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Performance of Power Sector in Karnataka in the Context of Power Sector Reforms

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PERFORMANCE OF POWER SECTOR IN KARNATAKA IN THE CONTEXT OF POWER SECTOR REFORMS

Laxmi Rajkumari[1] and K Gayithri[2]

Abstract

This is an attempt to assess the performance of Karnataka power sector, using select technical and financial performance indicators. A Power Sector Performance Index (PPI) is computed using the methodology used for Human Development Index. Some technical indicators, like energy deficit, installed capacity, per capita electricity consumption, have improved in the post-reform period; nonetheless, the state lagged behind other major Indian states. Total installed capacity and total electricity generation showed significant trend break in 1999; however, the capacity utilisation rate remained quite low. The T&D loss fell tremendously over time. Average revenue realisation rate rose after reform, although the rate differs greatly across consumer categories. Collection efficiency was highest in HESCOM, while the AT&C loss was lowest in MESCOM in 2013-14. Overall, the PPI value increased from 1998-99 to 2012-13 indicating better performance after reform, and, the ranking improved from the 8th to 3rd position, showing improved performance vis-a-vis other states.

Key Words: Power sector reform, Karnataka Power Sector, Performance, Power Sector Performance Index

Introduction

In any sector, reforms ensue mainly because of persisting problems in the sector which fail to improve over time. Power sector is a very crucial sector for economic growth. The share of power sector in the total plan outlay is about 10% in the 12th Five-year Plan (Planning Commission, 2013-14). In 2014, the Government of India launched the 24*7 "Power for All Initiative" with State governments to provide 24*7 power access to all by 2019. However, the sector is marred with numerous problems. There is still lack of power access in many households. Power shortages, inefficient operational performance and grave financial situation of the State Electricity Boards (SEBs) were taking a toll on the overall growth of the economy, as electricity is one of the most important infrastructural inputs in all sectors of the economy. These problems prompted a series of policy and regulatory changes in the sector. Power sector is in the Concurrent List, and hence, both the Centre and State have the jurisdiction to make policy changes. The first major change in the sector at all-India level was opening up of electricity generation to private sector in 1991, mainly to augment the inadequate resources from public sector, and enable more capacity building. After that, the wave of World Bank-led power sector reforms swept across different states in India, which led to unbundling and corporatisation of SEBs, along with setting up of independent Regulatory Commissions. Further, Electricity Act 2003, considered the major power

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sector reform in India, unified all existing laws and aimed to introduce competition in the sector. The reforms were considered essential due to a multitude of problems faced by power sector during that time.

Karnataka is the 7th largest Indian state by area (5.8% of the total geographic area), with 1,33,57,027 households (Census of India, 2011). However, its electricity industry still faces many technical and financial problems. The peak deficit and energy deficit in the state are 6.8% and 4.4% respectively in 2015-16 (Central Electricity Authority, 2016). This poses a serious concern for future growth and development of the state, as electricity is a key input in the economic activities. Karnataka undertook power sector reforms in 1999, with the Karnataka Electricity Reforms Act (KERA). Subsequently, many other reforms and policies were formulated to improve the power sector performance in Karnataka. The major reforms are listed in Table 1:

Table 1: Major Power Sector Reforms in India and Karnataka

Reform/ Policy	Year	Feature/ Detail
The Electricity Law (Amendment) Act, 1991	1991 October	Amendment to the Electricity Supply Act 1910 and 1948. Private companies can build, own, and operate power stations subject to certain terms and conditions
Karnataka Electricity Reform Act (KERA)	**1999 August**	Provisions for establishment of KERC within 90 days, with its functions and powers Restructuring of electricity industry-unbundling of KEB and corporatisation to form KPTCL and VVNL Karnataka Electricity Regulatory Commission (KERC) constituted in Oct 1999 - To regulate the purchase, distribution, supply and utilisation of electricity, and tariff and charges payable as well.
4 Electricity Supply Companies (ESCOMs) were established after unbundling distribution from KPTCL	2002 June	Bangalore Electricity Supply Company (BESCOM) Gulbarga Electricity Supply Company (GESCOM) Hubli Electricity Supply Company (HESCOM) Mangalore Electricity Supply Company (MESCOM)
Electricity Act	**2003**	Central government initiative "to consolidate the laws relating to generation, transmission, distribution, trading and use of electricity and generally for taking measures conducive to development of electricity industry, promoting competition therein, protecting interest of consumers and supply of electricity to all areas, rationalization of electricity tariff, ensuring transparent policies regarding subsidies, promotion of efficient and environmentally benign policies, constitution of Central Electricity Authority, Regulatory Commissions and establishment of Appellate Tribunal."
1 more ESCOM formed	2004	Chamundeshwari Electricity Supply Company (CESCOM)

Source: Economics Survey of Karnataka, various years; pib.nic.in

The important policies in the power sector are provided in Table 2:

Table 2: Important Power Sector Policies in India and Karnataka

Policies	Time of launch	Detail
National Electricity Policy	2005	Under the provisions of Section 3 (1) of the Electricity Act 2003 Aimed to give access to electricity to all households in next 5 years, to fully meet the power demand by 2012, to make financial turnaround and achieve commercial viability of electricity sector
Rajiv Gandhi Grameen Vidyuktikaran Yojana (RGGVY)	2005 April	Central Government Scheme of Rural Infrastructure and Household Electrification to achieve the National Common Minimum Programme objective of providing access to electricity to all rural households over 4 years. ₹ 5,000 crore provided for the X[th] Plan and 90% capital subsidy provided for rural electrification
Restructured Accelerated Power Development and Reform Programme (R-APDRP)	2008	Central scheme with total outlay of ₹ 51,577 crore to reduce distribution losses, achieve energy efficiency and energy accounting.
Nirantha Jyothi Yojana	2008-09 (on pilot basis)	State government project to segregate electricity load in rural areas to agricultural and non-agricultural consumers, in order to supply 24 hours electricity to rural households and small industries, while monitoring quality supply to irrigation pumpsets. The Government of Karnataka approved the implementation of the project in two phases, at the total costs of ₹ 2,123 crore with 40% equity and 60% to be borrowed as loan by the ESCOMs (GoK, 2016)
Deen Dayal Upadhyaya Gram Jyoti Yojana	2015	Central Government Scheme which will replace the RGGVY scheme, and contains the following components: • Separation of agricultural and non-agricultural feeders • Strengthening and augmentation of sub - transmission & distribution (ST&D) infrastructure in rural areas, including metering at distribution transformers, feeders and consumers end

Sources: Economic Survey of Karnataka, various years; Ministry of Power, Government of India

The reforms and policies were expected to improve the overall performance of power sector in Karnataka. The paper has six sections: the first section gives a brief introduction of the power sector reforms in India and Karnataka, the second section presents the existing literature in the area. The third section provides the details of the variables, data sources and methodology used in this study, and the empirical results are shown in the fourth section. Section five elucidates the Power sector Performance Index (PPI) and the last section concludes the study.

Literature Review

Studies related to electricity industry in India mostly discuss the problems existing in the sector, the issues with reform process, and the general performance of the sector. One of the major origins of the problem in Indian power sector was the de-metering of agricultural consumption and offering extensive power subsidies, which became routine political instruments since the late 1970s (Dubash and Rajan, 2001). The State Electricity Boards (SEBs) already had cash flow problems and state governments failed to compensate them for the subsidies. Hence, cross subsidies from industry started. With industries turning to captive generation plants, the additional revenues were not able to counter the losses from agriculture. This added to the commercial losses of the SEBs.

One of the key motivations for power sector reform in developing countries, including India, was to improve financial state and attract private capital to the power sector, to reduce the burden on the public sector budget (Jamasb, Newberry and Pollitt, 2005; Singh, 2006). Private sector was allowed in generation in 1991 to augment the inadequate resources. However, during the 1990s, the Independent Power Producers (IPPs) and the State Electricity Boards (SEBs) faced numerous problems in executing the required goals in due time. The private sector had not contributed significantly in the early 1990s, due to the problems faced by the Independent Power Producers (IPPs) in litigation/renegotiation of Power Purchase Agreements (PPAs), in financing, in risk sharing (eg. construction risk, market risk, fuel supply risk), in obtaining clearances (like cost estimate clearance, techno-economic clearance, water-availability clearance, pollution clearance, forest and environment clearance, etc), and in obtaining fuel linkage agreements (like licences for importing fuel). Public sector still remained a major player in the sector. Also, the proposed tariffs at private plants appear to be higher than those by state undertakings (D'Sa, Murthy and Reddy, 1999; Kannan and Pillai, 2002; Ninan, 2012).

