Report of the Committee Set-up to review the BESCOM Efficient Lighting Program

Bangalore Electricity Supply Company (BESCOM)

Bureau of Energy Efficiency (BEE)

Central Electricity Authority (CEA)

United States Agency for International Development (USAID)

International Institute for Energy Conservation (IIEC)

March 2006

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Acknowledgements

BELP evaluation committee benefited from observations made by some of the participating suppliers. The committee also acknowledges the suggestions given by several individuals during the review meetings:
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List of abbreviations

BEE	Bureau of Energy Efficiency (India)
BELP	BESCOM Efficient Lighting Program
BESCOM	Bangalore Electricity Supply Company Limited
CFL	Compact Fluorescent Lamp
CO_2	Carbon Dioxide
DSM	Demand-Side Management
ECA	Energy Conservation Act 2001 (India)
ECO	Energy Conservation and Commercialization Project
EE	Energy Efficiency
ESCO	Energy Services Company
GHG	Greenhouse Gas
GOI	Government Of India
GWh	Gigawatt Hour
KWh	Kilowatt Hour
LCC	Life Cycle Cost
M & E	Monitoring & Evaluation
MOP	Ministry Of Power (India)
MU	Million Units (Electricity)
M & V	Monitoring & Verification
MW	Mega Watt
NGO	Non-Governmental Organization
NPV	Net Present Value
PF	Power Factor
USAID	United States Agency for International Development
WB	The World Bank

Executive summary

Institution of the Energy Conservation Act 2001 by the Government of India and technical assistance extended by several multi-lateral donor agencies has resulted in the implementation of energy conservation measures. Being a direct beneficiary, role of the utilities in promoting demand-side management and energy conservation measures among its consumers is obvious. BESCOM has taken the first step towards initiating such initiatives.

Being the first large-scale attempt in promoting efficient lighting in the domestic sector, the BESCOM Efficient Lighting Program (BELP) paved the way to other utilities to implement similar initiatives. Suggestions made during the initial review phase of this initiative prompted the committee to evaluate any adverse impacts of CFLs as a technology on power quality. Benefits of changing the conventional lamps with CFLs, as discussed in the report, far-outweigh the power quality issues. Moreover, the option of improving the power factor of the CFLs threatens the cost-effectiveness of shifting to CFLs by the customers.

BELP pilot scheme has enhanced the customer awareness related to using efficient lighting technologies in the country. This has also created interest among the manufacturers in participating in the utility-driven demand-side management schemes.

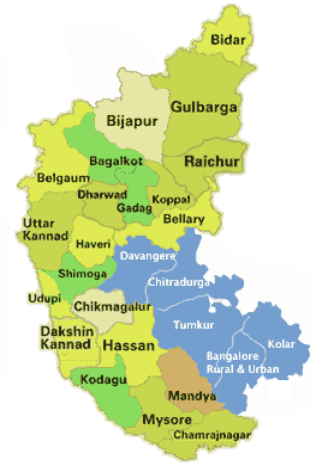
1. Purpose of this report

1.1 Background

USAID/India initiated the Energy Conservation and Commercialization (ECO) project in 2000 aimed at promoting the widespread commercialization of energy efficiency technologies and services in India, which would have a direct impact on the reduction in growth of greenhouse gas (GHG) emissions. In 2001, the Government of India passed the Energy Conservation Act and established a statutory coordinating body under the Central Government, the Bureau of Energy Efficiency (BEE). The BEE was officially established in March 2002, and the BEE Action Plan was subsequently approved and released in August 2002.

The Energy Conservation and Commercialization II (ECO II) project has been designed to promote widespread commercialization of energy efficiency technologies and services in India. The project supports the development of policy and market interventions that would enhance the capabilities of the private, financial, and government sectors for deploying market-based mechanisms for end-use efficiency investments. Demand-side Management (DSM) is one of the thrust areas of the BEE Action Plan and DSM case studies developed under ECO II Project will be used for national policy formulation.

IIEC worked with the Bangalore Electricity Supply Company Ltd (BESCOM) in implementing a series of Demand-Side Management (DSM) demonstration projects in the State of Karnataka under the ECO II Project. The aim of the demonstration projects was the development of a sustainable model for market driven DSM programs that would benefit the utility, customers and society as a whole. Figure below identifies the BESCOM distribution network comprising of Bangalore Urban, Bangalore Rural, Kolar, Tumkur, Chitradurga and Davangere circles.



BESCOM Distribution Network

Figure 1.1 BESCOM Distribution Network

BESCOM has a connected load of 7,360 MW and a customer base of 4,657,000 (2002-03). Over 60% of the customers are in the residential sector. It is reported that there was a peak capacity deficit in Karnataka in the range of 500 to 1000 MW in 2003. Under the current residential tariffs customers with monthly usage below 200 kWh are subsidized (ie. the average tariff is below the bulk supply tariff). Research has shown that end-uses in the domestic sector contribute to the system peak load especially in the evenings, predominantly by the residential and small commercial sectors. The use of energy efficient lighting would provide significant benefits to BESCOM, including the following:

- Reduction of system peak demand
- Improvement of system load factor
- Improvement of power quality
- Improvement of customer relations

During the initiation of the DSM initiatives in Bangalore, management expressed the need to develop a program having design, implementation, monitoring and verification components with a probable private sector participation. A detailed program design that was used during the program inception is attached as **Annexure 1**.

