Industrial DSM for Indian Power Sector

Mahendra Rane, Dhruv Chhabra and Rangan Banerjee

Abstract— This paper focuses on energy efficiency in the cement sector which constitutes about 5% of total electricity consumption of the industry. A Sankey diagram has been drawn which shows electricity flow in seven energy intensive industrial sectors in 2005. These sectors consume about 35% of total industrial electricity consumption. A methodology for load modeling of typical plant has been proposed which can be used for analyzing the impact of Demand Side Management (DSM) options or load management. This has been done with the help of a case study of a cement plant of 6500 TPD capacity of cement production. Energy audited details for last five years were analyzed to evaluate energy saving potential for typical plant. A methodology has been proposed for evaluating the energy efficiency potential for cement industry with the help of a case study. Cost effectiveness of these options has been analyzed with the help of Conservation Supply Curve for the plant.

Keywords—Demand Side Management, Cement, Conservation Supply Curve, Energy Efficiency.

I. INTRODUCTION

ELECTRICITY is an important input for the economic development of the country. India had a peak shortage of 13.8%, an energy shortage of 9.9% in 2007[1]. The Ministry of Power estimates indicate the requirement of an additional 100 GW in the next ten years. This would need significant capital investment and result in increased carbon dioxide emissions. In this context, it is necessary to focus on Demand Side Management (DSM) as an option to augmenting supply. In this paper we focus on DSM in India's industrial sector.

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. 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 sectors for electricity consuming about 32% [1] of total electricity consumption in 2005. Though there are some energy efficient plants in the country but average specific electricity consumption lags the best achieved in the world. An energy balance for the industrial sector has been done as shown in Fig. 1.

This paper analyzes the energy efficiency scenario of the cement industry, which is one of the energy intensive industries. Cement manufacturing is the energy intensive process in which electricity contributes about 20 % of the total energy consumption. This process includes many stages in series configuration as shown in Fig.2.

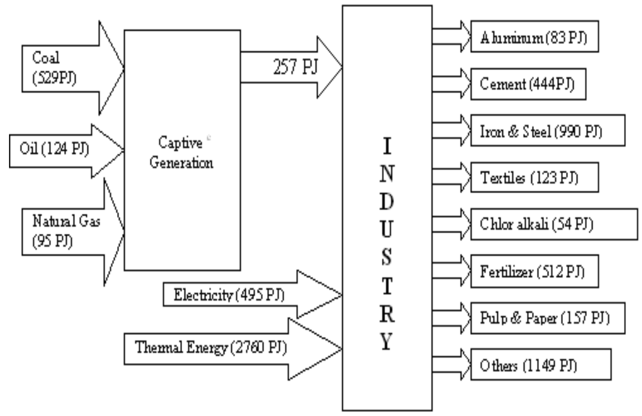

Fig. 1 Industrial energy balance for 2004-05

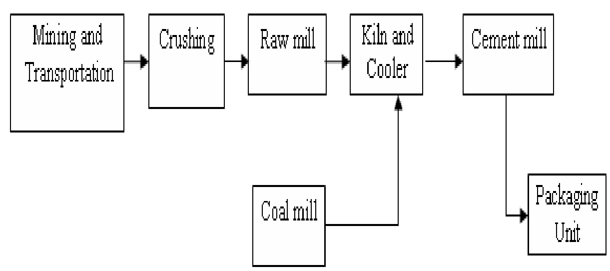

Fig. 2 Process block diagram of cement plant

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% [2] 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 [3].

A methodology has been proposed to quantify the energy savings potential of cement sector with the help of case study of Ultra Tech Cement, Tadipatri plant. The energy conservation options implemented in the plant during the last five years have been considered. These options are classified under seven broad categories. Based on this Conservation Supply curve (CSC) for the plant has been developed for the base year 2006-07. A case study of a 6500 Tonnes per day (TPD) cement plant is used to quantify the impact of DSM on the load curve with the help of physical based load model.

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II. ENERGY EFFICIENCY SCENARIO OF ULTRA TECH CEMENT, TADIPATRI

Ultra Tech Cement, Tadipatri plant located in Andhra Pradesh has installed capacity of 2.3 millions tones per annum (MTPA).The plant manufactures Ordinary Portland Cement (OPC)-56 %, Portland Pozzolana Cement (PPC)-16 % and Blast Furnace Slag Cement (BFSC) - 28% [3]. The annual electricity consumption of the plant was 191 MU in 2006-07. Trend of specific electricity consumption of the plant for last five years is shown in Fig. 3.