Further, vertically integrated SEBs were unbundled into generation, transmission and distribution entities, and independent regulatory commissions were formed. Further, the Electricity Act 2003 also introduced numerous policy changes, like licence-free thermal generation, non-discriminatory access to transmission system, multiple licensees, which aimed to introduce competition in the power market. The distribution segment requires to be improved tremendously to achieve long term sustained growth of the power sector (Singh, 2006).

Jamasb *et al* (2005) presented empirical studies focusing on the determinants and key steps of reforms, as well as the impact of the reforms measures on the performance indicators. Few important works mentioned in their paper were: Steiner (2001) that found positive and significant correlation between utilisation rate and private ownership as well as unbundling of generation and transmission, from panel data analysis of 19 OECD countries for the period 1987-1996; Zhang, Parker and Kirkpatrick (2002) who showed privatisation will lead to increased capacity and higher output, provided it is accompanied by competition and independent regulation; Plane (1999), Hattori (1999), Delmas *et al* (2003) so on who studied the impact of different parts of reforms on the efficiency of production. The paper concluded that electricity sector reform has remained a work-in-progress, and there is considerable scope of learning from lessons around the world; however, there is a need for a more up-to-date analysis. Basically, the review of the reform pointed out that there is a great need for comprehensive, high quality data which would help in clearly defining and measuring the indicators to assess, monitor and compare reforms.

The performance of Indian power sector during 1991-2001 was studied by Sharma, Nair and Balasubramanian (2005) using select technical and economic indicators. They found that the restructuring that initiated in 1991 had not improved the technical efficiency, financial position and customer satisfaction. The social objectives of providing access to all also could not be fulfilled effectively. Bhattacharya and Patel (2007) also analysed the efficacy of power sector reform in India, through the change in commercial orientation of the utilities. They calculated an Index of Revenue Orientation (IRO) for 2001-02 and 2004-05, and observed that the sector is still not financially viable, and the AT&C losses are still high. Some states improved more significantly than other states. The variability across states and even between utilities within states is highly significant.

A World Bank study also assessed the financial performance of India's power sector through a state performance index created using the analytical hierarchy process (AHP) method with 11 variables during a five-year period - 2005-06 to 2009-10 (Khurana and Banerjee, 2015). They showed that Gujarat, West Bengal and Himachal Pradesh occupied the top positions in the 5-year period. Karnataka's financial performance was poor; however, it improved immensely in the last two years to occupy the 4th rank in 2009-10. Uttar Pradesh, Bihar and Madhya Pradesh continued to be the worst performers over the 5-year period. The study concluded that power purchase costs played a key role in the worsening finances of the utilities, the High Tension/Low Tension ratio played a significant role in T&D losses and consequently in power purchase costs, and regular tariff revisions helped in recovering the rising costs.

A comprehensive study focusing on the power sector performance in Karnataka alone covering recent years seems to be lacking in literature. Sakri, Nagabhushan and Khaparde (2006) discussed the Karnataka power sector reforms and policy changes, including private sector participation since 1991, Electricity Regulatory Commissions Act 1998, Electricity Act 2003, Accelerated Power Development and Reform Programme (APDRP), so on. However, this study was mostly a discussion and did not critically analyse the performance of the sector in the pre- and post-reform periods. Hence, this paper would endeavour to provide a macro study of the overall performance of Karnataka power sector in the context of the reforms.

Variables, Data Sources and Methodology

Variables:

The power sector performance in Karnataka would be evaluated through different variables related to the technical and financial aspects of the sector. Sharma *et al* (2005) analysed the performance of Indian power sector by grouping variables under two important types of indicators - Technical Indicators and Economic Indicators. This study would use a similar approach, although with modifications in the variables and the years, in order to observe the pre- and post-reform period. Firstly, we take the reform year in Karnataka as 1999, as Karnataka Electricity Reform Act, 1999, was the major reform which unbundled and corporatized KEB to form KPTCL and VVNL, along with KERC as an independent regulator.

The study categorises the indicators into 1] Technical indicators, and 2] Economic/ Financial indicators, the details of which are listed in Table 3. Some of these indicators are studied by Sharma *et al* (2005) through descriptive analysis.

Table 3: Select Performance Indicators of Power Sector

Variables	Detail/ definition	Explanation
TECHNICAL INDICATORS		
Energy deficit (%)	Energy requirement - availability	Gap between electricity demand and supply
Peak power deficit (percentage)	Gap in the peak demand and peak met	Indicates the gap between the peak demand and peak met
Addition of Installed capacity - By different modes: • Total (MW) • Hydro (MW) • Thermal (MW) • RES (MW)	Installed capacity (IC) is the maximum electric output a generator can produce under specific conditions IC can be by modes of • hydro-electric generation • different types of thermal electricity generation • renewable Energy Sources (RES)	Addition of IC indicates addition of investment in power generation Different modes of generation have different positive and negative aspects.
Addition of Installed capacity - By Ownership • By public sector (MW) • By Private sector (MW)	IC by public sector and private sector	Growth of IC by public and private sector reflects the reform impact
Growth of Electricity generation (%)	Generation is the actual electricity generated from the IC in a specific amount of time	How much of the IC is actually generated, which reflects the inefficiency in generation process
Capacity Utilisation (kWh/kW) %	Actual generation (kWh) / Installed capacity (kW) Actual electricity generation / Maximum electrical output that can be generated from the IC at 100% capacity in a given year	The ratio of actual generation to maximum electricity output from the IC in a year, which signifies the percentage utilisation of capacity
Transmission and Distribution (T&D) loss (%)	Loss in energy during the transmission and distribution of electricity from point of generation to end-users	Shows the condition of the technology and efficiency of transmission system
Per capita consumption of electricity (kWh)	Total gross energy available (utilities+non-utilities) / Population	Indicator of the level of electricity access to end users, which signifies the level of power sector development
Rural Electrification (%)	Percentage of villages electrified Rural households electrified	Reflects the progress of many policies aimed to provide electricity access to all
ECONOMIC INDICATORS		
Average tariff of electricity (Paise/ kWh)	Average price of per unit of electricity provided to end users	Lower tariffs are favourable for consumers; however, utilities need to cover the supply cost.
Unit cost of power supply (paise/ kWh)	Cost of supplying one unit of power	Cost of power supply should ideally decline with better performance
Average revenue recovery as % of Cost (%)	Average tariff*100/ Unit cost of supply	Important factor for sound financial health of the utilities
Collection efficiency (%)	= (Revenue realised* 100)/ Revenue billed	Important indicator of commercial orientation of the utility, as it shows the percentage of revenue realised *vis-a-vis* revenue billed
Aggregate Technical & Commercial (AT&C) loss (%)	= [Units input - Units realised]*100/ Units input Where, Units realised = Units billed * collection efficiency	Indicates both the technical and commercial losses in energy

Source: Compiled by the authors

Data Sources

The data for above variables are taken from different sources, as shown below:

- General Review (All-India Electricity Statistics), Central Electricity Authority, Ministry of Power Government of India,
- Annual Report on the working of State Power Utilities and Electricity Departments, Planning Commission, Government of India,
- TERI Energy Data Directory and Year Books (TEDDY), Tata Energy Research Institute, New Delhi.

Methodology for Trend Break Analysis

To check if there was a significant break in the trend in/after the reform year (1999), trend break analysis using dummy variable is considered a better method, as it allows to check for breaks in different years, in contrast to Chow test for structural stability, which has to assume a specific year. In addition, the trend break analysis gives the significance for intercept and slope, which Chow test does not give. Trend break analysis using dummy variables is, thus, conducted for many important indicators; however, the results are shown only for those variables which show significant breaks, namely, Total Installed capacity, Public Installed capacity, Total Electricity Generation, Public Electricity Generation, Per capita electricity consumption, and Transmission & Distribution loss (T&D loss).

The periods of study are 1980-81 to 2014-15 for installed capacity; 1980-81 to 2011-12 for electricity generation; 1991-92 to 2014-15 for Public Installed capacity, Public generation, and Per capita electricity consumption; and 1991-92 to 2012-13 for T&D loss. The units of Installed capacity, Electricity Generation, Per capita electricity consumption, and T&D loss are megaWatt (MW), GigaWatt hour (GWh) or million units (MU), kiloWatt hour (kWh), and percentage (%) of availability, respectively.

The methodology used for the trend break analysis is by running the following regression:

$$\mathbf{IC} = \alpha + \beta * t + \gamma * D + \delta * (D * t) \qquad \text{where,}$$

IC = installed capacity,

t = time,

D = dummy variable = 0 till a specific year (where the break may be present), and 1 for remaining years

D*t = interactive term

α, β, γ and δ are the coefficients.