1.2 BELP sum-up meeting

BESCOM and IIEC organized a Sum-up meeting on 17 December 2005 that was attended by the top management from the Bureau of Energy Efficiency, USAID, BESCOM, KPTCL and IIEC. Based on specific suggestions made by Mr. V. S. Verma, Director General, Bureau of Energy Efficiency, a committee was constituted with the mandate to address some of the issues related to BELP. Constitution of the committee is as follows:

Chairman of the Committee: **Mr. B. R. Vasanth Kumar**, Director (Technical), Bangalore Electricity Supply Company
Convener: **Mr. B. T. Prakash Kumar**, Technical Assistant to Director (Technical), Bangalore Electricity Supply Company
Members:
Mr. B. N. Satyapremkumar, Communications and Reforms Coordinating Officer, Bangalore Electricity Supply Company
Mr. Alok Gupta, Director, Central Electricity Authority
Mr. S. K. Tyagi, Sr. Manager, Bureau of Energy Efficiency
Mr. S. Vishwanatha Prasad, Chief General Manager – BMAZ, Bangalore Electricity Supply Company
Mr. Govindraju, Executive Engineer, Karnataka Power Transmission Corporation Limited
Mahesh Patankar, Sr. Project Manager, International Institute for Energy Conservation
Invitees:
Mr. V. A. Rodrigues, Manager, Bangalore Electricity Supply Company
Mr. H. S. Gururaja, Consultant, International Institute for Energy Conservation

1.3 Terms of reference for the committee

Committee was given the following clear mandate.

- Evaluate peak demand reduction and energy savings from sales of Compact Fluorescent Lamps (CFLs) under BELP – *data on the sales of CFLs from the three suppliers and non-participating suppliers will be generated by IIEC and BESCOM*
- Evaluate contribution of above savings in the overall planning of power distribution in Bangalore city considering new connections in the domestic and other sectors – *data on power development to be provided by BESCOM*
- Evaluate power quality issues related with the use of CFLs. Following steps are envisaged in completing this task
    - Review of national and international CFL specifications (power factor, harmonics, voltage fluctuations)
    - Review of manufacturing of CFLs in the domestic and international market and the prevalent technical specifications
    - Review of power factor correction techniques relevant to CFLs
    - Suggestions on power factor correction techniques related to the use of CFLs considering technical and commercial viability
- Suggest technical measures to be taken up during the next phase of BELP and CFL programs in other utilities

1.4 Committee meetings

Constitution of the committee is as per **Annexure 3**. Committee, before finalizing this report, met twice (30 January 2006 in Bangalore and 20 February 2006 in Mumbai). During the two meeting of the committee (30 January 2006 and 20 February 2006), the committee reviewed the program design documents and BELP Sum-up meeting presentations (Annexures 1 and 2). Some of the next steps identified by the committee are as follows:

- The comparison of the load curve of the BESCOM system must be made for the two similar days
- All the supporting documents for the sale of the CFL under the project need to be enclosed with the project report – *this data was obtained as emails from the suppliers and being a commercially sensitive sales data, it is difficult to obtain the documentation*
- The effect of VAT on sales also needs to be brought in the report
- Increase in sales of CFL along with growth of consumers may also be shown for the period considered
- Sale of other suppliers may also be shown – *this is still being obtained*
- Customer satisfaction reports may be obtained from the customers/RWA – *an independent survey agency made this observation*
- Billing analysis comparison should be made for the same period of 2004 and 2005. The sample supporting documents may also be enclosed - *this is still being obtained*

- The survey report from the customer that they are benefited with the scheme may also to be enclosed.

Observations made by the committee and its recommendations are highlighted in the next sections against the progress of BELP.

2. Peak-demand Reduction, Energy Savings and Utility Benefits

2.1 Progress of BELP

2.1.1 Sales growth

During the BELP implementation, sales relevant to the participating suppliers was tracked monthly. **Figure 2.1** below shows the increasing sales volume during the tenure of the implementation comparing this with the same time-period during the last year.

