Council on Energy, Environment & Water

Retail Tariffs for Electricity Consumers in Bangalore: A Forward Looking Assessment

KAPARDHI BHARADWAJ, KARTHIK GANESAN, AND NEERAJ KULDEEP

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Editor: Karthik Ganesan

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Karthik Ganesan is a Research Fellow at the Council on Energy, Environment and Water (CEEW), India. As a member of the team at CEEW his research focus includes the development of long-term energy scenarios for India (based on an in-house cost-optimisation model) and energy efficiency improvements in the industrial sector in India. Linked to his work in industrial efficiency is his role as the principal investigator in an effort to identify critical mineral resources required for India's manufacturing sector. In addition, he supports on-going work in the areas of energy access indicators for rural Indian households and carried out a first-of-a-kind evaluation of the impact of industrial policies on the RE sector in India.

Prior to his association with CEEW he has worked on an array of projects in collaboration with various international institutions, with a focus on low-carbon development and energy security. His published (and under review) works include Rethink India's Energy Strategy (Nature, Comment) the Co-location opportunities for renewable energy and agriculture in North-western India: Trade-offs and Synergies (American Geophysical Union), Valuation of health impact of air pollution from thermal power plants (ADB), Technical feasibility of metropolitan siting of nuclear power plants (NUS), Prospects for Carbon Capture and Storage in SE Asia (ADB). His role as a research assistant at a graduate level focused on the linkages between electricity consumption and sectoral economic growth using a time-series approach.

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He has been actively involved in renewable energy and sustainability activities. He was the founding member of Team Shunya, first ever team from India to qualify to participate in prestigious Solar Decathlon Europe 2014, an international competition to build and demonstrate a 700 Sq. ft. net zero energy solar powered house. He also initiated the Energy Club at IIT Bombay where he organised various events to raise awareness about sustainability and RE technologies.

Neeraj holds an M. Tech in Energy Systems and a B. Tech in Energy Science and Engineering from Indian Institute of Technology (IIT), Bombay.

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Executive Summary

Estimating the future cost of electricity requires an understanding of the different components that make up an electricity bill, the regulatory procedures and influences that impact the tariff for each of these components, and the market and political forces that affect these tariffs. Each component of an electricity bill is determined by a variety of factors. In order to provide clarity on the build-up of power supply costs, the overall cost is broken down into four parts - power procurement costs, transmission charges, distribution charges and cross-subsidy charges. Should there be more clarity (in due course), on specific trends of each, the forward-looking trends can be fine-tuned accordingly.

The four components that make up an electricity bill and their influences is as follows:

- Power procurement costs – the cost to source the power from generators which is driven by the overall mix of generation, the cost of fuel for each generation source, the efficiency of those generators, and the capital and operational cost of each generator. In addition, this component also accounts for (technical) losses incurred in transmission and distribution as well.
- Transmission charges – the cost to transport the high-voltage power from the generators over the inter-state and intra-state lines to the distribution companies (DISCOMs) infrastructure which is driven by the cost of building and maintaining these lines as India's need for electricity grows.
- Distribution charges – the cost to distribute and transform to lower voltages the power from the transmission lines to individual customers which is driven by the cost to build and maintain the infrastructure to deliver power and to comply with Renewable Procurement Obligations from each state. This also includes operating and administrative expenses of a DISCOM.
- Cross-subsidy charges – additional cost for commercial and industrial customers to offset the total delivered cost of electricity to domestic customers which is driven by political matters in each state.

This report examines each of these factors in detail. In order to showcase the relative influence of different factors, this report has considered two scenarios, with varying energy mix based on renewable energy (RE) capacity additions and some expectations on changes in cross-subsidy that is inherent in the power sector. The two scenarios - high RE penetration and low RE penetration, are (both) conservative estimates of future RE capacity additions, going by the ambitions expressed by the current government. The variable components of each of these sources (energy charges) are assumed to vary as shown in the table below:

Table 1 – Assumptions in power procurement costs

Source	Assumptions
Coal	Energy charges assumed to increase by 9.1% year-on-year
Wind	Energy charges assumed to increase by 0.3% year-on-year
Hydro	Energy charges assumed to increase by 1.3% year-on-year
Solar	Energy charges assumed to decrease by 5% year-on-year

Source: CEEW assumptions

Transmission charges will rise as per the investments made in the overall network (inter-state as well as intra-state). To the extent possible, the investment plans of the utilities have been captured and converted to equivalent impact on every unit of electricity transmitted.

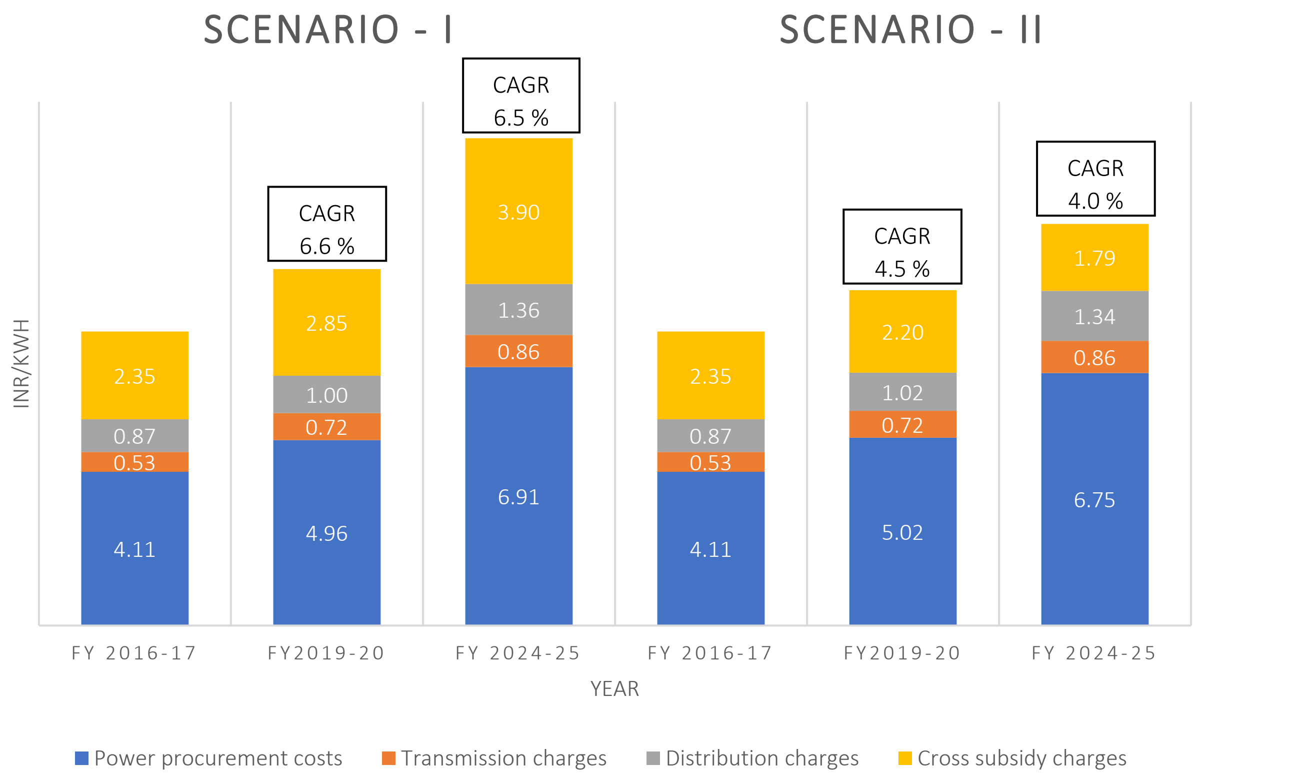
Distribution charges, based on the operating expenses of a DISCOM, are a complex mix of administrative and O&M expenses, capital expenditure and employee expenses. For the purposes of this study, operating expenses of DISCOMs (distribution charges) have been assumed to constitute 15% of the overall cost of supply. This represents the upper bound of the range of values seen in the DISCOMs that operate in Banga.

The cross-subsidy component can have a telling impact on future tariffs. Extensive review of tariff orders provides no insight to the science of the cross-subsidy determination. However, policy makers acknowledge that reduction of cross subsidies (across consumer categories) is one of the major drivers for regulatory reforms. This constitutes a significant assumption in this assessment and is considered in parallel with the scenarios that depict two different energy mixes. The ratio of the average billing rate for a consumer category (ABR) to the overall average cost of supply (ACoS) is an indicator of tariff rationalisation for that category of consumers. Going forward, in both the scenarios, some rationalisation is expected. This ratio is assumed to be decreasing to +/- 20% in high RE scenario and 0% in the low RE scenario.

Observations

Power procurement costs continue to constitute the largest share of the cost of supply. The illustration below indicates the share of components in future tariffs for commercial consumers of BESCOM.

Figure – 1 ABR for commercial consumers of BESCOM



Source: CEEW estimates

Power procurement cost is dictate by the rate of growth of the energy charges associated with the various sources of electricity. The large penetration of RE in both scenarios, brings down overall procurement costs. A fundamental expectation is that cost of generation from fossil fuel based sources will continue to increase (in real terms).[1]

1 All the estimations in this report are expressed in **nominal terms.** Growth rates assumed in the analysis cover inflation adjustment.

Summary of Results

Based on the assumptions for each of the components that make up an electricity bill, CEEW estimates that electricity costs for Commercial customers will rise at an expected CAGR of 6% and for Industrial customers will rise at an expected CAGR of 5%. Some general trends emerged from the study:

- The urban city of Bengaluru consumes 50% of the demand of BESCOM, growth in demand for BESCOM can be attributed to booming population migration to the city.
- The IT-hub of the city is facing problems in augmenting its distribution infrastructure. There is heavy demand for reliable supply to these areas, and existing distribution infrastructure is inadequate to serve to the growing demand.
- Right-of-way issues have restricted augmentation of supply infrastructure in these areas.
- Consumers in BESCOM areas do not pay as high electricity prices as consumers in Mumbai or Delhi. This is because of the low power procurement costs, cheap power from hydro plants in the state has contributed to lower costs.
- BESCOM enjoys a diverse energy mix, with significant contributions from wind, nuclear and hydro plants. However, in dry seasons (or when there is scanty rainfall) low hydro generation affects the supply position of BESCOM. To cover for this shortfall, BESCOM procures costlier power from short term markets, escalating its power purchase costs.