The coefficient of the dummy variable, γ**,** indicates the intercept difference between the years before and after the year, while the coefficient for interactive dummy variable, δ**,** indicates the difference in slope before and after the dummy year. Thus, *if the two coefficients are significant, it means that the value and growth rate of the variable has significantly increased/decreased in that particular year.*

Methodology for calculating Power Sector Performance Index (PPI)

We calculate an Index, called *Power Sector Performance Index (PPI)* to capture an overall performance of Karnataka power sector. To calculate PPI, we deploy the same methodology used in calculating Human Development Index (HDI), which is a composite statistic of 3 indicators, published by United Nations Development Programme (UNDP). HDI is used to rank countries and indicate level of human development in the countries. Similarly, the PPI will be calculated for major states of India for 2 years (signifying pre- and post-reform periods), and worked out to check 1) the status of Karnataka power sector *vis-a-vis* other states and 2) the change between the two years. The details of the variables and methodology are given in Table 4:

Table 4: Performance Indicators used to calculate PPI

Dimensions	**Indicators**	**Dimension Index (DI)**	**Geometric Mean of DI**
Technical Performance	Installed capacity (IC) per capita in the state in one year - kW	$IC_{1998-99}$ $IC_{2012-13}$	Geometric Mean of all the Dimension Indices is calculated for the two years separately $GM_{1998-99}$ $GM_{2012-13}$
	Growth in Total generation over last year	$G_{1998-99}$ $G_{2012-13}$	
	Capacity Utilisation rate- %	$U_{1998-99}$ $U_{2012-13}$	
	Energy deficit - %	$E_{1998-99}$ $E_{2012-13}$	
	Peak deficit - %	$P_{1998-99}$ $P_{2012-13}$	
	Transmission & Distribution (T&D) loss - %	$TD_{1998-99}$ $TD_{2012-13}$	
Financial Performance	Average Revenue realisation as % of cost - %	$ARR_{1998-99}$ $ARR_{2012-13}$	$GM_{1998-99}$ $GM_{2012-13}$
	Commercial loss -with Subsidy - per capita - Rs	$L_{1998-99}$ $L_{2012-13}$	

Source: Compiled by the authors

The details of time period and states are shown in Table 5:

Table 5: Details of Time Period, States and Methodology used to Calculate PPI

Features	Detail	Explanation
Years	1998-99 2012-13	Before power sector reform in Karnataka in 1999 (KERA) Signifying After-reform period Start of 12th Five-year plan Most recent period for which the data for all variables are available for all states
States	17	Data for all the variables are available for the 2 years only in 17 states [The details of missing data in states are shown in Appendix]
Formula used to calculate Dimension Index (DI) of indicators	$Dimension\ Index\ (DI) = \frac{Actual\ Value - Minimum\ value}{Maximum\ value - Minimum\ value}$ Where, Minimum value = Global Minimum of the values in 2 years Maximum value = Global Maximum Geometric mean of DI of all indicators under the 2 Dimensions are taken for each year - GM_1 and GM_2	The formula is the same as used in HDI calculation and can be used to derive at an Index to rank the states according to the power sector performance. The HDI calculation methodology has been critiqued to have some limitations. A *few important limitations are that it is overly simplistic with little conceptual/ theoretical basis, and there are issues with functional form of HDI, mainly relating substitutability assumptions with additive form, normalization of indicators, and choice of equal weight (Klugman, et.al.,2011). However, it could be used to get a broad picture of the performance, as it has used geometric mean, and the indicators are equally important to be assigned different weights.*
Formula to derive PPI	PPI = Geometric mean of GM_1 and GM_2	The PPI of the 2 years is used to rank the states and check the change in ranking as well.

Source: Compiled by the authors

The modifications and adjustments to the original methodology made for the negative indicators are as follows:

- For the negative indicators, like energy deficit, the Dimension Index is adjusted as: **Adjusted DI = 1 - DI**, which makes it consistent with positive indicators for index calculation.
- For positive indicators, the Global Minimum is reduced by 10%, while for the negative indicators, the Global Maximum is increased by 10% before using in the formula. This is for convenience in calculations and does not harm the consistency and comparability of the Index across time.

Empirical Results

Technical Indicators

Energy and peak deficit

Energy deficit refers to the gap between energy requirement and availability in the state, while the peak deficit is the difference between the peak demand and met. These variables reflect the general status of power supply in a state. Energy deficit and peak deficit in Karnataka have declined from 8.3% and 15.5% in 1999-2000 to 5.2% and 6.8% respectively in 2015-16, as shown in Table 6.

Table 6: Peak Deficit and Energy Deficit in Karnataka (%)

Year	1995-96	1996-97	1997-98	1998-99	1999-2000	2011-12	2012-13	2013-14	2014-15	2015-16
Peak deficit (%)	-25.7	-28.5	-27.5	-15.5	**-15.5**	-18.9	-13.5	-7.2	-4.5	**-6.8**
Energy deficit (%)	-20.7	-27.1	-20.3	-13.2	**-8.3**	-11.2	-13.9	-9.5	-4.3	**-5.2**

Source: TERI Energy Data Directory and Year Books (TEDDY), Tata Energy Research Institute, New Delhi, and Central Electricity Authority (CEA), Government of India, New Delhi

This fall in deficit is definitely an improvement in supply scenario, which could be due to increase in electricity generation by Renewable Energy Sources (RES) in recent years, as seen in Figure 2. However, compared to many major states, the deficit is still high in Karnataka (Table 7). The deficit is higher than many major states, while lower than only a few states like Uttar Pradesh and Jammu & Kashmir. Much progress is, therefore, needed to meet the peak demand in the state.

Table 7: Energy and Peak Deficits (%) in Selected Major Indian States

States	2015-16	
	Energy deficit (%)	**Peak deficit (%)**
Gujarat	0	-0.3
Andhra Pradesh	-0.1	-0.1
Maharashtra	-0.3	-1.8
Kerala	-0.5	-3.1
Tamil Nadu	-0.7	-0.1
Karnataka	-5.2	-6.8
Uttar Pradesh	-12.5	-14.6
Jammu & Kashmir	-15.3	-15.2

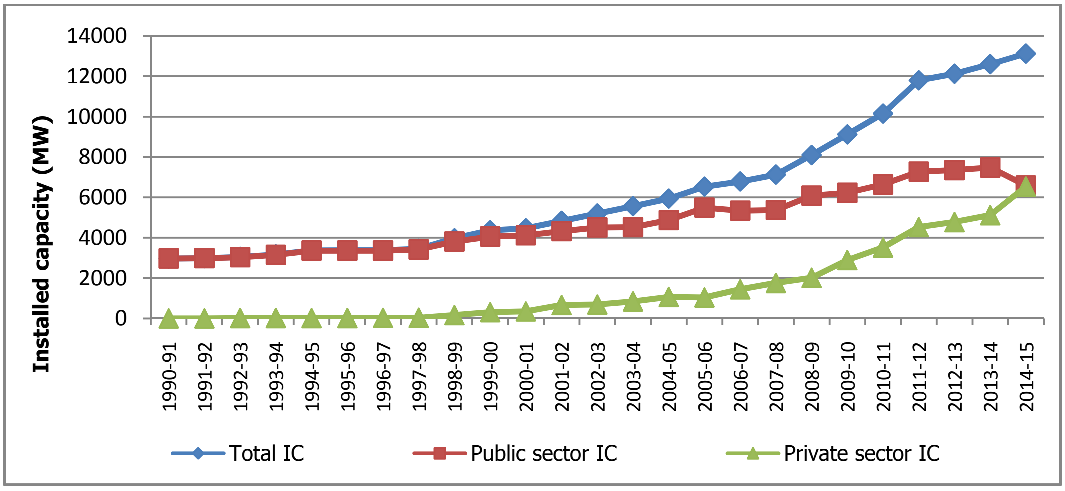
Source: Compiled from CEA, 2015-16

Installed capacity and Electricity Generation

Enhancing power supply in the state requires the investment in power sector that leads to establishment of installed capacity. The installed capacity (IC) in Karnataka increased from 2970.2 MW in 1990-91 to 13124.5 MW in 2014-15 (CEA, 1991, 2015), growing at a Compound Annual Growth Rate

(CAGR) of about 6.4%. The trend of growth in total IC, IC by public sector and private sector are shown in Figure 1.