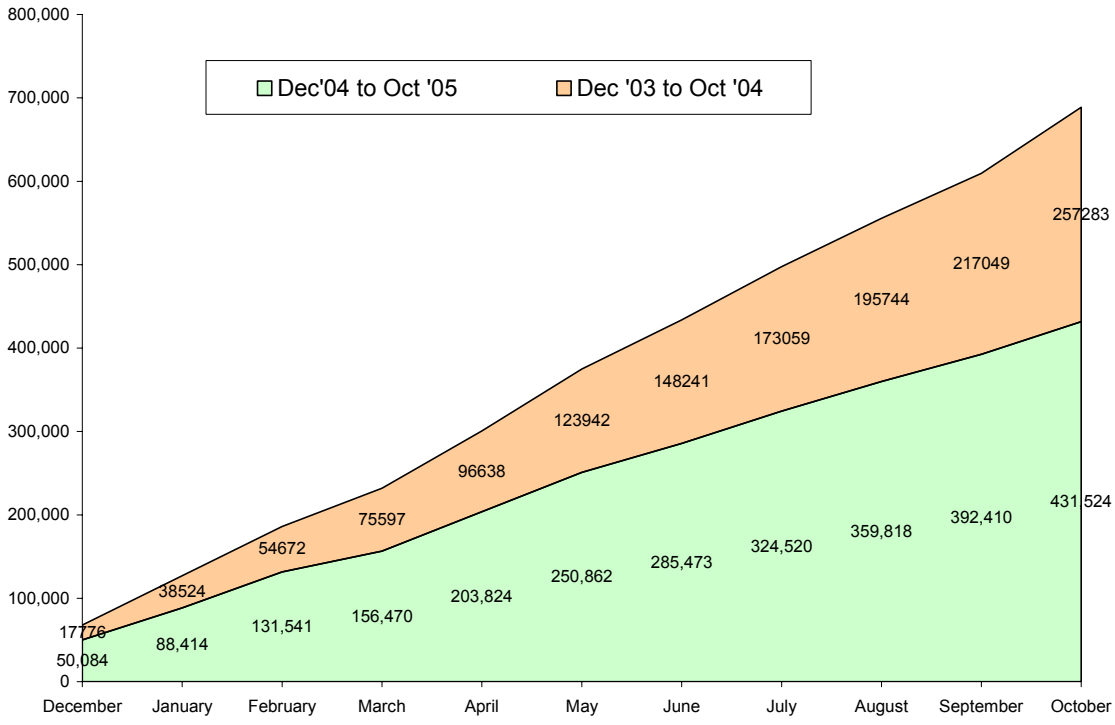


Figure 2.1 Monthly Sales - CFLs

CFL sale is seen increasing all through the program implementation tenure. Specifically, the important events and month where the CFL sale increased can clearly be attributed to key events during the program. A comparison of the sales during the program period and the corresponding period last year reveals an increase of more than 70%. Estimation of benefits to the utility and consumers made in this report is made on the basis of **175,000 (difference between the last and current year's sales)** and the total sale of **430,000 CFLs.** Sales data received from the suppliers is attached as **Annexure 4**.

Several implementation strategies evolved during the program implementation have also clearly had an impact over the CFL sales. ***Figure 2.2*** identifies the some of the events and resulting changes in the CFL sales. Program launch, road-shows in key sub-divisions had a positive impact on the sales and inception of Value Added Tax (VAT) in the state of Karnataka has had negative impacts.

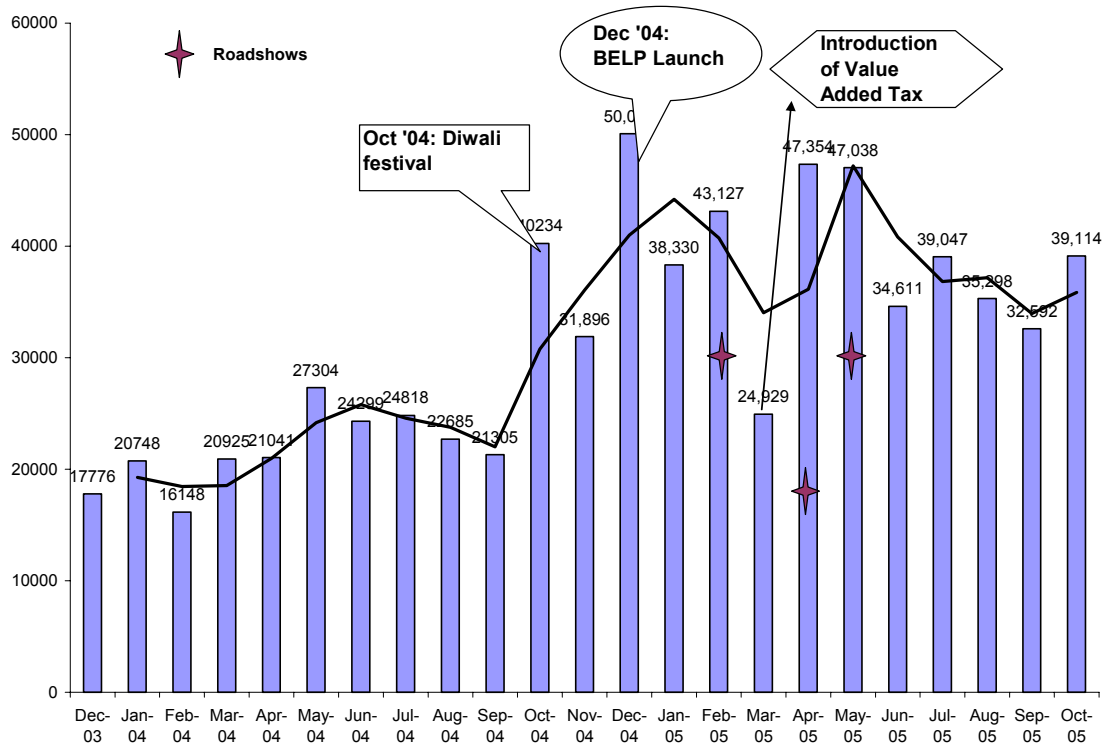


Figure 2.2 Pre and Post-implementation Sales Progression and Events

Note on sales of non-participating suppliers
Participating suppliers enjoy a market-share of close to 50%. Though data from at least 10 other suppliers active in the Bangalore market is not available, total CFL sales in Bangalore market is estimated to be at least 860,000.

