantiate the prevalence of impacts along with a comparative analysis of trends in land prices. The *spatial and behavioural impacts* were then analysed with plausible reasoning, indicative data, as well as anecdotal evidence. In-depth informal interviews were conducted with expert individuals to obtain a

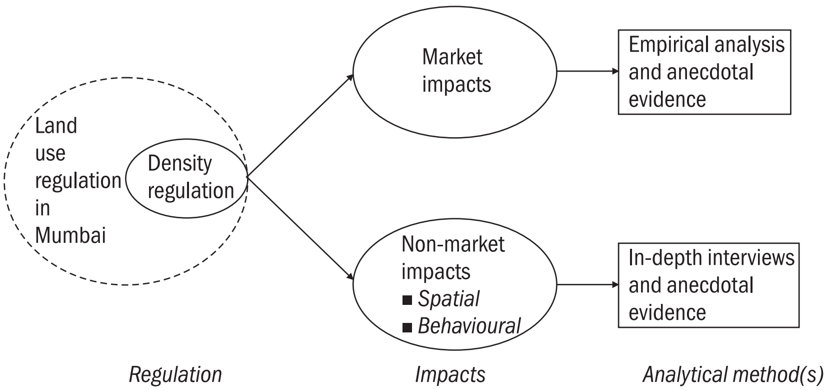

Figure 2 Analytical framework of the study

greater understanding of the underlying issues, causal relations, and possible explanations as these are subject to multi-attribute causation and different reasoning. A structured questionnaire survey would have provided more definite answers in such an evaluation but was not used due to the following reasons: (a) the nature of the subject is such that it needs to be discussed in detail in the structured questionnaire in order to obtain valid responses, which is not the case with informal deep interviews, (b) a structured questionnaire survey cannot elicit responses to complex questions like the current one, and it lacks adequate information desired by the interviewee and cannot present it in adequate terms as the issue crosses more than one subject theme. Moreover, general discussion/opinion with the normal population would not have possibly led to any conclusive direction. These difficulties could be overcome in a deep intensive informal interview, which was resorted to in the study.

In the following sections, an analysis of impacts on land markets is presented first, followed by an examination of spatial and behavioural impacts. Finally, the relevant policy implications are discussed.

Impacts on land market

The market impacts of regulation stem from its constraining of the free and unfettered operation of land (and housing) markets. Ceteris paribus, density regulation constrains the operation of land (and housing) markets, either by fixing supply or by raising demand, or both, thus, leading to either price rise, quantity reduction, or both (as implied in Figure 1). This is more plausible under conditions of either rigidity or fixity of supply of land for housing. The case for development control (hence, density control) restraining the supply response and availability is more plausible in case of Mumbai as it has the geometrical and topographical limits to the expansion of development on land (due to sea on three sides and a national park on its outskirts). Moreover, due to the ULCRA (Urban Land Ceiling and Regulation Act), the supply responsiveness of land for housing needs has become highly limited. Evidently, the only other dimension in which the city could grow, that is, vertically, is limited by the FSI restrictions and other related development-control regulations.

Against this backdrop of land (and housing) supply rigidity/fixity, demand for housing is on the rise due to the rapid increase in population in Mumbai. The population has been steadily rising at a growth rate of almost 2% per year though it receded in the recent past. Under these conditions, price of the housing unit (or land for development) rises rapidly as in the case of Mumbai. The residential and commercial property prices in some parts of the city are not only highest in the country but also one of the highest in the world, indeed only next to those prevailing in New York and London (Soman 2002). However, it must be noted that high property prices are also a result of other restrictive legislations like the ULCRA (mentioned earlier) and RCA (Rent Control Act), which froze the rents on houses and, thereby, limited the supply of rental housing (Nallathiga 2003). Nevertheless, density controls operate on a wider urban space, resulting in far-reaching and significant impacts.

It is difficult to assess the extent of impact of density regulation without establishing controls and obtaining micro-level data. However, as a first step, an attempt was made in another study to assess the impact on ward-level property prices (Nallathiga 2001). Whereas a detailed explanation of the assessment has been made in Nallathiga (2004a), hereunder, a summary of the approach and the results is presented. The process of determination of residential property prices on the urban space can be modelled from supply-side factors (for example, public goods provision and transport system) as well as demand-side factors (for example, income, taxation, and population) in equilibrium condition (see Box 1 for details of modelling). Using this model, a statistical analysis of property prices across space and time was done using multiple linear regression, which suggested that the density regulation could have accounted for almost 40% of the prevailing property prices (Nallathiga 2004a; 2001).[2] This proportion is relatively very high as other chief variables explain only 60% of the price. Further, perhaps, it reveals the stringency of more than one type of regulation affecting land and housing markets in Mumbai, not all of which have been included in the model.

Density regulation would have also affected the net housing availability, which, in turn, would have affected the supply of housing units in the formal sector. Insofar, the housing supply of market has not been able to match with an ever-increasing demand for housing units for several reasons: plethora of

[2] A complete discussion of the model and analysis is reserved here for lack of space and want of focus on the outcomes of the study rather than modelling method.

Box 1 The market impacts of density controls on land markets and housing in Mumbai

Literature reviewed suggested that a multi-variate approach to measurement of land use regulation impacts is favoured, and found to be appropriate to the current study of density regulation impacts. Hence, evaluation of price impacts followed a multi-variate model of land prices determined by other factors in a similar manner to that of Case and Mayer (1995). In this model, land prices can then be modelled as a function of PG (public goods), E (externalities), T (taxation), I (income), DC (development [density] control), and TS (transportation system), and mathematically expressed as

$$P = \beta_0 + \beta_1 PG + \beta_2 E + \beta_3 T + \beta_4 I + \beta_5 DC + \beta_6 TS + \varepsilon$$

The data set comprised cross-sections of 23 wards in the city for two-time points – 1994 and 1999, respectively – and normalized by ward population. The variable public goods is a composite variable of ten public services/amenities and the variable externalities comprises five such services. The variable transportation system was a qualitative variable (dummy) of access to it. Density regulation had been introduced in the form of policy variable of the FSI to test the effect of it on land prices.

The OLS (ordinary least squares) regression analysis was carried out to model the relationship, followed by which statistical testing was done to check for prevalence of multi-collinearity, heteroskedasticity, and auto correlation in the data. In both stages of modelling, density regulation assumed statistical significance in cross-sections as well as pooled regression analysis. Results indicate that marginal propensity of density regulation on land prices is very high in the CBD (Central Business District) whereas that is not the case in the suburbs. The density control accounted for almost 40% of the land prices, which is relatively very high to a variable of density control.

However, besides density regulation, other forms of government intervention, for example, ULCRA (Urban Land Ceiling Regulation Act) and RCA (Rent Control Act), also influenced the operation of land and housing markets. The complexities of these regulations render the difficulty of making a clear-cut distinction of the impacts caused by density regulation; it is even more difficult to ascribe these impacts to density regulation.

Sources Nallathiga (2004a and 2001)

legislations, long time taken for building approvals, and, more importantly, limited availability of land that can be developed and low FSI allowed. Moreover, factors such as speculative holding of land and institutional constraints might have contributed to a shortage between the demand[3] for, and supply of the housing units. This has also been acknowledged in the plan document.

> *…housing supply has been steadily increasing in response to the increase in house prices from less than 20 000 units between the 1950s and 1970s to over 40 000 units during the 1980s. The average annual supply of housing in the BMR during 1984–91 was 47 417 units. Even after this supply, a deficit of 45 000 units per annum persists. This shortage is likely to increase to 59 000 by 2021 if the supply is not increased…* (BMRDA 1995, p. 245–246)

Such a high impact of density regulation on land and housing price would have affected the affordability of the housing unit (by raising the price to that extent), and the effect would have been relatively very high for the poor, leaving the formal housing options not available to them. No wonder, they do not have any option other than staying in informal settlements (or slums). However, this would have resulted from a combined effect of all other regulations (such as ULCRA, RCA, and other DCRs). This view is also shared by others, for example,

> *…Land pricing, building code and safety regulations have effectively priced the poor out of the real estate market…The poor have no access to a formal legal dwelling or legally built work space. About 50% of Mumbai's 12 million people resides in slums……Restricting growth coupled with low uniform FSI has made the city non-responsive to the needs of the poor, if not out right anti-poor, especially in the view of the absence of rental housing market…* (Subodhkumar 2001, p. 6)

The resulting high property prices have not only been a bane to the development of the city, but they also affected other processes, as outlined below.

Spatial impacts

Mumbai city has three spatially distinct areas – the island city, suburbs (eastern and western), and extended suburbs – within its city limits and there exist other peri-urban townships in

[3] Owing to lack of data on housing demand, housing needs are used as a proxy here to indicate the disequilibrium conditions in market.