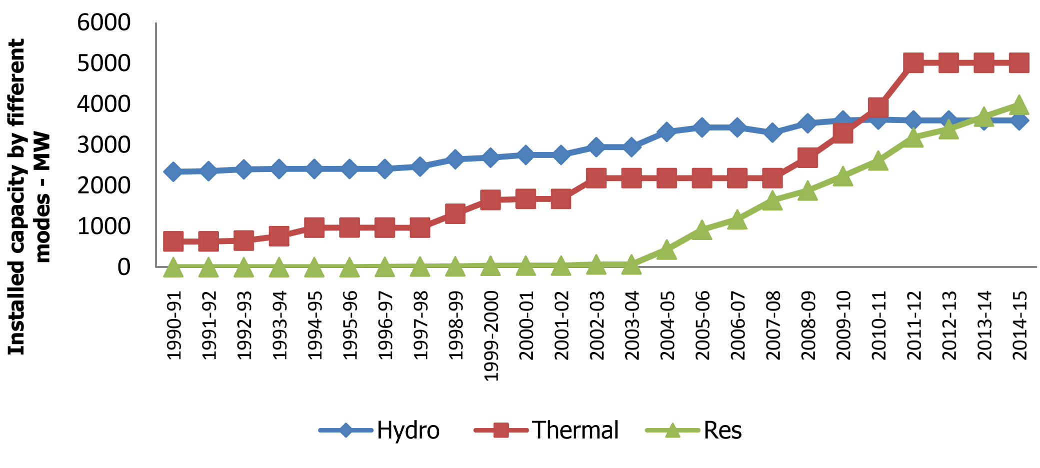
Figure 1: Installed Capacity (by ownership) in Karnataka - MW



Source: Compiled from General Review, CEA, various years

The growth of IC by public sector is slowing down while that of private sector is rising. In 2014-15, the Public IC declined by about 894 MW from previous year, while Private IC increased by 1419 MW. The private sector capacity seems to have continuously risen since the mid-2000s. The installed capacity by different modes, namely, Thermal, Hydro and Renewable Energy Sources (RES), are shown in Figure 2.

Figure 2: Installed Capacity (by modes) in Karnataka - MW



Source: Compiled from General Review, CEA, various years

In terms of modes of production, the thermal mode has overtaken the hydro mode around 2010-11, and is contributing the most to total IC in recent years, while the hydro IC has slowly declined over the years. The RES mode has increased tremendously since 2003-04, probably due to huge encouragement to set up more IC through RES, as it utilizes the naturally available resources, has lesser environmental effects, and helps utilities shift from inadequate resources like coal. About 67% of the private IC is under RES, and remaining 33% in thermal mode.

IC is the maximum electric output that can be generated; however, the actual generation is usually lesser than the maximum output, depending on the production efficiency of the plants. Hence, it is important to check the growth in actual electricity generation *vis-a-vis* growth in IC. Table 8 gives the Average Annual growth rates (AAGR) of IC and generation in the pre- and post-reform periods. The private sector IC is growing at the highest rate at 29.7% in the post-reform period. The pre-reform period AAGR of Private IC is abnormally high because there was a sudden increase in IC in 1998-99 from a very small base. If we observe the post-reform period, the growth rate in total IC (8.4%) is more than that in electricity generation (7.7%), which indicates that the actual generation might be lagging behind despite addition of IC, due to inefficient production or technological constraints.

Table 8: Average Annual Growth Rates, AAGR (%) of IC and Total Generation in Karnataka

Period	Total IC	Public IC	Private IC	Total Generation
Pre-reform 1991-92 to 1998-99	3.8	3.2	68.2	5.1
Post-reform 1999-2000 to 2012-13	8.4	4.9	29.7	7.7

Source: Computed by the authors

Trend Break Analysis

It is imperative to check whether the observed increase in Total Installed capacity and Total Generation is statistically significant, and if there is significant break in the trend after the reform in 1999.

Total Installed Capacity

For total installed capacity, the regression is run in log model for 35 years from 1980-81 to 2014-15, to capture the trend in growth rate of total installed capacity:

$$\mathbf{lnIC = \alpha + \beta*time + \gamma* D99 + \delta*(D99*time)}$$

where, lnIC = log (Installed capacity)

D99 = 0 for years till 1998-99, = 1 for years from 1999-2000 onwards.

There is autocorrelation in the regression; hence, the regression is run after correcting for autocorrelation.

Table 9: Trend Break Analysis - Total IC in Karnataka

Variable	Coefficient	t-Statistic	Prob.
C	7.55*	134.80	0.00
Time (t)	0.04*	10.35	0.00
D99	-0.75*	-5.85	0.00
D99*t	0.04 *	6.28	0.00
AR(1)	0.55	4.29	0.00
R-squared	0.99		
Sum squared residual	0.05		

Note: * indicates Significant at 1% level of significance

Source: Computed by the authors

Table 9 shows the intercept and slope coefficients are significant. The differential intercept coefficient is -0.75 (significant), while the differential slope coefficient is 0.04 (significant). Thus, the intercepts and slopes for the two periods before and after 1999-2000 are significantly different. The differential growth rate of total installed capacity for the two periods is about 0.04*100 = 4%. It implies that the average growth rate of total installed capacity in the period after 1999-2000 is about 4% more than the period before. Hence, there is a *significant break* in the trend of growth of total installed capacity in *1999-2000* itself, probably due to the increasing average annual growth rate of private sector capacity during that period.

Public Installed Capacity

Checking for the trend break in public sector IC, we use the linear model, since its growth rate was not quite significant over these years.

After checking for many years, we found significant break in 2001-02, with the following regression function (after correcting for autocorrelation):

PubIC = λ+ θ*t + μ*D01 + ω* (D01*t) where,

PubIC = public installed capacity,

t = time,

D01 = 0 till year 2000-01, 1 from 2001-02.

The results of the regression are shown in Table 10:

Table 10: Trend Break Analysis Result - Public IC in Karnataka

Variable	Coefficient	t-Statistic	Prob.
c	1623.00*	13.81	0.00
T	112.45*	12.74	0.00
D01	-3384.56*	-8.05	0.00
D01*t	156.84*	9.25	0.00
AR (1)	0.28	1.58	0.12
R-square	0.99		
Sum squared residual	780469.00		

Notes: * indicates Significant at 1% level of significance

Source: Computed by the authors

Both the intercept and slope coefficients are significant, indicating the presence of significant break in the trend of public installed capacity in 2001-02. The total IC growth shows significant break in 1999-2000, while the public IC indicates break in 2001-02, reflecting that the trend break in total IC in 1999-2000 is potentially due to the increasing growth in private sector installed capacity. The private sector entered the market around 1992-93 and increased suddenly in 1998-99, after which the capacity addition continuously rose. The growth rates of the private installed capacity are quite fluctuating, especially during the mid- to late 1990s. Hence, using regression or average annual growth rates give misleading results.

Total Generation

For total generation also, we found break in 1999-2000 as well, running the following regression:

$$\mathbf{Gen = \theta + \lambda*T + \omega*D99 + \tau*(T*D99)}$$

where, Gen = Total generation,

T= time,

D99 = dummy variable = 0 before 1999-2000, 1 for period after

θ, λ, ω, τ - intercept and co-efficient

Table 11: Trend Break Analysis Result - Total Generation in Karnataka

Variable	Coefficient	t-Statistic	Prob.
C	5068.23**	2.15	0.04
T	582.49*	3.16	0.00
D99	-25205.4*	-3.38	0.00
D99*T	1333.78*	3.77	0.00
AR (1)	0.52	2.47	0.02
R-squared	0.97		

Notes: **indicates Significant at 5% level of significance,

* indicates Significant at 1% level of significance

Source: Computed by the authors

Table 11 shows that the increase in the value after 1999-2000 is statistically significant, which might be due to the policies implemented since 1990, which encouraged private sector participation in generation, and not an immediate result of the 1999 reform. Further, we investigated if there was significant break in the trend of public and private sector generation separately. Public sector generation did not have any significant break in any year from mid-1990s to mid-2000s, even though public IC exhibited break in 2001-02.

Private Sector Generation

For private generation, we found significant break in 2005-06, as shown in Table 12:

Table 12: Trend Break Analysis Result - Private Generation in Karnataka

Variable	Coefficient	t-Statistic	Prob.
C	-1714.42	-1.05	**0.31**
T	346.11**	2.13	**0.05**
D05	-29152.89*	-7.03	**0.00**
D05*T	1880.27*	6.95	**0.00**
AR(1)	0.52**	2.50	**0.02**
R-squared	0.98		

Notes: **indicates Significant at 5% level of significance,

* indicates Significant at 1% level of significance

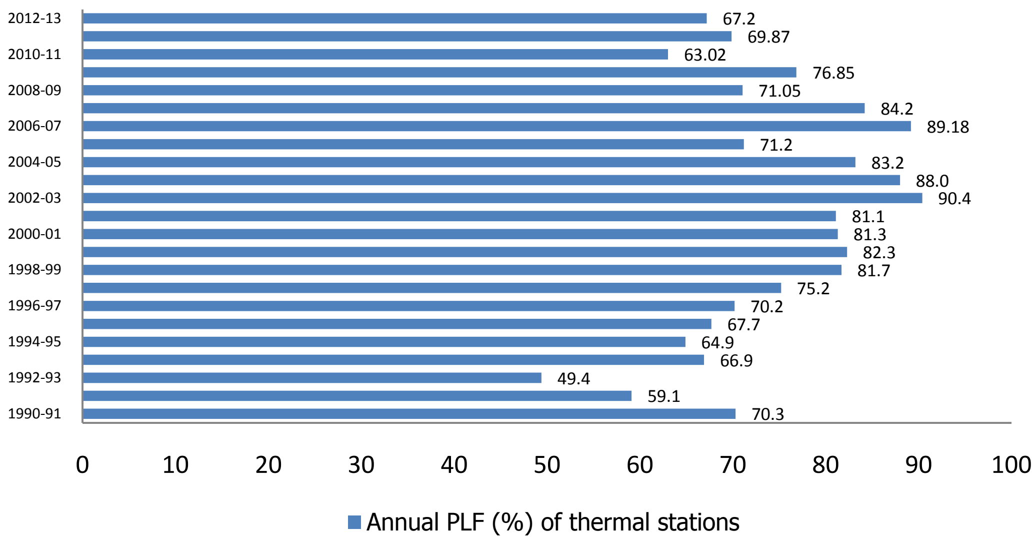
Source: Computed by the authors

The difference in the break year for IC and generation itself highlights the difference in the growth of IC and generation over time. This would be clearly observed through capacity utilisation rate.

