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Transmission and distribution sector of kerala: a comparative study of pre and post electricity act period.

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***Abstract**: Electricity act 2003 has brought many changes in transmission and distribution sectors. A quick analysis of the progress taken place in Kerala State has shown that significant changes have taken place in transmission and distribution sectors during this period. It helped the State to overcome the power crisis by importing more electricity from outside and the State has to further strengthen both its inter-state as well as intra state transmission network.*

***Key words**: Transmission, Distribution, High Tension (H.T.) Lines, Low Tension (L.T.) Lines, Distribution transformers and Sub stations.*

Introduction

Far reaching implications are contained in the electricity act 2003 enacted in the country and this has brought wide changes to the electricity sector especially to transmission and distribution sectors. It includes (a) introduction of open access facilities (b) provision given for private companies to build transmission lines for captive use or for common use (c) consumers can enter into direct commercial relationship with generating company or trader after open access is provided. (d) distribution licenses are free to undertake generation and generation companies are free to undertake distribution licenses (e) power trading is being recognised as an activity that can be taken up after authorisation of regulatory commission (f) State governments can un-bundle State Electricity Boards (SEBs) and can create companies (g) all States should have regulatory commissions (h) strict provisions to deal with power theft and (j) metering to be made in 100%. These provisions contained in the electricity act 2003 has provided

ample opportunities to increase competition, decrease state interventions and improving power provisions to all sectors.

Review of Literature

Review of Literature has however shown that very few studies have been conducted so far on the impact of electricity act 2003 in the power sector. Although some studies have been done in Tamil Nadu, Andhra Pradesh, Punjab and Haryana but these studies are conducted in a short period immediately after the introduction of the act. Anupama Sen and Tooraj Jamasb (2012) study using the panel data for 19 states in India for the period from 1991 to 2007 showed that individual reform measures have affected economic variables differently and the nature of reforms in individual states would determine these economic outcomes. It is also found in this study that due to political economy factors, outcomes have tended to be adverse in the initial stages of reforms and may improve as reform progresses beyond a 'baseline level'. The activities and performance of power system in the state of Assam both in pre and post restructuring period on the basis of both primary and secondary data was analysed by Prabirkumar Purkayastha (2012). It showed that insufficient power generation in the state is the basic cause for inadequacy of power supply in the state.In another study, Kanni Angayar (2008) studied the physical and technical performance of power sector in Tamil Nadu during the period 1986 to 2006.The analysis was carried out by dividing the study period in to two parts i.e. 1986 -87 to 1997-98 and 1998-99 to 2005-06. The study showed that average performance installed capacity of power sector in Tamil Nadu during the second period was comparatively better than the average performance of installed capacity during the first period. It also showed that Transmission and Distribution Loss and power purchase costs are found to be high making troubles to the sector.

In Kerala context, major studies related to energy sector were mostly done before electricity act of 2003. Vijaya Mohanan Pillai and Kannan (2001) has made a detailed analysis of the cost of inefficiency involved in the time and cost overruns in the power projects of Kerala State Electricity Board (K.S.E.B.) and their possible causes in this working paper "Time and cost over runs of the power projects in Kerala". The authors point out that the arguments by the Government in favour of private sector participation in power generation capacity addition under the pretext of resource crunch is found to be flimsy to the extent that the Government is actually overspending on each of the projects under taken. Pavithran (2004) has made a techno economic analysis of the power system of Kerala in this book on "Economics of power generation, transmission and distribution –A case study of Kerala". Findings of his study include(1) Capital investment in the power sector is low even after the energy crisis of 1980s(2)Rate of growth of supply side variables lagged behind that of demand side variables during 1957-1995 period (3) Actual generation exceeded the design value of generation for major hydro power projects during 1988-95 period. World Wide Fund (WWF) and World Institute of Sustainable Energy (WISE) (2013) made a scientific attempt to assess the renewable energy potential of Kerala in this report "The energy report-Kerala -100% Renewable energy by 2050".This report attempts to model the energy requirement of Kerala up to 2050 in order to access the feasibility of meeting 100% of the State's energy demand with renewable sources. The

central finding of the study is that Kerala can meet over 95% of its energy demand with renewable sources by 2050. On a broad level, the study findings indicate that while the existing pattern of growth (BAU growth) would lead to overdependence on fossil fuels, aggressive interventions in energy efficiency, energy conservation and carrier substitution can curtail demand significantly.