Vasai-Virar, Mira-Bhayandar, Thane-Kalyan, and Navi Mumbai in the adjoining districts, which are well-connected by the suburban transportation system. The spatial structure of the population distribution (see Figure 3) reveals that the island city has almost stopped growing following the 1950s, whereas the suburbs started taking the burden of most of the population, which is evident from the share of population between the two. The observed lack of growth in population density of the island city itself presents the scenario of a host of regulations restricting the inner city's (which is the island city here) growth and re-development.[4] In fact, renewal of the island city infrastructure in order to take the burden of water supply and sewerage disposal was proposed a long time ago, but implementation is still pending. Nevertheless, these spatial differences, in turn, would have resulted in other impacts (discussed below under subsections of town cramming, gentrification, urban sprawl, housing quality, and residential neighbourhoods).

Town cramming

A rapid population growth has resulted in high population densities across the Mumbai city. Until 1961, most of the population

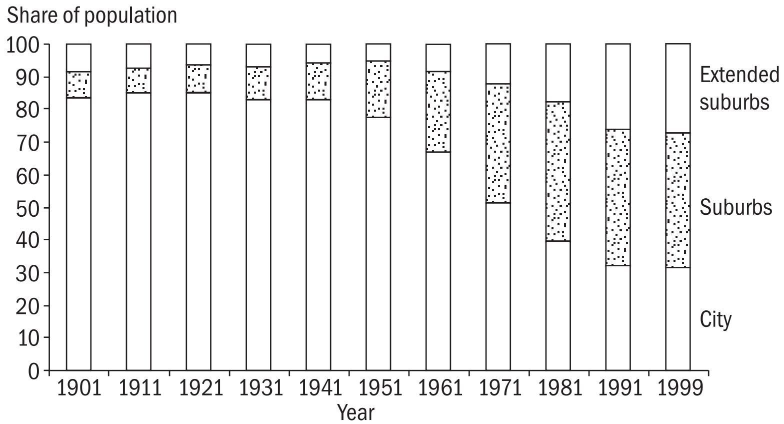

Figure 3 Temporal changes in patterns of share of population
Source BMRDA (1995)

[4] Density regulation is one of the regulations affecting the island city's development. Another major regulation is that concerning the derelict land, meant for textile industrial use, which has not been allowed to be re-developed for residential/commercial use under the existing development control regulations.

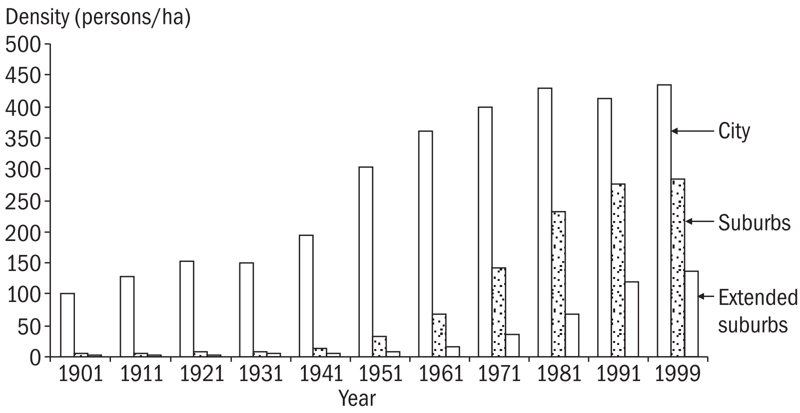

Figure 4 Temporal changes in population density patterns in Mumbai
Source Calculated from BMRDA (1995)

lived in the island city and the population density was 350 persons per hectare. However, subsequently, the suburbs began to grow at a much faster rate in the past three decades or so, taking their density closer to the city levels. The restriction of further growth of the island city through building regulations (including density controls) and decongestion policies would have arrested the growth of the inner city on one hand, resulting in inevitable, rapid growth of suburbs on the other. The increase in population density of the suburbs and stabilization in the island city imply a town cramming-like situation prevailing in the suburbs, evident in Figure 4, as re-development of the inner city has hardly been taking place when the suburbs began to grow fast.

> *...low FSI in central areas makes renewal difficult and perpetuates congestion because there is no incentive for assembling parcels of land for renewal, which would have provided much needed space for parking and other amenities...* (Subodhkumar 2001. p.10)

The shortage of housing might have also led to emergence of informal and poor-quality housing in the form of slums and squatted settlements across the region (which was discussed earlier), but predominantly in the suburbs (Figure 5). This increased share of slum population in suburbs is also owing to the constraint on housing options for poor through operation of development regulations (including density regulation) in the

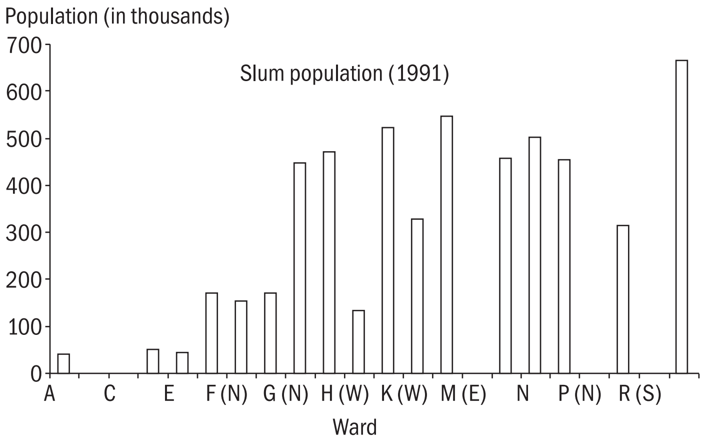

Figure 5 Spatial distribution of slum population in Mumbai
Source NIUA (1994)

island city as well as suburbs, which, in turn, is resulting in a situation like cramming. This is also reflected in the plan document.

> *…the current annual private supply of houses in BMR is 31 000 units, which even at the prevailing house prices (per unit area) is unaffordable to middle income groups leaving apart the low income group and the poor. The private market essentially leaves out the poor and the public sector supply is very limited. As a result, the shelter needs of 53% of the poorer (or 45 000 households) are satisfied in the informal market every year. This supply is in the form of further densification of existing slums and growth of new slums…* (BMRDA 1995, p. 248)

Gentrification

The location of existence of slums in Mumbai[5] is another indicator of the phenomenon known as 'gentrification', in which the poor are filtered down through the housing market, left behind in poor dilapidated buildings. Alternatively, they shift to suburbs where land prices are low. Essentially, this filtering process displaces the poor spatially as they are priced out of the market. In such a process over space, high-income groups gentrify the

[5] According to MMRDA, approximately 43% of the population living in slums is below the poverty level and another 26% belongs to low/middle income groups (BMRDA 1995).

housing, generally occupied by low-income groups, which is also echoed in the plan document. Density regulation might have exacerbated the situation by restricting the output of the housing units to disfavour the poor.

> *...on account of the density, FSI and construction standards prescribed in the development control regulations and building byelaws operating in most parts of BMR during 1964 to 1991 (The DCRs for Greater Bombay have been substantially modified in March 1991), the private sector supply has mostly been in the form of units with an average area of about 40 m^2 each built in multi-storeyed apartments. These were not affordable to over 60% of the households...* (BMRDA 1995, p. 247–248)

The spatial location of slums also implies gentrification. The island city is no longer inhabited by low-income groups but by high-income groups, leaving the poor displaced to cluttered and squatted settlements in suburbs (Figure 5). Also, formal house prices as well as rents are not within the reach of low- and middle-income groups (thanks to the prevalence of density regulation, which would have contributed to it), taking away a substantial proportion of the household income, as implied below.

> *...the affordability profile of the population may appear implausible, as the maximum budget is perhaps less than the price of most houses available in the formal housing market of Bombay. Currently, most of the finances in the market come from wealth (accumulated savings) and not from income. As wealth distribution is more skewed, 50% of Bombay's population is in slums* (BMRDA 1995).

The symptoms of gentrification are being observed in the fringe areas of the island city and the suburbs, where the high-income class has gentrified the housing areas, formerly occupied by the industrial working class. It is expected in theory that the rich will move to the suburban areas for want of more space when a strong public transport system prevails. However, in Mumbai, it happened in an almost opposite direction on account of high land values (which can be attributed partly to density regulation) leading the poor to move out from central and fringe areas to the suburbs.

Urban sprawl

An increase in the population density in suburbs and extended suburbs has also been resulting in the sprawling of the city along the major transport corridors, and the uniform densities encourage it. Further, it has been observed that the townships beyond the municipal jurisdiction have also been experiencing some growth, which is concentrated along the major transportation corridors extending to more than 60 km away from the CBD. While urban sprawl is an uneconomic organization of the population and economic activities (in terms of service delivery and resource consumption), it has been forced to be followed because of the low-uniform FSI permitted in the city and suburbs as a consequence of density regulation. This is also reflected in others.