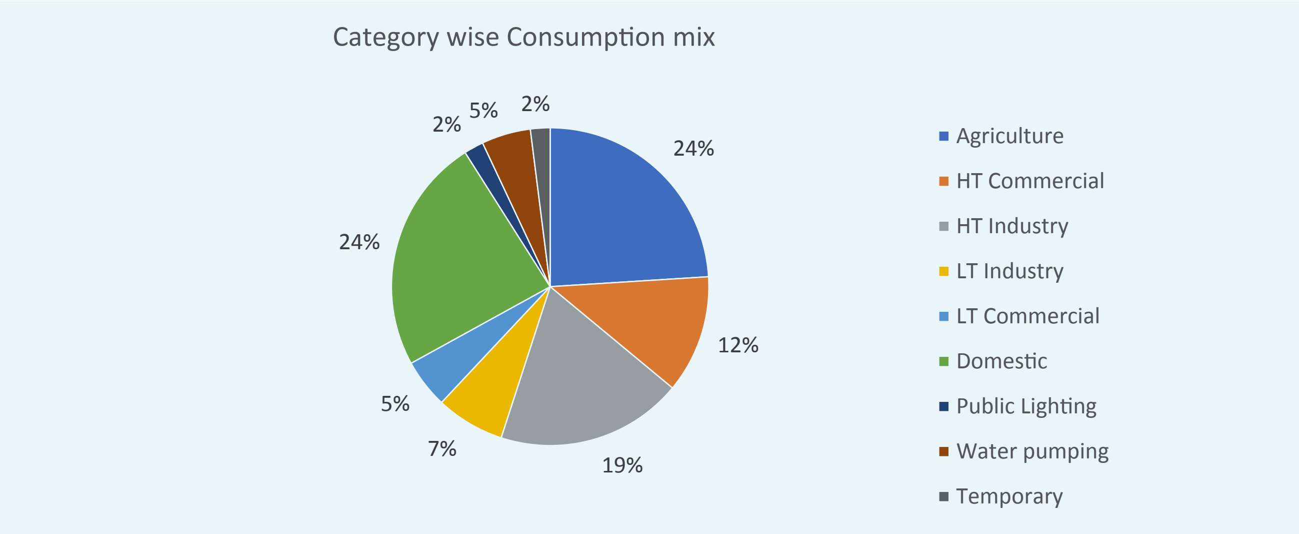
Other factors that this study did not consider could also influence electricity prices:

- While the government has indicated a goal of reducing cross-subsidy charges, it may prove politically difficult to accomplish for the foreseeable future.
- Higher penetration of renewables, which are intermittent sources of power, requires a smarter transmission and distribution network to enable balancing of power sources and reliability. These costs are not fully known but could substantially aid or hinder the penetration of renewables.
- Environmental commitments arising from the Paris Agreement would reduce the utilisation of coal plants and when coupled with the potential need to set higher RE targets, an overall increase might be seen for natural gas based generation. As a result, overall cost of procurement could rise. This could be alternatively considered equivalent to a scenario where a carbon price is in place.
- The rates estimated in this report are **exclusive** of electricity duty and other taxes levied, as decided from time to time by the Government. These charges are payable over and above ABR estimations.

1. Introduction

The Bengaluru Electric Supply Company (BESCOM) caters to eight out of thirty districts in the state of Karnataka, and caters to 45% of electricity demand in the state. Electricity consumption in urban areas of the DISCOM is much higher than that of rural or agricultural consumers, 53% of the sales is from Bengaluru city (BESCOM, 2017). The consumption mix of BESCOM is diverse, which is important to cross subsidies agricultural and residential consumers and for recovery of revenues, figure 2 below shows the consumption mix of BESCOM as per Annual Revenue Requirement (ARR) filings for FY 2017-18.

Figure 2 – Consumption mix of BESCOM



Source: From ARR filings of BESCOM

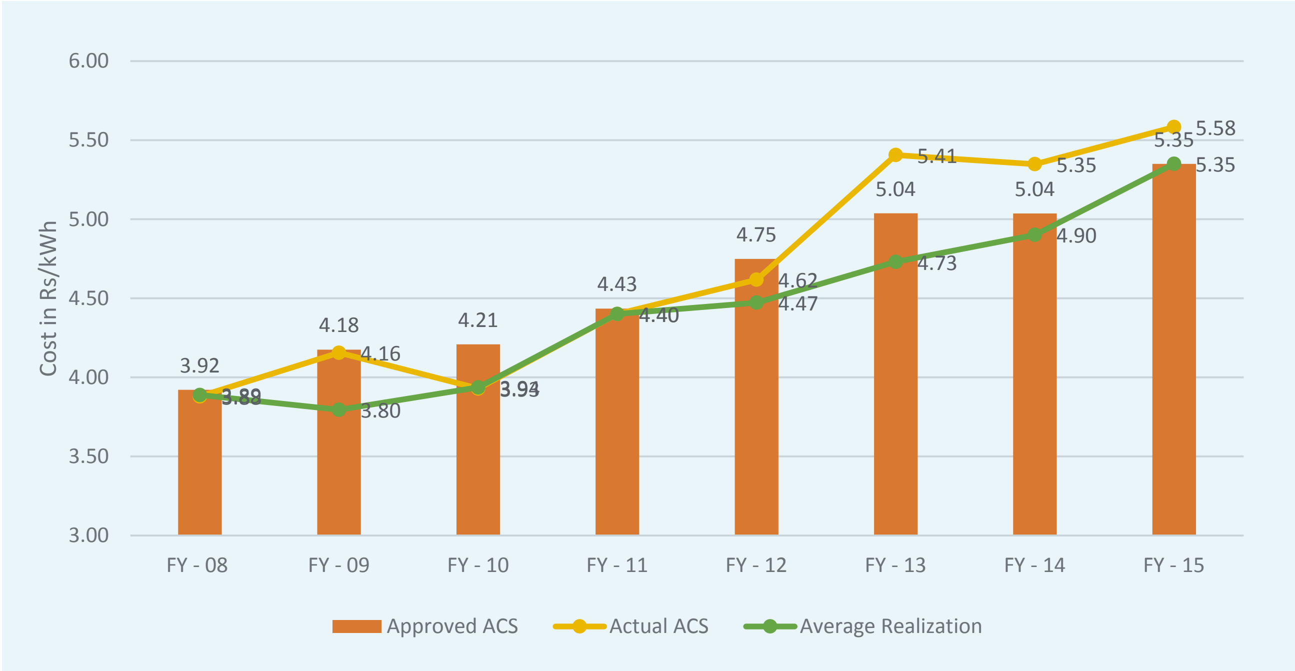
The figure above shows the subsidised categories – domestic and agriculture, consume about half of the mix, while the subsidizing category – HT & LT, commercial and industrial consumers, contribute 43% of the energy mix. Further, revenue stream of BESCOM is affected because of unpaid bills from urban local bodies and municipal corporations, and irrigation pump-sets dating back as early as 2008.[2]

The challenges for BESCOM are plenty. Every year 3 lakh new consumers (BESCOM, 2016) are added to the network. To ensure reliable supply, metering and billing of these consumers, BESCOM has to accurately predict load growth and revenue requirements and deficit, in its filings. Further, BESCOM is struggling to accurately forecast load growth with the known factors and has indicated as much in its latest tariff filing.

Apart from load forecasting, rising power purchase costs and O&M costs have added to the challenges of BESCOM. The challenge of catering to increasing consumer base has its costs, it calls for additional infrastructure and personnel, which have to be passed on to the consumers. Above listed challenges have contributed to increase in revenue loss for BESCOM. Figure 3 below shows the gap in revenue required and realised.

2 As per the Business plan of BESCOM for 2021, 40% of the dues receivable for BESCOM are due to Urban local bodies and rural local bodies. 22% of the dues receivable are from irrigation pump-sets.

Figure 3 – Gap between ACoS and revenue realised for BESCOM



Source: Chapter 1, ARR filing of BESCOM FY 2017

In this context, this report attempts to estimate electricity tariff for consumers in BESCOM areas, it details the methodology, assumptions in the estimates and the limitations in these estimates. This exercise is aimed to understand retail electricity tariffs, in the context of varying energy mix, and the impact of this on the power purchase costs, thereby, overall tariffs. The estimates also incorporate two scenarios of RE growth and the impact on cost of procurement.

For the purpose of estimation and analysis, this report has sourced majority of the data from previous ARR orders of the Karnataka Electricity Regulatory Commission (KERC). The data for estimations of transmission and power procurement costs is sourced from the Karnataka Power Transmission Company Ltd (KPTCL) and Central Electricity Authority (CEA) reports.

It is important to note that there is fair amount of uncertainty associated with the estimates, owing to the fact that power procurement cost, transmission charges and the administrative expenses can vary significantly given their dependence on multiple factors, which are susceptive to real market conditions. All this adds to the complexity of tariff estimation.

2. Cost of Supply Model

BESCOM is one of five DISCOMs serving consumers of Karnataka, it caters to a majority of urban consumers in the state. In our estimations, the cost of supply model is followed to arrive at different tariff rates for consumers. The cost of supply model has various key components involved in the computation of the retail tariff, like – power purchase costs, inter and intra-State transmission charges, operating expenses of DISCOMs, etc. Of these components, power purchase costs constitute nearly 73-79% of the annual expenses of DISCOMs, which forms the basis for further discussions on the cost of power from different energy mixes, in the following chapters.

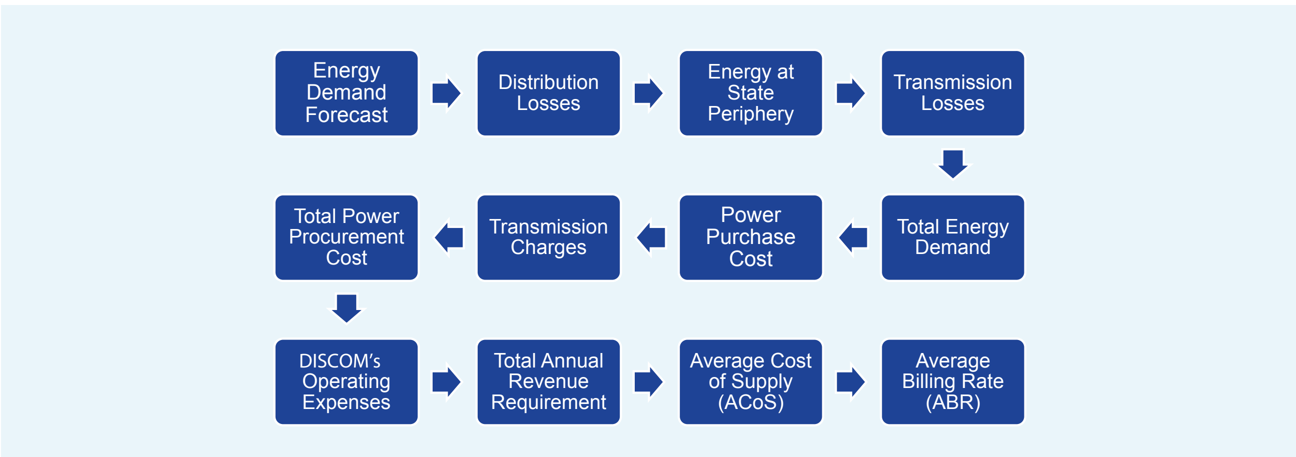
2.1 ARR of DISCOMs - Overview

BESCOM is one of the better performing DISCOMs in India. It ranks sixth best within forty-one DISCOMs rated by Power Finance Corporation (Power Finance Corporation, 2017). Its technical and commercial losses are relatively low, whilst catering to a sizeable urban-rural consumer mix. Supplying electricity through extensive distribution networks requires a comprehensive structure to determine ARR and the retail supply tariffs. DISCOMs use the cost of supply model to determine tariff rates in order to recover the incurred expenses from the consumers.