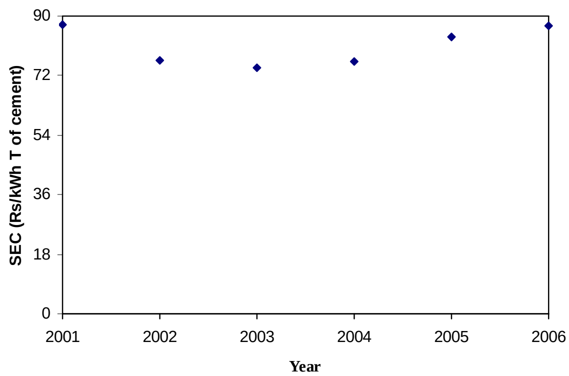

Fig. 3 SEC of the plant from 2001-06 (Source: BEE)

A. Methodology

Energy conservation measures implemented in the plant during 2001-06 were considered. These measures result in energy savings which were analyzed along with their cost of investment. These measures include 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 7 broad categories as given below:

- Variable Speed Drive (VSD)- Application of VSD, installation of other energy efficient devices to the motor
- Energy Efficient Motor (EEM)- 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)
- Energy Efficient Lighting (EE Light)- Energy efficient lighting measures like Compact Fluorescent Lamp (CFL), metal halide in place of High Pressure Mercury Vapor lamp (HPMV), automation of plant lighting
- Optimization- Optimizing various parameters like operating voltages, pressure, air flow, optimizing lighting requirement
- Sizing- Sizing of motor, modification of existing equipment structure
- Waste Heat Recovery (WHR) - Power generation from waste heat recovery of exhaust gas, use of waste heat for drying ash and fuel)
- Others- All other measures which can not be classified into above six categories

Initial investment for each measure which was done in different years was accumulated to the base year 2006-07 considering corresponding rate of inflation. This accumulated cost of investment has been annualized assuming real discount rate of 10% and 30% with the life of 20 yrs.

Annualized cost = CRF * Acc. cost of investment (1)

where,

CRF is the Capital Recovery Factor has been given as

$$CRF = [d\,(1+d)^{n}] / [(1+d)^{n} - 1] \quad (2)$$

Based on annualized cost of investment and the saved energy, Cost of Saved Energy (CSE) has been calculated as

CSE = Annualized capital cost / energy saved (3)

B. Energy Saving Potential of the plant

By applying the above methodology for each DSM option the energy saving potential was calculated as shown in TableI.

TABLE I
CSE FOR DIFFERENT DSM OPTIONS

E.C. Option	Energy Saving MWh	Annual saving (Lakh)	Acc. Investment (Lakh)	CSE with d = 0.1 (Rs/kWh)	CSE with d = 0.3 (Rs/kWh
Optimization	330	12.9	1.66	0.06	0.15
Other	2058	80.8	27.19	0.16	0.40
Sizing	953	37.3	13.30	0.16	0.42
EEM	248	9.7	8.40	0.40	1.04
VSD	1642	64.2	115.87	0.83	2.14
EE light	31	1.2	2.52	0.96	2.47
WHR	23450	920	3300	1.65	4.24

C. Conservation Supply Curve

Conservation Supply Curve (CSC) is a snapshot of the cost effectiveness of all the energy efficiency measures being considered at that point in time [4]. The width of each step (plotted on the X-axis) represents the annual energy saved by that option. The height of the step (plotted on Y-axis) shows the CSE for each of the options. All EC options are arranged in the incrementing order of CSE. The advantage of using CSC is that it provides a clear, simple framework for summarizing a variety of complex information about energy efficient technologies, their costs, and the potential for energy savings. DSM option was compared on the basis of CSE with the energy tariff. CSC has been drawn for the plant considering 10% and 30% discount rate as shown in Fig. 4. CSC concludes that all DSM options implemented in the plant found to be cost effective for d = 0.1. Even with discount rate of 30%, except WHR all options are found to be cost effective.