> *…City plan proposed a low uniform FSI; placed a restriction on the growth of the industry in the city central areas. The underlying assumption was that in the absence of policy intervention to restrain the growth, the city will keep growing unabated. This of course is not borne out by the fact that even in case of Mumbai, it can be seen in the land use pattern and profile of the city and the suburbs…* (Subodhkumar 2001, p. 8)

Moreover, development of the urban sprawl has been resulting in a burden on the provision of public goods, particularly on the public infrastructure like mass transport. The suburban trains carry the passenger beyond their conveyance capacity in suburbs and between suburbs and the nearby townships. The commuter population has been forced to stay so far in order to avoid high land prices and rents as well as low housing supply in the island city and suburbs. As a result, long commutes and large crowds are a common sight. Such an excessive burden on the public infrastructure is evident from the long and exhausting commute travel by public transport and an accompanying loss in production efficiencies.[6] Huge crowds in trains and bus carriages during peak commuting hours as well as high congestion and pollution levels on roadways are also a result of it. Similarly, sanitation facilities have been poor despite the adequate water

[6] Mumbai is fortunate to have a higher dependency on public transport (that is, rail and bus transport) and intermediate public transport (that is, auto-rickshaws and taxis), rather than private transport.

supply. In fact, renewal of infrastructure in the island city (water supply and sewerage network) and expansion/up-gradation of the suburban rail infrastructure have long been pending. However, the CRZ (coastal regulation zone) provisions also restrict the development of land and infrastructure in the island city and result in urban sprawl (Nallathiga 2004b).

Housing quality and neighbourhoods

It is noteworthy in this context that the stock of old and dilapidated buildings has been prevailing, mostly in the inner and fringe areas of the island city (Figure 6). There is a stock of 19 500 buildings of old and dilapidated state, which were constructed prior to 1950 (BMRDA 1995). However, most of them exist in the island city for different reasons, ranging from government intervention (for example, Rent Control Act), heritage regulations, development control regulations, to perverse institutions built around poverty (for example, reluctance to vacate the buildings due to high house prices and market rents). However, it is the lack of re-development of these buildings that led to an inelastic response of housing supply in the island city (thus, aiding expansion of the suburbs) on one hand, and imposed perils of building collapse on the other. Density regulation might have added to this complexity by not providing enough incentives for re-development of land and construction of housing units in a profitable manner, which as a result, are not re-developed.[7]

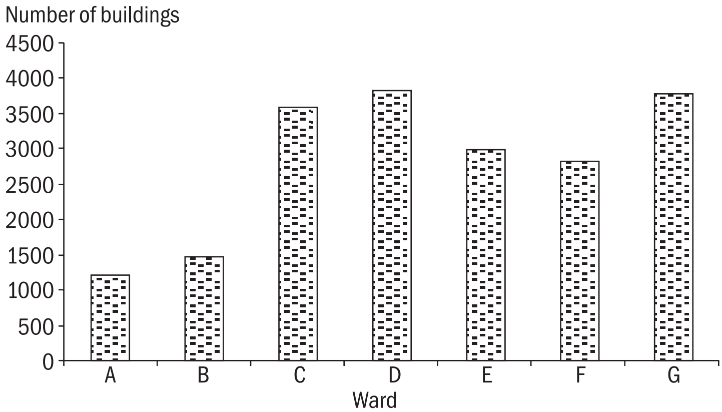

Figure 6 Spatial distribution of slum population in Mumbai
Source NIUA (1994)

[7] This might be one of the reasons, which at best would have exacerbated it.

> *...further, about 25% of the poor live in old tenements constructed prior to 1950, which are in a dilapidated state. A further 50% of the low to middle income group lives in slums as well as in old dilapidated buildings...* (BMRDA 1995, p. 245)

In addition to poor quality of individual dwelling units, the residential quality of life in several areas and their neighbourhoods has been deteriorating: again, thanks to prevalence of the regulatory regime. For example, the suburbanization of people and expansion of suburbs due to density regulations have been resulting in juxtaposition of slums with high-rise buildings in suburbs, thereby creating blighted landscapes, and leading to deterioration of aesthetics and environmental quality of neighbourhoods. The squalor condition of the living environment is evident from the fact that about 50% of the population was residing in slums according to the Census of India (1991). Proliferation of slums in suburbs, particularly along the transportation corridors of the city, where public land is normally easily available for encroachment, has resulted in unhygienic living conditions. Deterioration of the physical environment due to cramming and the unsanitary conditions prevailing in slums clearly indicate a decline in the residential quality of life in Mumbai.

Behavioural impacts

Development controls would have also influenced the behaviour of agents significantly, which might either further affect the operation of market adversely or lead to harmful practices. Two important impacts – speculation and rent-seeking – are examined below.

Speculation

The rapid rise of house and land prices in Mumbai, particularly during the 1990s, made investment in property taking speculative dimensions. The agents (mostly, the rich merchant and business class) purchased land or housing units to hold them until the ripe moment, marked by a rapid price rise due to excessive demand. Consequently, large amounts of land and housing units were locked up in the hands of rich speculators who were reluctant to release them with the expectations of a further price rise.[8] This has resulted in an artificial and short-term increase in demand for land parcels and housing units, in addition to the demand arising from population growth. Density controls would have restrained the responsiveness of supply of housing units by constraining development on a parcel of land, making it worthy to hold land and housing units with such expectations, and thus, in turn, would have exacerbated their speculative holding (Nijman 2000).

The imperfect and inefficient state of housing markets in Mumbai is also due to the complexities of the good housing unit that is, housing is both consumption good and investment asset. The investment nature of the good might lead to speculative tendencies associated with it in the market when expectation of price rise would persist, which was the case in the past. This is also reflected in the plan document. As mentioned above, the speculative conditions would have been exacerbated by density regulation.

> *...the real estate market easily absorbs unaccounted income and in a situation of growing demand offers safe and assured returns and liquidity. Such speculative investment has led to sizable units being kept vacant. Therefore, total investment of the private sector appears to be more than the investment requirement of all incremental households...* (BMRDA 1995)

Rent-seeking

We now examine the development of rent-seeking from the land use regulations like density control. Economic rents are essentially accruals or returns to factor inputs in excess of the market price. While avoiding the controversial connotations referred to this term, (for example, Mills [1989] refers to the rent-seeking activities as those which do not lead to any direct production of output, which may be contestable as most of the professional and technical services might be classified under rent-seeking activities), rent seeking has been viewed here as a behavioural outcome resulting in agents becoming involved in activities like

[8] Speculation may effectively disappear when holding costs, that is, monitoring and maintenance costs or opportunity costs, are very high, or even when agents are penalized through land taxes.

corruption, tacit agreements, and lobbying. Agents may flout the development control regulations like density controls by either covertly providing false information about the construction activity, bribing the regulating inspectors, or even overtly through political support and lobbying. As land prices are high in Mumbai due to excessive (or choked) demand, there are excessive returns to the factor input land[9] (or economic rents), which can be deployed to either obtaining deviances in regulations, seeking political and lobbying group support, or even for legal wrangling. This is often more pronounced when there is a flow of 'black' money,[10] or when wealth is distributed disproportionately high among a few as reflected in the plan document.

> *...however, despite a high proportion of poor households, private supply of such high-cost housing is more than half the size of the incremental need. This is due to high concentration of wealth among a few who are very rich...* (BMRDA 1995)

High rents to land prevail due to the derived nature of demand for land and the inelastic supply. Density regulation might increase the rents by affecting both the above, and these excessive returns might be used for unproductive activities, resulting in wastage of resources. The prevalence of rent-seeking activities partly reflects the problems associated with monitoring and enforcement of development control regulations, such as density controls, which become significant when the regulations remain restrictive and do not change over time and/or when the demand for land is very high.

Policy implications

The density regulation impacts that were discussed earlier are needed to be drawn to the attention of policy-makers and decision-makers. In this section, these impacts are discussed in light of theory and empirical literature on land use regulation impacts first, to imply the need for reforms, and following it, the implications pertinent to Mumbai are discussed. The discussion ends with an argument on the need for shifting away from blanket density control/regulation towards density planning and flexible

[9] Here it is assumed that the maintenance costs (except for monitoring encroachment) of land after procurement and before selling are almost zero.

[10] Black money, here, refers to the unaccounted income flowing into economic activities.

density regimes, and undertaking several other mechanisms that can maximize the allocation of land for housing purposes.

Literature on justification for land use regulations is well read and has been guiding the planning policy for a long time. However, literature also suggests that land use regulation in less developed countries often fails to achieve greater efficiency and equity in use of urban land for several reasons (Courtney 1983): the static nature and inflexibility of standards, administrative costs, the power of particular interest groups, corruption, and speculation. Quite often, government intervention, without careful consideration of a country's particular position, results in distortions in the functioning of land markets and housing (Whitehead 1983), also, often resulting in unintended effects on the urban economic growth (Staley 1997). Like several other nations, India had intervened in land markets and housing in cities in various forms, ranging from direct provision to regulation. However, on the whole, this intervention had not been successful. On the contrary, it has led to serious distortions due to the fact that these interventions are rigid in design (for example, standards) as well as remain unchanged over time and over the changing market environment. It has been observed that the density regulation might have also resulted in much wider impacts on land and housing markets, spatial differences, and behavioural outcomes. This is also implied in the UNCHS (1993) criticism of the results of land use regulation policies in Mumbai.