The expenses that are incurred by DISCOMs are either towards operations and maintenance, administrative purposes or for power procurement from generators. Power procurement cost also incorporates inter-state and intra-state transmission line losses, distribution losses and transmission charges. DISCOMs are required to estimate their aggregate revenue requirement based on expenses they will incur in the following financial year, which is then reviewed by KERC. The regulatory process involved in estimating ARR for DISCOMs is shown in the Figure 3.

The methodology followed in this study estimates the future trajectory of the key components out of all ARR components (Fig. 4), while assuming the rest to be following the historical trend observed so far. The detailed estimation process and assumptions are discussed in the following chapters.

Figure 4 – Regulatory process in estimating ARR and retail supply tariffs

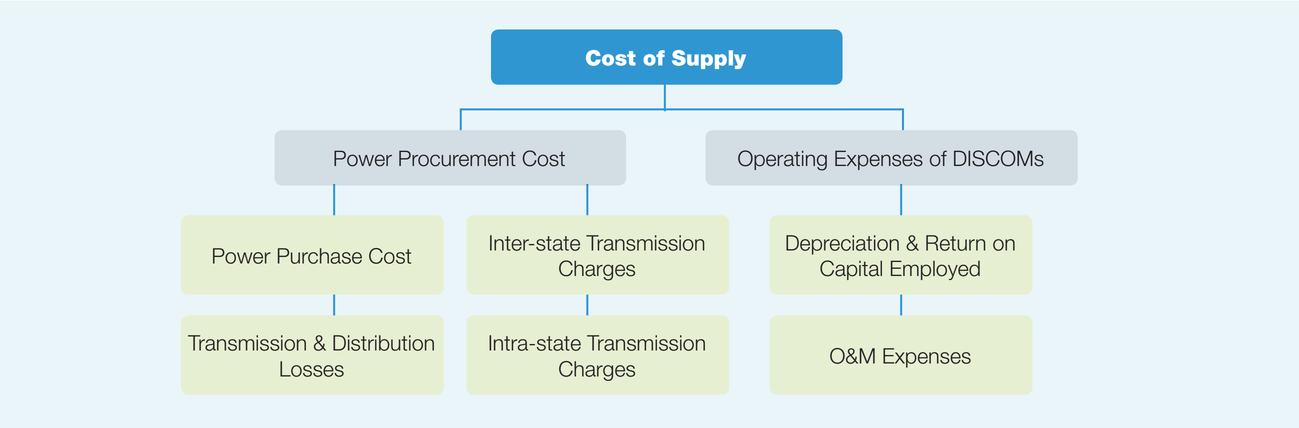


Source: CEEW compilation of ARR documents

2.2 Observations in the Cost of Supply

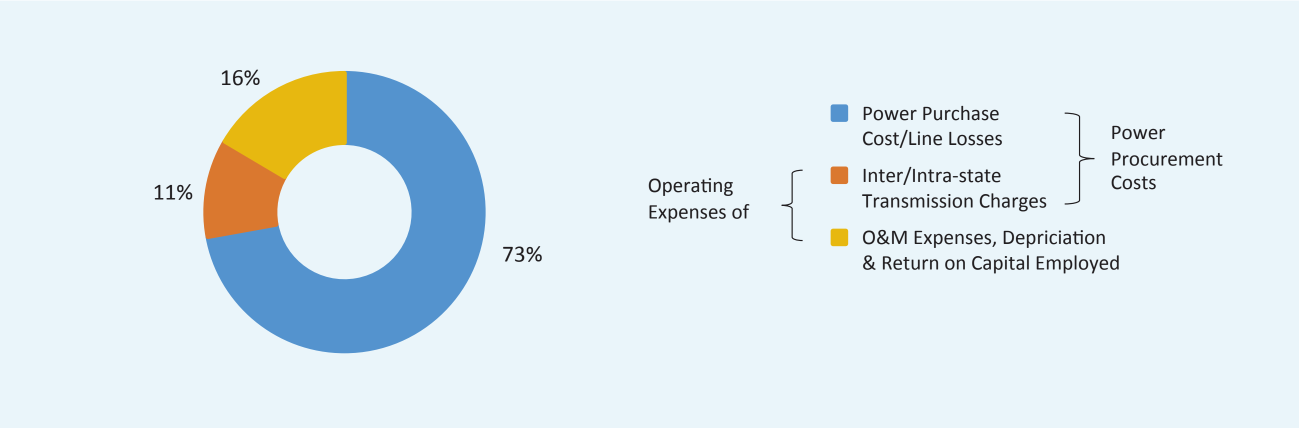
An assessment of data from the BESCOM filings show the key components of the cost of supply (Fig. 5). It is observed that the cost of power purchase forms the major portion of the ARR, varies from 73-79% for BESCOM (Fig. 6). The transmission costs on the other hand, constitute a relatively smaller portion of the cost of supply (Fig. 6), when compared to Council on Energy, Environment and Water (CEEW) report on estimations of retail tariffs for Delhi DISCOMs (CEEW, 2017). This is because, the capital cost of transmission assets has been recovered, the transmission charges are levied to recover O&M costs. Distribution comprises expenses towards loan repayment, depreciation, operations and maintenance, employee remunerations, pensions etc. (Fig. 5). These distribution related cost trends indicate that their share has remained relatively unchanged in the overall cost of supply. Also, observing a flat trend in transmission costs and budgetary outlays for the transmission sector (both at state and central levels), an estimation of transmission costs has been undertaken in the analysis. Thus, the approach for overall cost of supply is driven primarily by the power purchase quantum, the energy generation mix and the cost of supply from each source.

Figure 5 – Components of Cost of supply



Source: CEEW analysis

Figure 6 – Share of cost of supply components



Source: CEEW compilation from ARR for FY 2016-17

3. Estimations of Cost of Supply

As mentioned in the previous section, the key components in the estimation of the cost of supply for DISCOMs are – power procurement cost, which includes energy demand, power purchase costs, transmission and distribution losses, transmission charges of DISCOMs, and DISCOM expenses like O&M costs, salaries of employees, etc.

The overall energy demand has been increasing at a rate of 8% in the ten-year period ending FY 2015-16. In the same period, share of energy demand of industrial and commercial (HT demand) consumers indicates an increasing trend with a growth of 8% and **10%**, respectively. Interestingly, total HT and LT demand have both been increasing at a rate of about 8%, indicating a consistent HT to LT ratio. KERC, in its orders suggested that, DISCOMs must improve their HT-LT ratio to 1, to reduce their technical losses.

The power purchase cost includes payments to generators which constitutes fixed costs and variable costs, where fixed costs comprise **10-11%** of total DISCOM expenditure. The variable component of the tariff, which includes the fuel costs and the operating performance of the generating plant, is the key driver of future costs and is used to project power purchase costs in the future, comprise **62-63%** of total DISCOM expenditure. Rest of the DISCOM expenditure is spent in covering for transmission charges and operating expenses of DISCOMs. Since this study uses the energy balance system and follows the electricity from the demand side to arrive at the costs, T&D losses are integral to the power procurement costs. The above-mentioned parameters affect the power procurement costs, but in order to compute the total cost of supply, the transmission charges paid to central and state transmission utilities as well as Load Despatch Centre, also need to be considered. Transmission charges include intra-state transmission charges, inter-state transmission charges and SLDC charges. SLDC charges are minimal and insignificant to DISCOMs.

These parameters are used to estimate the total cost of supply (Table 4). Some factors like fuel prices, changes in the energy mix of generation plants and generation tariffs tend to affect the cost of supply more significantly than others.

3.1 Power Procurement Cost to DISCOMs

Power procurement cost has the largest share in total ARR for DISCOMs. Power procurement cost, inclusive of power purchase costs, transmission losses and transmission charges, represents about **80%** of total revenue requirement. Estimation of power procurement cost is based on the quantum of power sourced from different generating stations. In order to budget the power procurement costs based on the quantum of power to be procured, it is necessary for DISCOMs to determine current energy demand and project future energy demand. Energy demand values also help DISCOMs plan their energy mix along with the procurement costs associated with it. BESCOM, sourced most of it power from coal based power plants (about **71%**), **13%** from hydro generating stations, share of wind power is about 8%, and the remaining **11%** is procured largely from nuclear power plants, solar and open access.

Karnataka is one of the renewable resource-rich states, with significant installed capacity of wind power plants and ambitions to scale-up solar power. Apart from renewable sources, the state has many hydro power plants which generate power at relatively low cost, because these are old plants with low cost PPAs. Nuclear power adds to the wide range of options available, in the state, with the Kundankulam nuclear plant in neighbouring Tamil Nadu supplying to BESCOM, apart from the Kaiga nuclear power plant.

3.1.1 Estimating Energy Sales

The first step in estimating power procurement costs is to estimate the electricity demand of the DISCOM. DISCOMs have multiple energy users, and assessing the total energy demand in the future becomes more accurate when the energy demand of each individual consumer category is projected based on its current and historical growth trend. The challenges of estimating demand were discussed in the introduction chapter. BESCOM, in its filings uses CAGR method to estimate category-wise sales, they have considered 4-year CAGR for the next control period FY-17 to FY-19. A similar approach was used in estimating future sales growth.