2.1.2 Pricing benefits

Benefits of the competitive bidding process in the utility-sponsored DSM initiatives are evident from Table 2.1.

Table 2.1 Changes in pricing and warranty of participating and non-participating suppliers

	Before BELP	After BELP
Pricing		
Average cost of 11 Watt CFL, Rs.	150	125
Average cost of 14 Watt CFL, Rs.	170	145
Warranty		
Warranty by participating suppliers, months	6	12
Warranty by non-participating suppliers, months	0	12

As the price dynamics under the competitive domestic market is very high, BELP evaluation committee recommends putting in to place a system that will ensure periodic revision of prices offered to the customers.

2.2 Benefits to utility

BESCOM load-shape captured at different times before and after the program design represents an evening peak, primarily contributed by the domestic lighting. Market survey during the inception stage of this initiative concluded that the lighting sector contributes to the evening peak and current technologies used included incandescent lamps (40, 60, 100 Watts) and fluorescent tube-lights (typically 40 Watts). However, despite BELP, additional lighting load from the commercial and additions in domestic sectors, current load-shape does not reflect the reducing peak as the BESCOM system is still faces challenges of evening peak. ***Figure 2.3*** shows a typical system load shape.

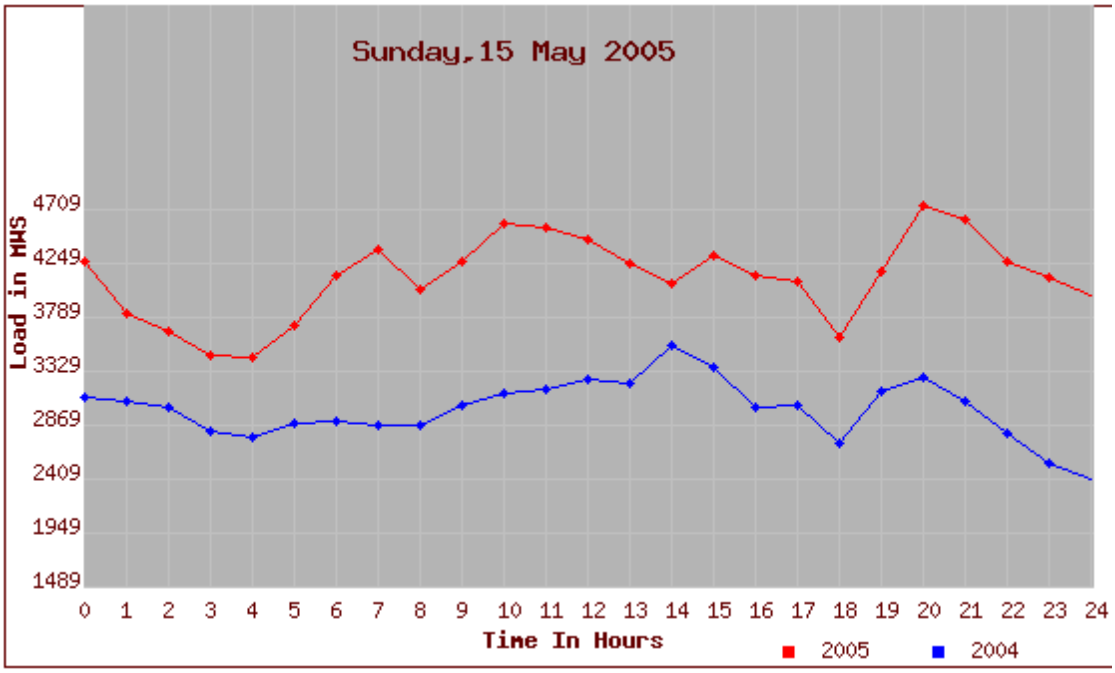


Figure 2.3 BESCOM Load Shape

2.3 Domestic sector consumption in BESCOM

BESCOM domestic customer base is increasing. With an assumption of average connected load of 3 KW, domestic sector is expected to contribute at least 60% peak demand and load. Figure 2.4 shows the domestic-sector growth and Figure 2.5 shows the domestic sector load-growth.