> *...The pursuit of policies for city planning, land use and ownership, and public housing apparently in isolation of each other has had deleterious consequences for affordable housing for different income groups. The lack of coordination has led to a lack of convergent institutional response (from agencies) and a failure to comprehend different elements of shelter needs of people, such as freely functioning land market, provision of infrastructure, framework for legal shelter provision of housing and community services, supply of housing finance, etc., and also the failure to involve community in different stages of planning and provision of shelter...* (UNCHS 1993)

Density regulation has long been used as a town planning tool to restrict the population and housing densities to reduce the burden on the provision of infrastructure facilities. But the purpose gets defeated if such regulations result in a mere shifting of densities into suburban areas[11] to impact upon urban space and behaviour of agents, while affecting housing and land markets as well. The need for relaxing density controls and other land use regulations has been emphasized in the BMRDA (1995) plan document as well as Phatak (2000). Recent attempts to reduce such effects by allowing variances in the form of 'TDRs (Transferable Development Rights)' in case of infrastructure development and slum re-development might be expected to mitigate the effects partially, particularly those against the poor. Results of such programmes are awaited, but at least one attempt has been made to get away from them. Such a hope is expressed in the plan document.

> *...In the 1991 regulations (GoM 1991), the maximum permissible density has been substantially increased allowing dwelling units of a size of 22.2 m^2. Thus, the legal obstruction against construction of smaller units/net hectare is overcome to imply an average plot size of about 30 m^2. This would allow for a good mix of small and large units for a given layout or subdivision. The former is only an enabling regulation, its impact is yet to be seen...* (BMRDA 1995)

Throughout the world, efficient use of potential built-form density is becoming increasingly important, and planning compact cities is gaining popularity among the urban planners. Although the concept of compact cities is gaining popularity in light of sustainable development issues, it is still debated among planners and academic (for example, Owens 1988; Breheny 1997; and Gibbs 1997). However, the principles of compact city appear to be more appealing now than in the past. In the UK, increasing the current practice of density has been looked upon as a potential method of housing future population and households (DETR 1998); the same holds true in case of the European Union. Typical examples of cities with high and efficient densities include Singapore, Hong Kong, and Bangkok in the east and New York, San Francisco, and Washington in the west.

[11] Furthermore, the physical infrastructure is burdened but there was inadequate response through its expansion due to fiscal problems (partly the loss of property tax revenue) and policies.

In light of the existence of these examples and the evolving thinking about the positive use of density, the utilization of density as a flexible tool of planning for accommodating more people might be appropriate than restricting densities, which has led to a variety of problems in a rapidly growing city like Mumbai. Viewing the density regulation as a method of controlling development and limiting the burden on infrastructure provision are not the responsible methods of urban governance. Rather, the local authorities need to expand infrastructure, improve delivery efficiency, and adopt economically efficient methods of urban management. For example, planning agreements and pricing of public services are positive win-win approaches, which make the city land and housing markets become efficient and the physical quality of life also improves in the due process. As implied in the compact city debate (Jenks and Burgess 2000), the burden on infrastructure and on the city needs to be evaluated carefully (particularly, by avoiding problems associated with very high densities) to expand the extent and range of infrastructure services provided. This needs to be coupled with market-based and incentive-compatible practices setting foot.

Acknowledgments

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How price reform revolutionized the operational discipline of India's power sector*

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Abstract

The development of an incentive-based tariff scheme has had a significant impact on the operation of the Indian power sector. Voltage fluctuations have been minimized, greater supply made available, and costs reduced. All this was achieved through the ABT (availability-based tariff) introduced in 2000. This paper considers the development, implementation, and results of this sector's change bulk tariff system.

* The views expressed in this paper are of the authors and not of the World Bank.
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Background

India's century-old electricity industry has grown rapidly since the country's Independence in 1947.[2] Of the approximate 112 000 MW (megawatt) of installed capacity in 2004, 31 600 MW was provided by the central sector generating capacity.[3] However, despite these investments, much of the country is still blighted with power shortages and the grids constantly face demand and supply mismatches. Until recently, the situation was further exacerbated by grid indiscipline. In their attempts to draw their allocation of central sector generation, at times when grid supplies were restricted due to plant unavailability, the state utilities dragged down the system frequency, often to unstable levels. Also, to supply the power even when not required, bulk generators would continue to drive the system to unnecessarily high frequency levels rather than backing down their capacity. This indiscipline led to large fluctuations in the grid frequency, and on a number of occasions, complete grid blackouts occurred causing serious losses to India's economy and damage to expensive system components and local equipment.

In the 1990s, in parallel with the state-level power sector reforms, India's transmission and system operations went through an extensive national restructuring programme. POWERGRID (Power Grid Corporation of India Ltd), established by the GoI (Government of India) in 1989, took up the implementation of this programme. Between 1994 and 1996, all RLDCs (regional load dispatch centres) and their operational responsibilities were transferred to POWERGRID from the Central Electricity Authority.

The bulk supply tariff mechanism for sale of electricity from central generating stations was initially a single-part tariff. A unit price per generated kilowatt-hour covered all costs related to generation, including capital expenditures as well as other costs such as those of operating, maintaining, and fuelling the power stations. States tended to compare the total cost of central generators with the variable cost of their own stations as for

[2] India's installed capacity has grown from 1362 MW in 1947 to about 112 000 MW in 2004. In 1963, India's electricity system was divided into five electrical regions to promote the concept of integrated power system developments transcending state boundaries—the northern, western, southern, eastern, and north-eastern.

[3] Output from the central stations is shared among the states in India on an agreed basis—the Gadgil formula.

them the fixed costs of state-owned stations were sunk costs. This made central generation appear more expensive than state-owned stations, even though on a variable cost basis the former was often cheaper. Also, no formal scheduling process for fixing generation and drawal levels existed. There was no system of merit order dispatch. The demarcation of scheduling and dispatch responsibilities between the different stakeholders was unclear. Tariff did not encourage the states to invest in installation of power factor correcting capacitors, which, in many instances, led to unavoidable and expensive exchanges of reactive power and the concomitant low voltages.[4] Furthermore, buyers were not liable to pay the fixed costs associated with the share of capacity allocated to them. Thus, buyers who decided not to draw energy could avoid payment of the inherent fixed charge related to it, which then had to be paid for by the buyers drawing energy. This was unreasonable because it disproportionately increased the cost of energy for those buyers who actually drew energy within their entitlement. Further, the generators were even provided financial incentives for achieving high PLFs (plant load factors), which were attained, by continuing to generate even when the consumer demand had dimi-nished. Thus, the single-part tariff mechanism actually encouraged grid indiscipline. By the end of the 1980s, the GoI was intent on replacing the current single-part tariff with a tariff system that would address these problems.

Development of an alternative bulk supply tariff mechanism

With a view to reduce or eliminate the problems caused by the then existing single-part tariff, India's Ministry of Power constituted the K P Rao Committee[5] to review tariff. The committee's recommendations were a major step towards a two-part tariff

[4] Reactive power is an engineering concept used to describe the background energy movements in an alternating current system. These energy movements arise from production of electric and magnetic fields in equipment connected to the system. Reactive power flows give rise to reduced voltages and higher losses across the system. Thus, it is necessary to maintain reactive power balances between sources of generation and points of demand on a zone-by-zone basis. The problems associated with reactive power are predominantly overcome by connecting to the system banks of reactive power-supplying capacitors, and to be most effective, they need to be sited at the point of load.

[5] The K P Rao Committee submitted its *Report of the Committee on Fixation of Tariffs in Central Sector Power Stations* in June 1990.

system.[6] However, there was room for further modification and improvement. For example, the recommendations included that the PLF be used as a basis for calculation of fixed cost portion, thus continuing to send misleading signals to the generators during low demand periods. Also, compared to international standards, the targets set for plant loadings were too low. Besides, tariff did not provide for any incentives to encourage grid discipline. Finally, although the GoI accepted the recommendations in their entirety, implementation was only partly carried out.

When POWERGRID was established in 1989, the GoI had discussed with the World Bank the implementation of reforms in the bulk supply tariffs under the umbrella of the ongoing central-level power sector reforms. Simultaneously, it, supported by multilateral funding, was developing modern system coordination and control facilities and regional power pools. It also began carrying out a programme to strengthen interconnections between the regional systems with the intent of eventually moving towards a national grid. This would facilitate (a) movement of power between regions (in essence, improving utilization of the existing available generation capacity) and (b) increased power imports from the neighbouring countries. These developments and the emerging regional electricity markets of the early 1990s enabled generators and state-level utilities to improve the efficiencies of their system operations, and facilitated the trading of power, which was needed to supplement supplies being received under long-term power purchase agreements. However, to further facilitate and reduce the cost of energy trades, a radical change in the bulk supply tariff was needed and POWERGRID worked together with their consultants on a proposed new incentive-based tariff design.