Capacity Utilisation

Capacity utilisation means the rate at which the existing capacity is being utilised to actually generate power. Alongside timely and adequate addition of capacity, the utilisation rate of the existing capacity is equally an important factor to improve the power supply situation in an economy. Under-utilisation of capacity has been an issue in India for decades; however, in the face of power deficit situation, inadequate capacity addition and increasing demand, the utilisation is expected to be higher. Nonetheless, in 1997-98, in the face of power deficit, only 54% of the existing capacity in India was utilised, while it was 56.6 % for Karnataka (Kannan and Pillai, 2001). They affirmed that one important cause of such low capacity utilisation is the poor technical efficiency. Technical efficiency is determined mainly by Plant Load Factor (PLF), and plant availability factor, PAF (which in turn is determined by forced outages). Units are sometimes shut down due to planned maintenance, intended to ensure their proper running conditions, and also due to lack of adequate system load and of water in case of hydro plants. PLF and PAF are usually considered in case of thermal plants. PAF = 1 - planned maintenance rate - Forced outage ratio. For Karnataka, the PLF of thermal plants in state sector has declined from about 81.7% in 1998-99 to 67.2% in 2012-13 (Figure 3). The falling PLF could be a major factor for the declining CU. The reforms did not directly focus on improving the capacity utilisation, and technology. The average PLF of private sector thermal plants is much higher (87.4% in 2012-13) than the state sector (67.2%) (TEDDY, 2015).

Figure 3: Annual Plant Load Factor (%) of Thermal stations in State sector in Karnataka



Source: TERI Energy Data Directory and Year Books (TEDDY), Tata Energy Research Institute, New Delhi

Diving the period into pre- and post-reform (1999 as reform period), we see that the average PLF in state sector is higher after reform (Table 13). However, PLF depends on many factors like age of generating plant, quality of coal, and its timely and adequate availability, shortcomings in energy evacuation, and equipment deficiencies (Kannan and Pillai, 2001).

Table 13: Statistics of PLF (%) of Karnataka State Sector Thermal Plants

Period	Maximum	Minimum	Mean
Pre-reform 1990-91 to 1998-99	81.7	49.4	67.3
Post-reform 1999-2000 to 2012-13	90.4	63.0	78.5

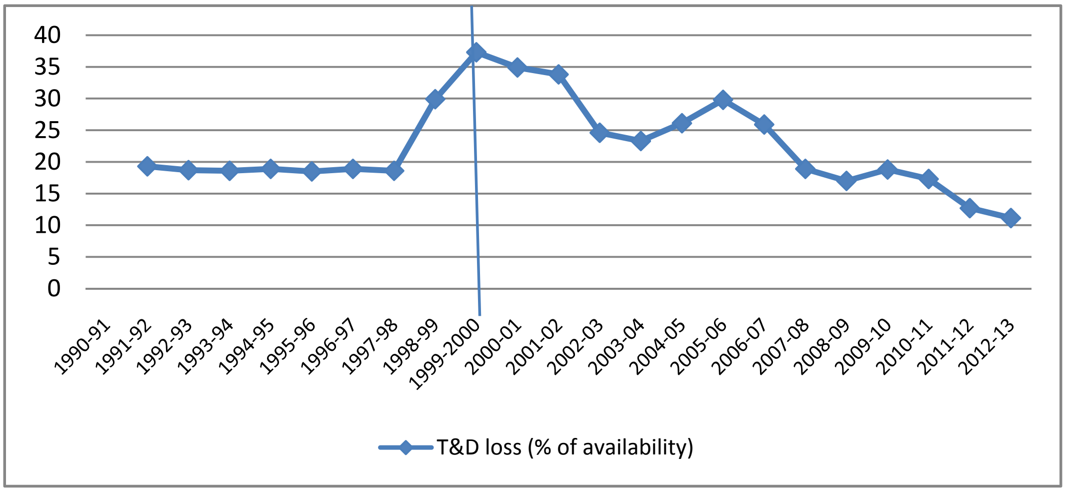
Source: Computed by the authors

Transmission and Distribution losses (%)

The loss in electricity due to transformation, transmission, and distribution, including unaccounted electricity is referred to as T&D loss (% of availability). The T&D losses are mainly due to unavoidable 'technical' losses (technical factors in transmission) as well as avoidable commercial losses (theft). An efficient transmission system depends on number and quality of transformers, transmission lines, as well as the technology level of the existing system. The T&D losses are not measured by electrical engineering computations, and are obtained as a residue, after taking out metered consumption. The

KEB's assignment of T&D losses was suspect, as the reported T&D losses from 1984 to 1994 was decreasing, even though the load of LT load was increasing (as, without major system improvements, T&D losses should increase with increase in share of LT loads) (Reddy *et al*, 1997). Figure 4 shows that T&D loss in Karnataka has come down tremendously from about 37.3% in 1999-2000 to 11.1% in 2012-13, indicating improvement in transmission mechanism. However, due to lack of proper calculations or measurements, it is difficult to definitely point to a real decline in the energy loss.

Figure 4: Transmission and Distribution Losses (% of availability) in Karnataka



Source: CEA and TERI Energy Data Directory and Year Books (TEDDY), Tata Energy Research Institute, New Delhi

Trend Break Analysis

The trend break analysis also showed that the T&D loss exhibited significant break in 1999-2000, as shown in Table 14:

Table 14: Trend break analysis result- T&D loss (%) in Karnataka

Variable	**Coefficient**	**t-Statistic**	**Prob.**
C	16.20*	6.39	0.00
T	0.88**	1.76	0.09
D99	35.77*	8.34	0.00
D99*T	-2.71*	-4.95	0.00
R-squared	0.82		

Notes: **indicates Significant at 10% level of significance,

* indicates Significant at 1% level of significance

Source: Computed by the authors

Table 15: T&D Loss (% of availability) in Selected Major Indian States

States	T&D loss as % of availability	
	2013-14	2014-15
Karnataka	10.2	**11.5**
Tamil Nadu	10.8	11.1
Gujarat	18.1	19.28
Kerala	14.9	15.4
Andhra Pradesh	20.1	17.9
Maharashtra	21.8	20.4
Bihar	47.3	46.3
Jammu & Kashmir	54.7	53.1

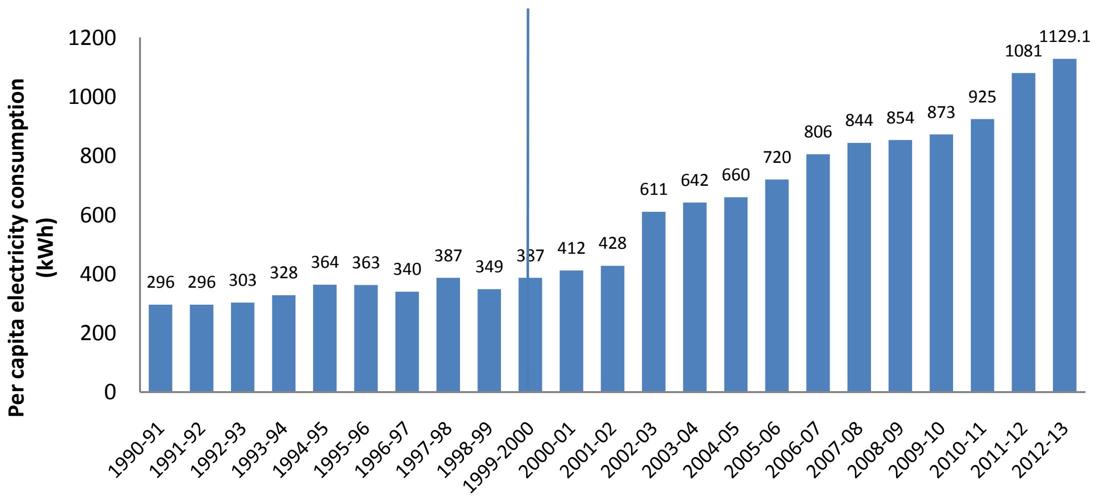
Source: CEA, 2014

Table 15 highlights that T&D loss in Karnataka slightly rose from 10.2% to 11.5% in 2014-15; nonetheless, it is still lower than other major states (CEA, 2016), reflecting better transmission and distribution system in the state.

