IOSR Journal of Computer Engineering (IOSR-JECE)
ISSN : 2278-0661, ISBN : 2278-8727, PP : 07-13
www.iosrjournals.org

ANALYSIS OF ENERGY SAVING OPPORTUNITIES IN CEMENT SECTOR

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ABSTRACT: *With the growing economy India is facing energy shortage of 9.6% in 2006-07. Capacity addition of 49GW was under construction out of 78GW planned in this closing five year plan. Capacity addition also creates environmental problems. In this context Demand Side Management shows potential to reduce this supply demand gap. This paper analyses Demand Side Management (DSM) in the cement sector of India to reduce peak shortages with cost effective measures. It also proposed cost effectiveness of DSM measures using Conservation Supply Curve. Estimate shows energy saving potential of 2100 GWh using different cost effective measures compared to capacity addition.*

Keywords—*Demand Side Management; Energy Saving Potential in cement sector; Conservation Supply Curve*

I.INTRODUCTION

Electricity consumption is a key indicator of economic development of any country. Per capita consumption of electricity is not even 20% of world's average. This affects India's growth negatively. Maharashtra, one of the leading state in the country, also experiences a peak shortage of 5GW. This result into load shedding in even industrial sector affects the industrial growth. The Ministry of Power kept target of 78GW capacity addition in XI (FYP) five year's plan, but could succeed to achieve only 63% of that target [1]. All of These projects are under construction and requires significant capital investment. This will also affects our resolution of voluntarily reduction of CO2 emission by 25% by 2020.

In this context, it is necessary to focus on Demand Side Management (DSM) as an option to augmenting supply. Demand Side Management (DSM) is the process of modification of the customer loads to meets the utility load shape objectives. This may involve energy efficiency, load shifting or load management. In fact DSM measures allow customers to use electricity more efficiently or at times which do not coincide with system peak period.

Indian industrial sector is one of the leading consumers of electricity consuming about 32% [2] of total electricity consumption in 2005. Seven industries who are the major consumer of electricity consume about 60% of total electricity consumption. Bureau of Energy Efficiency referred them as a designated consumer.

II.REVIEW OF INDIAN CEMENT SECTOR

2.1 Cement Manufacturing Process

Cement Sector is one of designated consumer, consumes 20% of total energy consumption. India is second largest cement producer in the world. This process includes many stages in series configuration as shown in the Fig.1

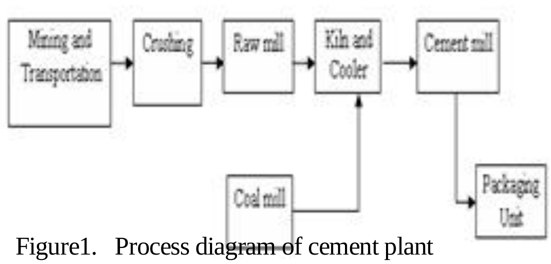

Figure1. Process diagram of cement plant

Cement manufacturing is the energy intensive process involves both thermal and electrical energy. Electricity is mainly required during raw material extraction, grinding, finished grinding and packaging. It also required for different stages of production like conveyors, compressors, fans and pumps. Most Indian plants based on the dry process as it is consumed about 9% [3] less power compared to conventional wet process. Blending of cement is also another method of energy saving as it consumes less power without affecting the quality of cement [4].

2.2 Electricity Demand of Cement Plant

Indian cement sector consumed about 10 Billion kWh of electricity in 2005 [2]. Specific Electricity Consumption (SEC) which is the key indicator of electricity consumption of the plant was varies from 60 kWh/t to 113 kWh/t with average value of 88 kWh/t [4]. Electricity is required to drive different motors in the plants like compressors, fans conveyor belts, crusher etc. As shown in Fig.2, about 60 % of total electricity has been consumed in raw material grinding and cement grinding thus grinding technology has a major impact on total electricity demand [5]. Therefore cement plants using Vertical Roller Mills (VRM) and High Pressure Grinding Rolls (HPGR) for raw material and cement grinding instead of ball mill will have lower power consumption. In certain cases, some measures used to improve thermal efficiency lead to more electricity consumption. For example, installation of grate cooler technique for clinker cooling reduces thermal energy requirement but consumes more power. Finally, quality of cement required also has an impact on power consumption. For example, for good quality strength development, finer cement is required which requires more power for fine grinding.