A wide range of factors could affect electricity demand and consumer share in a region. Whilst estimating energy sales for each consumer category, it is important to note the historical trends. BESCOM uses time series trends for multiple years (up to 10 years) to estimate future energy sales. Building on this approach, this study estimates energy sales for each consumer category considering optimum growth rate based on the energy demand growth trends witnessed in recent years as well as long historic trends. Although, decade-long growth trends indicate a rate of about 8% for industrial and commercial categories, demand estimations in this report have assumed a conservative growth rate for both categories based on more recent trends. Some assumptions have been made to project the future sales of these categories, which are given below:

HT-2(a) (i) – Industrial consumers – The growth trends for this category have been negative in the last three years, estimations assume a conservative **1.6%** growth rate in sales, which is a 4-year CAGR.

HT-2(b) (i) – Commercial consumers – The growth trends in recent years show a low growth rate, estimations assume growth rate at **3.2%**, which is a 5-year CAGR.

LT-2(a) (i) – Domestic consumers – Based on growth rate observed in urban population of Bengaluru area, consumption is assumed to grow at **7.2%** is expected to.

Table 2 - Energy sales estimations for different categories (in MU)

Particulars*	FY 2007-08	FY 2016-17	Average Sales from FY 2007-08 to 20015-16	% share of Average Sales	FY 2019-20	FY 2024-25
Domestic	3367	6722	4917	23%	8394	11856
Non-Domestic	2688	4776	3904	19%	5650	7207
Industrial	4015	5947	5255	25%	6351	6963
Agricultural	3607	6819	5390	26%	7794	10318
Total	**14915**	**26473**	**21074**		**30782**	**39506**

Source: CEEW estimations, from ARR documents of respective DISCOMs
** All figures are total of HT & LT sales for respective category*

Table 2 above shows the energy sales estimations for different years and share of each category-wise sale. This is not exhaustive list of consumer categories, the share of these categories however, is a percentage of total sales. Domestic & agricultural category sales are growing at a consistent rate as, growth rate of industrial or commercial (non-domestic) categories on the other hand has flattened and relatively lower. Hence, the share of industrial and commercial sales is coming down in total sales.

3.1.2 Power Purchase Cost

Power purchase cost (which is a sub-set of total power procurement cost) refers to the cost incurred by a DISCOM for purchases of power from the various generation stations. Power purchase cost is calculated based on fixed and variable cost of each generating plant and total quantum of electricity sourced from respective plants. BESCOM sources its power primarily from state generator-KPCL and central generation companies

– NTPC, NLC, DVC and NPCIL. Apart from these, BESCOM also procures power from independent power plants in the state and renewable energy plants. It becomes cumbersome to track changes in annual price rise for each of the plants, and estimate cost of generation from upcoming plants. To overcome this, DISCOMs either use the generation tariff approved by the Central Electricity Regulatory Commission (CERC) in Multi Year Tariff (MYT) orders or assume a certain hike in the tariff based on historical trends for all generating plants. However, the actual generation tariff could be different from the one assumed for ARR, which is then adjusted in true-up petitions.

Determination of Generation Tariff for Power Plants

Generation tariff for power plants consists of fixed and variable components, which represents capital expenditure and fuel expenditure respectively.

Fixed cost component (capital expenditure) includes depreciation, interest on loan, return on equity, interest on working capital, operations and maintenance expenses and special allowances.

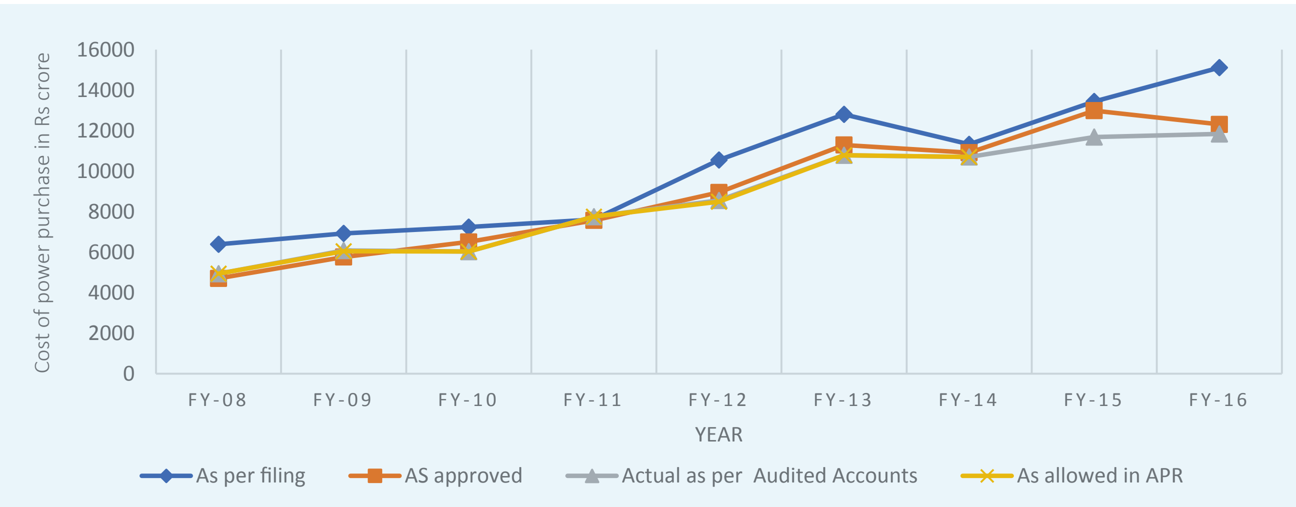
Variable cost components (fuel expenditure) is dependent on consumption of primary and secondary fuel. Consumption of primary and secondary fuel depends on operating parameters, heat rate, plant load factor, auxiliary consumption, plant availability factor, calorific value of fuel etc. of a particular plant.

Based on the fixed and variable cost components of power plants which are supplying power to BESCOM, it is observed that the fixed cost component represents about **10-11%** of the total revenue requirement. The variable component, on the other hand represents **62-63%** of the total revenue requirement, the escalations assumed in the variable component are based on historical trends of fuel sources. A similar share in the final tariff is assumed for the fixed cost component when forecasting for 2020 and 2025. The variable component of the generation tariff is the key driver of future costs of procurement, and is based on fuel prices and the actual operating performance of power plants.

Apart from long-term power purchase agreements (PPAs) with various generating stations, BESCOM procures about **2.3%** of its sales in the short-term market. In their ARR filings, BESCOM has cited low generation output from hydro power plants, delay in commissioning of plants, with whom they have signed PPAs, as the reasons for error in estimating availability from existing generation plants. This has prompted them to procure from the short-term markets, which is costlier than average power purchase cost of BESCOM.

Due to inaccuracies in demand estimations, approved power purchase cost is higher than actual cost of power. The figure below shows the difference in projected, actual and costs approved in the performance review of BESCOM.

Figure 7 – Power purchase costs of BESCOM



Source: Chapter 1, ARR filing of BESCOM FY 2017

BESCOM had to restrict supply to different consumer categories due to shortage in availability of power, mainly owing to low water storage in the state hydro plants[3]. The load restrictions for different consumer categories are discussed in detail in Annexure-I.

To meet the shortfall in power, the following measures were taken by BESCOM:

- Short term purchases of 645 MW, under open access and section 11[4]
- PPA signed with Damodar Valley Corporation (DVC) for 450 MW
- Utilizing 92 MW of unallocated power from central generating stations

This problem will keep recurring in years of scanty rainfall, which will escalate the power purchase costs for that financial year. BESCOM is integrating SCADA data on power supply for different areas, with data log of transmission licensee – KPTCL. This will provide real time data on supply restrictions, which can be shared in public domain.

For estimating the power procurement cost, two scenarios are considered, which capture variation in the energy mix for BESCOM. The scenarios are shown in the figure below:

Figure 8– Generation mix assumed for estimation of power purchase costs

Scenario I - Low Renewables

Renewables contribute to 12% of the total supply by 2020 and 16.8% by 2025.

Share of hydro is assumed to decrease from 12.8% to 10.8%.

Share of nuclear is assumed to decrease from 4.9% to 3.9%.

Open access purchase currently at 2.3% is assumed to decrease to nil.

Share of gas based power is 1.8% by 2025, due to new stations coming up in the state.

Scenario II - High Renewables

Renewables contribute to 16% of the total supply by 2020 and 20% by 2025

Share of coal capacity is decreasing in proportion with increasing capacity of renewables.

Share of hydro is increasing to 14.4% in 2020, and decreasing to 12.1% by 2025.

Share of gas is assumed at 4.7% in 2020 and 3.6% in 2025 because of new units coming up in the state.

Source: CEEW assumptions

The scenarios mentioned above take the varying generation mix into account. The fuel price escalations (done on annual basis) and their impact on variable charges for thermal generation is discussed below.

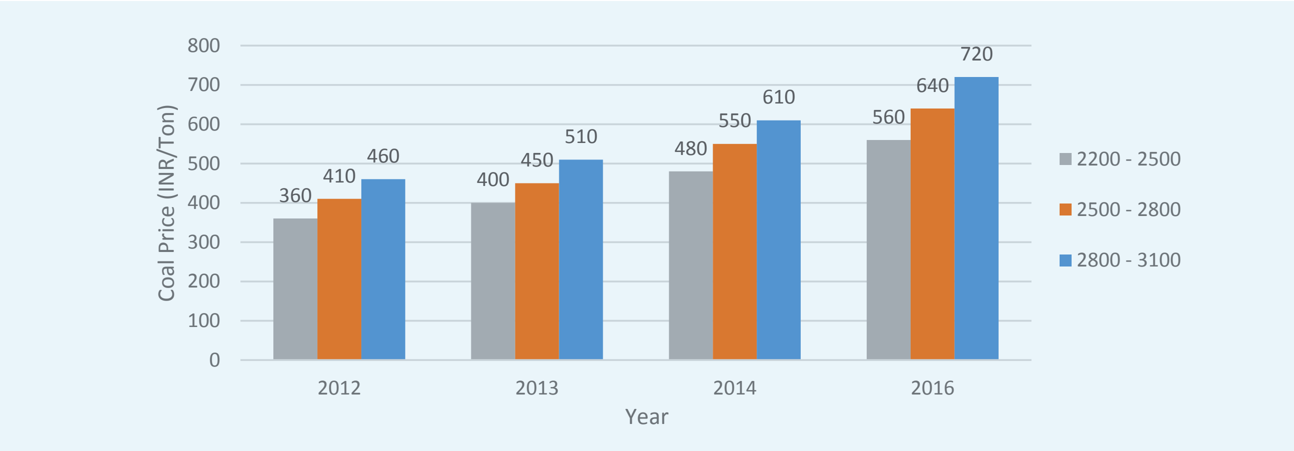
- The orders indicate **9.1**% hike in variable charges for coal, based on six-year data of domestic coal prices from power plants operating in India. The figure below shows the coal price escalation from 2012 to 2016.
- Hike in variable costs for gas power plants is assumed at **6.2**% (Amol Phadke, December 2016). This is the 10-year CAGR for LNG prices.