Methodology

Since provisions contained in electricity act 2003 have brought changes in transmission and distribution sectors, attempt has been made in this paper to study its impact so far. For studying this, 28 years' time series data was used- 14 years data prior to electricity act (1989-90 to 2002-03) and 14 years data after the enactment of electricity act (2003-04 to 2016-17). Key parameters representing both transmission and distribution sectors were selected for the study and this includes (1) extension of 220 k V lines, (2) extension of 110 k V lines (3) extension of 33 k V lines and (4) number of substations established during the study period in the transmission sector and (1) extension of High Tension (H.T.) lines (2) extension of Low Tension (L.T.) lines (3) number of distribution transformers established (4) number of street lights established and (5) number of service connections provided in the distribution sector. These components can be considered as vital factors influencing the transmission and distribution infrastructure of a power system. Growth rate was then calculated separately for each of these factors. Curve estimation and paired t test was also done for these two periods for each of these factors and compared the changes happened during these periods.

Results and Discussion

One of the important change happened in Kerala in power sector is that the State has gone for more import from outside the State as the demand – supply gap widened. From a power surplus State in the beginning of 1980's, it has turned out to be a power shortage State and now it imports nearly 70% of its demand from outside. Stagnation in generation has aggregated the situation. Major hydro sources of the State are already used and the balance large hydro sources were went into issues due to environmental and political reasons. As the prices of diesel and naphtha increased, generation of electricity from thermal plants have become uneconomical and many units of the thermal power plants started were either closed or decommissioned. So filling the Demand-Supply gap in electricity became a major problem in power sector planning and importing of electricity from outside the State is found to be the possible option left. It is calculated that peak demand of the State for the year 2015-16 was 4004 megawatt (M.W.) but the installed capacity of the State was only 2200 megawatt (M.W.). Balance was met through central share, purchase from Independent Power Producers (I.P.P.) from the State or from outside the State. The 18th Electric Power Survey (E.P.S.) by central electricity authority (CEA) has projected that State's projected peak hour demand may touch 4900 megawatt (M.W.) by 2017-18, 6398 megawatt(M.W.) by 2022-23 and 12,000 megawatt (M.W.) by the end of 2032. As per this projection, the State will require to add an import of 2000 megawatt (M.W.) by 2018, 4000 megawatt (M.W.) by 2022 and 8000 megawatt (M.W.) by 2032 to the existing network. But due to limited transmission capacity, Kerala is presently meeting it

through maximally utilizing its capacity, but incurs transmission and distribution losses. This can be reduced if it is properly strengthened.

The existing interstate transmission capacity of Kerala is presented in Table 1. It can be seen from the table that Kerala is having four numbers of grid sub stations at 400 /220 k V level with total interstate transformation capacity of 3150 Megavolt Amperes (MVA) with Power Grid Corporation of India Limited (P.G.C.I.L.) & Kerala State Electricity Board Limited (K.S.E.B.L.) together. This means that interstate transmission capacity of the State is inadequate to meet its demand and requires to double its inter- state transmission capacity from the present level if it has to meet its demand through import from outside the State. Hence transmission and distribution sector has to play an important role in ensuring interruption free electricity as generation is not picking up in proportion to the increase in demand.

Table.1: Details of existing interstate transmission system of Kerala

Status of existing inter- state transmission system of Kerala					
Sl.No.	Agency	Voltage Ratio	No. of Transformers	MVA capacity	Total transformer capacity(MVA)
1	Power Grid Corporation of India Limited(PGCIL)				
a	400 k V Pallipuram	400/220 k V	3	3X315	945
b	400 k V Elapully	400/220 k V	2	2X315	630
c	400 k V Cochin-East	400/220 k V	2	2X315	630
2	Kerala State Electricity Board Limited(KSEBL)				
a	400 k V Madakkathara	400/220 k V	3	3X315	945
	Total				3150

Source: 24X 7 Power for all, Government of India Report.

Growth rate was first calculated and is presented in table 2.

Table.2. Growth rates in key parameters of transmission and distribution sectors: Comparison of pre and post electricity act periods.