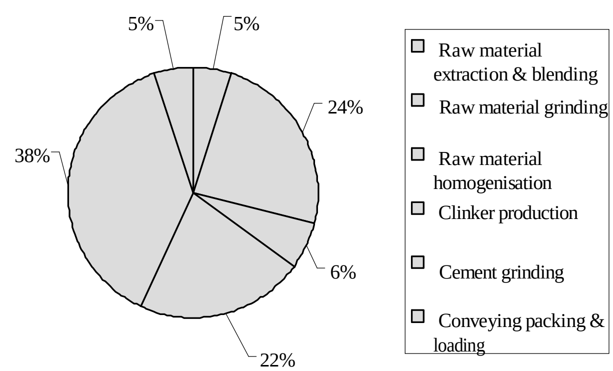

Figure2. SEC of typical cement plant

Average value for Indian plant = 88kWh /t

III. METHODOLOGY FOR ESTIMATION ENERGY SAVING POTENTIAL OF CEMENT SECTOR

3.1 Analysis of plants participated for National Energy Conservation Awards

Bureau of Energy Efficiency (BEE) every year awarding industry unit by "National Energy Conservation Awards" who has implemented best practices of energy efficiency in their plant. As part of it participating units submitting details about the energy efficiency measures implemented in their plant. The data consists of energy savings achieved in the plant due to EC measures along with the cost of investment and the brief description about the EC measures. Energy conservation data of ten cement plants from 2001-06 has been taken from BEE which is used for our analysis. Details of these plants enlisted in the Table I

Table I Profile of the case study plants

Name of the plant	Product Portfolio[3]	Production (Mt)	Energy consumption[1] (GWh)	SEC (kWh/t)[2]
Madras cement, Alathiyur	OPC-14%, PPC-86%	2.8	164.3	59.9
UltraTech cement, Gujarat	OPC-90%,PPC-10%	5.3	440	83
Dalmia cement, TamilNadu	OPC-40%,PPC-60%	2.7	211	77
Ultra tech cement, A.P.	OPC-56%,PPC-16%	2.3	191	83
Vasavadatta cement, Gulbarga	OPC-90%,PPC-10%	2.1	166	79
Chettinad cement, Karikkali	N.A.	1.5	103	69
Chettinad cement, Karur	OPC-38%,PPC-57%	2.1	149	71
Grasim cement, Raipur	OPC-32%,PPC-15%	2.2	144	67
Lafarge Cement,Sonadh	OPC-18%,PPC-16%	1.4	99.8	71
Shree cement, Beawar	OPC-76%,PPC-24%	2	129	64.5

Data includes both crosscutting measures like application of VSD, retrofitting with energy efficient motors, sizing of motors and energy efficient lighting with other measures like optimization of various parameters, sizing different equipment, waste heat recovery from exhaust gases and many other measures. These measures have been classified under nine broad categories as given below.

1. Variable Speed Drive (Application of VSD, installation of other energy efficient devices to the motor)
2. Efficient Motor System (Retrofitting existing motor by energy efficient motors, installation of Slip Power Recovery System (SPRS), delta to star connection of motor, retrofitting by energy efficient pumps or fans)
3. Energy Efficient Lighting [Energy efficient lighting measures like Compact Fluorescent Lamp (CFL), metal halide in place of High Pressure Mercury Vapor lamp (HPMV)].
4. Optimization (Optimizing various parameters like operating voltages, pressure, air flow, optimizing lighting requirement)
5. Automation (Automation of plant lighting, Automation of process circuits)
6. Additives (Addition of material that will reduce electricity consumption)
7. Additional Equipment (Installation of equipment which will lead to reduce electricity consumption)
8. Equipment Modification & Retrofits (Modification or retrofit of existing equipment which results into reduced power consumption)
9. Waste Heat Recovery (Power generation from waste heat recovery of exhaust gas, use of waste heat for drying ash and fuel)

After classifying these measures into different categories, each measure has been analyzed for its cost effectiveness. Investment cost for each measure is referred to the base year of 2006-07 by considering annual inflation rate based on industrial consumer price index. This investment cost referred to the base year of 2006-