After the GoI conducted detailed consultations, the CERC (Central Electricity Regulatory Commission)[7] held hearings and considered the evidence from all concerned parties. It passed orders in January 2000 for implementation of the new bulk power tariff[8] for the country. The CERC's detailed order also covered

[6] The payment to the generator was split into fixed costs and energy charge components but was also dependant on the plant's achieved utilization—the PLF (plant load factor).
[7] Consequent to the formation of Central Electricity Regulatory Commission in 1998, the mandate for fixing tariffs for the central sector generating stations was passed on by the government to it from May 1999.
[8] CERC orders (including the availability-based tariff, dated 4 January 2000) can be seen at <www.cercind.org>.

various aspects, including (a) procedures for determination of available capacities, (b) handling of unallocated shares from a given plant if not allocated by the GoI,[9] (c) force majeure conditions, and (d) establishment of penalties for mis-declaration of available capacities.

Conceptual design of market and tariffs

India's new bulk power market and tariff structure has many distinctive features, but in short, it is a system of commercial incentives to increase the efficiency and utilization of India's scarce generation and transmission resources, and to improve the reliability and security of supply. The frequency-linked pool rate for unscheduled interchanges, which is an integral component of the new bulk power tariff and trading system, is virtually unheard of outside India. The tariff's main features are described subsequently. Although it encompasses a much wider scope than the regular availability tariffs used in other countries, the new tariff regime is popularly known in India as the ABT (availability-based tariff).

Market mechanism

The market mechanism in India is one of decentralized scheduling, interstate and inter-regional trading, alongside the centralized dispatch of central sector generation at the regional level. This form of market mechanism provides maximum freedom to states. It enables them to make and to be responsible for their own operational decisions, and to bear the primary responsibility for operating at the minimum variable cost. The RLDCs perform the coordination and facilitation role. Each day is divided into 96 blocks of 15-minute periods for the measurement of average frequency and estimation of unscheduled interchanges. Specially designed meters have been installed for this purpose at all interface points. The bulk buyers and the generators provide RLDCs with one-day-in-advance demand and availability schedules. RLDCs then coordinate with participants of the regional power pool to decide the following day's schedules. There is also a provision to enable changes to be made to the schedules if exceptional circumstances arise. The RLDCs are responsible for metering the interchanges and maintaining accounts of the regional pools.

[9] 15% capacity of every central generation plant is unallocated and can be allocated to any state at GoI's discretion.

Interchange tariff

The new bulk power tariff regime identifies the interchanges between the central sector generators and state utilities in two ways. An interchange, which is as per the agreed schedule of dispatch for the period of interchange, is termed as *scheduled interchange,*[10] and any other interchange is called the *UI* (*unscheduled interchange)*. The UI is calculated for a generator as the difference between the actual energy generated and the scheduled energy to be generated during a given period. Similarly, for a user, it is the difference between the actual energy drawn from the regional grid and the energy scheduled to be drawn during a given period. Also, to provide disincentives for reactive power drawls, there are voltage-dependent charges along with incentives for drawing/injecting reactive power into the grid.

- *Scheduled interchange tariff* Each of the entities is allowed a significant latitude to negotiate transactions, which are in mutual interest of the parties to the transactions. Both, (a) non-standard interchange products with market-based pricing and (b) standardized products with cost-based pricing are possible. In the cost-based pricing mechanism, the tariff is in two parts: (a) fixed cost recovered through a capacity charge and (b) variable cost recovered through an energy charge. For the non-standard interchange product, each price element is based on the market and may or may not directly be linked to cost.
- *UI tariff* The UI tariff is linked to principles of grid control tariff with the addition of a frequency-sensitive component. It is based on deviations from the scheduled interchange as well as being linked to deviations from India's nominal frequency of 50 cycles per second (Hz). During low-frequency periods, usually caused by inadequate generating capacity, the UI is priced at the marginal variable energy costs associated with supplying it within the region. However, during high frequency periods, which usually occur when there is plentiful supply of generation, UI is priced at a relatively low cost so that its suppliers may not necessarily recover all their variable costs for these periods. The base UI rate is now 5.70 rupees (initially 4.20 rupees) per kilowatt-hour for

[10] Long-term power purchase agreements, such as National Thermal Power Corporation's bulk power purchase agreements, would be covered under the scheduled interchange.

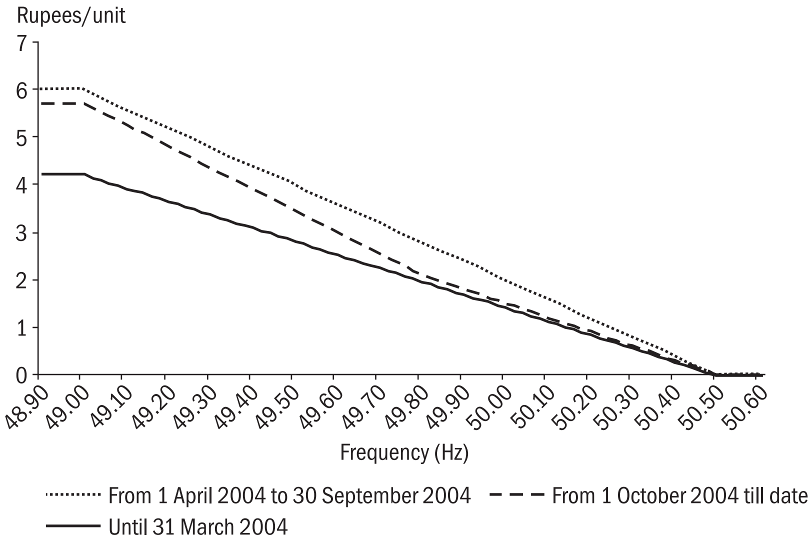


Figure 1 Unscheduled interchange charges and their link to system frequency

interchange at the grid frequency[11] of 49.0 Hz or below, and becomes zero at frequencies of 50.5 Hz and above (Figure 1).

- *Reactive energy* The tariff mechanism includes incentives to encourage participants to provide adequate quantities of power factor correcting capacitors in their systems. When the actual voltage is low compared to the nominal voltage at the point of supply to the utility's transmission system, consumption of reactive power is charged at the equivalent of an average carrying cost of capacitors multiplied by the total reactive power consumption during that period. The same rate will be paid to utilities, which provide reactive power to the transmission grid under low voltage conditions.[12] On the other hand, if the actual voltage is greater than nominal at the utility supply terminal, such absorption of reactive power will also be paid for at the same rate. Imposition of reactive power charges will induce bulk purchasers to invest in and to appropriately operate reactive power compensation equipment. The specified rate is payable/receivable when voltages deviate

[11] Grid frequency for the purpose of these charges will be the average during each of the 15-minute time blocks.

[12] A utility can change the amount of reactive power it is contributing to the system by installing capacitors, and switching them in or out according to the system requirements.

beyond ±3% of normal voltages, and is 40 rupees for each MVARh (million volt ampere reactive hour) exchange, with a provision of 5% per annum escalation from 1 April 2001. The rate is the same for all voltage deviations beyond the normal range.

Transmission tariff

The charges to a state utility for use of the regional transmission system are based on the pro rata share of the total annual carrying cost of transmission-related investments, excluding any investment for coordination or dispatch activities and any facilities that serve only one utility. The pro rata factor is a ratio of each state utility's entitlement of the regional central sector generation capacity to the total central sector generation capacity within the region. The annual carrying cost of transmission-related investments, which serve only one state utility, will be fully paid for by that particular utility.

Generation tariff

The tariff accommodates, with respective values, the interchange of electricity from thermal and hydroelectric sources.

- *Thermal generation* Under the new bulk power tariff mechanism, the fixed and variable cost components are treated separately. Payment of the fixed cost, and thus return on the generating company's investment, is linked to the availability of the plant, that is, its capability to deliver power on a day-by-day basis. The total amount payable to the generating company over a year towards the fixed cost depends on the average availability (megawatt delivering capability) of the plant over the year. If the average, which is actually achieved over the year, is higher than the specified norm for plant availability, the generating company will be rewarded with a higher payment, and vice versa. This is the first component of ABT and is termed as the *capacity charge*. Thus, there is an incentive to generators to ensure, with operational efficiency, that actual availability for generation is above the specified norms.[13] The capacity charges are determined on an annual basis but settled monthly.

[13] The norms for plant availability, above which an incentive would be provided, are specified by the Central Electricity Regulatory Commission.

The second component of ABT is the *energy charge*, which accounts for the variable costs of supply. It is made up of the fuel cost of both primary fuel (for example, coal) and secondary fuel (for example, start-up oil) based on the standardized accounting methodology of the power plant for generating energy as per the given schedule for the day. It is important to note that the per-unit energy charge relates to the scheduled generation and not to the actual generation and plant output.

In cases where there are deviations from the schedule (for example, if a power plant delivers 600 MW when it was scheduled to supply only 500 MW), the energy charge payment would be for the scheduled generation (500 MW) only, and the excess generation (100 MW) would be handled through the UI tariff described above. Hence, if the grid is being injected with surplus power at the time of interchange and thus the frequency is above 50.0 Hz, the UI rate will be low. However, if generation is being provided during a deficit period (in which case the system frequency would be below 50.0 Hz), payment for the extra generation will be at a higher rate.

