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Drivers for Energy Efficiency in Indian Railway Workshops

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Abstract: - Two major railway coach repair workshops involved in periodical overhauling of broad gauge passenger coaches located in south India has been undertaken for studying the drivers for energy conservation (EC). The study covers a period of six calendar years from 2007 to 2012 and takes into account the various activities in terms of maintenance of coaches and production of components the energy input for both the workshops. Carriage Repair Workshop Hubli (UBLS) Central Workshops Mysore (MYSS) have introduced many an EC measures yielding good results. The extended study was then undertaken to analyse the drivers for energy efficiency in both of these workshops. The main stakeholders in both the workshops viz. the officers and senior section engineers (SSE's) were interviewed separately and their experience on the drivers for EC were sought. Totally seven drivers for EC were arrived at from the discussions with the stakeholders. To rank these seven drivers a questionnaire was devised to capture the data from both of these workshops and weighted average method adopted for ranking. The stakeholders were briefed of the questionnaire so as to make them accustomed to it. 82 respondents from UBLS and 41 respondents from MYSS filled up the forms in all respects which were used for analysis using weighted average method. Results show the similar first three ranking in both the workshops with total weighted average of greater than 0.5. The top ranked driver of both the workshops was dedication of the top management, engineers and staff with a weighted average score of 0.18 and 0.19 respectively from MYSS and UBLS respectively. The driver "awareness and adoption of latest technologies for EC" is a close second with a weighted average of 0.16 and 0.17 respectively from MYSS and UBLS respectively. Capacity utilization is ranked third which again is common for both the workshops. It was found that due to better awareness about environment at MYSS, it was ranked fifth when compared to UBLS wherein it was ranked the last at seventh position. These results clearly indicate that Railways is mainly driven by the dedication of its personnel and its sustenance and improvements on the energy front continue to contribute mainly by them. Indian Railways has 45 such workshops which are major energy consumers catering to the preventive maintenance of its fleet and thus railways need to keep their human resource motivated to contribute towards EC and reduce its carbon footprint.

Keywords: *- Carriage Repair Workshops, Drivers for Energy Efficiency, Energy Conservation, Indian Railways, Weighted Average*

I. INTRODUCTION

Indian Railways (IR) has 53220 number of passenger coaches which are given major attention in the form of periodical overhauling (PoH) at an interval of 18 months at carriage repair workshops [1]. Indian Railways has 45 workshops spread over the nation in its 17 zones to cater to periodic overhauling of all the coaches apart from some catering to the freight stock, locomotives [2]. South Western Railway over Indian Railways has two workshops which are undertaking PoH of passenger coaches one located at Hubli and the other located at Mysore. UBLS is one of the few workshops which have aggressively introduced numerous EC (EC) measures which have given good results and successfully sustained the same. MYSS too has kept pace and has implemented the agenda issued by Railway Board for EC. Major effort has been undertaken by MYSS to replace its aged centralized reciprocating air compressor by state of art microprocessor controlled screw compressor in July 2013, thereby ensuring savings in electricity consumption. UBLS during 2012-13 overhauled 761 coaches, carried out refurbishment of 140 coaches and undertook manufacturing of 2700 bogies and its

subassemblies employing over 3100 staff with 2877 being in the technical staff and others being in ministerial and other supporting categories[3]. The details of various categories of staff at UBLS and MYSS, activities undertaken by both the workshops and the manpower utilization are furnished in table 1 and table 2 below. The workshop has six technical officers who are managing the organisation with the help of 240 engineers (Including Electrical) who are the frontline managers and are responsible for the quality and quantity of daily output.