Per capita electricity consumption

This is another important indicator of power sector performance, as it reflects the per capita consumption level by consumers, and indirectly the accessibility of electricity to all population. As shown in Figure 5, the annual per capita consumption of electricity (utilities and non-utilities) in Karnataka has slowly increased over the years. The AAGR in the pre-reform period is 2.7%, while that in the post-reform period is 9.2%, which is a tremendous sign.

Figure 5: Per Capita Electricity Consumption (kWh) in Karnataka



Source: CEA and TERI Energy Data Directory and Year Books (TEDDY), Tata Energy Research Institute, New Delhi

Trend Break Analysis

The Per capita electricity consumption (pcec) trend shows a significant break in 1998-99, as shown in Table 16:

Table 16: Trend Break Analysis Result - Per Capita Electricity Consumption (pcec) in Karnataka

Variable	Coefficient	t-Statistic	Prob.
C	285.57*	9.48	0.00
T	13.64**	2.03	0.06
D98	-395.45*	-9.38	0.00
D98*T	41.43*	5.95	0.00
R-squared	0.99		

Notes: **indicates Significant at 10% level of significance,

* indicates Significant at 1% level of significance

Source: Computed by the authors

Electricity consumption is highly associated with economic growth. Many studies have revealed causality relations between these two variables in either way, or both ways. Whether electricity consumption precedes economic growth, or, *vice versa*, has been a topic of great interest for many researchers, who studied the direction of causality between the two, for different countries, different years, and with different methodologies, thereby drawing corresponding policy implications (Ghosh, 2002; Altinay and Karagol, 2005; Narayan and Smyth, 2005; Wolde-Rufael, 2006; Ho and Siu, 2007; Abosedra *et al*, 2009; Gupta and Sahu, 2009; Acaravci and Ozturk, 2010; Adom, 2011; Masuduzzaman, 2012; Abbas and Choudhury, 2013; Pempetzoglou, 2014).

Table 17: Per Capita Electricity Consumption in Selected Major Indian States in 2014-15

States	Per capita Electricity consumption - kWh
Gujarat	2105
Punjab	1858
Tamil Nadu	1616
Orissa	1419
Maharashtra	1257
Karnataka	**1211**
Rajasthan	1123
Andhra Pradesh	1040
Kerala	672
Uttar Pradesh	502

Source: CEA, 2016

Table 17 highlights that per capita electricity consumption in Karnataka in 2014-15 (1211 kWh) is higher than a few states like Rajasthan (1123 kWh), Uttar Pradesh (502 kWh), Kerala (672 kWh), however, much lower than many major states, like Punjab (1858 kWh), Gujarat (2105 kWh), Tamil Nadu (1616 kWh), so on. There is much scope for improvement.

Rural Electrification

Rural electrification is a key ingredient of the policy objective of providing electricity access to all. Karnataka has started to carve out the roadmap for the 24*7 Power for All Initiative to meet the objectives by 2018-19. As for the progress in rural electrification, the percentage of villages electrified in Karnataka as on 31-03-2015 is 99.9% (CEA, 2016). However, the definition of village electrification is that 'A village would be declared electrified if - electricity is provided to public places like Schools, Panchayat Offices, Health centres, Dispensaries, Community Centres etc. and the number of households electrified are at least 10% of the total number of households in the village.' Hence, not all the households are electrified yet. Even in this definition, we observe that Karnataka is lagging behind other major states (Gujarat, Haryana, Punjab) having 100% rural electrification since 1998-99, as shown in Table 18. In terms of rural households also, only 87% are electrified as per Census 2011 (Planning Commission, 2013-14), which is higher than all-India average of 55%, however, lower than Tamil Nadu (91%), Kerala (92%), and Punjab (95%).

Table 18: Rural Electrification in Selected Major Indian States- % of Villages

Major states	1998-99*	2014-15**	Change
Haryana	100.0	100.0	0.0
Punjab	100.0	100.0	0.0
Gujarat	100.0	100.0	0.0
Maharashtra	100.0	100.0	0.0
Andhra Pradesh	100.0	100.0	0.0
Kerala	100.0	100.0	0.0
Tamil Nadu	100.0	100.0	0.0
West Bengal	77.6	99.9	22.3
Karnataka	**98.6**	**99.9**	**1.3**
Himachal Pradesh	99.0	99.8	0.8
Madhya Pradesh	95.4	99.1	3.7
Rajasthan	92.2	98.9	6.7
Uttar Pradesh	78.6	98.4	19.8
Jammu & Kashmir	97.5	97.9	0.4
Bihar	70.9	93.0	22.1
Assam	77.0	88.6	11.6
Meghalaya	45.8	85.9	40.1

Notes: * As per 1991 census, ** As per 2011 census

Source: Compiled by the authors from CEA, various years

Economic Indicators

Average tariff (paise/ kWh), Unit cost of supply (paise/ kWh), and Recovery rate

The tariff rate is different for different categories of consumers, and further varies with different slabs of consumption, which makes comparisons across time a little complicated. Hence, we consider the average tariff of sale of electricity to consumers. It has increased over time from 205.8 paise/ kWh in

1999-2000 to 476.9 paise/ kWh in 2013-14. However, the average tariff at constant (2004) price, after deflating with GDP deflator (using GSDP - Electricity, Gas and Water supply), increased minutely from 233.5 paise/kWh to 234.6 paise/kWh. The unit cost of supply has also increased from about 279.6 p/kWh to 504.8 p/kWh at current price. However, at constant 2004 price, the unit cost actually fell from 317.3 p/kWh to 248.3 p/kWh. Although the price did not rise much, the fall in cost probably led to the hike in average revenue recovery from 73.6% in 1999-2000 to 94.5% in 2013-14 (Table 19).

Table 19: Average tariff, Unit cost of power supply and Cost recovery in Karnataka

5 years before reform					
Year	**Average tariff (paise/kWh)**	**Average tariff at constant 2004 price**	**Unit cost of power supply (paise/kWh)**	**Unit cost at constant 2004 price**	**Average revenue recovery as % of cost of supply**
1995-96	114.4	195.4	152.3	260.1	75.1
1996-97	140.6	219.8	187.3	292.9	75.1
1997-98	152.2	222.2	179.4	261.9	84.9
1998-99	192.2	249.9	242.6	315.5	79.2
1999-00	**205.8**	**233.5**	**279.6**	**317.3**	**73.6**
After 10 years of reform					
2009-10	351.0	239.1	408.8	278.5	85.9
2010-11	428.7	264.9	456.6	282.1	93.9
2011-12	433.2	234.8	472.7	256.2	91.7
2012-13	456.9	232.3	500.5	254.5	91.3
2013-14	**476.9**	**234.6**	**504.8**	**248.3**	**94.5**

Source: Computed from Annual Report on the working of State Power Utilities and Electricity Departments, Planning Commission, Government of India, various years

The increase in cost recovery rate through tariff enhances the financial viability of the utilities. However, at disaggregate level, the cost recovery would be vastly different for different consumers, as few consumer categories cross-subsidizes the other categories, by paying more than cost-of-supply. Table 20 shows the different average tariffs for main consumer categories for the year 2013-14.

Table 20: Consumer Category-wise Average Tariff of Electricity in Karnataka, 2013-14

Main Consumer categories	**Average tariff Paise/kWh**	**Unit cost of supply Paise/kWh**	**Recovery rate %**
Domestic	422.8	504.8	83.8
Commercial	784.3	504.8	155.4
Agricultural	306.7	504.8	60.8
Industrial	610.2	504.8	120.9

Source: Computed from Annual Report on the working of State Power Utilities and Electricity Departments, Planning Commission, Government of India, various years

The cost recovery rate for 'Commercial' and 'Industrial' consumers are much higher than 100%, which implies that they pay more than the cost of supplying power to them, thereby cross-subsidizing the 'Domestic' and 'Agricultural' consumers, whose tariffs are unable to recover full cost of supply. The cross-subsidization policy was proven to be sub-optimal in a study using data from a distribution company in Uttar Pradesh, and it was suggested to reduce the industrial tariffs in India (Chattopadhyay, 2004). Industries start resorting to their own captive power generation, which lead to reduction in Industrial consumers, thereby lowering the revenue realisation of the utilities.