- *Hydro generation* The tariff methodology for conventional hydro generators is a *hybrid cost allocation tariff,* in which recovery of the annual fixed cost is divided between plant availability payments and payments from energy sales because there is no fuel cost (variable charge) associated with hydro generation. The availability payment is based on the mechanical availability of the plant and ensures full recovery of the fixed costs once the target availability is met. The CERC has ordered the use of a *capacity index*, which is related to the availability of water and availability of the machines. This index ensures that lack of water does not affect the payment of fixed costs to generators when the generator's machines are available. Incentive charges would be paid whenever a generator ensures a higher availability of its plant.[14] The primary (designed) energy charge is linked to 90% of the variable cost of the most efficient central sector thermal unit in the region. This rate is also used for merit order dispatch. Hydro generators also receive benefits for

[14] Currently, the hydro generators get incentive/disincentive on annual fixed cost less primary energy charges, for every percentage of availability above/below 85%.

secondary energy (energy generated in excess of design energy when there is more than the expected level of water flow), which is valued at the same rate as the primary energy. Various tariff principles have been provided for by the CERC to cover different types of hydro stations.[15]

Impact of ABT—experience since 2002

The actual implementation of ABT took a considerable time, reflecting the challenges of implementing fundamental reforms in a federal structure having a number of independent participants with conflicting interests and capacities. The first region to take the lead was the western region where implementation started from 1 July 2002. Subsequently, all other regions (the most recent being the northeastern region from 1 November 2003) have decided to implement the reforms and the new bulk power market tariff regime. Thus, the pricing methodology is being applied to power that crosses state boundaries. The intent is that it should also be applied to intrastate transactions in due course.

Improved trading under scheduled interchange

One of the key changes noted after implementation of the ABT regime has been the improvement in the discipline with which utilities forecast their demand schedules and the generators provide the daily availability of their plants. Based on this data, the SLDCs/RLDCs prepare an optimal generation schedule and dispatch the required generation in line with the economic merit order.[16] This also facilitates better resource planning for the generators and better load management for the utilities.

Majority of the bulk power transactions are under the long-term bilateral PPAs (power purchase agreements). With implementation of the availability-based two-part tariffs under this regime, generators are recovering their fixed costs, independent of the actual generation required. With this change, merit order operation has started in earnest in a way experienced never before in India. This is evident from the increased utilization of the

[15] Pumped storage, run-of-the-river, and reservoir types. These orders can be viewed at the CERC's website. <www.cercind.org>.

[16] 'Schedule', in the Indian context is used to indicate the quantum of planned generation indicated to the load dispatch centre, and 'Dispatch' is the actual level of the load supplied by the generating unit.

more efficient/low-cost pithead plants in comparison to the more expensive plants located at the load centres. For example, generation from a pithead plant (Singrauli) at a PLF of 98.4% is at a much higher level as compared to a PLF of 77.5% for the more expensive variable cost plant located at (Dadri) in the Northern region. Backing down generation during the off-peak hours no longer necessarily results in a financial loss to the generating station, and this neutralizes the earlier perverse incentive towards not backing down.

The two-part tariff for scheduled interchange of power has allowed for an increasing share in power supply for some of the power-deficit SEBs (state electricity boards) while other power-surplus SEBs are able to earn revenues by trading this surplus. Significantly, it appears that more power is being extracted from the same power system as system operation is optimized. In addition to operation of pumped storage and exploitation of available captive plant, part of this apparent power surplus has come from a more efficient draw down of the SEB's entitlements in various central sector plants and IPP (independent power producer) plants contracted under the long-term PPAs.

Improved operation of hydropower stations

Introduction of the ABT regime has greatly helped in optimizing the operation of hydropower plants and enabled effective utilization of the pumped storage facilities. Water is being conserved for peak-hour generation, wherever feasible, in coordination with the demand for irrigation facilities. Pumped storage hydro stations are also able to operate. For example, for the first time after it was commissioned, a 400-MW pumped storage station at Kadamparai in Tamil Nadu is now being operated under pumped storage mode (after ABT implementation started in the southern region in January 2003). The plant began pumping during the off-peak hours and generating during peak hours. The stabilized system frequency helps the operation of the Kadamparai plant whose equipment has been designed for operation between 49.5–50.2 Hz, and the high UI rates recover its cost of pumping and regeneration. This operation has continued even though during the past three years, the region faced drought conditions leading to a reduction in water flows and low generation levels. Figure 2 shows the energy generation in the past three years in both the generation mode and the pumped mode.

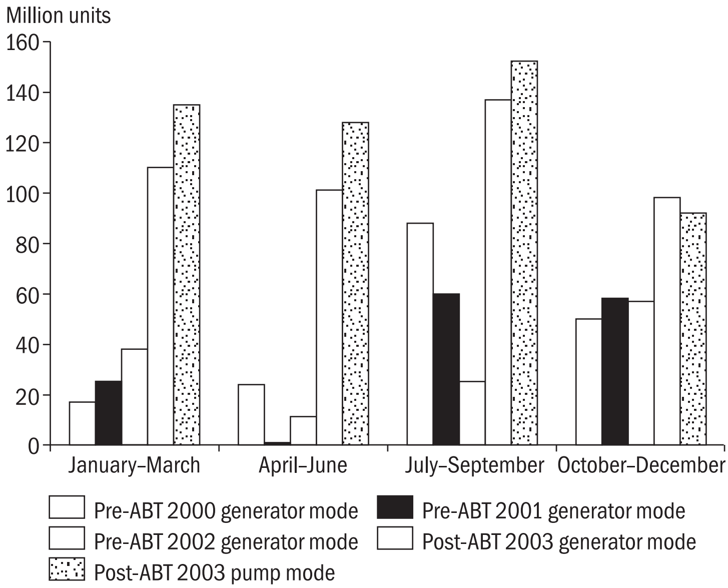


Figure 2 Utilization of Kadamparai pumped storage plant

Improved grid discipline

The UI tariff, with its link to frequency, has improved grid discipline (Box 1) and increased opportunities for power trading as well as harnessing the underutilized decentralized generation, including captive and renewable stations. In order to establish the incentive, the UI-rate at low frequency periods is higher than the variable cost of most decentralized generators and is higher than the total cost of many decentralized generation options.

The UI charges have led off-takers to make contracts for power rather than just abusing the grid and overdrawing their schedules. From implementation till April 2004, 42 026 million rupees have been exchanged across all regions. This constitutes about 12% of the total power bill for scheduled exchange during the same period. Table 1 provides region-wise details of the UI

Box 1 Illustration of the discipline imposed by the new system

Shortly after the ABT (availability-based tariff) was introduced, Tamil Nadu contracted with Kerala for purchasing power from the Kayamkulam CCPP as despite its high cost of 3.80 rupees per unit, this power was cheaper than the cost of overdrawal of 4.20 rupees per unit from the grid from the implementation of ABT.

Table 1 Region-wise details of the UI (unscheduled interchange) charges exchanged between stakeholders from inception of the new bulk power tariff reforms

Region	*UI charges billed* (rupees)[a]	*Amount paid* (rupees)[b]	*Per cent realized*
Northern	28 196	23 027	82
Western	17 262	15 729	91
Southern	12 392	12 392	100
North-eastern	2 590	2 383	92
Eastern	15 930	14 470	91
Total	**76 370**	**53 225**	**86**

[a] Billing up to December 2004 since inception of the new bulk supply (ABT) tariffs
[b] Collection till February 2005 for the billed amount

charges exchanged between stakeholders from inception of the new regime. It also records actual payments made by them against the billing, which stands at a good 86% level. There are about five major defaulters and some of these cases are due to the pending resolution of their power shares with the new states, carved out of the existing states. The CERC, on appeals filed by the RLDCs, has agreed to pursue the defaulting states seriously for as per the grid code, payment of the UI charges has priority over other payments. However, a suitable mechanism for ensuring compliance by states on payment of the UI charges needs to be developed by the CERC, government, and RLDCs.

Improved quality of supply (grid frequency and voltages)

The most significant benefit of these reforms has been a considerable improvement in the grid supply quality, which will help utilities ensure a better quality of supply to consumers. Incentives for better scheduling and penalties for overdrawing have led to a dramatic reduction in frequency variation on the grid. Previously, frequency and voltage fluctuations were significantly beyond the levels expected in most other countries. This improvement has led to enhanced efficiency of the equipment operation (Box 2).

Figure 3 shows the grid frequency in the southern region comparing a week of new tariff regime (ABT) implementation against the same period a year before.

Box 2 Karnataka—impact of improvement in the quality of supply

The city of Bangalore in Karnataka had been suffering from an acute water shortage for many years due to a low-voltage at the booster stations on the T K Hally–Bangalore pipeline. With the recent improvement in voltage at these booster stations, the water supply to Bangalore has increased substantially. Similarly, farmers in Karnataka are now much more satisfied with the supply voltage and frequency. They find an improvement in the volume of water pumped, and it has helped them cope with the limited hours of power supply. Industries like the Kudremukh Iron Ore Company are also able to operate their sensitive machinery efficiently because of the improved voltages, which was not possible before the bulk power market reforms.