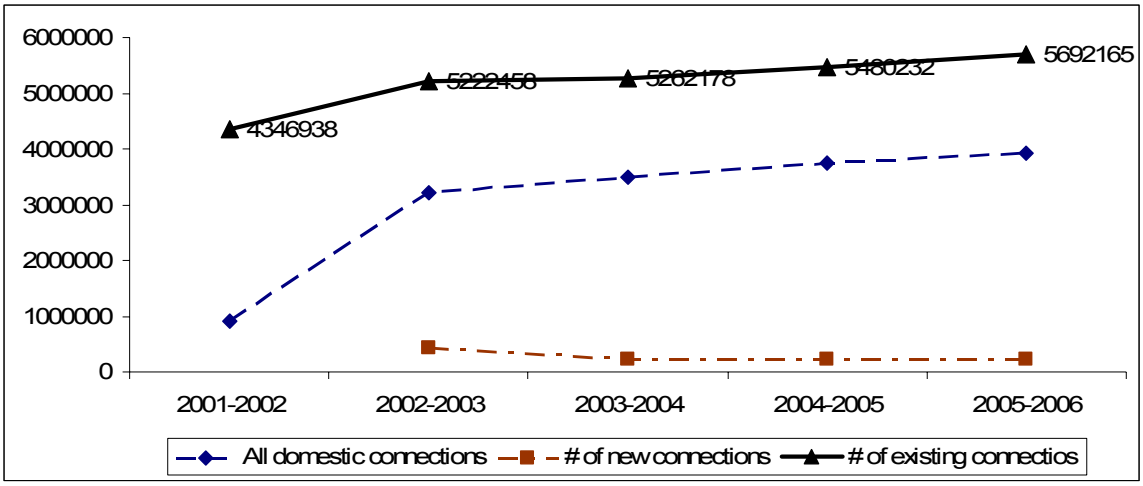


Figure 2.4 Growth – domestic sector in BESCOM

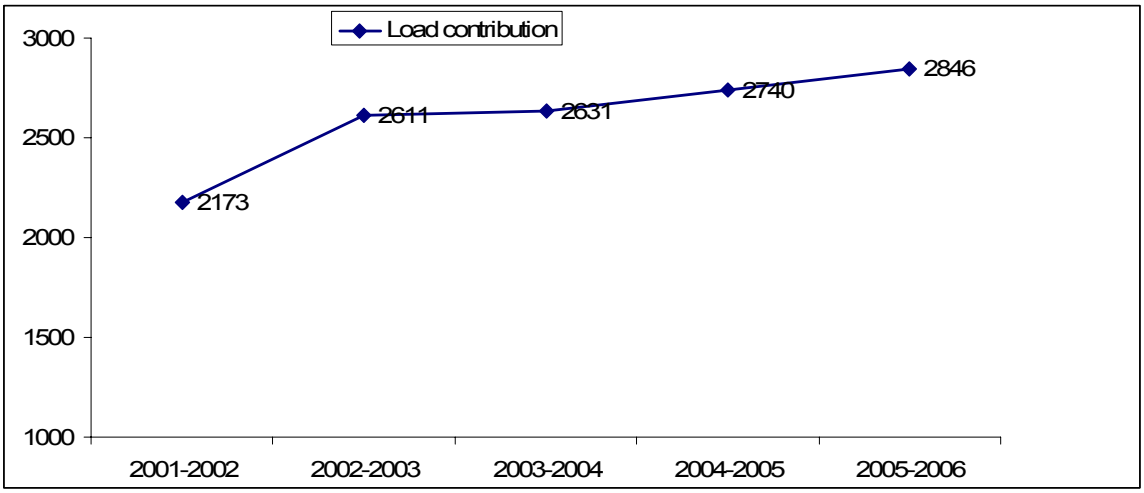


Figure 2.5 Load growth – domestic sector

As common feeders cater to all kind of load under the BESCOM system (consistent with all other utilities in India), impact of efficient lighting products is extremely difficult to implement. Based on the engineering analysis, however, reduced load and annual consumption are projected as in Table 2.2.

Table 2.2 Peak demand and energy consumption reduction benefits of CFLs

Total peak demand reductions, MW		
	Conventional	Efficient
Technologies	Incandescent Lamps (A)	Compact Fluorescent Lamps (B)
Average rating, Watts	60	11
Number of CFLs sold		
# of CFLs sold (C)	430000	
Diversity factor	100%	
Coincidence factor	100%	
T&D losses (D)	18%	
Total peak reduction		
Peak demand savings (MW) (E) ((A-B)*C)/((1-D)*1000000)	**25.695**	
Number of hours per day, Hrs (F)	4	
Number of days (G)	365	
Annual energy savings – utility (MU) (H) (E*F*G/1000)	**37.5147**	
Cost of power purchase (Rs./Unit) (I)	2.2	
Reduced cost of power purchase (Rs. Lakhs) (H*I/10)	825	
Cost of setting up new generation capacity (Rs. Crores/MW) (J)	4	
Avoided cost of generation, Rs. Crores (E*J)	**102.78**	
Benefits with BELP impact alone (considering 175,000 CFLs)		
Peal demand savings (MW)	**10.46**	
Annual energy savings (MU)	**15.267**	
Reduced cost of power purchase (Rs. Lahks)	**335**	

Reduced energy consumption also results in the greenhouse gas emission reduction (reduction of CO_2). Based on an emission factor of 1 Kg CO_2 per kWh electricity, annual greenhouse gas emission reduction for the 175,000 additional CFLs sold in the system is approximately 15267 Mtons of CO_2.