On the other hand, the cost of power supply comprises many components (Table 21):

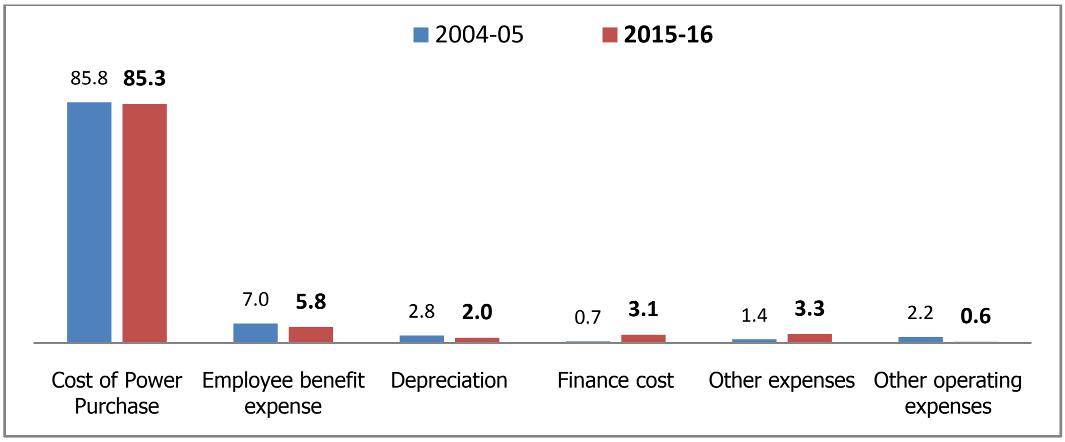
Table 21: Cost Structure of Power Supply in Karnataka in 2013-14

Major Components	Power Purchase	Operation & Maintenance (O&M)	Estt/ Administrative	Depreciation	Interest	Misc
Cost (paise/kW)	418.3	2.9	44.9	10.4	22.6	5.5
Percentage (%)	**82.9**	0.6	8.9	2.1	4.5	1.1

Source: Computed from Annual Report on the working of State Power Utilities and Electricity Departments, Planning Commission, Government of India, various years

The share of 'Power purchase' is the highest in the cost component, followed by 'Administrative expenses' and 'Interest'. Thus, the higher the cost of power purchase, the higher would be the cost of power supply. Taking the case of BESCOM, we see that the change in percentage share of cost components to total cost, from 2004-05 to 2015-16 is not very significant (Figure 6). The share of employee benefit expenses has come down from 7% in 2004-05 to 5.8% in 2015-16. Also, the average annual growth rate (AAGR) of this component from 2011-12 till 2015-16 (9.7%) is lower than that of power purchase cost (11.3%), depreciation (12.5%), so on.

Figure 6: Share of Cost Components in Total Cost (%)- BESCOM, Karnataka



Source: Compiled by the authors from Annual Reports, BESCOM, various years

Collection efficiency and AT&C losses (%)

The five distribution companies in Karnataka have different ratios of different consumer categories in their respective areas of distribution, and hence, have different revenue generating capacity. However, their collection efficiency, which reflects the ability to collect revenue from the billed units, could be compared. Also, the Aggregate Technical and Commercial (AT&C) loss indicates the loss in energy due to technical as well as the collection inefficiencies. These variables highlight the commercial orientation and financial viability of the utilities. It is observed that HESCOM has the highest collection efficiency (CE) (97.1%) and MESCOM has the lowest AT&C loss (14.8%) in 2013-14, followed by BESCOM, while CESCOM has the lowest CE and highest AT&C loss (Table 22).

The difference in the collection efficiency might be due to the shares of different consumer categories in the districts each ESCOM is responsible for. However, in general, the CE is increasing over time for most of the ESCOMs, while the AT&C loss is declining, which indicates that the ESCOMs seem to be improving in their performance over time after the reform.

Table 22: Collection Efficiency (CE) and AT&C Losses (%) of 5 ESCOMs in Karnataka

Year	BESCOM		GESCOM		HESCOM		MESCOM		CESCOM	
	CE (%)	AT&C loss (%)	CE (%)	AT&C loss (%)	CE (%)	AT&C loss (%)	CE (%)	AT&C loss (%)	CE (%)	AT&C loss (%)
2004-05	92.9	30.0	90.6	43.0	80.3	41.8	93.0	27.0		
2005-06	87.6	35.8	77.6	52.7	83.0	40.4	93.7	20.8	76.6	46.0
2006-07	95.9	26.9	82.2	47.0	86.7	37.4	103.8	12.1	84.5	40.6
2007-08	91.7	26.6	79.4	41.3	79.1	40.7	90.8	21.7	80.6	37.7
2008-09	97.0	19.2	82.7	38.8	88.1	33.9	98.8	14.0	91.7	25.3
2009-10	92.9	21.1	83.2	38.1	90.3	28.5	93.4	18.4	85.9	28.2
2010-11	90.3	22.8	95.2	25.8	92.9	26.2	97.9	13.8	84.3	28.7
2011-12	90.5	22.6	97.1	24.0	95.5	23.6	93.6	17.9	84.7	29.0
2012-13	92.7	20.5	100.9	18.3	99.3	20.4	97.0	14.6	82.0	30.4
2013-14	94.2	18.9	84.6	30.5	97.1	20.4	**96.7**	**14.8**	77.5	33.9

Source: Compiled by the authors from TERI Energy Data Directory and Year Books (TEDDY), Tata Energy Research Institute, New Delhi, various years

Power Sector Performance Index (PPI)

Power Sector Performance Index (PPI) is computed by unifying select indicators of power sector performance, following the methodology used in calculating HDI, with slight adjustments and modifications. The justifications for taking 17 states and the indicators are given in the Appendix.

The select indicators used in the Index and their preferred directions are given in Table 23:

Table 23: Indicators Used to Calculate PPI and the Preferred Direction

Sl. No.	Indicators	Direction
1	Installed capacity per capita(IC) - kW	Higher the better
2	Growth in Total generation - %	Higher the better
3	Capacity utilisation rate - %	Higher the better
4	Energy deficit - %	Lower the better
5	Peak deficit - %	Lower the better
6	T&D loss - %	Lower the better
7	Average revenue recovery as % of cost	Higher the better
8	Commercial loss - with subsidy - Per capita- Rs	Lower the better

Source: Computed by the authors

The PPI is calculated for the two years for 17 states of India (Table 24):

Table 24: Power Sector Performance Index (PPI) for 17 Major Indian States

States	PPI-1999	PPI-2012	Change in PPI value	Ranking -1999	Ranking -2012	Change in Ranking	Value	Ranking
Gujarat	0.68	0.89	0.21	4	1	3	↑	↑
West Bengal	0.60	0.73	0.13	11	4	7	↑	↑
Karnataka	**0.63**	**0.74**	**0.11**	**8**	**3**	**5**	↑	↑
Maharashtra	0.72	0.82	0.10	2	2	0	**Same**	**Same**
Madhya Pradesh	0.49	0.59	0.10	15	7	8	↑	↑
Assam	0.49	0.55	0.06	16	10	6	↑	↑
Jammu & Kashmir	0.18	0.21	0.03	17	16	1	↑	↑
Uttar Pradesh	0.53	0.53	0.00	13	11	2	↓	↑
Andhra Pradesh	0.61	0.58	-0.02	10	8	2	↓	↑
Meghalaya	0.61	0.58	-0.03	9	9	0	**Same**	**Same**
Punjab	0.69	0.60	-0.09	3	6	-3	↓	↓
Himachal Pradesh	0.74	0.64	-0.10	1	5	-4	↓	↓
Haryana	0.65	0.50	-0.14	7	12	-5	↓	↓
Kerala	0.66	0.47	-0.19	6	14	-8	↓	↓
Tamil Nadu	0.67	0.48	-0.19	5	13	-8	↓	↓
Rajasthan	0.60	0.34	-0.27	12	15	-3	↓	↓
Bihar	0.50	0.18	-0.32	14	17	-3	↓	↓

Source: Computed by the authors

In the calculation of Dimension Indices for the two years, we have used Global Minimum and Global Maximum in the formula, thereby enabling comparability of the Index values across time. We make the following observations from the table:

- The Index value for Karnataka has improved from 0.63 in 1999-98 to 0.74 in 2012-13. This implies that the power sector performance in Karnataka has slightly improved after reform. However, due to the 14-year gap between the two study periods, there is the possibility of large fluctuations in the variables over the interval; we refrain from interpreting it strongly. Nonetheless, the PPI value for Karnataka increased in 2012-13 compared to 1998-99.