Growth rates during pre and post electricity act periods		
Item	**Pre-electricity act period**	**Post electricity act period**
220kV	162.78	8.6
110kV	58.77	16.68
33kV	120.48	269.94
High Tension (H.T.) Lines	63.31	78.77
Low Tension (L.T.) Lines	108.17	42.53
Number of Distribution Transformers	104.06	117.44
Number of Street lights	64.53	65.3
Number of service connections	117.67	64.31

Source: Authors estimate.

Among all the factors considered in transmission and distribution sectors during pre and post electricity act periods, more growth rate was found in the development of 33 k V lines in the State during the post electricity act period (269.94%). Growth rate in the extension of 220 k V lines (162.78%) and 110 k V lines (58.77%) took place more during the pre-electricity act period. However, all the transmission lines

have shown positive growth both in the pre-electricity act period and post electricity act period. The growth in the transmission lines of 33 k V lines in the state during the study period brought more connectivity especially to the voltage shortage Malabar areas and it helped to increase its intra state electricity network. It has brought development in agricultural sector, business and in other areas including education sector. The increase in the high voltage line capacity of the transmission system especially that of 220 k V lines and 110 k V lines was inadequate indicating that inter-state transmission capacity of the State has to be strengthened if it has to bring more electricity from outside. The present system of evacuating around 3200 megawatt (M.W.) with a backbone of 220 k V line is inadequate. It requires further increasing of transmission capacity of the system by inducting 400 k V lines but it requires heavy investment. It is to be noted here that Government investment in this sector is found to be declining over the years. In the first five year plan, 39.4% of the plan outlay was set apart for energy sector, it has declined to 18.8% in the sixth five year plan and finally to 7.2% in the 12th five year plan. Shortage of investment is one among the reasons for the slowdown in the growth in 220 k V and 110 k V transmission lines and presently attempt is being made by the Government to finance it through Kerala Infrastructure Investment Fund Board (K.I.I.F.B.).

Substations are essentials for the proper functioning of transmission and distribution network and its development in Kerala was given in table 3. It can be seen from the table that Kerala is having 402 substations during the study period. All these stations together have a total capacity of 18781.1 megavolt amperes (MVA). This includes 1 no. of 400 k V substation, 22 no. of 220 k V sub stations, 156 no. of 110 k V sub stations, 78 no. of 66 k V substations, 144 no. of 33 k V sub stations. Of this, 400 k V substation have a capacity of 1365 Megavolt Amperes (MVA), 220 k V substations have a total capacity of 6991 Megavolt Amperes (MVA), 110 k V sub stations have a total capacity of 7391 Megavolt Amperes (MVA) , 66 k V sub stations have a total capacity of 1719 Megavolt Amperes (MVA) and 33 k V sub stations have a total capacity of 1315 Megavolt Amperes (MVA) capacity. Among the substations and its capacities, the State has more 110 k V sub stations (156 numbers).

Table 3: Development of Sub stations in Kerala

Development of Sub stations in Kerala												
Year	**400 k V**	**Cpacity(MVA)**	**220 k V**	**Cpacity(MVA)**	**110 k V**	**Cpacity(MVA)**	**66 k V**	**Cpacity(MVA)**	**33 k V**	**Cpacity(MVA)**	**Total Sub Stations**	**Total Capacity (MVA)**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**
Upto 1989	0	0	7	2483	28	1457	46	986.4	0	0	81	4925.8 (26.2%)
During 1989-2003	1	1365	9	2195	68	2511	17	306.9	16	145	111	6523.2 (34.7%)
During 2003-2017	0	0	6	2313	60	3423	15	426.1	128	1170	209	7332.1 (39.03%)
As on 2016-17	1	1365	22	6991	156	7391	78	1719	144	1315	402	18781.1 (100.00)

Source: Authors estimate.

The break-up of the total capacity of the sub stations in column 13 of the table 3 shows that 39.08% of the total capacity added during the entire transmission development of the State belongs to 2003-2017 period. During this period, 209 sub stations were newly started. Similarly, 7332.1 Megavolt Amperes (MVA) was

added during this period out of the total 18,781.1 Megavolt Amperes (MVA) at present. Total capacity addition during 1989 to 2003 period was 6523.2 Megavolt Amperes (MVA) with 111 new sub stations. It comes 34.7% of the total addition during this period. Up to the year 1989, there are only 81 substations existed in the State with a total Megavolt Amperes (MVA) capacity of 4925.8 (26.2%). This shows that substation development took place more during the post electricity act period when compared to other periods. The table also tell us the lacuna of the State i.e. the inadequacy of sufficient number of 400 k V substations and its transmission lines in the system.