2.4 Benefits to consumers – billing analysis

One of the interventions during BELP were to ensure proper use of the CFLs at appropriate locations. Marketing campaigns ensured this aspect of the consumer education. Figure 2.6 reports the reduction in the energy consumption relevant to only 6 consumers in BESSCOM. During the course of this monitoring and evaluation, billing analysis relevant to a wider range of consumers was carried out. Box below reports the

billing numbers, maximum and minimum variations and some analysis of the reduced bills.

Box – billing analysis

- 7-monthly (January to July) consumption (in the preceding 6 months and same period last year) for a sample of 100 BESCOM consumers reduced from 94072 units to 86932 units (7140 units).
- Average reduction in bills of All Electric Homes (AEH) is 400 units spread-over 7 months. Average increase in the bills of AEH is close to 500 units.
- Increasing consumption is easily attributed to increasing use of appliances and equipment.

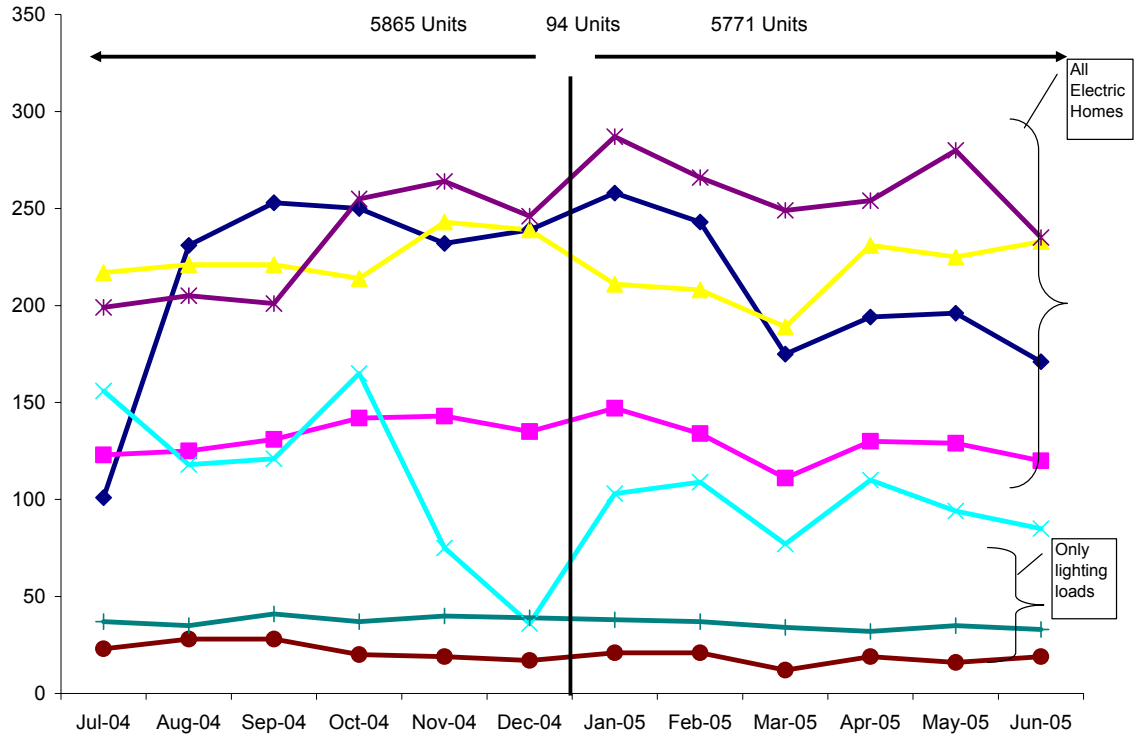


Figure 2.6 Consumer billing Analysis

BELP evaluation committee recommends following steps to capture better date on the utility benefits.

- Promote changing all the incandescent lamps with CFLs on a representative domestic feeder. BESCOM, with support from programs under Ministry of Power may install energy meters and capture the energy savings data
- BESCOM may capture the electricity use data through surveys on the same feeder to strengthen the arguments around the benefits of CFLs, either keeping other load constant or accounting for other domestic load (additional load with fans, ACs, refrigerators, TVs, VCD/DVD players, water heating elements and computers)
- BESCOM, with support from CEA and BEE, may complete the above study over the next six months (March-August 2006)

3. Power quality issues with CFLs

3.1 Importance of power quality in use of CFLs

Power factor of CFLs has been debated in the Indian energy sector at various levels. During the initiation stage of BELP, IIEC and BESCOM compared international power factor standards relevant to the use of CFLs and other like equipment. ***Table 3.1*** shows a comparison among available standards.

Table 3.1 Comparison of CFL standards

Country	Serial number of standards	Comment on the power factor > or =
Sri Lanka	SLS 1231: Part 1: 2002	0.5
India	IS	0.5
Australia/New Zealand	AS/NZS 60969:2001 IEC 60969	0.5
ELI	IEC 60969	0.5

In addition to the above, according to the article published by the International Association for Energy-Efficient Lighting (IAEEL), on the power quality of the CFLs and other household products of less than 25 Watts rating, power factor and harmonic distortions in the domestic sector are not relevant. IEC specifications for appliances/equipment less than 25 Watts do not have power factor recommendations. Similar products used in the household include domestic TV and computers. Proposed Energy Conservation Building Codes recommend power factor correction at an aggregate level (incomer of the individual buildings).