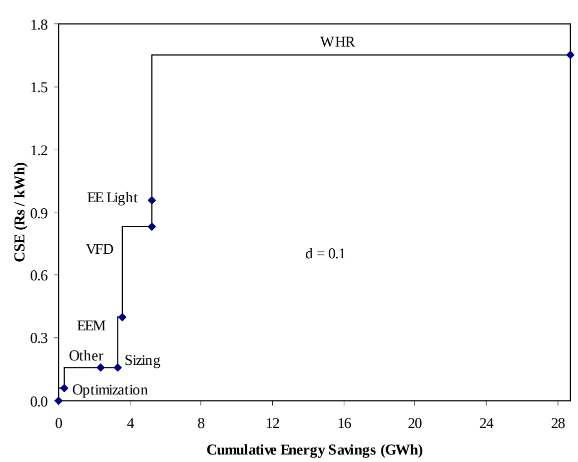

Fig. 4a CSC with d = 0.1

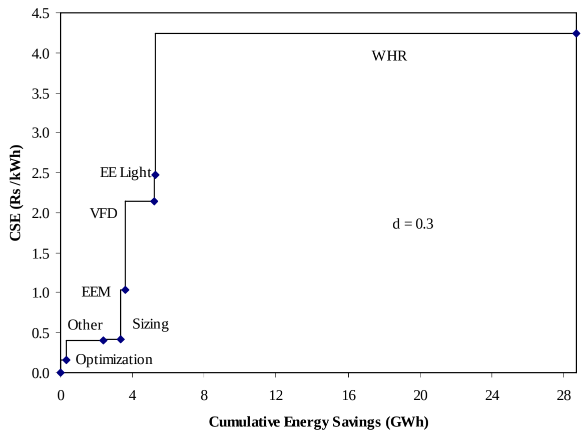

Fig. 4b CSC with d = 0.3

III. Typical Load Curve for Cement Plant

A typical load curve for cement plant has been constructed using physical based load model which can be used to analyze the impact of DSM on load curve.

A. Physical based load model

In this model, the load demand of equipment or a device is represented by the parameters of the physical process causing the load. Hence the name physical based load model [5, 6].Load demand of any equipment is represented by its capital stock and utilization factor. Capital stock represents the installed capacity or rated capacity. Utilization factor represents the effective utilization of the capacity under varying weather, economic, power and other conditions.

Assuming physical process load for a considerably long period, its randomness is assumed to be very small. To develop an hourly load profile of a manufacturing plant, we have to identify all the devices which consume electric power. Study of each of these devices separately is not practically possible. A better method is to group those devices which have a similar usage pattern or by assuming each section as one block.

B. Case study

The design data for different sections of a 6500 TPD cement plant has been considered for analysis. Plant data includes rated capacity of the motor (X_j), loading details of the motors (r_j) and time for which it is under operation. This data describes details of different loads along with their duration of operation. Load curve for this plant has been developed based on the following assumptions:-

- Expected demand for each section is assumed to remain constant or random process is assumed stationary over the span of an eight hour shift.
- Sufficient storage area for each process is assumed such that processes are independent.
- Most processes are assumed to be operating in first shift

C. Impact of DSM on load curve

Variable Speed Drive reduces the power input of motor depending upon speed variation requirement without affecting loading of motor. Application of VSD has been found to be economical for motors with large ratings [7]. Energy efficiency or down sizing of motor will change the loading of the motor. Thus value of '$X_j * r_j$' will be modified which is reflected as the impact of these options on the load curve as shown in Fig. 5 which shows that system peak reduces by 1.4 MW, about 5% of system peak demand.

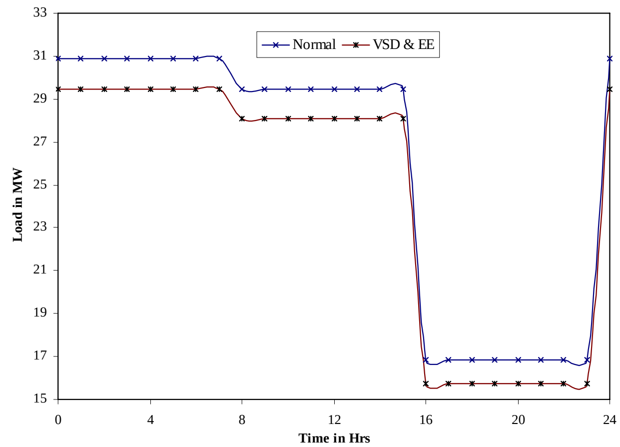

Fig. 5 Impact of DSM on cement plant load curve

IV. Conclusion

An energy balance has been constructed for industrial energy use in India. It is seen that seven energy intensive industries constitutes about 67% of total energy consumption. It also constitutes about 35% of total electricity consumption.

A case study for Ultra Tech Cement has been used and the energy conservation measures classified into seven categories. A CSC has been drawn. This shows about 15% energy saving has been achieved by the plant at CSE of 0.15-4.24 Rs / kWh which is less compared to energy tariff of 4.5 Rs / kWh. The method of drawing up CSC can help in identifying cost effective DSM options and including them in the supply mix. DSM options in industry can help to reduce energy shortages in the future. Application of this methodology (development of CSC) and extrapolation to the entire sector would help in quantifying savings through industrial DSM options.

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