Table.1 Staff position of UBLS and MYSS as on 01.01.2013

Dept.	UBLS			MYSS		
	Engineers/ Supervisors.	Gr. C & Gr.D	Total	Engineers/ Supervisors	Gr. C & Gr.D	Total
Mech	223	2322	2545	140	1293	1433
Electrical	17	315	332	9	134	143
Stores	30	216	246	4	118	122
Ministerial	19	115	134	5	83	88
Total	289	2968	3257	158	1628	1786

Table.2 Staff deployment by UBLS and MYSS during 2012-13

Sl	Activity	UBLS			MYSS		
		Engineers	Gr. C & Gr. D	Total	Engineers	Gr. C & Gr. D	Total
1	Coach PoH, IoH, RSP	1307	82	1389	1143	28	1171
2	Brake Van mfg (UBLS)	188	10	198	0	0	0
3	Bogie frame & its sub-assembly mfg (UBLS)	490	29	519	0	0	0
4	MW, Outstation Works	174	21	195	104	3	107
5	Toy Train mfg (MYSS)	0	0	0	87	2	89
6	Composite Brake Block Mfg (MYSS)	0	0	0	32	2	34
7	Total	2159	142	2301	1366	35	1401

Mfg. Manufacturing, RSP – Rolling Stock Programme, IoH – Intermediate Overhaul

Deployment of staff at UBLS towards carriage repair activity (which also includes rolling stock programme) is 1307 staff and 82 engineers as evident from table 2. The Production shops include High speed brake van manufacturing, Bogie frame and its sub-assemblies manufacturing and utilize 678 staff and 39 engineers. Maintenance shops in both the workshops not only undertake maintenance of machinery and plant but also take up new developmental activities.

The average cost of overhauling of one broad gauge coach as per 2012-13 inputs cost is Rs 0.95 million which is nearly 10% of the cost of a new coach and the share of energy towards the cost of coach maintenance is miniscule 0.5%. UBLS is one of the oldest workshops in this country and is undertaking diverse activities which include the core activity of coach PoH and also has forayed into fabrication of bogies, its sub assemblies and also manufactures brake van for the freight trains, this workshop has been taken up for detailed study. Earlier study clearly indicated that UBLS has initiated novel measures for EC and sustained the same over the years inspite of increase in the connected load it was considered a fit case to study in detail the drivers for EC. The study undertaken to analyse the drivers for energy efficiency at UBLS divided the respondents into four functional wings viz. coach repair shop, production shops, electrical and maintenance shop which also included the trainers of the workshop. These four groups represent the backbone of the workshops due to their education, experience and above all their contribution in successfully managing the activities on a day to day basis. The study reveals that majority of respondents have more than two decades of experience with a maximum of 42 years which clearly highlights the loyalty towards the organisation and very low attrition rates. MYSS during 2012-13 undertook PoH of 789 coaches including 650 non AC coach PoH [4] apart from manufacturing 1, 04, 865 composite brake blocks and three toy trains. In MYSS the strength of engineers is 138 when compared to 240 of UBLS and as such no division among the engineers was made for the analysis sake. MYSS annually

consumes 1, 03,572 liters of diesel apart from 63,584 units of electricity per month. MYSS during July 2013 has switched over from old reciprocating centralized air compressor unit (90kW) to new state of art microprocessor controlled 90 kW screw air compressor thereby leading to saving of 1250 units of electricity per month.

Table 3. Energy consumed by UBLS and MYSS for year 2011

Sl. No.	Type of Energy Carrier	Application	UBLS	MYSS
1	Diesel in liters	a. D. G. Set	11,000	15,600
		b. Transport vehicles	45,000	50,000
		Total Qty. of Diesel	**56,000**	**65,600**
2	Electricity in kWh	Machines, Cranes	**16,35,771**	**6,85,963**
		a. Coach POH	19380	11,000
3	LPG in kg	b. Production	16150	11,000
		c. Canteen	0	8,500
		Total LPG in Kgs	35,530	30,500
4	Total Energy	**GJ**	**9631**	**6385**