3 BESCOM in its MYT filing for FY17 to FY 19 stated that shortage was due to 50 percent water storage in Linganamakki, Supa & Mani major Hydel power plants hence Hydel generation has been restricted to 5 MU / day at these power plant.

4 As per section 11 of Electricity Act 2003, the state govt may operate and maintain any generating station in accordance with directions of the govt. The Commission may offset the adverse financial impact of the directions in such manner it considers appropriate.

- The generation tariff escalation assumed for hydro stations is **1.5%**, based on tariff approved by CERC for year 2015-16 to 2018-19.
- Tariff escalation for wind plants was assumed at **0.3%**, based on the historical trend of costs incurred by BESCOM.
- Solar tariffs are considered as per market trends. Current market trends show a steep decline in prices of upcoming plants, a decline of **5%** is assumed.
- Hike in costs for nuclear power plants was found to be minimal. Hence, no escalation in cost of procurement is assumed. Tariff escalation for other sources is assumed based on the historical trends.

Figure 9 - Coal price escalation based on its Gross Calorific Value



Source: Based on data from Coal India Ltd

Details on the generation mix and power procurement costs in both the scenarios are discussed in detail, in Annexure – II.

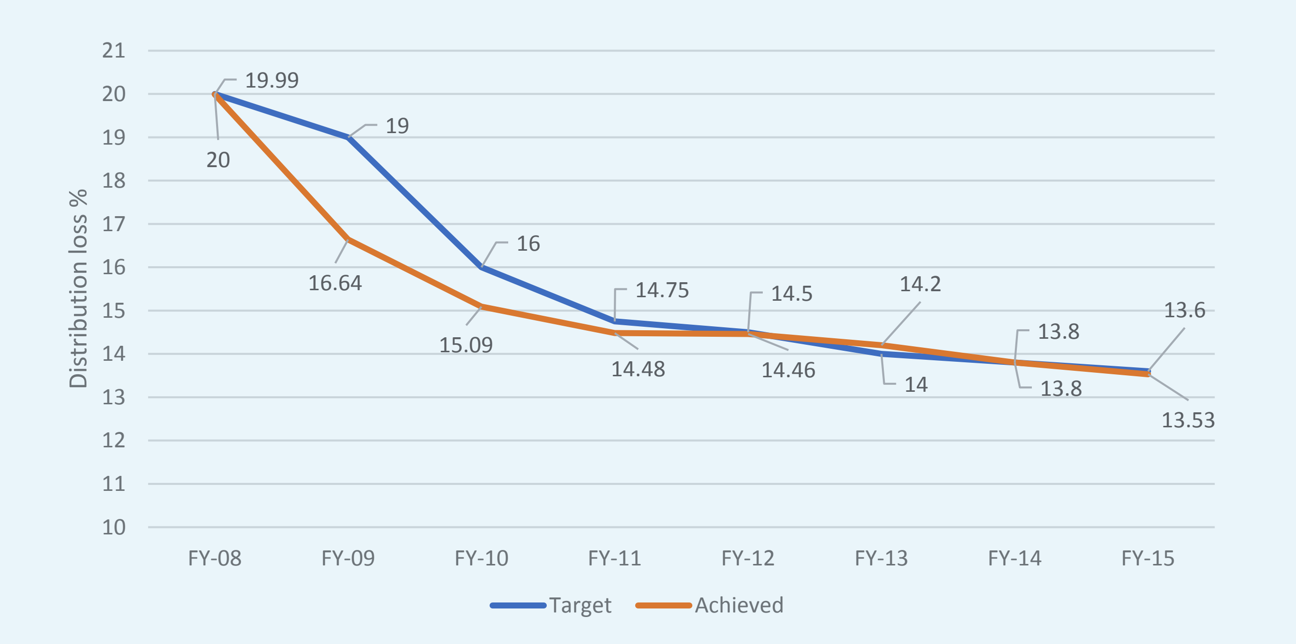
3.1.3 Estimation of Transmission and Distribution Losses

Transmission and distribution losses are used to estimate the power procurement cost, over and above the power purchase cost, since the additional cost due to transmission and distribution losses is borne by the DISCOMs and needs to be computed along with the retail supply tariff for consumers. Unlike CEEW's analysis on electricity tariffs for Delhi (CEEW, 2017), this analysis does not segregate inter-state and intra-state transmission losses. The inter-state transmission losses incurred for supplying power to BESCOM are assumed to be decreasing at a rate of **0.02%** year-on-year. KERC has considered the same decline in transmission loss, in its orders. Inter-state transmission losses are assumed to reduce from **3.90%** in 2015-16 to **3.72%** in 2024-25.

Energy balance estimations in this study follow the electricity from the demand side, which takes into account the transmission losses, distribution losses incurred beyond the state transmission periphery. Energy balance can also be estimated from the supply side, which involves the estimation of various plant availabilities, the number of units injected from each plant and the transmission losses incurred thereby.

BESCOM has successfully reduced its distribution losses, historical reduction is shown in the figure below.

Figure 10 – Reduction in distribution loss for BESCOM



Source: Chapter 1, ARR filing of BESCOM FY 2017

Although, distribution losses for BESCOM are below 15%, not all divisions in BESCOM area are facing loss levels below 15%. The KERC, in its analysis, in the ARR orders, estimated the distribution losses to decline by 0.2% year-on-year, in its MYT (Multi Year Tariff) orders. The same has been assumed for estimations of distribution losses of BESCOM (Table 3).

Table 3 - Transmission & Distribution losses, Energy at State Transmission periphery

Category	2016-17	2019-20	2024-25
Distribution losses %	13.20%	12.60%	11.60%
Transmission loss %	3.88%	3.82%	3.72%
Total Units at BESCOM Transmission periphery in MU	31730	36618	46416

Source: CEEW analysis

3.2 Transmission charges for DISCOMs

Transmission charges form a significant portion (7-9%) of the cost of supply for DISCOMs (Figure 5). The transmission charges for DISCOMs consist of three components as given below –

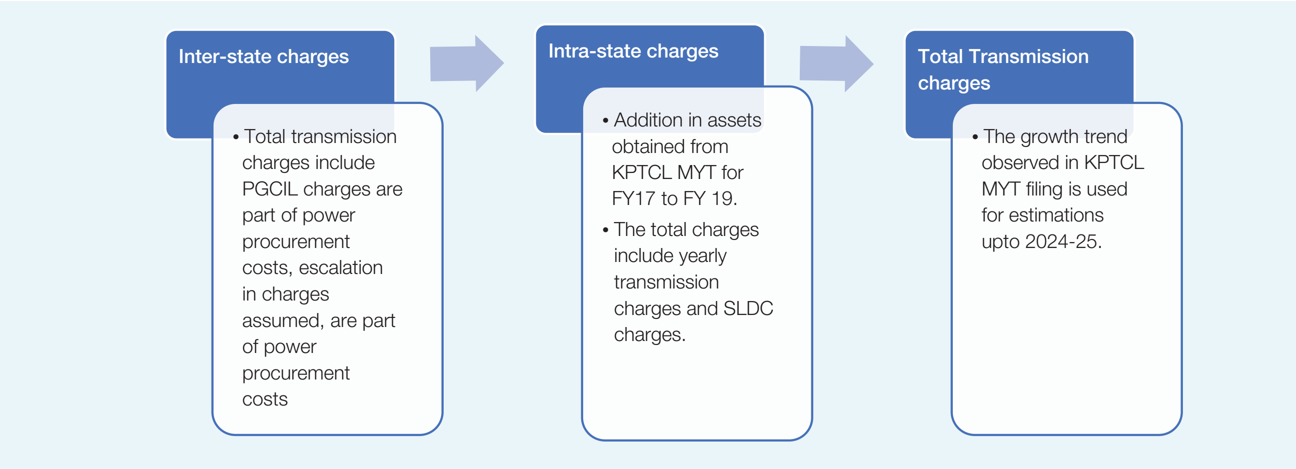
i. Inter-state Transmission charges

ii. Intra-state Transmission charges

iii. SLDC charges

The transmission charges shown in the tariff orders of BESCOMs are total transmission charges, including SLDC charges. The trends observed in total transmission charges show consistent growth. The state transmission licensee, KPTCL has projected transmission charges, in its MYT upto FY19, the same has been used in the estimations. For projections upto 2024-25, historical growth trend was used to arrive at total transmission charges. The inter-state transmission charges are included in the total charges. For estimating total transmission charges, the growth rate observed in KPTCL MYT was used to project total charges up to 2024-25. Figure 11 below shows the procedure for estimation of transmission charges.

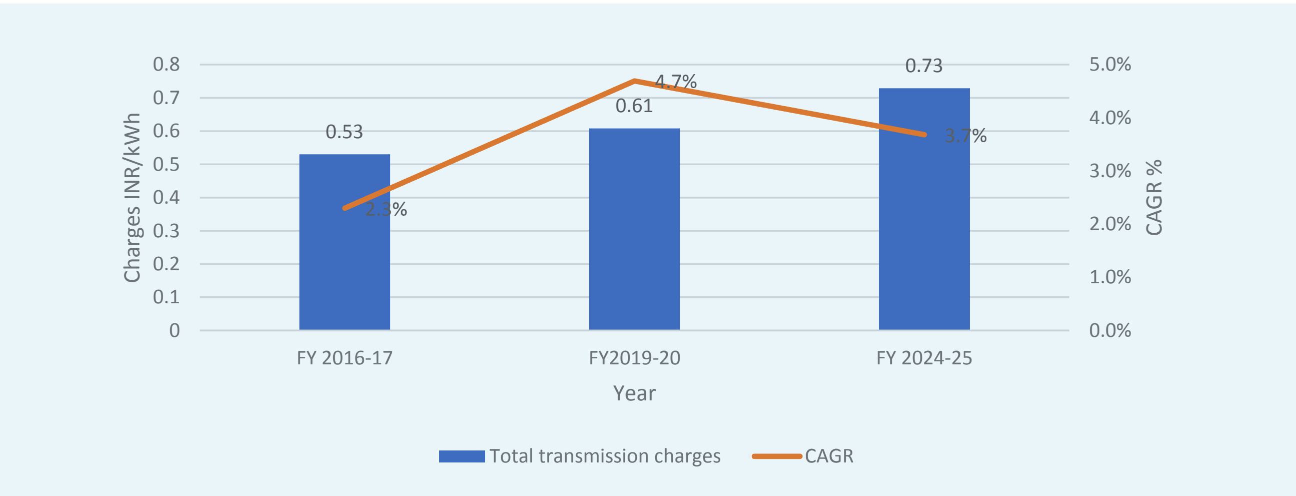
Figure 11 – Procedure for estimation of transmission charges



Source: CEEW assumptions for estimation of Transmission charges

The forecasts of transmission charges for BESCOM are shown in figure below. The growth shows an increase in transmission charges, between FY16 and FY19 the growth at 4.7%, which can be attributed to the augmentation of existing transmission capacity, to cater to growing demand in the state, majorly in BESCOM area. Further 3.7% increase is assumed to cater to increase in demand of the state.