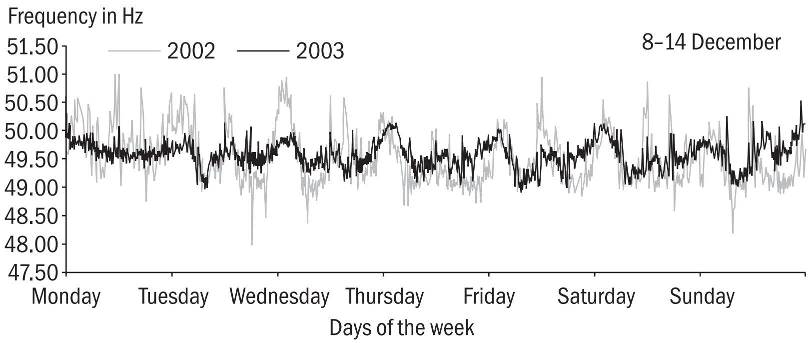


Figure 3 Frequency profile comparison for the southern region
Note Details available at SRLDC website <http://www.srldc.org/ftp/frequency/2003/50TH%20WEEK.jpg>.

POWERGRID has developed a measure of frequency variation, known as the FVI (frequency variation index), based on the variation above and below 50 Hz as measured at 10-second intervals.[17] Table 2 shows the value of this index in the period after implementation of the new bulk power tariff regime and in the same period of the previous year before implementation of the ABT.

Similarly, there have been substantial improvements in the voltage profiles on the grid and all regions have shown improvements, as can be seen in Figure 4.

[17] FVI= $\frac{10\sum(F-50)^2}{24 \times 60 \times 6}$ where, F is frequency measured at 10-second intervals.

Table 2 Frequency variation index before and after ABT implementation

Region 2002/03	*Frequency variation index*					
	*Prior to implementation**			*Post-implementation period*		
	Average	*Maximum*	*Minimum*	*Average*	*Maximum*	*Minimum*
Western	11.97	20.57	5.10	4.16	7.17	1.81
Northern	3.61	6.72	2.30	2.22	5.02	0.88
Southern	26.77	44.62	4.87	0.99	2.51	0.25
Eastern	10.35	13.40	8.71	1.91	4.08	1.22

* Based on comparable months according to the data available.

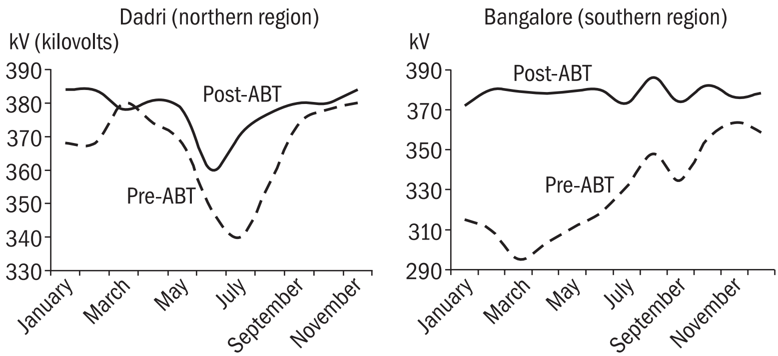


Figure 4 Minimum voltage profiles before and after ABT implementation (in 400-kV system)

There has also been an improvement in the levels of the peak demand met. Even when the effect of additional generation is isolated, substantially higher peak demand has been met while using the same generation available—as can be seen from Figure 5 for the eastern region where no generation was added during the period.

Efficiency gains

The most important benefit of the ABT to date is improvement in the supply availability and quality for consumers. Utilities are in a better position to know, well in time, the availability of generation, and although load shedding is still inevitable, they can plan their load scheduling better and give consumers more

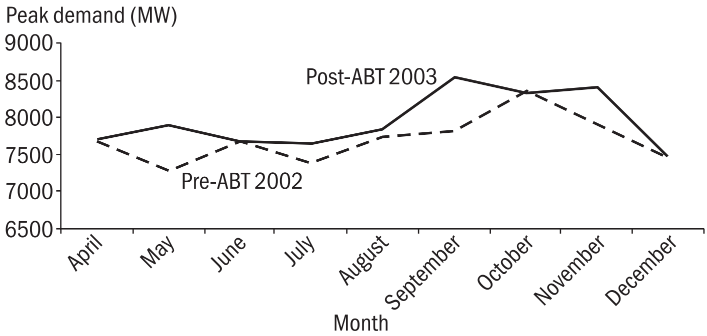


Figure 5 Peak demand met—eastern region

certainty. With a more consistent system frequency, voltages have improved and it is easier for utilities to provide supply to consumers with fewer voltage fluctuations. This results in more efficient operation of all types of electrical plant, machinery, and equipment. For example, increased water delivery for the same power leads to financial and economic benefits for India. Other financial and economic gains accrue from the following factors.

- It is now possible to set the under-frequency load shedding relays properly, and to get them to act effectively and save the system from collapse in case of a serious contingency (Box 3).
- Less stress is placed on the power equipment, which will consequently have a longer, useful economic life.
- The state's allocated share of power from different central stations now has a real meaning, both operationally and commercially. As opposed to the pre-ABT commercial mechanism, which recognized only the actual energy drawals, not

Box 3 Win-win situations

On the day of the last World Cup Cricket Final, Karnataka overdrew as much as 600 MW. Hydrostations were run in the neighbouring states to supply this power to Karnakata as 'unscheduled interchange'. (Operationally, this was not unscheduled as it was planned in advance, but the ABT regime afforded these states the opportunity to trade this power at UI rates.) This enabled Karnataka to ensure that there was no load shedding during the critical period and it improved the state's image, while the neighbouring states were well remunerated for providing short-term power, which would not have been possible under the previous tariff regime.

the share and schedules, now all states can either fully use their allocated shares of power from the central station or trade for any unused share through the UI mechanism or by bilateral transaction.

Reasons for mixed performance in different regions

The new tariff regime has not produced as much impact in some regions as in others. Although some of these differences are due to the grid characteristics, the major reasons for mixed performance have been the difference in preparation of the participating members in a region and determination to make the maximum gains from this new bulk supply tariff regime. Those achieving the highest gains have prepared simple decision-making charts to help the load dispatch centre staff to make effective decisions even at night, without waiting for approval of their senior officers. Further, RLDCs have been prompt in billing the UI charges and members have been prompt in paying their dues. For example in case of the southern region, payments against the UI charges are 99% of the billed amount as against the national average of 89%.

Issues requiring further resolution

The implementation experience, to date, has also brought into focus some issues that need further study and resolution. The CERC, GoI, and the market participants will have to resolve these issues.

- Some power stations are still working to maximize their PLF, the traditional measure of plant performance, rather than their availability and commercial efficiency. The performance incentive for generating company and their employees on performance needs to be changed to ensure that the incentives are aligned to the ABT system.
- Some of the generators still do not operate in 'free-governor' control mode. If stations were allowed to operate in the free-governor mode, the grid frequency could be smoothly controlled with automatic matching of the generation with the load demand. Most state-owned generating stations in the southern region are now operating in free-governor control mode. This is one of the reasons for the reduced grid frequency fluctuations in the southern region, but greater efficiency gains could be achieved if the other generating stations were also controlled like this.

- To be fully effective, the ABT system needs to be implemented at an intra state level as well as at the interstate level. Several states are already working on this and installing the necessary boundary meters to be able to allocate the UI charges amongst the distribution companies.
- As the ABT becomes accepted and grid discipline improves, the frequency-related element of this tariff may become unnecessary. Further, there is likely to be more power trade with the advent of open access mandated in the Electricity Act, 2003. This may necessitate changes to the national tariff regime and a review of the ABT mechanism. Thus, periodic reviews of the tariff system, the incentives therein, and the overall operation of the grid will be necessary if the system is to support the development of the power markets in India.
- The CERC and RLDCs should work on a mechanism to ensure that payment of the UI charges continues at the high levels seen over the past couple of years. The CERC may have to levy strict penalties on defaulting participants.

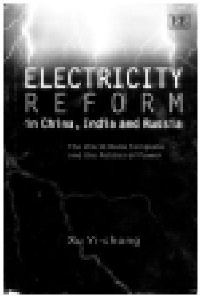
Summary: a win-win situation for India's power sector

Implementation of the ABT bulk power tariff regime has been possibly the most significant practical development in the power sector in India in the past decade. It has improved the quality of power supply dramatically, brought the much-needed commercial discipline among the generators and utilities, and laid the foundation of a power market. The ABT is already leading to improvements in what were highly volatile grid frequencies. Consequently, it is most likely to help prevent system collapses and lead to a more efficient use of India's current installed generating capacity. The impact of the new regime will also encourage increased investments in the power sector and will provide incentives to generators to enhance the output capacity of their power plants. This, in turn, will enable more consumer load to be met during the hours of peak demand. Also, because of tariff arrangements, generators will now back down generation during off-peak hours, which will result in economic benefits for India.