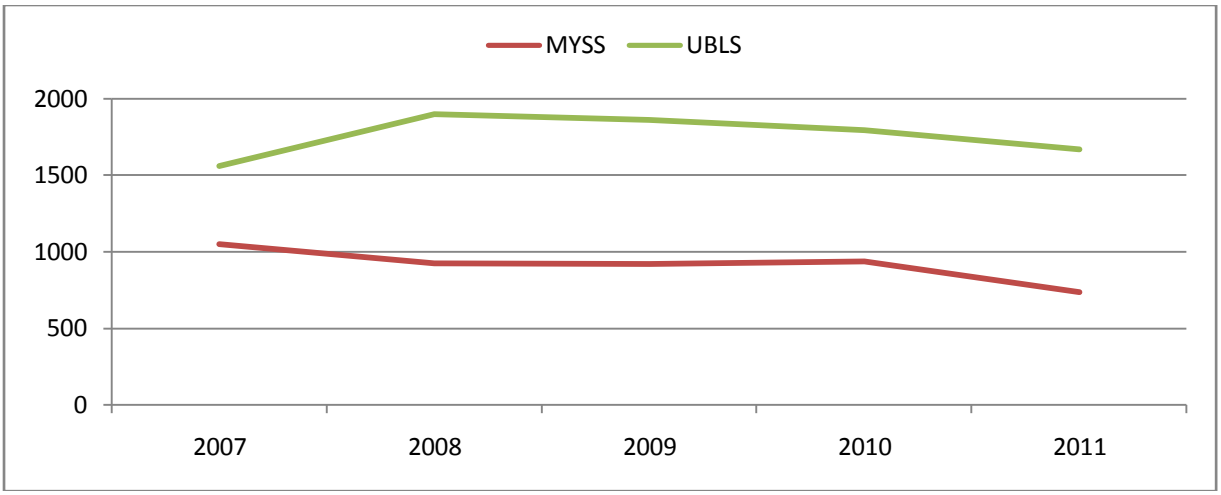

Fig. 1 Annual Electricity Consumption in Thousand kWh by UBLS and MYSS

The study reveals that from illumination point of view, the new technologies like T5 lamps, CFL, light pipe, metal halide lamps, tower lights with timers are already installed and as such there is little scope for improving energy efficiency in illumination area. The trend analysis of the energy consumption and energy bills shows that both the workshops have taken numerous steps to reduce the energy consumption over a period of time and thereby the overall cost of energy is reducing inspite of the increase in the energy costs by electricity distribution companies..

N. Nagesha and P. Balachander in their study [5] on drivers for energy efficiency in small scale industrial sector have considered the various drivers and prioritized the same using weighted averages method. More recently Patrik Thollander et.al [6] studied the various drivers for energy efficiency in energy intensive foundry sector using the survey method and as such we have adopted the method of survey to undertake the study. In order to continue progress in the field of EC, a study was required to determine the factors which lead to promotion of implementation and sustenance of EC measures. These factors can be taken up aggressively by other sister workshops to adopt and improve EC drives in their respective workshops.

II. METHODS AND MATERIAL

The author visited both the workshops over a period of four years and interacted with the team of officers and SSE's who manage the workshops. Based on the expert value judgment of the officers and SSE's

the seven drivers were listed and a common questionnaire framed for both the workshops. In UBLS 90 questionnaires were distributed among the respondents and 82 were received back duly filled in all respects. Six supervisors could not rank the drivers properly and were further guided to ensure that each rating appeared only once in the list. Out of the 82 respondents, 62 are diploma holders in engineering, 18 are engineering graduates and two are post graduates in engineering. The respondents include 4 officers, 44 SSE's and 30 Junior Engineers (JE). The average experience of SSEs is 24 years and that of JEs is 16 years. Initially the respondents were briefed about the questionnaire and were asked to rank the drivers in their functional areas as they perceived them. The questionnaire was administered to 4 out of 6 technical officers and 77 engineers out of 240 engineers of the shops (both mechanical and electrical put together) which cover 35% of the population. Similarly at MYSS the author briefed the respondents about the questionnaire and distributed 50 questionnaires. 42 questionnaires were received back duly filled in all respects.

The questionnaire was briefed to the respondents at both the workshops as they are not familiar with filling such forms and were instructed to rank the drivers from 1 to 7 as per their weight age and ensure that each rank from 1 to 7 was used once and also the details of their qualification and experience is mentioned in the form. The questionnaire was collected and analyzed using weighted average method. The weightage was arrived by adding 1 to 7 which totals to 28 and rank 1 was thus given a weightage of 7/28 = 0.25. Similar calculation yields weightage for rank 2 to 7 as 0.21, 0.18, 0.14, 0.11, 0.07 and 0.04 respectively. The data of the respondents were tabulated in the form of tables for both the workshops separately and also an overall table was prepared capturing the data of 123 respondents. The weighted average for each ranking was calculated and the drivers are ranked based on their weighted average score.