Among the indices in the distribution sector as given in table 2, growth rate was found to be more in respect of the extension high tension (H.T.) lines (78.77%), distribution transformers (117.4%), and number of street lights installed (65.3%) during the post electricity act period, while low tension (L.T.) lines (108.17%), and number of service connections provided (117.67%) have shown more growth during the pre-electricity act period. It means that more factors in the distribution sector have shown growth during the post electricity act period. It is also important that although its magnitude varied, all the selected variables in the distribution sector have shown growth during the study period. Although growth rate in service connections provided during the post electricity act period was less, it can be considered as a positive sign since total electrification drive is undergoing in the State and Kerala attained this position in 2017.

Curve estimation analysis was carried out to see the impact of electricity act on selected variables from transmission and distribution sectors and its result is presented in table 4 given below.

Table 4: Transmission and distribution sectors: Curve estimation results

Variable	Pre electricity act period					Post electricity act period				
	Linear	Anova		Coefficient		Linear	Anova		Coefficient	
	R^2	F	Sig.	B	Sig.	R^2	F	Sig.	B	Sig.
33kV	.496	11.81	.005	22.70	.005	.976	493.90	.000	108.004	.000
110kV	.943	196.89	.000	116.445	.000	.972	416.37	.000	41.865	.000
220kV	.972	416.373	.000	41.865	.000	.941	191.28	.000	18.305	.000
H.T. Lines	.997	4.75	.000	931.69	.000	.980	594.18	.000	2239.21	.000
L.T. Lines	.959	279.91	.000	8528.58	.000	.978	545.113	.000	6360.54	.000
Number of Distribution Transformers	.997	3.959	.000	1347.04	.000	.981	624.339	.000	3537.57	.000
Number of service connections	.991	1.296	.000	293728.20	.000	.994	2.038	.000	355375.89	.000
Number of Street lights	.939	184.655	.000	23681.77	.000	.995	2.328	.000	43550.99	.000

Curve estimation results shows comparing to pre electricity act period, beta values have yielded more better results in the post electricity act period. It means that after the enactment of electricity act in 2003,

variables selected representing transmission and distribution sectors have yielded better results and significant.

Paired t test was carried out to see whether is change in the values of variables for the selected indicators during during pre and post electricity act period . It was given in table 5.

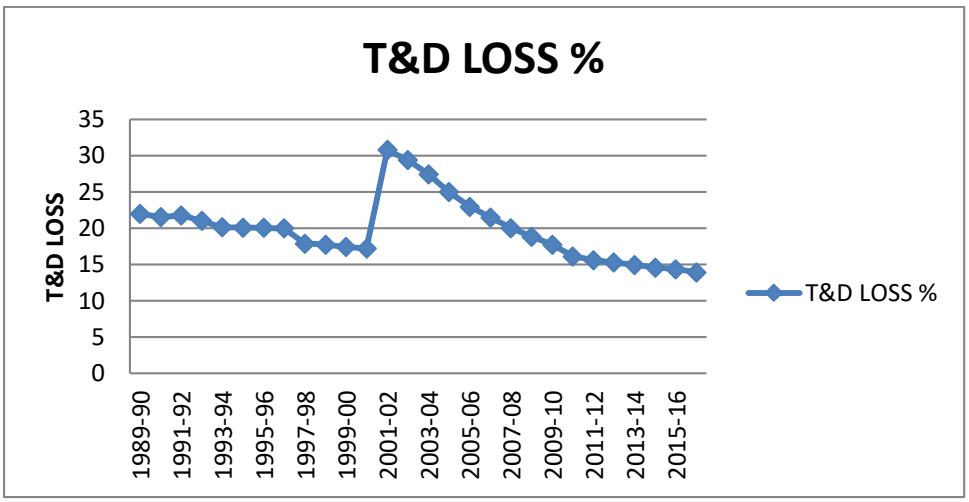
Table 5: Transmission and distribution sectors: Results of paired t test