Figure 12 – Total transmission charges



Source: CEEW estimations of transmission charges

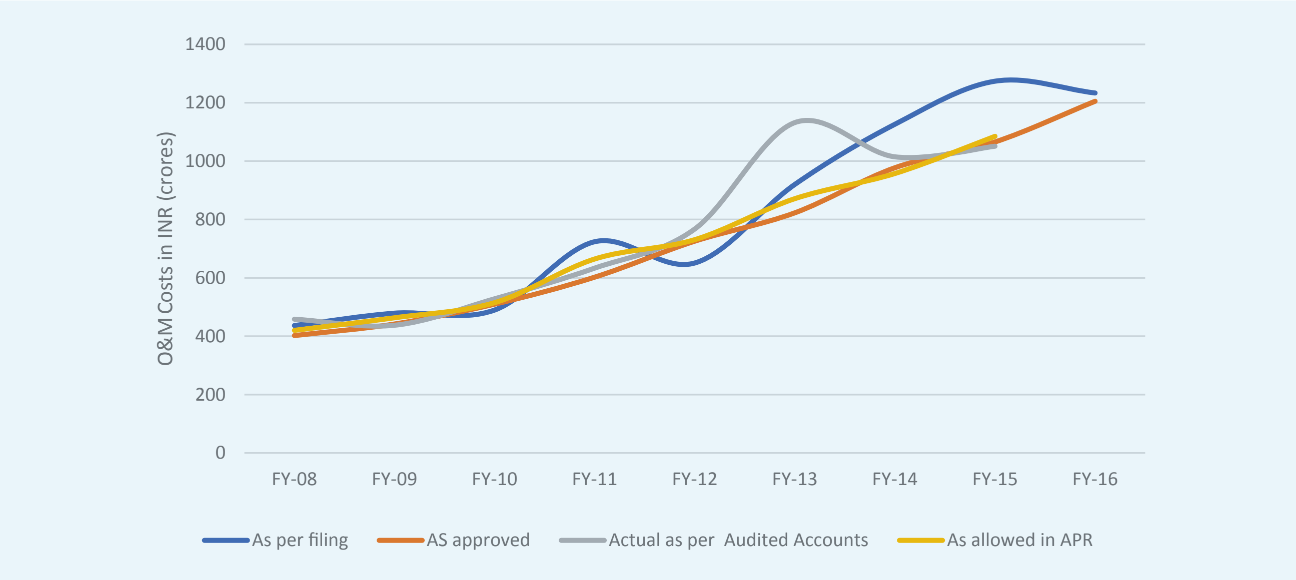
3.3 Charges of DISCOMs

As mentioned earlier in this report, DISCOM expenses for BESCOM constitute between **14-18%** of the total cost of supply. This study does not attempt the estimation of charges of DISCOMs which involve the following components:

- O&M Expenses
- Depreciation of Distribution assets
- Return on Capital Expenditure
- Working capital requirements

Historically, O&M costs have shown consistent growth. O&M costs includes employee costs, maintenance costs and administrative overheads. Growth trends for O&M costs of BESCOM are shown in the figure below.

Figure 13 – O&M cost trends for BESCOM



Source: Chapter 1, ARR filing of BESCOM FY 2017

KERC has been consistent in approving O&M costs, the figure above shows a steady growth in approved costs, in ARR orders and performance review. For the estimations, charges of DISCOMs are conservatively assumed to contribute to **15%** of the total Cost of Supply. This is based on historical operating ratios of BESCOM, which are discussed in Annexure – III, in detail. Further, given that the service levels of BESCOM are fairly good - with low technical losses, high level of metering and collection efficiencies, we do not expect any significant increase in outlay towards O&M and capacity enhancement, over and above what has been seen historically.

3.4 Cost of Supply Projections

Based on the assumptions laid out so far, the average cost of supply for BESCOM is estimated with two energy mix scenarios – low RE (16% capacity addition) and high RE (20% capacity addition) by 2024-25 (Table 5).

Table 4 – Average cost of supply for BESCOM

Average cost of supply (INR/kWh)	BESCOM	
	2019-20	2024-25
Scenario – I	6.68	9.14
Scenario – II	6.76	8.95

Source: CEEW estimations based on indicated assumptions

3.4.1 Uncertainties in the Forecast

The assumptions made are based on the data available for BESCOM, the actual ACoS could vary beyond the lower and higher estimates shown above. The parameters which could affect the cost (ACoS) further are fuels prices, change in generation mix, increased generation tariff due higher/unexpected expenditures (impact of salary hike by pay-commission) and increased capital inflow for repair and maintenance etc.

4. Average Billing Rate (ABR)

The Average Cost of Supply is not the tariff that is payable by the consumers. Some categories of consumers cross-subsidise the cost of supply for the other consumer categories. The impact of subsidies on the tariff for each consumer category can be seen from the ABR to ACoS ratio. **ABR is the actual billing rate applicable for each category of consumers.**

The ABR values are derived from the category-wise revenues available to the DISCOM. The ABR comprises fixed and energy charges, which are reflected in the electricity bills of the consumers, as per their contracted demand. Formula for ABR calculation is shown in the formula below:

ABR (for a particular consumer category) = **Revenue** expected from the respective category in INR (given in the tariff order)/**Approved sales** in MU (given in the tariff order)

For e.g. if Rs.100 crores in revenues are expected from the Industrial category consumer of a DISCOM, the approved sales are 100 MU for the same year, the ABR is

=100*10/100

= Rs10/kWh

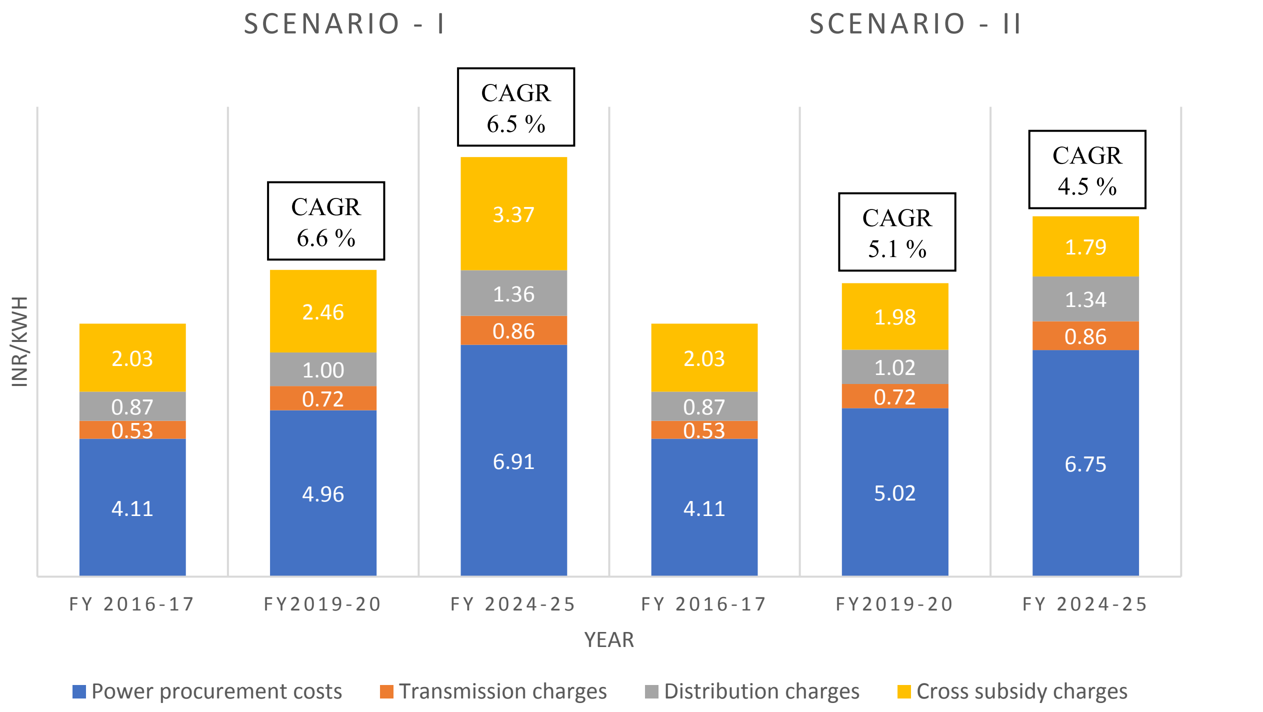
The forward-looking estimation of ABR rests on how the cross-subsidy changes over time. In each of the scenarios (described in section 3.1.2), there is an added assumption on the nature of variation of the cross-subsidy. Historical trends of ABR to ACoS ratio, for select categories is shown in Annexure-IV. The assumptions for each scenario are as below:

i. Low RE scenario – The ABR to ACoS ratio is assumed to remain same as existing ratio, up to 2024-25.

ii. High RE scenario – The ABR to ACoS ratio is assumed to adhere to the National Tariff Policy by FY 2024-25, where the ratio is within +/- 20% (Forum of Regulators and PwC, 2015) of the cost of supply.