3.2 Power factor and total harmonics distortion with CFLs

It can be seen that even the low PF CFL draws much less RMS current than the Incandescent Lamp (IL). The power factor will pose problems only when we compare equivalent voltage IL and CFL. Though the total harmonic distortion of the CFL is higher than IL, the total wattage of CFL in a house is very small as compared to other loads of the house of the consumer. Presently, our country is not fully geared up for harmonic control of the LT domestic sector as even for HT consumer harmonic control is not implemented. This issue may not be of great importance in the incentive programs.

While a 100 W IL draws 0.454 RMS current at 220 V, Unity power factor, the 25 W CFL will draw 0.227 RMS current at 0.5 power factor (NEEMA working paper – LSD 8-1999).

4. Awareness among BESCOM consumers

4.1 Consumers' perspectives

A preliminary survey was carried out by IIEC during the project period which reveals that close to 55% of the respondents purchasing directly from the retailers and 70% of the respondents purchasing under installments valued BESCOM branding as "important" (Figure 4.1).

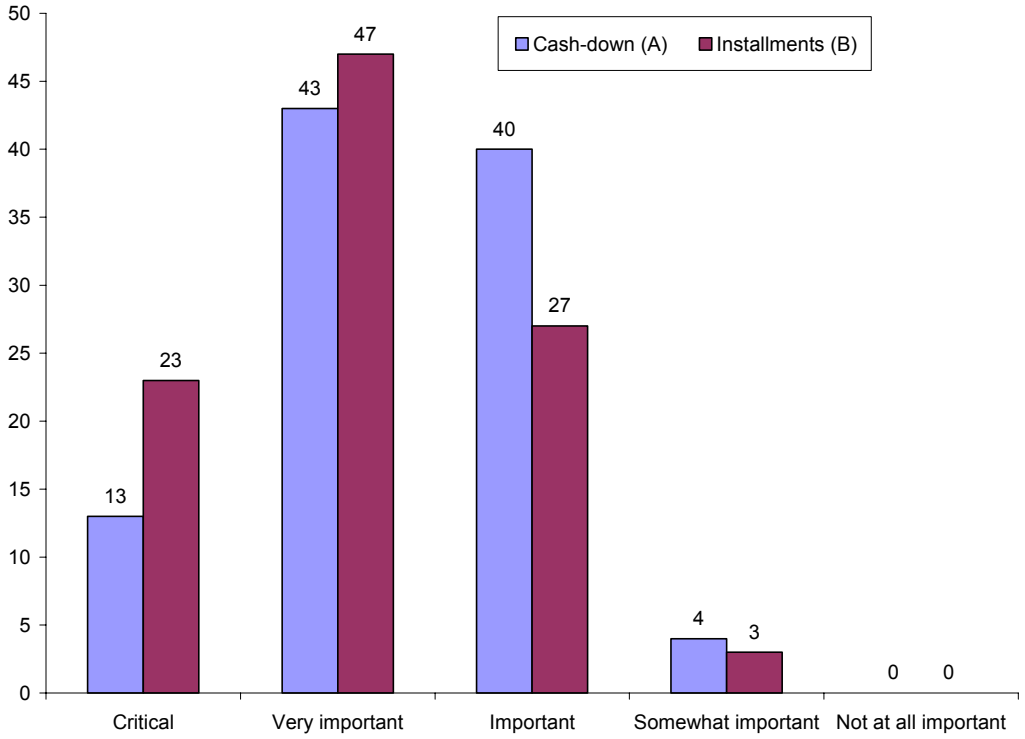


Figure 4.1 Importance of BESCOM Branding

As a part of the market evaluation, response from the non-participants was also captured. Perceptions of some of the non-participating suppliers are explained in Figure 4.2.