III. RESULTS AND DISCUSSIONS

The consolidated details of the driver analysis in UBLS covering the four groups of carriage Shop, production shops, maintenance shops and electrical wing are presented in tables No.4 below. The table shows the number of respondents choosing different ranks for each of the seven drivers considered in the study, apart from the weighted scores and the ranking for the respective group. 30 respondents out of 82 at UBLS ranked "dedication of management, engineers and staff" as the main driver for energy efficiency improvement which was seconded by 19 other respondents. The driver "awareness and adoption of latest technologies for EC" is a close second in all the four groups under study. It is very essential that unless the engineers are aware of the current technologies, improvements in energy front cannot be brought about. Due to increased awareness the major energy consuming equipment have been optimally loaded to reduce underutilization. This is one of the technical factors being introduced in UBLS. For example instead of having a centralized large capacity compressor like at MYSS, UBLS has gone for decentralization of air compressors, located them in the area where compressed air is required with capacities matching the requirement. As the engineers are all technically qualified and experienced, they do attach importance to EC measures and hence is ranked forth. Top management i.e. zonal railways and railway Board does encourage EC and awards energy efficiency shield to the best performing workshop. Also the officers, engineers with meaningful contribution are recognized and awarded during railway week celebrations annually. Officers from railway board, zonal headquarters review the position of workshops by personal inspections and also encourage EC activities by giving away spot awards. This is one good feature being adopted by railways to improve EC amongst the officers, engineers and staff.

The result analysis finds that all the four groups at UBLS show the similar ranking wherein it was evident that dedication of the top management, engineers and staff was the major driver for implementation and successful maintenance, sustenance of the energy efficiency measures. The ministry of railways i.e. railway board does circulate guidelines for implementing measures for EC and currently an list of 28 items is in force which is being actively pursued by the zonal railways. It is the sheer dedication of all the associates that the EC measures are properly installed, operated and successfully maintained. This was the major driver emerging from the analysis of all the four groups of the workshops. Railways has a dedicated organisation viz. Research, Design and Standards Organisation located at Lucknow in Uttar Pradesh which has a energy management cell and has come out with many a new technologies for energy efficiency for traction and non-traction applications. The awareness and adoption of latest technologies available for EC ranked second and the concern for planet earth, environment protection was ranked at the bottom. The workshop complies with all the statutory requirements of both central and state pollution boards and has got no issues with local pollution; it has never been an issue with the associates. It is evident from the study that as most of the engineers are elderly people who were educated two to three decades ago when environment was not an issue and as such they did not appreciate this driver as compared to the other six drivers. At railway workshops the share of energy as a percentage of total repairs or production cost is insignificant as such it is not considered as a major driving force.

Table. 4 Overall workshops weighted average scores of drivers at Carriage Repair Workshops- Hubli

Rank	1	2	3	4	5	6	7	Total	Weighted	Rank
Value	0.25	0.214	0.179	0.143	0.107	0.071	0.036	Response	Average	
Dedication of Mgt.	30	19	10	8	9	3	3	82	0.19	1
Awareness	12	20	23	10	7	6	4	82	0.17	2
Capacity Utilization	8	12	21	13	13	5	10	82	0.15	3
Top Management	12	6	5	19	12	16	12	82	0.14	5
Education of Associates	10	12	11	12	15	14	8	82	0.15	4
Recognition	3	9	8	15	17	24	6	82	0.12	6
Concern for planet Earth	7	3	3	6	9	15	39	82	0.08	7

Table. 5 Driver wise weighted average of all shops at Carriage Repair Workshops, Hubli

Weighted Average of	Officers & Electrical Shop	Maintenance Shop	Carriage Shop	Production Shop	Overall Workshop
Dedication of Mgt.	0.19	0.21	0.19	0.172	0.19
Awareness	0.17	0.16	0.17	0.161	0.17
Capacity Utilization	0.15	0.15	0.15	0.161	0.15
Top Management	0.14	0.13	0.14	0.156	0.13
Education of Associates	0.15	0.14	0.15	0.152	0.15
Recognition	0.13	0.12	0.13	0.114	0.13
Concern for planet Earth	0.08	0.09	0.08	0.087	0.09