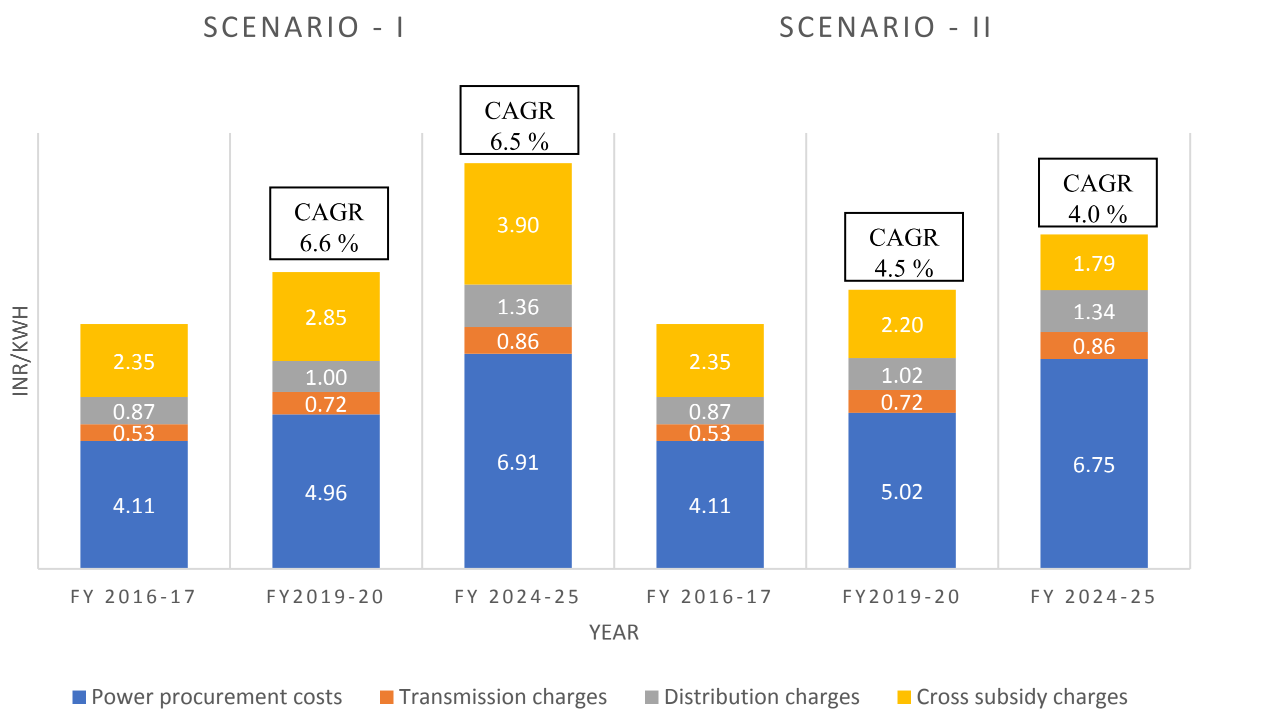
In the high RE scenario, the expectation is for some rationalisation of the cross-subsidy and an implicit reform of tariff across consumer categories. However, the political economy of such bold reforms would dictate the pace of such changes. Based on the above scenarios and assumptions, ABR for C&I consumer categories is estimated. The estimates show that increasing tariffs are evened out by the decreasing ABR to ACoS ratio. Despite increased penetration of low cost RE sources, the ACoS is seen to be increasing. However, this increase does not translate to an increase in tariff for the C&I category on account of the rationalisation of cross-subsidy (a tapering or lower ABR to ACoS ratio), as shown in Figure 14 and 15. ABR for C&I consumers in tabular form is given in Annexure-V.

Figure 14 – ABR for Industrial Consumers of BESCOM



Source: CEEW estimations based on indicated assumptions

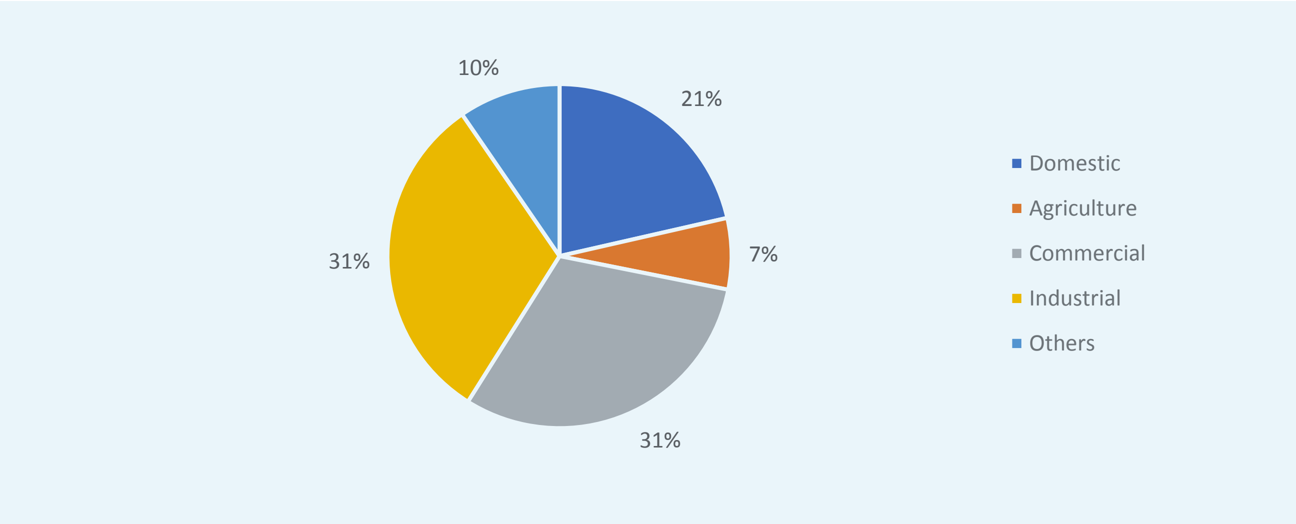
Figure 15 – ABR for Commercial Consumers of BESCOM



Source: CEEW estimations based on indicated assumptions

While Fig.1 detailed the consumption mix across the various consumer categories, Fig.15 reflects the contribution of each consumer category to the overall revenues of the DISCOM. The C&I consumers together, consume 43% (Fig.1) of its total demand, while their combined revenue share is 62% (Fig.15). This indicates the level of cross-subsidization of these categories of consumers. Therefore, it is paramount for BESCOM's revenue realization that they retain existing and future C&I consumers.

Figure 16 – Revenue share of categories of consumers



Source: Based on audited accounts of BESCOM FY14

5. Conclusions

5.1 Average Cost of Supply

The average cost of supply has been increasing significantly (6.5% increase annually) and is expected to do so in the future. However, this increasing average cost of supply cannot be realised in the tariff owing to an expected decrease in the cross-subsidy charge.

5.2 Cross-subsidisation - a key factor

Actual tariff levied on the consumers is different for different categories. Cross subsidising the domestic consumers is a common practice in many states. In Karnataka, historically, ABR to ACoS ratio has been uneven across all consumer categories (based on data from FY 2013-14 to FY 2015-16). Still, the C&I consumers have been paying for the majority of the subsidies to domestic and agricultural consumers.

The report by Forum of Regulators (Forum of Regulators and PwC, 2015) also suggests following multiple methods to estimating cost of supply and doing away with cross subsidies in all states. It is important to note that the National Tariff Policy has mandated states to bring down cross subsidies within +/-20% of ACoS. Although, some states have managed to bring down cross subsidies within +/-20% of ACoS, it is unlikely that this trend will be picked up across the country.

5.3 Role of Renewable Energy in Forecasting

It is envisaged that renewable sources, primarily solar, wind and biomass, could play a key role in confirming or differing with the forecasts in this study. Multiple scenarios are assumed, to accommodate this deliberate shift to renewables. However, the targets for renewables (175 GW capacity addition target by 2022) are ambitious, and there is uncertainty in reaching these targets. The cost of renewable, on the other hand also plays a major role in future energy choices, grid parity is a likely scenario in the next decade. Hence, all these factors could play a major role in the future energy markets.

5.4 Regulatory uncertainties in Tariff Design

The forecasting exercise undertaken does not take into account all the elements, as considered by any Regulatory Commission. Some of these elements are dependent on extraneous factors like hike in salaries of Government employees, failure to disburse timely payments by DISCOMs, rate of depreciation, sudden surges in fuel prices, or hikes in green cess for thermal power plants. These complications are inherent in tariff estimations. Further, they are subject to human decision-making, which could be based on factors extraneous to data based rationale. It is important to take cognizance of these uncertainties, before using the results of this exercise.

5.5 BESCOM vs Open Access

BESCOM, in its MYT filing for FY17 to FY19, has proposed to change the demand charges and energy charges levied on the HT-category consumers (especially C&I consumers). This proposal is mainly to deter competition from open access, and retain high paying consumers. BESCOM aims to increase the demand charges of HT-consumers and reduce the energy charges, this will increase revenue flow of DISCOMs. This is discussed in detail in Annexure-VI.

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Annexures

Annexure – I

Load restrictions in BESCOM area for different consumer categories are shown below, this is as per the BESCOM filing for MYT for FY17 to FY19.

- Domestic / Residential feeders in Bangalore City: 2-4 Hrs
- Commercial feeders: 2 Hrs
- Staggering of Holidays for industrial feeders
- Town feeders (Other than Bangalore City): 2-6 Hrs
- NJY feeders: 2-6 Hrs

Power supply restrictions to agricultural feeders is shown below.

- Rural mixed feeders: 3 phase: 4-5 hrs; Single phase: 7-8 hrs
- Agri feeders: 3 phase: 4-5 hrs; Single phase: 4 hrs

Annexure – II

The fixed and variable components of generation tariff from different fuels are escalated as follows:

Power procurement costs of different sources (INR/kWh)											
Particulars		FY 2016-17	FY 2017-18	FY 2018-19	FY 2019-20	FY 2020-21	FY 2021-22	FY 2022-23	FY 2023-24	FY 2024-25	FY 2025-26
Coal	Fixed	1.19	1.14	1.25	1.36	1.48	1.62	1.77	1.93	2.10	2.29
	Variable	2.54	2.78	3.03	3.30	3.60	3.93	4.29	4.68	5.11	5.57
	Total	3.74	3.92	4.28	4.66	5.09	5.55	6.06	6.61	7.21	7.87
Gas	Fixed	3.39	3.60	3.82	4.06	4.31	4.58	4.86	5.16	5.48	5.82
	Variable	4.14	4.40	4.67	4.96	5.27	5.60	5.94	6.31	6.70	7.12
	Total	7.53	8.00	8.49	9.02	9.58	10.17	10.80	11.47	12.18	12.94
Hydro	Fixed	0.15	0.15	0.15	0.15	0.16	0.16	0.16	0.16	0.16	0.17
	Variable	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.92	0.93
	Total	0.97	0.99	1.00	1.01	1.03	1.04	1.05	1.07	1.08	1.10
Nuclear	Fixed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Variable	3.02	3.02	3.02	3.02	3.02	3.02	3.02	3.02	3.02	3.02
	Total	3.02	3.02	3.02	3.02	3.02	3.02	3.02	3.02	3.02	3.02
Wind	Fixed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Variable	3.60	3.61	3.62	3.63	3.64	3.65	3.66	3.67	3.69	3.70
	Total	3.60	3.61	3.62	3.63	3.64	3.65	3.66	3.67	3.69	3.70
Solar	Fixed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Variable	6.00	5.70	5.42	5.14	4.89	4.64	4.41	4.19	3.98	3.78
	Total	6.00	5.70	5.42	5.14	4.89	4.64	4.41	4.19	3.98	3.78
Others	Fixed	0.00									
	Variable	5.45									
	Total	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45

Power procurement costs of different sources (INR/kWh)											
Particulars		FY 2016-17	FY 2017-18	FY 2018-19	FY 2019-20	FY 2020-21	FY 2021-22	FY 2022-23	FY 2023-24	FY 2024-25	FY 2025-26
Open-Access	Fixed	0.00									
	Variable	5.25									
	Total	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25

Thermal generation (coal and gas)

Fixed component for a coal power plant represents about 30% of total generation tariff. Variable component which consists fuel charges is about 70% of total generation tariff. Similarly, for gas based generation fixed and variable component is respectively about 45% and 65% of total generation tariff.