[1]Energy consumption considered for year 2006-07. It considered only electricity taken from utility. It was taken from company's annual report

[2] Energy Audited details submitted to BEE

07 has been annualized by considering the life of measures as 20 years and discount rate. There is debate about the choice of discount rate to evaluate the DSM measures, given that it may be based on perspective (society or investor) and the time frame discussed (for example long-term discount rates are assumed to be lower than short term) [6]. In our analysis we considered all long term measures we assumed discount rate of 10 % for the analysis. Based on above methodology Cost of Saved Energy (CSE) for each DSM measure has been calculated. Table II illustrates the calculation of CSE for Energy Efficient Motor System. In a similar manner calculation has been done for each measure and accumulated to each category as shown in Table III. This shows that about 7% energy has been saved in 2006 due to DSM measures implemented in those ten cement plants.

Table II CSE calculation for Efficient Motor System measures

E.C. Option	Annual Energy Saving (MWh)	Invest-ment (Million Rs)[1]	Investment in context of 2006 (Million Rs)	Annualized Cap. Cost (Million Rs/year)	CSE with d=0.1 (Rs/kWh)
Replacement of centrifugal pump with submersible pump	10	0.04 (2005-06)	0.04	0	0.5
Replacement of centrifugal pump with submersible pump	169	0.03 (2005-06)	0.03	0.04	0.2
Install Energy Efficient Motor for Packing House	5.4	0.03 (2003-04)	0.03	0	0.8
Coal Mill Drive High Efficiency Motor	43	0.3 (2002-03)	0.04	0.04	1
Cooler 6th Compartment High Efficiency Impeller Modification	72	0.02 (2002-03)	0.02	0.02	0.3

This DSM measures were analysed based on their cost effectiveness by using the concept of Conservation Supply Curve (CSC).Conservation Supply Curve rank energy efficiency measures by their Cost of Saved Energy (CSE), which accounts for both the costs associated with implementing and maintaining a particular EC measures and the energy savings associated with that option over its lifetime. Based on the Table III which summarised the CSE calculation for each DSM options, CSC can be developed as shown in Fig.3. Even the costliest DSM option adopted was Waste Heat Recovery which had CSE of 1.65 Rs/ kWh. This was found to be cost effective compared to average energy tariff of 4.5 Rs/ kWh. As these CSE calculations are based on actual data of EC measures in the plants this gave real insight of the value.

Table III CSE calculation for different DSM options

E.C. Option	Annual Energy Saving (GWh)	Annual saving (Million Rs)	Investment in context of 2006 (Million Rs)	Annualised Cost (Million Rs/year)	CSE (Rs/kWh)	CSE (US cent /kWh)
Automation	5.78	7.1	2.8	0.32	0.06	0.13
Additives	1.78	7	1	0.12	0.07	0.15
Optimisation	24.19	78.4	8.6	0.10	0.04	0.09
EnergyEfficient Lighting	0.87	3.2	3.7	0.43	0.50	1.1
Efficient Motor Systems	9.47	29.8	29.8	3.5	0.37	0.8
Variable Speed Drive	6.42	26.3	32.1	3.8	0.59	1.24
Additional Equipment	15.32	73.7	91.8	10.8	0.70	1.52
Equipment Modification & Retrofits	30.66	150.5	203.9	23.9	0.78	1.7
Waste Heat Recovery	23.45	92	330	38.7	1.65	3.6
	118	**480.7**	**703.6**	**82.6**	**0.70**	**1.52**