- Karnataka's ranking *vis-a-vis* other states has risen from 8th rank in 1998-99 to 3rd in 2012-13. In a World Bank study by Khurana and Banerjee (2015), Karnataka secured 4th rank in 2010, using the Analytical Hierarchy Process (AHP) methodology with 11 indicators. In both the studies, Gujarat occupied the 1st rank in 2009-2010 as well as in 2012-13. From this paper, we find that Karnataka has improved its performance compared to other states in the second period, as well as compared to its own status in 1998-99.
- Some states have improved tremendously both in terms of PPI value and rank (eg., Gujarat, West Bengal, Karnataka) in the post-reform period, while both the PPI value and rank declined for some states (eg., Kerala, Tamil Nadu, Bihar). The probable reason for such drastic changes could be seen from the percentage share of each indicator to total Dimension Index for each state (Table 25).

Table 25: Percentage Share of Each Indicator to Total Dimension Index for 17 Major Indian States

States	Years	Installed Capacity per capita	Growth in Generation	Capacity utilisation Gen/IC -	Energy deficit	Peak deficit	T&D loss	Average revenue recovery as % of cost	Commercial loss with subsidy-per capita
Haryana	1998-99	4.2	12.5	16.4	14.7	13.0	10.7	11.4	17.2
	2012-13	13.3	10.8	15.0	13.8	14.6	11.9	11.8	8.9
Himachal Pradesh	1998-99	2.3	12.6	17.6	15.8	18.5	16.5	16.9	17.4
	2012-13	23.1	17.0	14.9	17.2	5.4	19.5	17.8	12.3
Jammu & Kashmir	1998-99	1.7	4.9	5.4	12.4	6.4	5.7	0.5	9.8
	2012-13	4.8	11.9	16.5	1.7	2.2	2.6	9.3	2.7
Punjab	1998-99	8.1	13.2	19.0	14.6	18.5	16.9	11.3	12.8
	2012-13	11.9	10.1	20.4	15.4	3.0	18.9	13.7	20.5
Rajasthan	1998-99	1.8	11.9	19.2	14.4	15.7	12.1	10.5	16.4
	2012-13	8.1	13.4	16.2	17.0	18.4	16.9	8.6	2.1
Uttar Pradesh	1998-99	1.7	10.9	14.2	10.2	5.3	13.5	11.6	16.5
	2012-13	2.4	19.4	18.3	7.6	11.4	16.0	12.6	17.4
Gujarat	1998-99	6.9	12.6	17.5	12.3	7.6	15.8	11.8	18.2
	2012-13	21.3	17.1	15.6	19.0	22.0	19.8	21.2	23.0
Madhya Pradesh	1998-99	3.3	11.0	17.9	12.5	1.7	11.4	10.3	14.1
	2012-13	4.8	13.7	15.0	12.5	17.4	13.9	14.2	16.8
Maharashtra	1998-99	6.0	10.8	17.3	13.6	6.0	11.9	18.5	19.2
	2012-13	12.2	13.8	14.8	16.9	17.1	18.3	23.1	23.9
Andhra Pradesh	1998-99	3.9	11.0	17.6	10.9	12.3	11.4	9.2	18.8
	2012-13	9.3	9.5	16.9	6.9	6.0	19.4	16.4	19.0
Karnataka	1998-99	3.6	10.0	15.1	8.3	8.2	12.1	14.4	19.1
	2012-13	11.3	12.4	15.7	9.5	11.4	23.1	20.7	23.2
Kerala	1998-99	2.7	19.2	14.5	10.3	10.8	15.3	12.9	18.3
	2012-13	4.4	4.2	8.0	16.3	15.2	20.1	14.0	11.3

Tamil Nadu	1998-99	4.7	9.5	13.3	9.1	10.0	17.0	16.2	17.7
	2012-13	12.3	10.9	11.5	7.0	11.7	21.6	12.9	8.3
Bihar	1998-99	1.0	13.6	6.3	11.2	8.2	14.7	9.4	18.2
	2012-13	0.0	1.1	0.3	8.4	4.4	5.8	9.6	22.5
West Bengal	1998-99	2.4	11.4	13.2	14.6	14.6	13.8	10.1	17.5
	2012-13	4.6	11.6	20.0	18.6	14.2	17.2	21.2	23.0
Assam	1998-99	1.0	10.6	4.7	14.3	16.4	9.1	9.4	17.7
	2012-13	0.7	11.3	15.1	14.3	19.0	14.2	16.0	21.3
Meghalaya	1998-99	4.0	8.6	9.6	19.2	19.2	15.6	9.0	16.6
	2012-13	5.8	21.2	8.0	10.7	21.3	17.5	12.4	16.5

Source: Computed by the authors

The percentage share of indicators to total dimension index shows the contribution of each indicator to total index value in the two time periods. For the better performing states, the percentage share has increased for almost all indicators. For instance, the shares for all variables increased in case of Karnataka, Gujarat (except capacity utilisation), and West Bengal (except peak demand). For the states whose performance went down, the percentage share of each indicator mostly declined (eg. Tamil Nadu, Kerala). However, for Kerala, almost all variables increased in share, except for sharp fall in generation and capacity utilisation, which probably pulled down the overall index. One limitation of using capacity utilisation (with this definition) as an indicator is that the PLFs of plants are vastly different for different sources. For example, renewable energy sources like wind and solar, have very low PLFs, due to its nature of source, and hence, the overall capacity utilisation calculated in the paper may be low due to this reason. However, due to lack of a uniform measure of capacity utilisation for the states, we have used this definition in the paper. In the study by Khurana and Banerjee (2015), Kerala had been one of the top performing states in their analysis of financial performance of power sector till 2010. The AHP methodology they used is vastly different from the methodology used in this paper, and hence, the results cannot be compared.

Conclusions

After more than a decade of power sector reforms, Karnataka still faces power shortage. The energy and peak deficits in the state declined after reform; however, they are still very high compared to other major states of India, like Gujarat, Tamil Nadu, Kerala. The installed capacity (IC) has increased over time, with private sector growing much more than public sector, and thermal and RES installed capacity increasing faster than hydro. Total generation is, however, growing lesser than the installed capacity. The trend break analysis revealed that there is significant increase in Total IC and Total generation in 1999-2000 itself, probably due to the rising private sector participation. However, the private sector generation exhibited trend break only in 2005-06, while there was no break for public generation. This conforms to the low PLF for public sector thermal plants, as compared to the higher PLF for private sector plants in the post-reform period. The T&D losses have come down tremendously to about 11.5% in 2014-15, which are lower compared to most of the states as well. Per capita consumption has also increased at a higher AAGR after reform compared to pre-reform period and showed trend break in

1998-99; however, it is still lower than some major states. In terms of rural electrification, although 99.9% villages are electrified in Karnataka, only 87% rural households are electrified.

The average revenue recovery as percentage of unit cost of supply showed tremendous increase in the post-reform period; however, it is still not 100%, which should be the ideal case. Further, there is wide difference in the recovery rates across different consumer categories. Industrial and Commercial consumers pay more than cost-of-supply, while the recovery rates for agricultural and domestic consumers was way lower than 100%. Among the five ESCOMs, HESCOM has the highest collection efficiency and MESCOM has the lowest AT&C loss, while CESCOM turns out to be worst performing in this context. These parameters mostly depend on the share of the consumer categories in their area of supply and the strictness of collection.

The Power sector Performance Index (PPI) value for Karnataka increased in 2012-13, implying better performance in the post-reform period, although this conclusion is premature due to very long time gap between the two periods under study. After calculating the Index, the 17 states are ranked for the two time periods. Karnataka's rank *vis-a-vis* other states climbed up from 8^{th} rank in 1998-99 to 3^{rd} rank in 2012-13, reflecting better performance relative to other states. The share of all indicators to total dimension index also increased in the post-reform period. The policy implications that could be drawn with the present study are mostly suggestive from the observations so far. The weaker areas, like low capacity utilisation of existing plants should be investigated and proper measure should be undertaken, whether in terms of technical upgradation of plants, or increasing the demand from utilities by improving their financial condition. The rural electrification of households are still lagging behind, added with low quality supply and load shedding, hence, this area requires effective implementation of the existing electrification schemes. This would also help in improving per capita electricity consumption. The financial loss and cost recovery of the utilities also needs to improve tremendously, for which there are many issues besides economic considerations to deal with, especially the free/ low tariffs to agricultural consumers due to political reasons.

There are limitations to the study in terms of getting continuous time series data for many important variables before and after reform, especially for KEB which was unbundled in 1999. However, the analysis with existing data highlights few important trends over the years. The power sector reform in 1999 seems to have brought improvement in certain indicators, and overall performance. Nonetheless, there are still some loopholes hindering the fast development of Karnataka power sector, like lack of quality power access to all households, the differential pricing across consumers, affecting the utilities' finances with spill-over effect on demand for power from generation plants, which ultimately leads to low PLF. Therefore, there is huge scope for further improvement in Karnataka power sector, especially compared to other major states of India, to meet the demand-supply gap in electricity.

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