Table. 6 Weighted average scores of drivers in Central Workshops- Mysore

Rank	1	2	3	4	5	6	7	TR	WA	Rank
Value	0.25	0.21	0.18	0.14	0.11	0.07	0.04			
Dedication of Mgt.	9	10	12	2	3	1	4	41	0.18	1
Awareness	7	7	5	10	7	2	3	41	0.16	2
Capacity Utilization	6	10	7	5	6	6	1	41	0.16	3
Top Management	3	4	5	5	9	8	7	41	0.12	6
Education of Associates	2	7	5	13	5	5	4	41	0.14	4
Recognition	3	1	4	3	8	13	9	41	0.10	7
Concern for planet Earth	11	2	3	3	3	6	13	41	0.13	5

TR – Total Responses, WA – Weighted Average

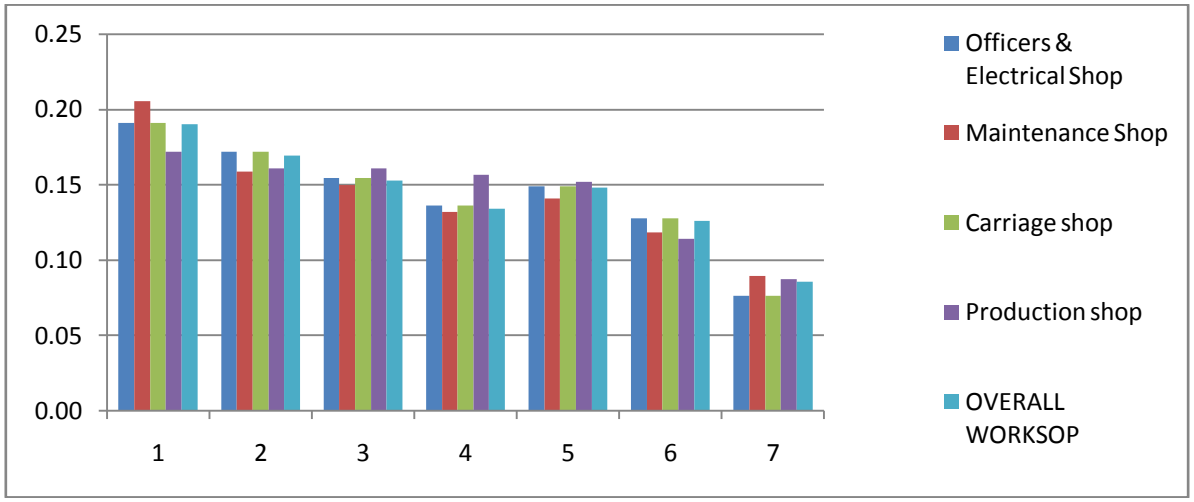

Fig. 2 Relative position of the drivers in the four group's driver wise at UBLS

LEGEND FOR FIGURE 2 AND TABLE 3

1. Dedication of management, Engineers and staff towards EC
2. Awareness & adoption of new technologies available for EC
3. Capacity Utilization of machines and plant
4. Top Management drive viz. by Railway Board and Zonal Railways
5. Education of Associates, Trainings provided
6. Recognition & Motivation of staff by Management towards EC
7. Concern for planet Earth, Environmental protection