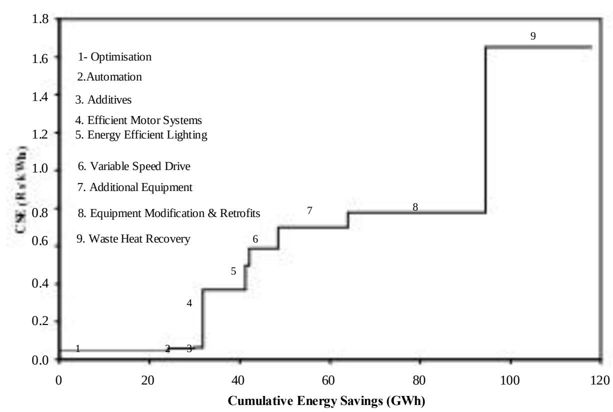

Figure3. Conservation Supply Curve for DSM in ten cement plant

3.2 Analysis for estimation of Aggregate energy saving potential of sector

Specific Electricity Consumption is the key indicator of status of electricity consumption of the plant. Specific Electricity Consumption of the plant depends upon factors like age of the plant, process adopted for production and product mix. In order to estimate energy saving potential of cement sector we analyze SEC[3] of thirty three cement plant as a case study based on the age and product profile of the plant. Those plants are having capacity of 102 Mt which represents 70% of the total production capacity of India. It shows that plant established after 1987 has SEC about the average SEC and has potential of achieving world's best values whereas plant established before 1987 has wide variation in their SEC. Based on this we have considered plant having age more than 20 years as old plant and plant having age less than 20 years as new plant. Energy saving potential of the plant has been estimated by using equation. The reference values for this estimation has been given in Fig.4

$$\text{Energy saving plant} = (SEC_{Plant} - SEC_{reference}) * \text{ production capacity of the plant}$$

[3] SEC of the plant has been considered for the year 2005-06

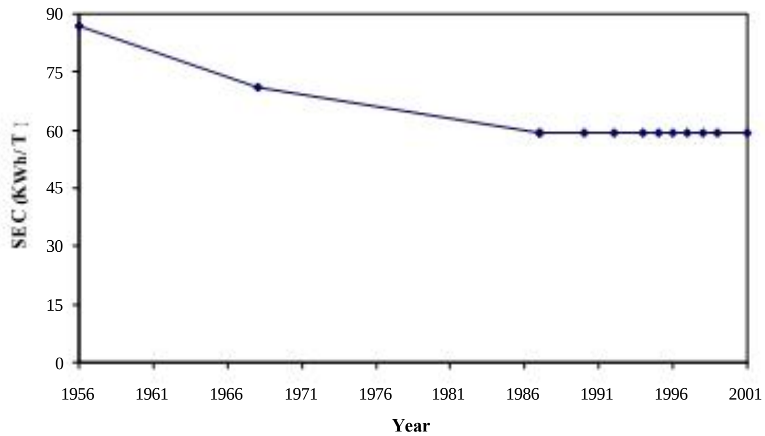

Figure4. Reference values for estimation of energy saving potential

3.3 Results: Energy saving potential of cement sector

Energy saving potential for these thirty three plants which were considered in this section has been estimated on the basis of their product mix. Plants have been categorized based on their product mix share as OPC, PPC, and BFSC based plants. Twenty three plants are considered as OPC based plants. Similarly, nine plants are PPC based and three plants are BFSC based plants. Table IV summaries the calculation of energy saving potential of these plants which are then extrapolated based on their production share at the aggregate level.

Table IV Energy saving potential of cement sector

Case Study						Aggregate	
Product Mix	No. of plants	Production Capacity (Mt)	Actual Production (Mt)	Energy saving potential (GWh)	Energy saved per tone (GWh/T)	Total Production (Mt)	Energy Saved (GWh)
OPC	21	58.7	52.07	973.5	18.70	55.3	1034.4
PPC	9	22.7	20.18	282.7	14.01	73.3	1027.1
BFSC	3	7.0	6.25	71.4	11.43	11.3	128.8
Total		**88.5**	**78.50**	**1327.6**		**139.9**	**2190.3**

This shows that cement sector has energy saving potential of 2190 GWh which can be achieved by Demand Side Management. This contributes about 20 % of the total consumption of the cement sector in 2005 and 1% of total industrial electricity consumption.

IV.CONCLUSION

The major problem in implementing Industrial DSM, that its potential has not been quantified properly. This paper focused on Demand Side Management in cement sector with the review of energy efficiency status achieved by the sector. It is based on actual energy savings achieved by the plants. It gives real insights on energy efficiency status of the ten cement plant and shows peak saving potential of 2190 GWh can be achieved by these cement sector with implementation of different measures implemented by case study plants. It also gives insight about cost effectiveness of these DSM measures. Cost of energy savings has been estimated are in about Rs. 0.7 kWh, which will be cheaper than cost of generation. It also help to keep environment clean.

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