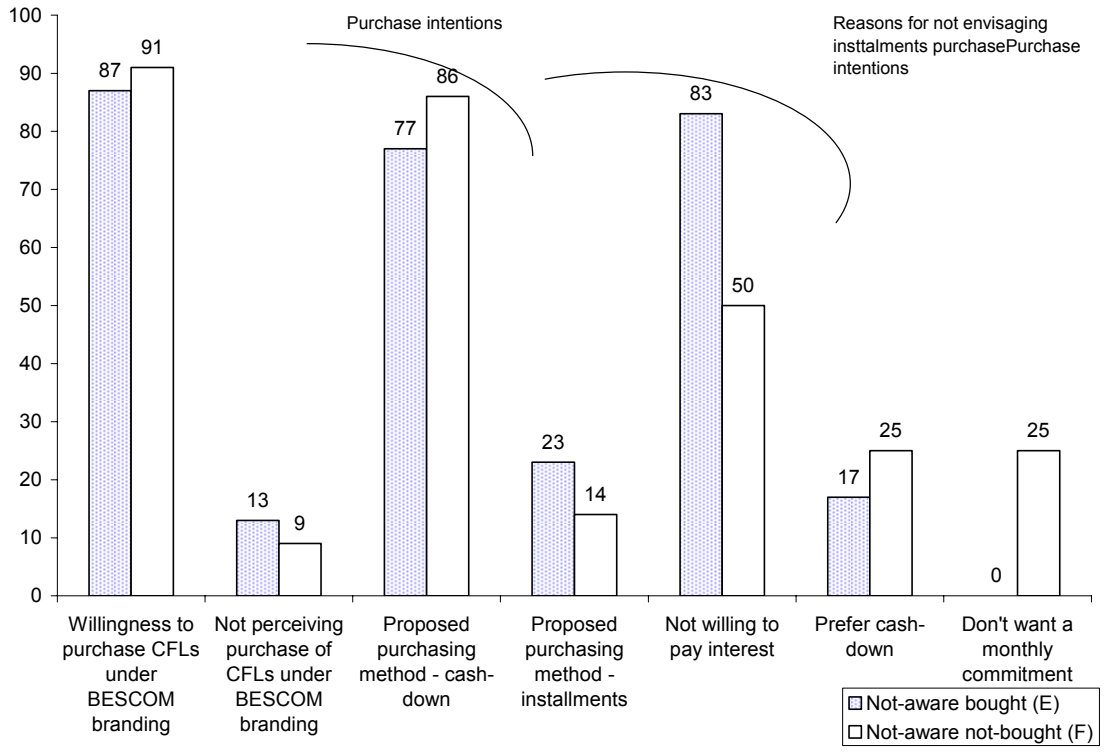


Figure 4.2 Willingness and Drivers of Non-participants in Next BELP Phase

4.2 Replication of BESCOM

BESCOM and IIEC have received request from several other utilities in the country to develop similar programs. At least two programs have taken shape in the past three months, which used technical and implementation features of BELP.

- Lighting initiative by Tata Power in Mumbai
- Lighting initiative by Maharashtra Distribution Company in Nashik

In addition to the above, BESCOM has take decision to expand this program in the Bangalore region and four more townships under its service territory.

5. Conclusions

This section of the report summarizes the findings of this committee discussed in relation to the Terms of Reference in Section 1.3.

Evaluation of peak demand from BELP

Peak reduction with the BESCOM system is in the range of 25.70 MW and annual savings is close to 37.515 MU. In monetary terms, the capacity offset benefit is in the range of 102.78 Crores (@ Rs. 4 Crores per MW) and avoided purchase of energy is in the range of Rs. 8.25 Crores.

Benefits to overall BESCOM power development plans

Savings accruing from the saved energy to individual customers is at an average of 8% when compared with the 7-month period of last year. With an average of 125 units consumed in a month by All Electric Homes – a classification of domestic sector, annual savings of 37.515 MUs resulting from BELP will result in avoided power development for at least 25,000 new connections in BESCOM with an average 125 units per month consumption.

Relevance of power quality issues

Power factor and total harmonic distortions relevant to CFLs are not too large as other loads in the domestic sector are more than the average CFL rating. Also, international power quality standards call for 0.5 and above power factor for CFLs. As the CFL costs would go up with the increased power factor and would also lead to higher heating of the lamps, in order to protect the warranty-issues of CFLs, no specific efforts are envisaged to improve the power factor of CFLs at this stage. On the other hand, as in case of other utilities in India (Reliance and Calcutta Electricity Supply Company), power quality correction at the Low-Tension side of the distribution transformers is recommended, which will be helpful in correcting the THD and PF of inductive loads (e.g. domestic pumping).

Annexure 1: BELP Program Design Document

Separate document attached

Annexure 2: BELP Sum-up Meeting Presentation

Separate document attached

Annexure 3: Photographs – BELP Launch and Road-shows

BELP Strategy Meetings

BELP Launch – December 2004

BELP Roadshows

Annexure 4: Sales data from suppliers

Indicative data from Philips

SALES OF CFL I IN BANGALORE

Eco II Paln of BESCOM

BANGALORE SALES*	
MONTH	SALES
October-03	14620
November-03	10170
December-03	11776
January-04	14578
February-04	11318
March-04	11387
April-04	13633
May-04	12243
June-04	15018
July-04	14866
August-04	13937
September-04	14855
October-04	13872
November-04	18830
December-04	21146
January-05	29580
February-05	
March-05	
April-05	
May-05	

* Confidential data only for Eco II Plan of BESCOM

OSRAM

Osram India Pvt Ltd.
Osram India Pvt Ltd.
Aug Wise Sales , Outstanding & Target for All India
Period Starting from : 01.01.2004 TO 31.12.2004

Ag/Aug	Description	January	February	March	April	May	June	July	August	September	October	November
	DEL											
10235	ECONOMY	6,170	4,830	9,538	7,408	15,061	9,281	9,952	8,748	6,450	26,362	13,066

Osram India Pvt Ltd.
Aug Wise Sales , Outstanding & Target for All India
Period Starting from : 01.01.2005 TO 31.07.2005

Ag/Aug	Description	January	February	March	April	May	June	July	**TOTAL**
	DEL								
10235	ECONOMY	8,750	18,328	13,346	18,058	13,986	14,465	13,186	**100,119**