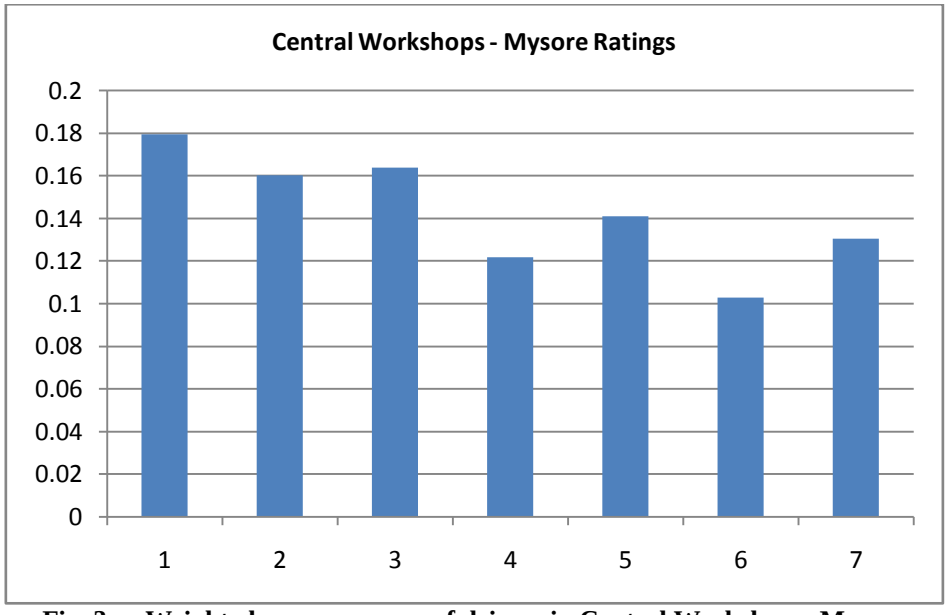

Fig. 3 Weighted average scores of drivers in Central Workshops- Mysore

A comparison of relative position of drivers in the four groups along with the overall workshop is illustrated in figure 1. On the whole all the four groups have the same ranking with dedication being at number 1, followed by awareness, capacity utilization, education, top management, recognition and the last being concern for planet earth. The rankings follow the order of questions except for position four and five which are swapped. The comparative bar chart of drivers in the study groups reinforces the inference deduced after comparing the four groups and it is clearly evident that the overall perceptions of the officers, engineers regarding the drivers to energy efficiency remain similar across the group irrespective of their functional activities.

It is easy to see the linkage among these findings. The lowest rank to environment is due to the fact that these workshops maintain a good quality of ambient air and follow the guidelines laid down by the pollution control boards. Accordingly the earlier activity of casting cast iron brake blocks at UBLS using cupola furnaces has been discontinued in the wake of increased indoor pollution levels. On a larger context the outcomes clearly indicate that railway workshops being government organizations maintain good environment conditions by utilizing clean fuels and procure the best and state of art equipments by way of global tendering process for the high end equipment. Necessary training and exposure to new ideas by way of conferences, workshops shall improve the energy management in all the shops.

IV. CONCLUSIONS

The result analysis finds show the similar first three ranking in both the workshops with total weighted average of greater than 0.5. The top ranked driver of both the workshops was dedication of the top management, Engineers and staff with a weighted average score of 0.18 and 0.19 respectively from MYSS and UBLS respectively. The driver "awareness and adoption of latest technologies for EC" is a close second with a weighted average of 0.16 and 0.17 respectively from MYSS and UBLS respectively. Capacity utilization is ranked third which again is common for both the workshops. It was found that due to better awareness about environment at MYSS, it was ranked fifth when compared to UBLS wherein it was ranked the last at seventh position. This clearly indicates that railways is mainly driven by the dedication of its personnel and its sustenance and improvements on the energy front continue to contribute mainly by them

The compilation of the data and its subsequent analysis has given the above results from which we can conclude that officers and electrical engineers group mention" dedication of management, engineers and staff towards the EC" as the strongest driver with an weighted score of 0.19. This is very apt from the fact that both the workshops have consistently reduced its energy requirements inspite of multifarious activities and also increases in quantities of few activities. Introduction of renewable energy in the form of solar thermal for water heating in canteen, solar PV for illumination of administrative building also has contributed to the energy savings. Study also reveals that in UBLS all the four groups have similar ranking for the drivers. The dedication of all the associates ensures that the energy usage is controlled, regular preventive maintenance of major equipment is undertaken, the health of the equipments are monitored and the subordinate staff are informally counseled for EC. The engineers and staff recruitment are undertaken in a very fair and transparent manner and as such the best get an opportunity to serve the great organisation. All the staff both supervisory and technicians are provided with induction training either for 6 months or for 12 months and as such it is essential that a module on EC should be a part of such training. This will improve the awareness and understanding of the concepts in energy management. Also the engineers and staff have ranked concern for environment at the last which calls for inculcating the importance of environment by way of educating them during their initial induction training.

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