CERC has specified the "energy charge rate" formula to translate fuel cost into per unit cost of electricity generation (variable component). The variable component is directly proportional to fuel charges, any increase in fuel cost will increase variable charges with same percentage. Hence, to estimate future generation tariff for coal and gas based plants, variable components is forecasted based on expected growth in coal and gas prices.

- For coal plants, 9.1% annual increase in coal price is assumed based on previous coal tariff orders released by Coal India Limited. Going forward, India is likely to less dependent on imported coal, so it is safe to consider fuel prices increase from Coal India Limited.
- For gas plants, 6.2% annual increased is considered based on gas prices in the international market since India largely rely on imported gas.

GCV Bands (Kcal/Kg)	Rs/Ton				CAGR
	2012	2013	2014	2016	
Exceeding 7000	*			*	
Exceeding 6700 and not exceeding 7000	4870	4870	4870	3450	-6.7%
Exceeding 6400 and not exceeding 6700	4420	3890	3890	3210	-6.2%
Exceeding 6100 and not exceeding 6400	3970	3490	3490	3000	-5.4%
Exceeding 5800 and not exceeding 6100	2800	2800	2800	2750	-0.4%
Exceeding 5500 and not exceeding 5800	1450	1600	1920	2280	9.5%
Exceeding 5200 and not exceeding 5500	1270	1400	1680	1920	8.6%
Exceeding 4900 and not exceeding 5200	1140	1250	1510	1700	8.3%
Exceeding 4600 and not exceeding 4900	880	970	1170	1320	8.4%
Exceeding 4300 and not exceeding 4600	780	860	1030	1180	8.6%
Exceeding 4000 and not exceeding 4300	640	700	840	970	8.7%
Exceeding 3700 and not exceeding 4000	600	660	800	910	8.7%
Exceeding 3400 and not exceeding 3700	550	610	730	860	9.4%
Exceeding 3100 and not exceeding 3400	500	550	670	780	9.3%
Exceeding 2800 and not exceeding 3100	460	510	610	720	9.4%
Exceeding 2500 and not exceeding 2800	410	450	550	640	9.3%
Exceeding 2200 and not exceeding 2500	360	400	480	560	9.2%
* For GCV exceeding 7000 Kcal/Kg, the price shall be increase by Rs 150/- per tonne over and above the price applicable for GCV band exceeding 6700 but not exceeding 7000 Kcal/Kg, for increase in GCV by every 100 Kcal/Kg or part thereof.					

Hydro Generation

For hydro stations, even though there are no fuel expenditure, tariff is still divided into fixed and variable component in about 50:50 ratio. For the generation tariff escalation for hydro station, tariff approved by CERC for year 2015-16 to 2018-19 is used for calculations. For remaining years, from 2019-20 to 2024-25, similar annual increase is considered as per following table.

Plants	2015-16	2016-17	2017-18	2018-19	CAGR
Chamera I	1.31	1.33	1.35	1.37	1.17%
Chamera II	2.25	2.3	2.34	2.39	1.47%
Chamera III	4.15	4.26	4.37	4.48	1.94%
Dhauliganga	2.16	2.2	2.24	2.27	1.24%
Dulhasti	4.90	5	5.1	5.2	1.47%
Parbathi III	3.89	3.93	3.97	4.01	0.75%
Salal	0.76	0.77	0.79	0.81	1.70%
Sewa II	3.60	3.66	3.73	3.8	1.37%
Tanakpur	1.94	1.99	2.04	2.09	1.82%
Uri-I	0.96	0.96	0.97	0.98	0.62%
Uri-II	2.08	2.1	2.13	2.16	0.98%

Nuclear Generation

Nuclear power plants has single part tariff, there is no variable component. The escalation in generation tariff is assumed to remain same, as per the tariff approved by CERC for nuclear power plants serving to BESCOM.

Plants	2015-16	2016-17	2017-18	2018-19
Kaiga APS	3.02	3.08	3.14	3.20
Kudankulam APS	3.02	3.88	4	4.04

Solar Generation

Solar prices are expected to decrease by 5-6% annually given the efficiency gains and reduction in costs. These rates are in line with long term tariff decline of solar power generation. Same is assumed while estimating future procurement cost from solar plants.

Year	Weighted Average Tariff
2010	12.16
2011	8.79
2012	8.23
2013	7.38
2014	6.49
2015	5.61
2016	4.43

Annexure – III

The operating ratios of BESCOM are shown in the table below. Direct employee costs, repair & maintenance costs and administrative over-heads are a part of O&M costs.

Sl.No	Particulars	FY-15	FY-14	FY-13	FY-12
1	Power purchase Cost	76.26%	76.77%	76.77%	78.84%
2	Transmission Cost	9.48%	10.52%	9.51%	10.17%
3	O&M Cost	7.79%	7.64%	7.63%	8.20%
	Direct Employees Cost	5.93%	6.07%	6.04%	6.76%
	Repair and Maintenance costs	0.41%	0.42%	0.36%	0.34%
	Administrative over heads	1.46%	1.16%	1.22%	1.10%
4	Depreciation	1.48%	1.01%	0.97%	1.30%
5	Interest and Finance charges	4.99%	4.05%	3.33%	2.56%
Total		100%	100%	100%	100%

Annexure – IV

The impact of subsidies on tariff for each consumer category can be seen from the ABR to ACoS ratio. Historical ABR trends are shown in the table below. The trends indicated uneven growth, for all sectors.

	Particulars	FY 2013-14	FY 2014-15	FY 2015-16
ABR/ACoS (In %)	Domestic	91%	83%	90%
	Non-Domestic LT	158%	144%	154%
	Non-Domestic HT	158%	151%	143%
	Industrial HT	180%	119%	137%
	Industrial LT	118%	113%	121%
	Agricultural	30%	36%	43%

The National Tariff Policy, has directed the DISCOMs to limit the ABR to ACoS ratio to +/- 20% of ACoS. Further, *Report on Roadmap for Reduction in Cross-subsidy*, prepared by PwC for the Forum of Regulators, has suggested alternative approaches for estimation of retail supply tariffs.

Annexure – V

The breakdown of ABR components for commercial consumers is given in the table below:

Commercial (Rs/kWh)		FY 2016-17	FY2019-20	FY 2024-25
Scenario I	Power procurement costs	4.11	4.96	6.91
	Transmission charges	0.53	0.72	0.86
	Distribution charges	0.87	1.00	1.36
	Cross subsidy charges	2.35	2.85	3.90
	Total	7.86	9.53	13.03
Scenario II	Power procurement costs	4.11	5.02	6.75
	Transmission charges	0.53	0.72	0.86
	Distribution charges	0.87	1.02	1.34
	Cross subsidy charges	2.35	2.20	1.79
	Total	7.86	8.96	10.74

The breakdown of ABR components for Industrial consumers is given in the table below:

Industrial (Rs/kWh)		FY 2016-17	FY2019-20	FY 2024-25
Scenario I	Power procurement costs	4.11	4.96	6.91
	Transmission charges	0.53	0.72	0.86
	Distribution charges	0.87	1.00	1.36
	Cross subsidy charges	2.03	2.46	3.37
	Total	7.54	9.14	12.50
Scenario II	Power procurement costs	4.11	5.02	6.75
	Transmission charges	0.53	0.72	0.86
	Distribution charges	0.87	1.02	1.34
	Cross subsidy charges	2.03	1.98	1.79
	Total	7.54	8.75	10.74

Annexure - VI

The tables below show the expenditure and revenues of BESCOM, for last 3 years.

Particulars	FY-13	FY-14	FY-15	FY-13	FY-14	FY-15
Details	Cost in Crs.			% wise contribution		
Capacity charges to the Generators	1326.22	1374.36	1405.6	11.1%	11.4%	10.2%
Transmission charge(KPTCL+PGCL) to Transmission utilities	1174.44	1301.92	1284.82	9.8%	10.8%	9.3%
Distribution-wire business	731.09	767.34	996.39	6.1%	6.4%	7.2%
Distribution-Supply business	500.29	585.55	852.55	4.2%	4.9%	6.2%
Total Fixed charge	3732.04	4029.17	4539.36	31.3%	33.4%	33.0%
Variable charge (Power purchase)	8203.23	8026.47	9233.47	68.7%	66.6%	67.0%
Total ARR	11935.27	12055.64	13772.83	100.0%	100.0%	100.0%

Source: Chapter 1, ARR filing of BESCOM FY 2017

Table – Receipts of BESCOM

Details	FY-13	FY-14	FY-15	FY-13	FY-14	FY-15
	Receipts in Crs.			% wise contribution		
Fixed charge	1124.97	1312.34	1551.02	10%	11%	12%
Energy Charge	9662.27	10237.34	11574.22	90%	89%	88%
Total	10787.24	11549.68	13125.24	100%	100%	100%

Source: Chapter 1, ARR filing of BESCOM FY 2017

- Revenue and expenditure in above tables are divided into fixed and variable components. Fixed expenditure contributes 33% of total costs and variable expenditure contributes 67% of the total costs.
- On the other hand, for revenues earned from tariffs – fixed costs contribute 11% and variable costs contribute 89% of total revenues.
- In majority of the categories, recovery of energy (variable) charges are not at the Commission determined slab rates. This is because there are payment rebates, time of day incentives, etc. Hence, recovery of complete energy charges from high paying consumers is not possible.
- The difference in fixed costs and fixed revenues is 23%(33% - 10% = 23%). The energy charges are high for HT consumers, that is the primary reason for opting for Open Access. If the fixed charges are increased, the HT consumers will be stick to DISCOM supply because fixed charges are levied irrespective of the units consumed from DISCOM supply.
- This proposition does not alter the tariff rates for consumers, instead it shifts the charges from variable to fixed.

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