Results of paired t test						
Variable	Period	Mean	Standard Deviation	t value	degrees of freedom	Significance (2 tailed)
33kV	Pre	64.19	134.86	-11.900	13	.000
	Post	1305.51	457.27			
110kV	Pre	2851.02	501.74	-14.10	13	.000
	Post	4125.47	177.63			
220kV	Pre	1578.09	641.27	-7.36	13	.000
	Post	2705.54	78.93			
H.T. Lines	Pre	2.58	3902.47	-13.30	13	.000
	Post	4.59	9461.41			
L.T. Lines	Pre	1.52	36434.365	-31.357	13	.000
	Post	2.48	26899.33			
Number of Distribution Transformers	Pre	2.94	5643.614	-11.78	13	.000
	Post	5.44	14940.283			
Number of service connections	Pre	4.96	1234427.31	-54.72	13	.000
	Post	9.85	1491013.36			
Number of Street lights	Pre	6.35	102236.31	-21.69	13	.000
	Post	1.15	182655.925			

The results of paired t test shows that p values for all selected indicators have shown less than 0.05 values thereby rejecting the null hypothesis and there is significant changes in the values of variables during pre and post electricity act period.

The developments took place in the transmission and distribution sector has helped the State to reduce its transmission and distribution (T&D) losses to an extent. The details of transmission and distribution loss in Kerala were graphically represented in figure 1.

Figure 1: Transmission and distribution loss of Kerala



As demand for electricity increased, transmission and distribution loss has also increased but its percentage has decreased from 2002-03 onwards. Transmission and Distribution (T&D) loss has touched the peak level in the year 2001-02 with 30.76%. Since then, it is on declining. It has come down to 13.93% in the year 2016-17. The decline in transmission and distribution (T&D) loss was due to the development took place in these sectors especially after 2003. The transmission and distribution loss now in Kerala is one of the lowest in India. The corresponding figure for the country during this period was 21.4%. One of the major reasons for the development took place in Kerala in transmission and Distribution sector was due to the co-ordinated and concerted efforts of State and Central Governments along with the crucial role played by Kerala State Electricity Board Limited (KSEBL) in planning and utilising the funds available. Efforts made by Local Self Governments at decentralised level is also worthy to mention. Apart from the own fund utilised by Kerala State Electricity Board Limited (KSEBL) and the fund earmarked by State Government for energy sector in its annual plan, specific schemes implemented by Central Government in this area like Rajiv Gandhi Gramin Vidyuthikaran Yojanan (RGGVY), Integrated Power Development Scheme (I.P.D.S.), Restructured Accelerated Development and Reform Programme (R-APDRP), and Deen Dayal Upadhyay Gram Jyoti Yojana (D.D.U.G.J.Y.) have also benefitted in strengthening the infrastructure of transmission and distribution sector.

Conclusion

It is found from the analysis that significant progress has achieved by the State in transmission and distribution sectors during the study period. Nine key factors representing the solidity of the sector were taken in to account for the study which showed remarkable growth during the study period. Out of this, five key factors namely extension of 33 k V lines, extension of high tension (H.T.) line, number of distribution transformers, establishing of sub stations, and number of street lights installed have shown more growth during the post electricity act period than pre electricity act period. Although growth in service connections provided during the study period have shown less growth during the post electricity act period, it can only be considered as a positive sign as total electrification drive proliferated the hopes and the State has later achieved this feet in 2017. Curve estimation analysis was carried out to quantify the impact of electricity act on selected variables and it has showed that selected variables representing

transmission and distribution sectors have yielded better results in the post electricity act period. Results of paired t test showed that p values for all selected indicators are less than 0.05 thereby rejecting the null hypothesis and indicating that there are significant changes in the values of variables during pre and post electricity act period. Moreover, it is also found that transmission and distribution losses were also consistently declined during the study period. All these achievements have attained at a time when Government is withdrawing its investment in this vital sector. Although all parameters selected for the study have shown positive results, but it also showed the lacuna of the system i.e. weaknesses in the 400 k V & 220 k V transmission lines and its over loading. So in order to bring more electricity from outside in future, State has to further strengthen both its inter-state as well as intra state transmission network. This requires heavy investment and State Electricity Board alone cannot meet this huge investment. It is a fact that when majority of the electricity is brought from outside, majority of the income collected from the sale of electricity will also go outside. So the present method of meeting the growing demand through importing more electricity from outside cannot be considered as a permanent solution, hence concerted effort is needed to generate more electricity domestically to achieve self-sufficiency and thereby to protect the energy security of the State.

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