The ABT regime has also encouraged interstate trading and merit-order dispatch, which will minimize the financial cost of power for the bulk purchasers with further benefits for India's economy. However, the real winner will be the consumer who in the past has suffered as a result of grid indiscipline. With proper control of grid frequency and improved system voltages, it will be easier for utilities to provide the consumer with more reliable supply of power, allow for more efficient use of equipment, and reduce the costs of back-up power supply reduced. Overall, reforms in the bulk power supply tariffs will result in an installed generation capacity supplying more energy at a lower cost. The new tariff will also result in less system component damage, increased interest by would-be investors, and substantial benefits for the Indian economy.

Book review

Electricity Reform in China, India and Russia: The World Bank template and the politics of power



359 pp.

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Reviewed by
K Ramanathan
Distinguished Fellow, TERI

International Journal of Regulation and Governance **5**(1): 61–65

Since the early 1990s, power supply industry in many parts of the world has been going through a process of reforms and restructuring. The template of reforms had similar features like unbundling of vertically integrated utilities, change from public ownership to private ownership, evolution of a competitive power market, and establishment of independent regulatory bodies. It was expected that the reforms would lead to a vibrant power sector, protection of consumer interests, and minimize government spending in the sector. To what extent the different countries have been able to realize the goals of reforms and viability, applicability, and feasibility of market-led reforms in the developing countries, however, remains a hotly debated topic. The California crisis added more fuel to this debate. Nevertheless, the reform programme is spreading to all parts of the world, always with high expectations. A critical and comparative study of the process of reforms in countries with different political, legal, and economic systems should therefore be most welcome at this juncture. This book aims precisely at this and covers three countries, namely China, India, and Russia. The author has chosen the countries keeping in view the striking differences and similarities, in terms of development of electricity industry, legal and constitutional set-up, and economic development.

The book is structured into nine chapters. The introductory one dwells briefly on the reform template and experiences of a few of the developed countries. It then debates that the World

Bank took the lead in developing a template for reforms following the experience in UK. The same was then applied in other developed and developing countries. According to the author, this was the resultant effort of 'the joint forces of the eager tutors of the Bank and international actors and the willing pupils of the local elite'. The observations are often quite sarcastic and this continues throughout the other chapters as well.

The second chapter examines the nature, organizational structure, and development of the electricity industry in different countries. Some of the inferences drawn are (a) ownership reform and restructuring need not take place simultaneously, it seldom did in the OECD (Organisation for Economic Co-operation and Development) countries, (b) to succeed, the reform model should fit to the local political and economic reality, and (c) competition is difficult when prices are inelastic or there are inadequacies in the generation, transmission, and distribution system. The author has tried to effectively highlight the risks involved in rushing through market reforms and to provide an eye-opener, especially for the developing countries with low levels of access to electricity.

The third chapter provides a brief survey of the political, legal, and economic systems of China, India, and Russia and an examination of their electricity industry. It also examines the interaction between political and economic institutions that govern the electricity industry in these countries. The author tries to conclude that there are 'some commonalties as well as many differences' between the three countries and hence a common reform template would not work. Some factual and editorial errors and omissions are however, seen in the text. A few of these in the Indian context relate to the growth in installed generation capacity in different plan periods (p. 66), structure of the industry (p. 73), absence of any mention to the 1998 Reform Act, the various state-level Acts and the Electricity Act, 2003 (p. 81), reference to the Indian Civil Service, etc. There is also an obvious mix-up of legends in Figures 3.1.

The fourth chapter examines how and why reforms were initiated in the three countries. The three triggering factors have been identified as external pressures from multilateral financial institutions (as the facilitating factor) and general economic reform in the country (as the contextual factor) and internal pressure due to immediate problems within the industry. Acknowledging that the factors varied significantly in the three countries, the author once again targets his criticism at the World Bank and the local 'technocrats and technopols' who try to copy the western models of reform.

The fifth chapter focuses on ownership reforms. It tracks the changing policies of the World Bank and its aggressive pursuit of corportatization and commercialization of state-owned enterprises by making it a conditionality for financial support. Experiences of the three countries are discussed at length, including the power politics, organizational conflicts, etc., which influenced reforms. In case of India, it is however restricted to Orissa. The lesson drawn towards the end namely, 'privatization is not a panacea for all ills' is a well-accepted fact.

The sixth chapter deals with the structural reforms of the electricity industry, namely the vertical and horizontal unbundling of the industry, functionally and organizationally. The author points out that by the end of the 1990s, the World Bank made structural reform a condition to developing and transition economies and provided 'solicited and unsolicited advice' to China, India, and Russia. Experiences of the three countries are detailed; in case of India it is again restricted to Orissa. There are a few verbatim repetitions within this chapter as well as with the chapter on ownership reform. Some of the statements also appear questionable. For example, it gives an impression that the international consultants deliberately projected a very low loss level (p. 211) in case of the OSEB (Orissa State Electricity Board) in India. Similarly, inadequacies in the transmission and distribution system have been quoted as the major reason for 'failure' in restructuring of the OSEB. The analysis also seems to extend to ownership reforms at places. The chapter again tries to conclude that 'public services can only be met with public obligations' and 'caution is needed in designing a specific model for reform in each country'.

The seventh chapter deals with regulatory reform in the three countries. The author has tried to conclude that 'it will take more than an independent regulatory agency to ensure fair competition, attract private investment, expand industry, or improve the economic performance of electricity enterprises'. The role of the government and the 'human and political realities' to be considered in regulation are reiterated in this context. The author quotes the experiences of China and Russia to make a point that without a formal and operational legal system, an independent regulatory agency cannot function effectively. The

Indian experience is once again primarily restricted to Orissa. A reader familiar with the Indian power sector will also notice a few omissions and factual inaccuracies. For example, there is no reference to the state-level reform acts (eight, excluding Orissa) and the Central Act of 2003. Similarly, the statement that 'the ERC Act, 1998, was amended in 2001 to confirm the authority of ERCs to set electricity tariff' (p. 256) and the references to electricity law of 2000 (p. 229) are not factually correct. The author's conclusion that the issue of how to regulate the wires segments remains an unsolved technical question even in the developed countries (p. 277) is also debatable.

The eighth chapter on 'Reform complications' opens with the statement that 'no government can stand back from responsibility of electricity supply because in the extent of failure, electorates will hold them responsible, no matter whatever arm's length arrangements they may have put in place'. Hence, the author argues out that attention must be given to the political realities and unique problems each country faces in the process of reforms to avoid rigid solutions. The chapter focusses in particular, on the non-payment or non-cash payment problems in the three countries. It also deals with subsidies and cross subsidies. In case of China, the author identifies the relationship between the government, banks, and state-owned enterprises as one of the major constraints on growth and reform. In India, the non-payment issue has been rightly brought out as one between the central public sector undertakings, SEBs, and end-users. The problem in Russia relates to overdue accounts payable and non-cash settlement. The author has traced the steep growth in barter transactions, bulk of which relates to sales of intermediate goods such as fuel, building materials, and electricity. The liquidity and credit squeeze in economy and some interesting stories of barter deals prevalent in the country (for example, payment of wages in Vodka to fishermen) have been cited (p. 313). The author has also rightly acknowledged that the non-payment problem in all the three countries is more than a sectoral issue and although there are some similarities, the causes are different and hence cannot be solved with a single package of market reform.

In the ninth and concluding chapter, the author has summarized his findings. He reiterates inter alia that (a) markets will not and cannot undertake the responsibility to ensure the public good and public service aspects; (b) a combination of private, local/state, joint-venture and public ownership can bring in competition and improved performance; (c) unbundling poses the risk of supply reliability; (d) guaranteeing universal access to electricity is imperative for human development and hence, pricing calls for delicate balancing of interests; and (e) one reform model does not fit all.

The book is an excellent addition to the literature on reforms in electricity. It has effectively articulated, albeit some repetitions, the risk of rushing through market reforms and adoption of a common template for reforms. How the local political and economic realities can impact reforms and the need for honouring the engineering and physical principles of the industry are also highlighted. It has also focused on the importance of the role of governments in reforming the sector. As regards India, it is, however, to be noted that the Orissa case cannot be taken as a representative of the country. The book should provide an interesting reading for policy-makers, reform consultants, and academics and help inculcate added pragmatism in their work on the electricity sector reforms.

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For journals: Davis G R. 1990. **Energy for planet earth**. *Scientific American* **263**(3): 55–62.
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For chapters of edited books: Sintak Y. 1992. **Models and projections of energy use in the Soviet Union**. pp. 1–53. In *International Energy Economics*, edited by T Steiner. London: Chapman and Hall.

For grey literature: Togeby M and Jacobsen U. 1996. **How conflicting goals concerning environment and transport influence the policy process?** Paper presented at the *Conference on Transport, Energy and Environment*, 3–4 October, Helsingor, Denmark.

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